Applied Thermodynamics

Vision and Mission of the Chandigarh University

Vision

"To be globally recognized as a Centre of Excellence for Research, Innovation, Entrepreneurship and disseminating knowledge by providing inspirational learning to produce professional leaders for serving the society"

Mission

M1: Providing world class infrastructure, renowned academicians and ideal environment for Research, Innovation, Consultancy and Entrepreneurship relevant to the society.

M2: Offering programs & courses in consonance with National policies for nation building and meeting global challenges.

M3: Designing Curriculum to match International standards, needs of Industry, civil society and for inculcation of traits of Creative Thinking and Critical Analysis as well as Human and Ethical values.

M4: Ensuring students delight by meeting their aspirations through blended learning, corporate mentoring, professional grooming, flexible curriculum and healthy atmosphere based on co-curricular and extra-curricular activities.

M5: Creating a scientific, transparent and objective examination/evaluation system to ensure an ideal certification.

M6: Establishing strategic relationships with leading National and International corporates and universities for academic as well as research collaborations.

M7: Contributing for creation of healthy, vibrant and sustainable society by involving in Institutional Social Responsibility (ISR) activities like rural development, welfare of senior citizens, women empowerment, community service, health and hygiene awareness and environmental protection

Vision and Mission of the Department of Mechanical Engineering

Vision

To be recognized as a center of excellence for research and innovation in Mechanical Engineering through contemporary as well as futuristic tools and technologies for serving the society at regional, national and global level

Mission

MD1: Providing quality education to the students in core and allied fields by implementing advanced pedagogies

MD2: Encouraging students towards research and development through advanced tools and technologies for providing solution to societal problems

MD3: Evolve and empower the students through core technical skills for becoming entrepreneurs and innovators

MD4: Inculcating employability and leadership skill for ensuring industry ready professional through hands on experiential learning and industrial collaboration

MD5: Developing professional and ethical standards in the mind of the young engineers by continuous learning and professional activities

1.2.State the Program Educational Objectives(PEOs)(5)

PROGRAM EDUCATION OBJECTIVES (PEOs):

PEO1: Graduates will have professional knowledge in the field of Mechanical Engineering and various other interdisciplinary domains.

PEO2: Graduates will have successful career in government services, research organizations, corporate sector, academic institutes and industries at national and international repute.

PEO3: Graduate will havecompatibility of modern engineering tools and technologies for deliberating solution of various engineering problems.

PEO4: Graduate will develop skill to address the concern of society, environment and communicate effectively to lead the interdisciplinary diverse team.

PEO5: Graduates will be effectively fit for higher education, innovations, research &development, entrepreneurship and professional development.

PROGRAM OUTCOMES (POs):

Program: Bachelor of Engineering (Mechanical Engineering)

Duration: 4 years

PO1. Engineering Knowledge: Apply knowledge of mathematics, science and engineering fundamentals and Production and Industrial Engineering specialization to the solution of complex Production and Industrial Engineering problems.

PO2. Problem Analysis: Identify, formulate, research literature and analyze complex Production and Industrial Engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex Engineering problems and design system components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.

PO4. Conduct investigations of complex Engineering problems: Use research-based knowledge and research methods including analysis, interpretation of data and synthesis of information to provide valid conclusions.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. The Engineer and Society: Apply contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams and in multi disciplinary settings.

PO10. Communication: Communicate effectively on complex Engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.

PO11. Project Management and Finance: Demonstrate knowledge and understanding of Engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life Long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs):

PSO1: Apply the knowledge of Production, Manufacturing and Industrial Engineering for analysis, optimization and development of mechanical system

PSO2: Apply the concepts of Design and Thermal Engineering to model, analyze and develop the mechanical components and systems

Course Outtcomes

After completion of this course will be able to

CO1: Apply the fundamentals of steam generator, nozzles, steam turbines, condensers and compressors.
CO2: Classify the different types of boilers, steam turbines, condensers and compressors.
CO3: Solve the problems related to boiler, steam nozzles, turbine, condenser, compressors.
CO4: Evaluate the performance characteristics of steam, nozzles, impulse and reaction turbines.
CO5: Select the boiler, nozzle, turbine, condenser and compressors for particular application.

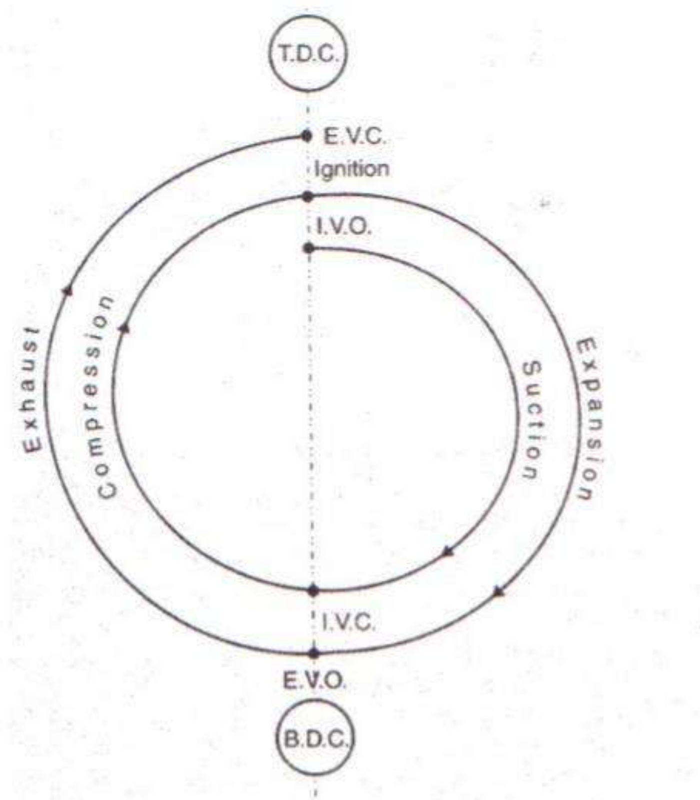
Experiment No. 1

Aim: To draw valve timing diagram of 4 stroke petrol engine and study of its impact on the performance of an IC engine.

Valve timing diagram for 4 stroke system

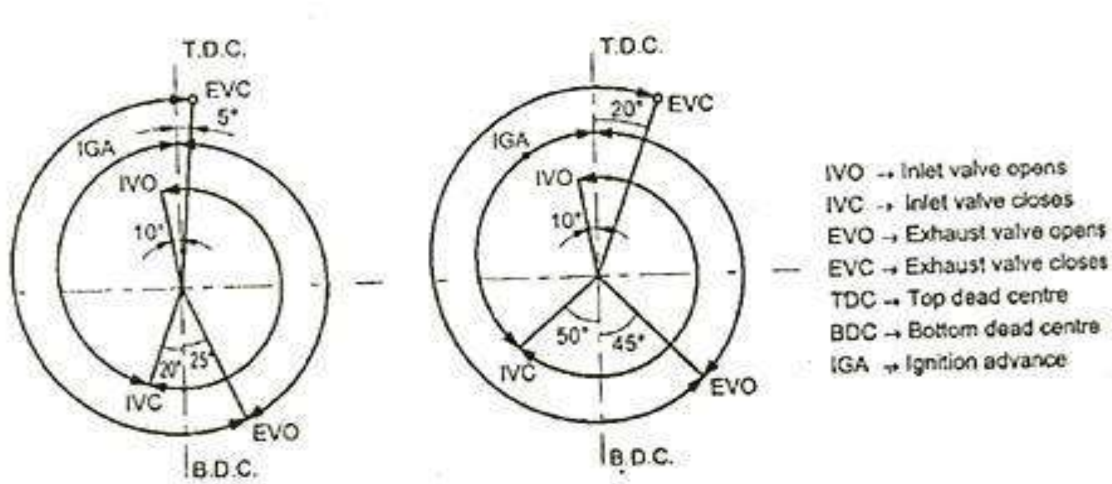
Theoretically it may be assumed that the valves open and close and the spark (or injection of fuel) occurs at the engine dead centers. However, in actual operation, the valves do not operate at dead center positions but operate some degree on either side of the dead centers. The opening occurs earlier and the exhaust continues even at later crank angles. The ignition is also timed to occur in advance of the completion of compression stroke.

The timing of these events, referred in terms of crank angles from dead center positions, is represented on a valve timing diagram. The correct timings are of fundamental importance for the efficient and successful running of the I.C. engine.



Theoretical valve timing diagram (four stroke Otto cycle engine).

Valve Timing Diagram For Petrol Engine



Low Speed Petrol Engine **High Speed Petrol Engine**

1. **Inlet valve:** Due to inertia effect and the time required in attaining full opening, the inlet valve is made to open somewhat earlier than TDC so that by the time the piston reaches TDC, the valve is fully open. For an engine running at low speed and with throttle opening, there is vacuum in the cylinder throughout the intake strike and on the completion of the strike the cylinder is almost filled with charge at atmospheric pressure. However, majority of I.C. engines run at tremendous speeds. Consequently during suction stroke the piston will reach the BDC Before the charge could get enough time to enter the cylinder through the inlet valve passages. Moreover, there is considerable resistance to the flow of charge through the air cleaner. Inlet valve is closed at BDC the cylinder by each cycle would receive charge less than its capacity and the pressure inside the cylinder would remain somewhat less than the atmosphere.

Consequently, in actual operation, inlet valve is kept open the cylinder pressure equals the atmospheric pressure. The inlet valve is open even during compression, some of the charge may be sent back to the induction pipe. On the contrary, the kinetic energy of the air fuel mixture (or air) produces the ramming effect which enables more charge to enter the cylinder. Theoretically it may be possible to induce charge more than volume capacity of the combustion space.
The greater charge sucked in by opening the inlet valve before TDC and closing it 40-45^0 after BDC increases the potential output of the engine.

2. **Ignition (or injection):** The TDC would be proper time to produce spark if the charge could burn instantaneously. However, there is lag between the timing of spark and that of actual

ignition. For best result with regard to power and economy, and to avoid explosion knock, the ignition of charge is timed to occur as early as the engine permits. At higher speeds the ignition timing is called ignition advance.

With too early ignition, the complete ignition may occur before the piston reaches the TDC and this may cause back explosion. The back explosion will cause the engine to run in the reversed direction of rotation.

3. **Exhaust valve:** The scavenging period (period available for discharge of burnt gases) is increased by opening the exhaust valve in advance i.e. before BDC and closing it with delay, i.e. after TDC Earlier opening makes it possible for the exhaust gases to leave by virtue of their pressure being higher than the atmosphere. During late closure, the kinetic energy of fresh charge is utilized to assist in the maximum exhausting cylinder. Thus scavenging is being obtained is being obtained at the cost of power from the expansion stroke. All the same a greater portion of the burnt gases is exhausted and this reduces the among of the work to be done by the piston on the return stroke.

It may be seen that for some part of the cycle near TDC both the valves are open and this period is called overlap.

PROCEDURE:

1. Observe the various parts of 4-stroke petrol engine and various strokes of engine. After this set the pointer at flywheel at zero
2. Now position at BDC on moving slowly the flywheel inlet valve opens before the position reaching to TDC.
3. Inlet valve opens before TDC and after slowly moved flywheel in the same direction. The position reaches TDC and then BDC
4. After BDC the inlet valve closes note the position of the inlet valve closes 20^0 after BDC
5. Slowly move the flywheel in same direction after closing of inlet valve suction stroke is completed.
6. Exhaust valve is opens at 25^0 before BDC exhaust valve closes 5^0 after TDC. Same time exhaust stroke completes and cycle is completed.

PRECAUTIONS:

1. Readings should be taking without parallax error.
2. Observe carefully the valves are closed or in open position.

Prepared By	Reviewed By	Checked By

Experiment No. 2

Aim: To draw valve timing diagram of 4 stroke diesel engine and study of its impact on the performance of an IC engine.

THEORY:

In four stroke cycle engines the four events namely suction, compression, power and exhaust take place inside the engine cylinder. The four events are completed in four strokes of the piston (two revolutions of the crank shaft). This engine has got valves for controlling the inlet of charge and outlet of exhaust gases. The opening and closing of the valve is controlled by cams, fitted on camshaft. The camshaft is driven by crankshaft with the help of suitable gears or chains. The camshaft runs at half the speed of the crankshaft. The events taking place in I.C. engine are as follows: 1. Suction stroke 2. Compression stroke 3. Power stroke 4. Exhaust stroke.

1. Suction stroke: During suction stroke inlet valve opens and the piston moves downward. Only air or a mixture of air and fuel are drawn inside the cylinder. The exhaust valve remains in closed position during this stroke. The pressure in the engine cylinder is less than atmospheric pressure during this stroke.

2. Compression stroke : During this stroke the piston moves upward. Both valves are in closed position. The charge taken in the cylinder is compressed by the upward movement of piston. If only air is compressed, as in case of diesel engine, diesel is injected at the end of the compression stroke and ignition of fuel takes place due to high pressure and temperature of the compressed air.

3. Power stroke: After ignition of fuel, tremendous amount of heat is generated, causing very high pressure in the cylinder which pushes the piston downward. The downward movement of the piston at this instant is called power stroke. The connecting rod transmits the power from piston to the crank shaft and crank shaft rotates. Mechanical work can be taped at the rotating crank shaft. Both valves remain closed during power stroke.

4. Exhaust stroke: During this stroke piston moves upward. Exhaust valve opens and exhaust gases go out through exhaust valves opening. All the burnt gases go out of the engine and the cylinder becomes ready to receive the fresh charge. During this stroke inlet valve remains closed. Thus it is found that out of four strokes, there is only one power stroke and three idle strokes in four stroke cycle engine. The power stroke supplies necessary momentum for useful work.

Inlet Valve opening and closing

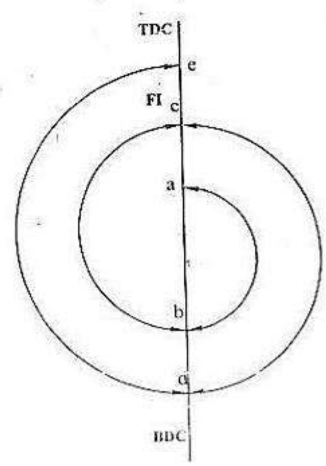
In an actual engine , the inlet valve begins to open 5°C to 25 °C before the piston reaches the TDC during the end of exhaust stroke. This is necessary to ensure that the valve will be fully open when the piston reaches the TDC. If the inlet valve is allowed to close at BDC , the cylinder would receive less amount of air than its capacity and the pressure at the end of suction will be below the atmospheric pressure . To avoid this the inlet valve is kept open for 25° to 40°after BDC.

Exhaust valve opening and closing

Complete clearing of the burned gases from the cylinder is necessary to take in more air into the cylinder . To achieve this exhaust valve is opens at 35° to 45° before BDC and closes at 10° to 20° after the TDC. It is clear from the diagram , for certain period both inlet valve and exhaust valve remains in open condition. The crank angles for which the both valves are open are called as overlapping period . This overlapping is more than the petrol engine.

Fuel valve opening and closing

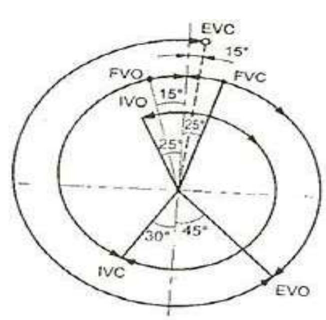
The fuel valve opens at 10° to 15 °before TDC and closes at 15° to 20 ° after TDC . This is because better evaporation and mixing fuel.



IDEAL VALVE TIMING DIAGRAM

ab - Suction (180°)
bc - Compression (180°)
cd - Expansion (180°)
de - Exhaust (180°)
FI - Fuel Injection
(Fuel Valve open and close at TDC immediately)

The valve timing diagram for actual engine is shown in figure for a typical diesel engine.



IVO – 25° before T.D.C.
IVC – 30° after B.D.C.
EVO – 45° before B.D.C.
EVC – 15° after T.D.C.
FVO – Fuel valve opens 15° before T.D.C.
FVC – Fuel valve close 25° after T.D.C.

Valve timing diagram of a Diesel Engine

PROCEDURE:

1. Observe the various parts of 4-stroke diesel engine and various strokes of engine. After this set the pointer at flywheel at zero
2. Now position at BDC on moving slowly the flywheel inlet valve opens before the position reaching to TDC.
3. Inlet valve opens before TDC and after slowly moved flywheel in the same direction. The position reaches TDC and then BDC
4. After BDC the inlet valve closes note the position of the inlet valve closes 30^0 after BDC
5. Slowly move the flywheel in same direction after closing of inlet valve suction stroke is completed.
6. Exhaust valve is opens at 45^0 before BDC exhaust valve closes 15^0 after TDC. Same time exhaust stroke completes and cycle is completed.

PRECAUTIONS:

1. Readings should be taking without parallax error.
2. Observe carefully the valves are closed or in open position.

Prepared By	Reviewed By	Checked By

Experiment No. 3

Aim: Determination of brake power, indicated power, friction power and mechanical efficiency of a multi-cylinder petrol engine running at constant speed (Morse Test) and to draw the heat balance sheet of multi-cylinder petrol engine.

INTRODUCTION:

The most commonly used source of power for motor vehicles, introduced by the German engineers Gottlieb Daimler and Karl Benz in 1885. The petrol engine is a complex piece of machinery made up of about 150 moving parts. It is a reciprocating piston engine, in which a number of pistons move up and down in cylinders. A mixture of petrol and air is introduced to the space above the pistons and ignited. The gases produced forces the pistons down, generating power. The engine-operating cycle is repeated after every four strokes (upward or downward movement) of the piston, this being known as the four-stroke cycle. The motion of the pistons rotates a crankshaft, at the end of which a heavy flywheel is connected. From the flywheel the power is transferred to the vehicle's driving wheels via the transmission system of clutch, gearbox, and final drive.

THEORY:

THE FOUR STROKE CYCLE

The 'stroke' is simply when the piston moves either all the way up or all the way down inside the cylinder. As you might guess, in the four-stroke engine each of the four strokes accomplishes something different. Therefore, let's have a look at the four strokes and see what happens:

SUCTION

The first stroke is called Suction. This is when the fuel and air mixture is drawn into the cylinder by the piston going down and producing suction. As the piston travels down the cylinder it creates a vacuum above it and the fuel mixture is drawn into the cylinder in the empty space left by the piston The piston starts at the top, the camshaft turns and pushes the tappets which causes the intake valve to open and the piston moves down to let the engine take in a cylinder full of air and fuel. This is also sometimes called the intake stroke.

Compression

Compression is the second of the four strokes. This is the stage when the fuel and air mixture is compressed and forced into the top of the cylinder ready for ignition. The camshaft has turned, pushed the tappets, which has in turn allowed the inlet valve to return to the closed position. The piston moves back up and compresses this fuel/air mixture. Compressing the mixture makes the explosion more powerful. As the valves are both closed, the cylinder is sealed and the mixture can't escape.

Ignition

As the piston reaches the top of the compression stroke, the spark plug 'fires' and ignites the highly compressed fuel and air mixture. The piston is then forced back down the cylinder by the resulting explosion, turning the crankshaft and generating the propulsion for the engine that makes the vehicle to go along the road.

Exhaust

This is when the exhaust gases (after the fuel is burnt) are forced out of the engine. Once the piston hits the bottom of its stroke, the exhaust valve opens. The piston travels back up inside the cylinder and this time it 'pushes' the exhaust gasses out through the now open exhaust vent. Now the engine is ready for the next cycle, so it intakes another charge of air and gas. And we are back to the intake stroke.

Multiple Cylinders

The vast majority of internal combustion engines used more than one cylinder. This is entirely a question of efficiency. The limitation of the Otto Cycle is that it only provides power to turn the crankshaft a quarter of the time. The logical solution is to have four cylinders with pistons turning the crankshaft so at any time there is always one cylinder in the power stroke and the crankshaft is turned at a fairly even rate. An even more powerful method is to use extra cylinders at intermediate points in the cycle so that one power stroke starts before the previous one has finished.

DESCRIPTION:

Four Cylinder, Four Stroke, Petrol Engine Test Rig with hydraulic brake dynamometer arrangement mainly consists of:

1. Loading Arrangement (Hydraulic brake dynamometer).
2. Fuel Input Measuring Arrangement,
3. Air intake measuring arrangement.
4. Arrangement for measuring the heat carried away by cooling water from engine jacket.
5. Arrangement for measuring the heat carried away by exhaust gases.
6. Panel Board Arrangement

A brief description and particulars on this test rig is given below:

LOADING ARRANGEMENT (HYDRAULIC BRAKE DYNAMOMETER):

Hydraulic brake dynamometer works on the principle of dissipating the power in fluid friction rather than in dry friction. In principle its construction is similar to that of a fluid flywheel. It consists of an inner rotating member or impeller coupled to the output shaft of the engine. This impeller rotates in a casing filled with fluid. This outer casing, due to centrifugal force developed, tends to revolve with impeller, but is resisted by a torque arm supporting the balance weight. The frictional forces between the impeller and the fluid are measured by the spring balance fitted on the casing the heat developed due to dissipation of power is carried away by a continuous supply of the working fluid, usually water. Regulating the sluice gates, which can be moved in and out to partially or wholly obstructive flow of water between impeller and the casing, can control the output.

FUEL INPUT MEASURING ARRANGEMENT:

Consists of self-mounting type fuel tank which is suitably mounted on a stand. The stand fixed on the air tank, fuel goes from the reservoir to fuel filter through a burette. The burette facilitates the measurement of the fuel consumption for a definite period of time with the help of a stopwatch.

AIR INTAKE MEASURING ARRRANGEMENT:

Consists of an air tank having on orifice plate with orifice and a manometer to measure the flow rate of air sucked by the engine.

Arrangement For Measuring The Heat Carried Away By Cooling Water:

Suitable piping system is fitted to the engine for circulating the cooling water for the engine. Thermocouples are provided to measure the inlet and outlet temperature of cooling water. For measuring the rate of flow of cooling water, a water meter is provided. With these entire arrangements one can find the heat carried away by cooling water.

Arrangement For Measuring The Heat Carried Away By Exhaust Gases:

It consists of exhaust gas calorimeter to measure the heat carried away by exhaust gases. Exhaust gas calorimeter consists of a central tube and an outer jacket. Exhaust gases passes through central tube and water is circulated in outer jacket to get the maximum Temperature difference of exhaust gases at inlet and outlet of calorimeter. The volume of water circulation is measured with the help of measuring cylinder and stopwatch. Thermocouples are provided to get the inlet and outlet temperature of exhausts gases and water circulated.

Panel Board Arrangement:

The units fitted on the Panel board are:

a) An ignition and starting switch to switch on the ignition circuit and to start the engine.

b) A Pilot lamp indicator for ignition.

c) A high voltage knife switches assembly for cutting of each cylinder for Morse Test. With the help of the four individual knife switches each cylinder can be cut off.

d) Throttle valve control mechanism to control the position of the throttle in relation to the speed of the engine.

Utilities Required:

6.1 Electricity supply: Single phase, 220V AC, 50 Hz, 5-15 Amp. combined socket with earth connection

6.2 Water Supply continuous @10 LPM at 1 Bar for engine & exhaust gas calorimeter cooling.

6.3 Floor Drain Required.

6.4 Petrol: 10 Ltrs.

6.5 Engine oil: Multi grade 20W40 4.5 liters.

6.6 Floor Area Required: 3 m x 1.5 m.

6.7 Exhaust Emission.

6.8 Tachometer for RPM measurement.

EXPERIMENTAL PROCEDURE:

7.1 STARTING PROCEDURE:

7.1.1 Close all the valves from V_1 to V_8.

7.1.2 Fill oil in the oil sump of engine. It should be in between the marks provided on the oil dipstick. If oil level is reduced, add clean oil (SAE–40) to the crank case by opening the cover of valve provided, at top of engine.

7.1.3 Fill the petrol in petrol tank.

7.1.4 Fill the manometer with water up to half of its height.

7.1.5 Fill the burette with petrol by opening the valve V_6, V_5, V_3 provided.

7.1.6 Supply the fuel to the engine by opening the valve V_4.

7.1.7 Switch on the main supply to the panel.

7.1.8 Connect water supply to the engine.

7.1.9 Connect the pipes from engine water outlet, calorimeter water outlet to drain.

7.1.10 Open the valve V_1 and V_2.

7.1.11 Set a flow rate for engine cooling water by valve V_1.

7.1.12 Set a flow rate for calorimeter cooling water by valve V_2.

7.1.13 Note down the reading of sensor T_3/T_4.

7.1.14 Open the valve V_8.

7.1.15 Ensure that load on the dynamometer is zero.

7.1.16 Rotate the key and switch on engine.

7.1.17 Set a pressure between 0.5 to 1 kg/cm^2 of hydraulic brake dynamometer by valve V_8.

7.1.18 Let the engine run for 5 minutes.

7.1.19 Increase the RPM.

7.1.20 Apply load on engine by dynamometer.

7.1.21 Wait for 10 minutes so that temperatures can stabilize.

7.1.22 Note the reading of load from control panel.

7.1.23 Note the RPM.

7.1.24 Note down the manometer readings.

7.1.25 Note down the temperatures by D.T.I.

7.1.26 Close the valve V_5 and note down the time to consume 10-20 ml of diesel by stop watch.

7.1.27 Open the valve V_5.

7.1.28 Measure the flow rate of water through engine jacket with help of water meter and stop watch for engine cooling.

7.1.29 Measure the flow rate of water through calorimeter with the help of water meter and stop watch for calorimeter cooling.

7.1.30 For morse test cut off the 1st cylinder by khief switch.

7.1.31 Reduce the load by dynamometer without changing throttle to attain constant RPM approximately same to RPM without cutting the cylinders.

7.1.32 Note down the load.

7.1.33 Note down the RPM.

7.1.34 Now cut on the 1st cylinder and set the original RPM, by increasing the load.

7.1.35 Repeat the steps for remaining three cylinder (one at a time).

7.1.36 Repeat the experiment for different load.

7.1.37 Repeat the experiment for different RPM.

Observation & Calculation:

8.1 Data:

Acceleration due to gravity g	= 9.81 m/sec^2
Calorific value of fuel C_V	= 44650 kJ/kg
Co-efficient of discharge for orifice C_d	= 0.64
Specific heat of water C_p	= 4.186 kJ/kg °C
Density of air ρ_a	= 1.21 kg/m^3
Density of fuel ρ_f	= 720 kg/m^3

Diameter of orifice d_o	= 0.027 m
Diameter of piston D	= 0.084 m
Stoke length of piston L	= 0.082 m
Number of cylinder N_C	= 4
Number of cycles n	= 2

8.2 Observation Table:

T_a = ____________ °C (Reading of sensor T_3 / T_4 before starting engine)

S.No.					
N (RPM)					
h_1 (cm)					
h_2 (cm)					
W (kg)					
x (ml)					
t (sec)					
T_1 (°C)					
T_2 (°C)					
T_3 (°C)					
T_4 (°C)					
T_5 (°C)					
T_6 (°C)					
V_E (ltrs)					
t_E (sec)					
V_c (ltrs)					
t_c (sec)					

W_{-1} (kg)					
N_{-1} (RPM)					
W_{-2} (kg)					
N_{-2} (RPM)					
W_{-3} (kg)					
N_{-3} (RPM)					
W_{-4} (kg)					
N_{-4} (RPM)					

CALCULATIONS:

$$BP = \frac{W * N * 0.746}{2000} \text{ (kW)}$$

$$W_f = \frac{x}{t} * \frac{\rho_f}{10^{06}} \text{ (kg/sec)}$$

$$W_{sf} = \frac{W_f}{BP} \text{ (kg/kW-sec)}$$

$$H_f = W_f * C_v \text{ (kW)}$$

$$\eta_{BT} = \frac{BP}{H_f} * 100 \text{ (\%)}$$

$$m_{EW} = \frac{V_E}{t_E} * \frac{\rho_w}{10^{03}} \text{ (kg/sec)}$$

$$\mathrm{H}_{ecw} = m_{ew} * C_P * (T_2 - T_1) \text{ (kW)}$$

$$m_{CW} = \frac{V_C}{t_C} * \frac{\rho_w}{10^{03}} \text{ (kg/sec)}$$

$$H_{CCW} = m_{CW} * C_P * (T_6 - T_5) \text{ (kW)}$$

$$H_{exh} = \frac{H_{CCW}}{(T_3 - T_4)} * (T_3 - T_a) \text{ (kW)}$$

$$H_{un} = H_f - (BP + H_{ecw} + H_{exh}) \text{ (kW)}$$

$$Q_a = C_d * a_O \sqrt{2gH} \quad (m^3/sec)$$

$$a_o = \frac{\pi}{4} * d_0^{\ 2} \quad (m^2)$$

$$H = \frac{h_1 - h_2}{100}\left(\frac{\rho_w}{\rho_a} - 1\right) \quad (m)$$

$$V_s = \frac{\pi * D^2 * L * N * N_c}{4 * 60 * n} \quad (m^3/sec)$$

$$\eta_{vol.} = \frac{Q_a}{V_s} * 100 \quad (\%)$$

MORSE TEST:

$$BP_1 = \frac{N_{-1} * W_{-1} * 0.746}{2000} \quad (kW)$$

$$IP_1 = BP - BP_1$$

$$BP_2 = \frac{N_{-2} * W_{-2} * 0.746}{2000} \quad (kW)$$

$$IP_2 = BP - BP_2$$

$$BP_3 = \frac{N_{-3} * W_{-3} * 0.746}{2000} \quad (kW)$$

$$IP_3 = BP - BP_3$$

$$BP_4 = \frac{N_{-4} * W_{-4} * 0.746}{2000} \quad (kW)$$

$$IP_4 = BP - BP_4$$

$$IP = IP_1 + IP_2 + IP_3 + IP_4$$

$$\eta_{mech.} = \frac{BP}{IP} * 100 \quad (\%)$$

$$\eta_{IT} = \frac{IP}{H_f} * 100 \quad (\%)$$

NOMENCLATURE:

Nom	Column Heading	Units	Type
a_o	Area of orifice	m^2	Calculated
BP	Brake power	kW	Calculated
BP_1	Brake power after cutting 1st cylinder	kW	Calculated
BP_2	Brake power after cutting 2nd cylinder	kW	Calculated
BP_3	Brake power after cutting 3rd cylinder	kW	Calculated
BP_4	Brake power after cutting 4th cylinder	kW	Calculated
C_d	Co-efficient of discharge for orifice		Given
C_p	Specific heat of water	kJ/kg °C	Given
C_V	Calorific value of fuel	kJ/kg	Given
D	Diameter of cylinder	m	Given
d_o	Diameter of orifice	m	Given
g	Acceleration due to gravity	m/sec^2	Given
H	Head causing flow of air through orifice	m	Calculated
H_{CCW}	Heat carried by water from calorimeter	kW	Calculated
H_{ecw}	Heat carried out by water from engine cooling jacket	kW	Calculated
H_{exh}	Heat carried out by exhaust gases	kW	Calculated
H_f	Heat supplied by the fuel	kW	Calculated
H_{un}	Heat lost in radiation or uncounted heat	kW	Calculated
h_1, h_2	Manometer readings of high and low level respectively	cm	Measured
IP	Indicated Power	kW	Calculated
IP_1	Indicated Power after cutting 1st cylinder	kW	Calculated
IP_2	Indicated Power after cutting 2nd cylinder	kW	Calculated
IP_3	Indicated Power after cutting 3rd cylinder	kW	Calculated
IP_4	Indicated Power after cutting 4th cylinder	kW	Calculated
L	Stoke length of engine	m	Given
m_{CW}	Mass of water entering calorimeter	kg/sec	Calculated
m_{EW}	Mass of water entering the engine cooling jacket per sec	kg/sec	Calculated
N	Revolutions per minute		Measured
N_{-1}	Revolutions per minute after cutting 1st cylinder		Measured
N_{-2}	Revolutions per minute after cutting 2nd cylinder		Measured

N_{-3}	Revolutions per minute after cutting 3rd cylinder		Measured
N_{-4}	Revolutions per minute after cutting 4th cylinder		Measured
N_C	Number of cylinder		Given
n	Number of cycles		Given
Q_a	Air consumption	m^3/sec	Calculated
T_1	Temperature of water inlet for Engine jacket	°C	Measured
T_2	Temperature of water outlet for Engine jacket	°C	Measured

T_3	Temperature of exhaust gases at inlet of calorimeter	°C	Measured
T_4	Temperature of exhaust gases at outlet of calorimeter	°C	Measured
T_5	Temperature of water at Inlet of calorimeter	°C	Measured
T_6	Temperature of water at Outlet of calorimeter	°C	Measured
T_a	Ambient air temperature	°C	Measured
t	Time taken to consume *x* ml of fuel	sec	Measured
t_C	Time for V_C	sec	Measured
t_E	Time for V_E	sec	Measured
V_C	Volume of water flows through calorimeter	Ltrs	Measured
V_E	Volume of water flows through engine	Ltrs	Measured
V_S	Swept Volume	m^3/sec	Calculated
W	Load cell reading	kg	Measured
W_{-1}	Load cell reading after cutting 1st cylinder	kg	Measured
W_{-2}	Load cell reading after cutting 2nd cylinder	kg	Measured
W_{-3}	Load cell reading after cutting 3rd cylinder	kg	Measured
W_{-4}	Load cell reading after cutting 4th cylinder	kg	Measured
W_f	Fuel consumption	kg/sec	Calculated
W_{sf}	Specific fuel consumption	kg/kW-sec	Calculated
x	Volume of fuel consumed	ml	Measured
ρ_a	Density of air	kg/m^3	Given
ρ_w	Density of water	kg/m^3	Given
η_{BT}	Brake thermal efficiency	%	Calculated
η_{IT}	Indicated thermal efficiency	%	Calculated
η_{mech}	Mechanical efficiency	%	Calculated
$\eta_{Vol.}$	Volumetric efficiency	%	Calculated
ρ_f	Density of fuel	kg/m^3	Given

Precaution & Maintenance Instructions:

10.1 Change engine oil after every 100 hours of total running or 6 months whichever is earlier.

10.2 Open cold water supply to the engine before starting the engine.

10.3 Fuel tank and fuel line should be clean and free from foreign particles.

10.4 The Morse test should be carried out only after the engine running conditions are stabilized at the required BP.

10.5 When a cylinder is cut off adjust the speed and load of the engine quickly because large time laps might result in the change in the working conditions of the engine.

10.6 Do not attempt to cut off two cylinders simultaneously, since it can develop severe engine vibration

Troubleshooting:

11.1 If the engine heats up, check the water supply to the engine jacket.

11.2 If engine does not start and the battery indicator not glow, check the battery if discharged, charge it.

11.3 If still engine does not start, check the fuel and fuel supply line. If air found in pipeline, remove it.

Prepared By	Reviewed By	Checked By

Experiment No. 4

Aim: Performance of a diesel engine from no load to full load (at constant speed) for a single cylinder engine in terms of brake power indicated power, mechanical efficiency and calculate the SFC (Specific fuel consumption) and further obtain power consumption curves and draw the heat balance sheet of single cylinder Diesel engine.

INTRODUCTION:

A Diesel engine is almost the same as a petrol engine but it burns a different type of fuel. Diesel is named after its inventor Rudolf Diesel, a German who first developed this type of fuel in the early 1900's. Diesel engines have mainly been used in lorries and buses because of their increased power and their reliability. They tend to be noisy and smelly compared to a petrol engine but are more economical to run.

In a diesel engine the compression stroke only compresses air and not fuel. In the ignition stroke compressed air is present with very high pressure and then fuel is injected into the engine cylinder with the help of an injector, resulting in generating enormous heat, which then ignites the fuel that is injected into the combustion chamber at that precise moment of maximum pressure. There is no need for a spark plug in a diesel engine. The compressed air is hot enough to cause the fuel to explode. This is because a diesel engine has a far higher "compression ratio" than does a petrol engine.

THEORY:

THE FOUR-STROKE CYCLE:

The 'stroke' is simply when the piston moves all the way either up or all the way down inside the cylinder. In the four-stroke engine each of the four strokes accomplishes something different. So, let's have a look at the four strokes and see what happens:

SUCTION:

The first stroke is called Suction. This is when the air is drawn into the cylinder by the piston going down and producing suction. As the piston travels down the cylinder it creates a vacuum above it and the air is drawn into the cylinder in the empty space left by the piston The piston starts at the top, the crankshaft turns and pushes on the tappets which causes the intake valve to open, and the piston moves down to let the engine take in a cylinder full of air. This is also called intake stroke.

Compression:

Compression is the second of the four strokes. This is the stage when the air is compressed and forced into the top of the cylinder ready for ignition. The crankshaft has turned, pushed the tappets, which have in turn allowed the inlet valve to return to the closed position. The piston moves back up and compresses this air. Compressing the air makes the explosion more powerful. As the valves are both closed, the cylinder is sealed and the compressed air can't escape from the cylinder.

Ignition:

As the piston reaches the top of the compression stroke, the injector injects the fuel and ignites the highly compressed air. The piston is then forced back down the cylinder by the resulting explosion, turning the crankshaft and generating the propulsion for the engine that makes the vehicle to go along the road.

Exhaust:

This is when the exhaust gases (after the fuel is burnt) are forced out of the engine. Once the piston hits the bottom of its stroke, the exhaust valve opens. The piston travels back up inside the cylinder and this time it 'pushes' the exhaust gases out through the now open exhaust vent. Now the engine is ready for the next cycle, so it intakes another charge of fresh air and we are back to the intake stroke.

Description:

Single Cylinder, Four Stroke, Diesel Engine Test Rig with Rope Brake dynamometer arrangement mainly consists of:

1. Loading arrangement (Rope Brake Dynamometer)
2. A Fuel Input Measuring Arrangement
3. Air intake measuring arrangement.
4. An arrangement for measuring the heat carried away by cooling water from engine jacket.
5. An arrangement for measuring the heat carried away by cooling water from exhaust gases.

6. A Control Panel.

Loading Arrangement:

A Rope Brake Dynamometer arrangement with a brake drum coupled to the engine shaft and provided with a cooling water arrangement and spring balances. The load can be varied by increasing the rope tension on the brake drum with revolving the hand wheel provided on the top of frame.

Fuel Input Measuring Arrangement

This arrangement consists of a fuel tank of suitable capacity mounted on a stand. The fuel goes to the engine through a burette. The burette facilitates the measurement of fuel consumption for a definite period with the help of stopwatch.

Air Intake Measuring Arrangement:

It consists of an orifice, a diaphragm base manifold and a U- tube manometer. With the help of orifice and manometer, the volume of the air sucked can be calculated.

Arrangement For Measuring The Heat Carried By Cooling Water From Engine Cooling Jacket.

Suitable pipefitting is provided for circulating the cooling water into the engine water jacket. For measuring the rate of flow of cooling water, a water meter is provided. With these entire arrangements, one can find the heat carried away by cooling water. The temperature of inlet and outlet water can be directly read from the Digital Temperature Indicator.

Arrangement For Measuring The Heat Carried Away By Exhaust Gases:

It consists of exhaust gas calorimeter to measure the heat carried away by exhaust gases. Exhaust gas calorimeter consists of a central tube and an outer jacket. Exhaust gases passes through central tube and water is circulated in outer jacket to get the maximum Temperature difference of exhaust gases at inlet and outlet of calorimeter. The volume of water circulation is measured with the help of water meter and stopwatch. Thermocouples are provided to get the inlet and outlet temperature of exhausts gases and water circulated.

UTILITIES REQUIRED:

6.1 Electricity supply; Single phase, 220V AC, 50Hz, 5-15 Amp. combined socket with earth connection.

6.2 Water Supply continuous @ 10 LPM at 1 Bar for engine & exhaust gas calorimeter cooling.

6.3 Floor Drain Required.

6.4 Floor Area Required: 3 m x 2 m.

6.5 Diesel: 10 Ltrs.

6.6 Engine oil: Multigrade 20W40 approx 1 Ltrs.

6.7 Exhaust Emission.

6.8 Tachometer: For RPM Measurement.

EXPERIMENTAL PROCEDURE:

7.1 STARTING PROCEDURE:

7.1.1 Close all the valves from V_1 to V_8.

7.1.2 Fill oil in the oil sump of engine. It should be in between the marks provided on the oil dipstick. If oil level is reduced, add clean oil (SAE–40) to the crank case by opening the cover of valve provided, at top of engine.

7.1.3 Fill the diesel in diesel tank.

7.1.4 Fill the manometer with water up to half of its height.

7.1.5 Fill the burette with diesel by opening the valve V_6, V_5, V_3 provided.

7.1.6 Supply the fuel to the engine by opening the valves V_4.

7.1.7 Switch on the main supply to the panel.

7.1.8 Connect water supply to the engine.

7.1.9 Connect the pipes from engine water outlet, calorimeter water outlet and brake drum water outlet to drain.

7.1.10 Open the valve V_1 and V_2.

7.1.11 Set a flow rate for engine cooling water by valve V_1.

7.1.12 Set a flow rate for calorimeter cooling water by valve V_2.

7.1.13 Note down the reading of sensor T_3/T_4.

7.1.14 Adjust the weight balances to zero.

7.1.15 Start the engine with handle and let it run for 5 minutes at no load condition.

7.1.16 Partially open the valve V_8 for brake drum cooling.

7.1.17 Apply load on engine with help of spring balances.

7.1.18 Wait for 10 minutes so that temperatures can stabilize.

7.1.19 Note the reading of spring balances.

7.1.20 Note the RPM.

7.1.21 Note down the manometer readings.

7.1.22 Note down the temperatures by D.T.I.

7.1.23 Close the valve V_5 and note down the time to consume 10-20 ml of diesel by stop watch.

7.1.24 Open the valve V_5.

7.1.25 Measure the flow rate of water through engine jacket with help of water meter and stop watch for engine cooling.

7.1.26 Measure the flow rate of water through calorimeter with the help of water meter and stop watch for calorimeter cooling.

7.1.27 Repeat the experiment for different load.

Closing Procedure:

7.2.1 When the experiment is over remove load on engine by hand wheel of spring balance.

7.2.2 Stop the engine.

7.2.3 Close the fuel supply by valve V_4

7.2.4 Close the cooling water supply to the engine and calorimeter after 10 minutes.

7.2.5 Open the valve V_7 to drain the water from calorimeter.

OBSERVATION & CALCULATION:

8.1 DATA:

Acceleration due to gravity g	= 9.81 m/sec^2
Calorific value of fuel C_V	= 43500 kJ/kg
Co-efficient of discharge for orifice C_d	= 0.64
Specific heat of water C_p	= 4.186 kJ/kg °C
Density of air ρ_a	= 1.21 kg/m^3
Density of water ρ_w	= 1000 kg/m^3
Density of fuel ρ_f	= 804 kg/m^3
Diameter of brake drum d_B	= 0.2 m
Diameter of rope d_R	= 0.012 m
Diameter of orifice d_o	= 0.017 m
Diameter of piston D	= 0.08 m
Stoke length of piston L	= 0.11 m
Number of cylinder N_C	= 1
Number of cycles n	= 2

8.2 OBSERVATION TABLE:

T_a = ____________ °C (Reading of sensor T_3 / T_4 before starting engine)

S.No.					
N (RPM)					
h_1 (cm)					
h_2 (cm)					
W_1 (kg)					
W_2 (kg)					
x (ml)					
t (sec)					
T_1 (°C)					
T_2 (°C)					
T_3 (°C)					
T_4 (°C)					

T_5 (°C)					
T_6 (°C)					
V_E (ltrs)					
t_E (sec)					
V_c (ltrs)					
t_c (sec)					

CALCULATIONS:

$$R_e = \frac{d_B + 2d_R}{2} \text{ (m)}$$

$$T = (W_1 - W_2) \times g \times R_e \text{ (N-m)}$$

$$BP = \frac{2 \times \pi \times N \times T}{60 \times 1000} \text{ (kW)}$$

$$W_f = \frac{x}{t} \times \frac{\rho_f}{10^6} \text{ (kg/sec)}$$

$$W_{sf} = \frac{W_f}{BP} \text{ (kg/kW sec)}$$

$$H_f = W_f \times C_v \text{ (kW)}$$

$$\eta_{BT} = \frac{BP}{H_f} \times 100 (\%)$$

$$m_{ew} = \frac{V_E}{t_E} * \frac{\rho_w}{10^{03}} \text{ (kg/sec)}$$

$$\text{H}_{ecw} = m_{ew} * C_P * (T_2 - T_1) \text{ (kW)}$$

$$m_{cw} = \frac{V_c}{t_c} * \frac{\rho_w}{10^3} \text{ (kg/sec)}$$

$$H_{ccw} = m_{cw} \times C_P \times (T_6 - T_5) \text{ (kW)}$$

$$H_{exh} = \frac{H_{ccw}}{(T_3 - T_4)} \times (T_3 - T_a) \text{ (kW)}$$

$$H_{un} = H_f - (BP + H_{ecw} + H_{exh}) \text{ (kW)}$$

$$a_o = \frac{\pi}{4} d_o^2, \text{ (m}^2\text{)}$$

$$H = \frac{h_1 - h_2}{100}\left(\frac{\rho_w}{\rho_a} - 1\right) \text{ (m)}$$

$$Q_a = C_d \times a_o \sqrt{2gH} \text{ (m}^3\text{/sec)}$$

$$V_s = \frac{\pi \times D^2 \times L \times N \times N_c}{4 \times 60 \times n} \text{ (m}^3\text{/sec)}$$

$$\eta_{vol.} = \frac{Q_a}{V_s} \times 100 (\%)$$

NOMENCLATURE:

Nom	Column Heading	Units	Type
a_o	Cross-sectional area of orifice	m^2	Calculated
BP	Brake power	kW	Calculated
C_d	Co-efficient of discharge for orifice		Given
C_p	Specific heat of water	kJ/ kg ^oC	Given
C_v	Calorific value of fuel	kJ/ kg	Given
D	Diameter of piston	m	Given
d_B	Diameter of brake drum	m	Given
d_o	Diameter of orifice	m	Given
d_R	Diameter of rope	m	Given
g	Acceleration due to gravity	m/sec^2	Given
H	Head causing flow of air through orifice	m	Calculated
H_{ccw}	Heat carried out by water from calorimeter	kW	Calculated
H_{ecw}	Heat carried out by water from engine cooling jacket	kW	Calculated
H_{exh}	Heat carried out by exhaust gas	kW	Calculated
H_f	Heat supplied	kW	Calculated
H_{un}	Heat lost in radiation and uncounted heat	kW	Calculated
h_1, h_2	Manometer reading (high and low level respectively)	cm	Measured
L	Length of stroke of piston	m	Given
m_{cw}	Mass of water entering the calorimeter	kg/sec	Calculated
m_{ew}	Mass of water entering the engine cooling jacket	kg/sec	Calculated
N	Revolutions per minute	RPM	Measured
N_c	Number of cylinders		Given
n	Number of cycles		Given
Q_a	Air consumption,	m^3/sec	Calculated
R_e	Mean effective radius	m	Calculated

T	Torque	N-m	Calculated
T_1	Temperature of water inlet for Engine jacket	^oC	Measured
T_2	Temperature of water outlet from Engine jacket	^oC	Measured
T_3	Temperature of exhaust gases inlet for calorimeter	^oC	Measured
T_4	Temperature of exhaust gases outlet from calorimeter	^oC	Measured
T_5	Temperature of water inlet for calorimeter	^oC	Measured
T_6	Temperature of water outlet from calorimeter	^oC	Measured
T_a	Ambient air temperature	^oC	Measured
t	Time taken for *x* ml	sec	Measured
t_c	Time for V_c	sec	Measured
t_E	Time for V_E	sec	Measured
V_c	Volume of water flows through calorimeter	Ltrs.	Measured
V_e	Volume of water flows through the engine jacket	Ltrs.	Measured
V_s	Swept volume.	m^3/sec	Calculated
W_1	Applied weight	kg	Measured
W_2	Dead weight	kg	Measured
W_f	Fuel consumption,	kg/sec	Calculated
W_{sf}	Specific fuel consumption	kg/kW-sec	Calculated
x	Volume of the fuel consumed	ml	Measured
ρ_a	Density of air	kg/m^3	Given
ρ_f	Density of fuel	kg/m^3	Given
ρ_w	Density of water	kg/m^3	Given
η_{BT}	Brake thermal efficiency	%	Calculated
η_{vol}	Volumetric efficiency	%	Calculated

PRECAUTION & MAINTENANCE INSTRUCTIONS:

10.1 Always check the oil level in the engine before starting and make sure that sufficient oil is present in the engine.

10.2 Never starts the engine at loaded condition.

10.3 Change engine oil after every 100 hours of total running or 6 months whichever is earlier.

10.4 Open cold water supply to the engine before starting.

10.5 Fuel tank and fuel line should be clean and free from foreign particles.

10.6 If diesel tank was empty before filling the diesel, remove air trapped in fuel line by opening the vent screw.

TROUBLESHOOTING:

11.1 If the engine heats up, check the water supply to the engine jacket.

11.2 If engine does not start, check the fuel and fuel supply line, if air found in pipeline, remove it.

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Experiment No. 4

Aim: Performance of a diesel engine from no load to full load (at constant speed) for a single cylinder engine in terms of brake power indicated power, mechanical efficiency and calculate the SFC (Specific fuel consumption) and further obtain power consumption curves and draw the heat balance sheet of single cylinder Diesel engine.

INTRODUCTION:

A Diesel engine is almost the same as a petrol engine but it burns a different type of fuel. Diesel is named after its inventor Rudolf Diesel, a German who first developed this type of fuel in the early 1900's. Diesel engines have mainly been used in lorries and buses because of their increased power and their reliability. They tend to be noisy and smelly compared to a petrol engine but are more economical to run.

In a diesel engine the compression stroke only compresses air and not fuel. In the ignition stroke compressed air is present with very high pressure and then fuel is injected into the engine cylinder with the help of an injector, resulting in generating enormous heat, which then ignites the fuel that is injected into the combustion chamber at that precise moment of maximum pressure. There is no need for a spark plug in a diesel engine. The compressed air is hot enough to cause the fuel to explode. This is because a diesel engine has a far higher "compression ratio" than does a petrol engine.

THEORY:

THE FOUR-STROKE CYCLE:

The 'stroke' is simply when the piston moves all the way either up or all the way down inside the cylinder. In the four-stroke engine each of the four strokes accomplishes something different. So, let's have a look at the four strokes and see what happens:

SUCTION:

The first stroke is called Suction. This is when the air is drawn into the cylinder by the piston going down and producing suction. As the piston travels down the cylinder it creates a vacuum above it and the air is drawn into the cylinder in the empty space left by the piston The piston starts at the top, the crankshaft turns and pushes on the tappets which causes the intake valve to open, and the piston moves down to let the engine take in a cylinder full of air. This is also called intake stroke.

Compression:

Compression is the second of the four strokes. This is the stage when the air is compressed and forced into the top of the cylinder ready for ignition. The crankshaft has turned, pushed the tappets, which have in turn allowed the inlet valve to return to the closed position. The piston moves back up and compresses this air. Compressing the air makes the explosion more powerful. As the valves are both closed, the cylinder is sealed and the compressed air can't escape from the cylinder.

Ignition:

As the piston reaches the top of the compression stroke, the injector injects the fuel and ignites the highly compressed air. The piston is then forced back down the cylinder by the resulting explosion, turning the crankshaft and generating the propulsion for the engine that makes the vehicle to go along the road.

Exhaust:

This is when the exhaust gases (after the fuel is burnt) are forced out of the engine. Once the piston hits the bottom of its stroke, the exhaust valve opens. The piston travels back up inside the cylinder and this time it 'pushes' the exhaust gases out through the now open exhaust vent. Now the engine is ready for the next cycle, so it intakes another charge of fresh air and we are back to the intake stroke.

Description:

Single Cylinder, Four Stroke, Diesel Engine Test Rig with Rope Brake dynamometer arrangement mainly consists of:

1. Loading arrangement (Rope Brake Dynamometer)
2. A Fuel Input Measuring Arrangement
3. Air intake measuring arrangement.
4. An arrangement for measuring the heat carried away by cooling water from engine jacket.
5. An arrangement for measuring the heat carried away by cooling water from exhaust gases.

6. A Control Panel.

Loading Arrangement:

A Rope Brake Dynamometer arrangement with a brake drum coupled to the engine shaft and provided with a cooling water arrangement and spring balances. The load can be varied by increasing the rope tension on the brake drum with revolving the hand wheel provided on the top of frame.

Fuel Input Measuring Arrangement

This arrangement consists of a fuel tank of suitable capacity mounted on a stand. The fuel goes to the engine through a burette. The burette facilitates the measurement of fuel consumption for a definite period with the help of stopwatch.

Air Intake Measuring Arrangement:

It consists of an orifice, a diaphragm base manifold and a U- tube manometer. With the help of orifice and manometer, the volume of the air sucked can be calculated.

Arrangement For Measuring The Heat Carried By Cooling Water From Engine Cooling Jacket.

Suitable pipefitting is provided for circulating the cooling water into the engine water jacket. For measuring the rate of flow of cooling water, a water meter is provided. With these entire arrangements, one can find the heat carried away by cooling water. The temperature of inlet and outlet water can be directly read from the Digital Temperature Indicator.

Arrangement For Measuring The Heat Carried Away By Exhaust Gases:

It consists of exhaust gas calorimeter to measure the heat carried away by exhaust gases. Exhaust gas calorimeter consists of a central tube and an outer jacket. Exhaust gases passes through central tube and water is circulated in outer jacket to get the maximum Temperature difference of exhaust gases at inlet and outlet of calorimeter. The volume of water circulation is measured with the help of water meter and stopwatch. Thermocouples are provided to get the inlet and outlet temperature of exhausts gases and water circulated.

Utilities Required:

6.1 Electricity supply; Single phase, 220V AC, 50Hz, 5-15 Amp. combined socket with earth connection.

6.2 Water Supply continuous @ 10 LPM at 1 Bar for engine & exhaust gas calorimeter cooling.

6.3 Floor Drain Required.

6.4 Floor Area Required: 3 m x 2 m.

6.5 Diesel: 10 Ltrs.

6.6 Engine oil: Multigrade 20W40 approx 1 Ltrs.

6.7 Exhaust Emission.

6.8 Tachometer: For RPM Measurement.

Experimental Procedure:

7.1 Starting Procedure:

7.1.1 Close all the valves from V_1 to V_8.

7.1.2 Fill oil in the oil sump of engine. It should be in between the marks provided on the oil dipstick. If oil level is reduced, add clean oil (SAE–40) to the crank case by opening the cover of valve provided, at top of engine.

7.1.3 Fill the diesel in diesel tank.

7.1.4 Fill the manometer with water up to half of its height.

7.1.5 Fill the burette with diesel by opening the valve V_6, V_5, V_3 provided.

7.1.6 Supply the fuel to the engine by opening the valves V_4.

7.1.7 Switch on the main supply to the panel.

7.1.8 Connect water supply to the engine.

7.1.9 Connect the pipes from engine water outlet, calorimeter water outlet and brake drum water outlet to drain.

7.1.10 Open the valve V_1 and V_2.

7.1.11 Set a flow rate for engine cooling water by valve V_1.

7.1.12 Set a flow rate for calorimeter cooling water by valve V_2.

7.1.13 Note down the reading of sensor T_3/T_4.

7.1.14 Adjust the weight balances to zero.

7.1.15 Start the engine with handle and let it run for 5 minutes at no load condition.

7.1.16 Partially open the valve V_8 for brake drum cooling.

7.1.17 Apply load on engine with help of spring balances.

7.1.18 Wait for 10 minutes so that temperatures can stabilize.

7.1.19 Note the reading of spring balances.

7.1.20 Note the RPM.

7.1.21 Note down the manometer readings.

7.1.22 Note down the temperatures by D.T.I.

7.1.23 Close the valve V_5 and note down the time to consume 10-20 ml of diesel by stop watch.

7.1.24 Open the valve V_5.

7.1.25 Measure the flow rate of water through engine jacket with help of water meter and stop watch for engine cooling.

7.1.26 Measure the flow rate of water through calorimeter with the help of water meter and stop watch for calorimeter cooling.

7.1.27 Repeat the experiment for different load.

Closing Procedure:

7.2.1 When the experiment is over remove load on engine by hand wheel of spring balance.

7.2.2 Stop the engine.

7.2.3 Close the fuel supply by valve V_4

7.2.4 Close the cooling water supply to the engine and calorimeter after 10 minutes.

7.2.5 Open the valve V_7 to drain the water from calorimeter.

. Observation & Calculation:

8.1 Data:

Acceleration due to gravity g	= 9.81 m/sec^2
Calorific value of fuel C_V	= 43500 kJ/kg
Co-efficient of discharge for orifice C_d	= 0.64
Specific heat of water C_p	= 4.186 kJ/kg °C
Density of air ρ_a	= 1.21 kg/m^3
Density of water ρ_w	= 1000 kg/m^3
Density of fuel ρ_f	= 804 kg/m^3
Diameter of brake drum d_B	= 0.2 m
Diameter of rope d_R	= 0.012 m
Diameter of orifice d_o	= 0.017 m
Diameter of piston D	= 0.08 m
Stoke length of piston L	= 0.11 m
Number of cylinder N_C	= 1
Number of cycles n	= 2

8.2 Observation Table:

T_a = ____________ °C (Reading of sensor T_3 / T_4 before starting engine)

S.No.					
N (RPM)					
h_1 (cm)					
h_2 (cm)					
W_1 (kg)					
W_2 (kg)					
x (ml)					
t (sec)					
T_1 (°C)					
T_2 (°C)					
T_3 (°C)					
T_4 (°C)					

T_5 (°C)					
T_6 (°C)					
V_E (ltrs)					
t_E (sec)					
V_c (ltrs)					
t_c (sec)					

CALCULATIONS:

$$R_e = \frac{d_B + 2d_R}{2} \text{ (m)}$$

$$T = (W_1 - W_2) \times g \times R_e \text{ (N-m)}$$

$$BP = \frac{2 \times \pi \times N \times T}{60 \times 1000} \text{ (kW)}$$

$$W_f = \frac{x}{t} \times \frac{\rho_f}{10^6} \text{ (kg/sec)}$$

$$W_{sf} = \frac{W_f}{BP} \text{ (kg/kW sec)}$$

$$H_f = W_f \times C_v \text{ (kW)}$$

$$\eta_{BT} = \frac{BP}{H_f} \times 100 (\%)$$

$$m_{ew} = \frac{V_E}{t_E} * \frac{\rho_w}{10^{03}} \text{ (kg/sec)}$$

$$H_{ecw} = m_{ew} * C_P * (T_2 - T_1) \text{ (kW)}$$

$$m_{cw} = \frac{V_c}{t_c} * \frac{\rho_w}{10^3} \text{ (kg/sec)}$$

$$H_{ccw} = m_{cw} \times C_P \times (T_6 - T_5) \text{ (kW)}$$

$$H_{exh} = \frac{H_{ccw}}{(T_3 - T_4)} \times (T_3 - T_a) \text{ (kW)}$$

$$H_{un} = H_f - (BP + H_{ecw} + H_{exh}) \text{ (kW)}$$

$$a_o = \frac{\pi}{4} d_o^2, \text{ (m}^2\text{)}$$

$$H = \frac{h_1 - h_2}{100}\left(\frac{\rho_w}{\rho_a} - 1\right) \text{ (m)}$$

$$Q_a = C_d \times a_o \sqrt{2gH} \text{ (m}^3\text{/sec)}$$

$$V_s = \frac{\pi \times D^2 \times L \times N \times N_c}{4 \times 60 \times n} \text{ (m}^3\text{/sec)}$$

$$\eta_{vol.} = \frac{Q_a}{V_s} \times 100 (\%)$$

Nomenclature:

Nom	Column Heading	Units	Type
a_o	Cross-sectional area of orifice	m^2	Calculated
BP	Brake power	kW	Calculated
C_d	Co-efficient of discharge for orifice		Given
C_p	Specific heat of water	kJ/ kg ^oC	Given
C_v	Calorific value of fuel	kJ/ kg	Given
D	Diameter of piston	m	Given
d_B	Diameter of brake drum	m	Given
d_o	Diameter of orifice	m	Given
d_R	Diameter of rope	m	Given
g	Acceleration due to gravity	m/sec^2	Given
H	Head causing flow of air through orifice	m	Calculated
H_{ccw}	Heat carried out by water from calorimeter	kW	Calculated
H_{ecw}	Heat carried out by water from engine cooling jacket	kW	Calculated
H_{exh}	Heat carried out by exhaust gas	kW	Calculated
H_f	Heat supplied	kW	Calculated
H_{un}	Heat lost in radiation and uncounted heat	kW	Calculated
h_1, h_2	Manometer reading (high and low level respectively)	cm	Measured
L	Length of stroke of piston	m	Given
m_{cw}	Mass of water entering the calorimeter	kg/sec	Calculated
m_{ew}	Mass of water entering the engine cooling jacket	kg/sec	Calculated
N	Revolutions per minute	RPM	Measured
N_c	Number of cylinders		Given
n	Number of cycles		Given
Q_a	Air consumption,	m^3/sec	Calculated
R_e	Mean effective radius	m	Calculated

T	Torque	N-m	Calculated
T_1	Temperature of water inlet for Engine jacket	^oC	Measured
T_2	Temperature of water outlet from Engine jacket	^oC	Measured
T_3	Temperature of exhaust gases inlet for calorimeter	^oC	Measured
T_4	Temperature of exhaust gases outlet from calorimeter	^oC	Measured
T_5	Temperature of water inlet for calorimeter	^oC	Measured
T_6	Temperature of water outlet from calorimeter	^oC	Measured
T_a	Ambient air temperature	^oC	Measured
t	Time taken for *x* ml	sec	Measured
t_c	Time for V_c	sec	Measured
t_E	Time for V_E	sec	Measured
V_c	Volume of water flows through calorimeter	Ltrs.	Measured
V_e	Volume of water flows through the engine jacket	Ltrs.	Measured
V_s	Swept volume.	m^3/sec	Calculated
W_1	Applied weight	kg	Measured
W_2	Dead weight	kg	Measured
W_f	Fuel consumption,	kg/sec	Calculated
W_{sf}	Specific fuel consumption	kg/kW-sec	Calculated
x	Volume of the fuel consumed	ml	Measured
ρ_a	Density of air	kg/m^3	Given
ρ_f	Density of fuel	kg/m^3	Given
ρ_w	Density of water	kg/m^3	Given
η_{BT}	Brake thermal efficiency	%	Calculated
η_{vol}	Volumetric efficiency	%	Calculated

Precaution & Maintenance Instructions:

10.1 Always check the oil level in the engine before starting and make sure that sufficient oil is present in the engine.

10.2 Never starts the engine at loaded condition.

10.3 Change engine oil after every 100 hours of total running or 6 months whichever is earlier.

10.4 Open cold water supply to the engine before starting.

10.5 Fuel tank and fuel line should be clean and free from foreign particles.

10.6 If diesel tank was empty before filling the diesel, remove air trapped in fuel line by opening the vent screw.

TROUBLESHOOTING:

11.1 If the engine heats up, check the water supply to the engine jacket.

11.2 If engine does not start, check the fuel and fuel supply line, if air found in pipeline, remove it.

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Prepared By	Reviewed By	Checked By

Experiment No. 7

Aim: To determine the efficiency of vertical/Horizontal condenser.

INTRODUCTION:

When saturated vapor is brought in contact with a cooled surface, heat is transferred from the vapor to the surface and a film of condensate is produced. During the process of condensation, one can obtain either film wise or drop wise condensation. If the surface is wettable, film wise condensation occurs; otherwise drop wise condensation occurs. However one cannot completely eliminate mixed condensation.

FOR VERTICAL CONDENSER:

The heat transfer coefficients obtained during film wise are $1/5^{th}$ to $1/6^{th}$ of drop wise condensation. In the case of vapor condensation on a vertical tube , the condensate film flows downward under the influence of gravity , but is retarded by the viscosity of the condensate film. The flow will normally be streamline and heat flows through the film by conduction. Nusselt has derived a theoretical relation for the determination of film heat transfer coefficient in terms of physical properties of condensate film, characteristic dimension and the temperature driving force. The film coefficient for condensation over a vertical plate of height, L, is given by:

$$h_o = 0.943\left(\frac{k^3\rho(\rho-\rho_s)\,g\,\lambda_s}{L\,\mu\,\Delta T}\right)^{1/4} \qquad \text{................(1)}$$

FOR HORIZONTAL CONDENSER:

The heat transfer coefficients obtained during film wise are $1/5^{th}$ to $1/6^{th}$ of drop wise condensation. The value of the condensing coefficient for a given quantity of vapor on a given surface is significantly affected by the position of the condenser. In a vertical tube about 60% of the vapor condenses in the upper half of the tube, Provided that the condensate film is flowing under laminar flow condition, the average condensation coeff. In case of a horizontal condenser shall be around 3 times as great as the vertical coefficient. Nusselt has derived a theoretical relation for the determination of film heat transfer coefficient in terms of physical properties of condensate film, characteristic dimension and the temperature driving force. The film coefficient for condensation over a horizontal cylinder of outerdiameter = D is given by:

$$h_o = 0.729\left(\frac{k^3\rho(\rho-\rho_s)g\,\lambda_s}{\mu D\Delta T}\right)^{1/4} \qquad \text{..................(2)}$$

For N number of tubes, eq^n (2) is writen as

$$h_o = 0.729\left(\frac{k^3\rho(\rho-\rho_s)g\,\lambda_s}{ND\Delta T\mu}\right)^{1/4} \qquad \text{................ (3)}$$

The physical properties are evaluated at film temperature, T_f, for both type of condenser, where

$$T_f = \frac{1}{2}(T_h + T_w)$$

Description:

The set-up consists of two shell and tube heat exchanger mounted horizontally and vertically named as horizontal condenser and vertical condenser. Shell is made of S.S. and tubes are made of copper. The experiment is conducted on one type of condenser at a time. Water passes through the tubes and steam condenses over the tubes. Steam generator is provided with heater to generate the steam. The heater is controlled by digital temperature control. A valve is provided to allow the steam either in horizontal condenser or in vertical condenser. Steam is supplied to the condenser from the steam generator. Steam trap is provided to collect the condensate in condenser. A valve is used to regulate the flow of steam. Rotameter is provided to control the flow rate of water. Temperature sensors and digital temperature indicator are provided to measure the inlet and outlet temperatures of water and steam.

Utilities Required:

6.1 Electricity supply: Single phase, 220 V AC, 50 Hz, 32 Amp MCB with earth connection.

6.2 Water supply: Continuous @ 5 LPM at 1 Bar.

6.3 Floor drain required.

6.4 Floor area required: 1.5 m x 1 m

EXPERIMENTAL PROCEDURE:

STARTING PROCEDURE (FOR VERTICAL CONDENSER):

7.1.1 Close all the valves V_1-V_{14}.

7.1.2 Open funnel valve V_9 & air vent valve V_{10} of steam generator and fill 3/4th of it with water.

7.1.3 Close both the valves V_9 –V_{10}.

7.1.4 Fill water tank with cold water.

7.1.5 Ensure that switches given on the panel are at OFF position.

7.1.6 Connect electric supply to the set up.

7.1.7 Set the desired steam temperature (110 to 120 ^{o}C) in the DTC by operating the increment or decrement and set button of DTC.

7.1.8 Switch ON the heater and wait till desired temperature achieves.

7.1.9 Switch ON the pump.

7.1.10 Open water supply valve V_6 and adjust the flow rate of water by control valve V_4.

7.1.11 Open steam supply valve V_1 of steam generator.

7.1.12 Open valve V_3 for supply of steam to condenser.

7.1.13 Open vent valve V_8 before steam trap of condenser to release air and then close it.

7.1.14 Record temperatures, flow rate of cooling water and steam pressure.

7.1.15 At steady state (constant temperatures) start the stop watch and collect the steam condensed in measuring cylinder.

7.1.16 Note down the time and volume of steam condensed.

7.1.17 Repeat the experiment for different flow rates of cold water.

Closing Procedure (For Vertical Condenser):

7.2.1 When experiment is over switch OFF the heater.

7.2.2 Partially open vent valve V_{10} of steam generator to release pressure.

7.2.3 Switch OFF the pump.

7.2.4 Switch OFF the main power supply.

7.2.5 Drain cold water tank by open the valve V_{14}.

7.2.6 Drain water from the condenser by open the valve V_{12}.

7.2.7 Drain water from steam generator by the drain valve V_{13}.

Starting Procedure (For Horizontal Condenser):

7.3.1 Close all the valves V_1-V_{14}.

7.3.2 Open funnel valve V_9 & air vent valve V_{10} of steam generator and fill 3/4th of it with water.

7.3.3 Close both the valves V_9-V_{10}.

7.3.4 Fill water tank with cold water.

7.3.5 Ensure that switches given on the panel are at OFF position.

7.3.6 Connect electric supply to the set up.

7.3.7 Set the desired steam temperature (110 to 120 ^{o}C) in the DTC by operating the increment or decrement and set button of DTC.

7.3.8 Switch ON the heater and wait till desired temperature achieves.

7.3.9 Switch ON the pump.

7.3.10 Open water supply valve V_5 and adjust the flow rate of water by control valve V_4.

7.3.11 Open steam supply valve V_1 of steam generator.

7.3.12 Open valve V_2 for supply of steam to condenser.

7.3.13 Open vent valve V_7 before steam trap of the condenser to release air and then close it.

7.3.14 Record temperatures, flow rate of cooling water and steam pressure.

7.3.15 At steady state (constant temperatures) start the stop watch and collect the steam condensed in measuring cylinder.

7.3.16 Note down the time and volume of steam condensed.

7.3.17 Repeat the experiment for different flow rates of cold water.

Closing Procedure (For Horizontal Condenser):

7.4.1 When experiment is over switch OFF the heater.

7.4.2 Partially open the vent valve V_{10} of steam generator to release pressure.

7.4.3 Switch OFF the pump.

7.4.4 Switch OFF the main power supply.

7.4.5 Drain cold water tank by open the valve V_{14}.

7.4.6 Drain water from the condenser by open the valve V_{11}.

7.4.7 Drain water from steam generator by open the valve V_{13}.

Observation & Calculation:

8.1 Data:

Diameter of tube D = 0.0127 m	Number of tubes N = 12
Acceleration due to gravity g = 9.81 m/sec^2	Length of tube L = 0.5 m

8.2.a Observation Table (For Vertical Condenser):

Sr. No.	P (kg/cm^2)	W (LPH)	T_1 (°C)	T_3 (°C)	T_4 (°C)	T_6 (°C)	V (ml)	t (sec)

8.2.b Observation Table (For Horizontal Condenser):

Sr. No.	P (kg/cm^2)	W (LPH)	T_1 (°C)	T_2 (°C)	T_4 (°C)	T_5 (°C)	V (ml)	t (sec)

Calculations (For Vertical Condenser):

$$T_h = \frac{T_1 + T_3}{2} \ (^\circ C)$$

$$T_W = \frac{T_4 + T_6}{2} \ (^\circ C)$$

$$T_f = \frac{T_W + T_h}{2} \ (^\circ C)$$

Find the properties of condensate (ρ, k, μ, C_p) at temperature T_f from data book.

ρ = ______ (kg/m^3)

k = ______ (W/m °C)

μ = ______ (kg/m-sec)

C_p = ______ (J/kg °C)

Find the property of steam (λ, ρ_s) at pressure P and temperature T_h from data book.

λ = ______ (J/ kg)

ρ_s = _____ (kg/m^3)

Find the properties of water (C_{pw}, ρ_w) at temperature T_W from data book.

C_{pw} = _____ (J/kg ^oC)

ρ_w = ______ (kg/m^3)

$$M_W = \frac{W \times \rho_W}{3600 \times 1000} \text{ (kg/sec)}$$

$$Q_W = M_W \times C_{Pw} \times (T_6 - T_4) \text{ (W)}$$

$$M_S = \frac{V \times \rho_S}{10^6 \times t} \text{ (kg/sec)}$$

$$Q_S = M_S \times \lambda \text{ (W)}$$

$$Q = \frac{Q_S + Q_W}{2} \text{ (W)}$$

$$\Delta T = T_h - T_W \text{ (}^oC\text{)}$$

$$\Delta T_1 = T_1 - T_6 \text{ (}^oC\text{)}$$

$$\Delta T_2 = T_3 - T_4 \text{ (}^oC\text{)}$$

$$\Delta T_m = \frac{\Delta T_1 - \Delta T_2}{\ln(\Delta T_1 / \Delta T_2)} \text{ (}^oC\text{)}$$

$$A = N \pi D L \text{ (m}^2\text{)}$$

$$U = \frac{Q}{A \, \Delta T_m} \text{ (W/m}^2\,^oC\text{)}$$

$$\lambda_s = \lambda + 0.68 C_P (T_W + T_h) \text{ (J/ kg)}$$

$$h_o = 0.943 \left(\frac{k^3 \rho (\rho - \rho_s) \, g \, \lambda_s}{L \, \mu \, \Delta T} \right)^{1/4} \text{ (W/m}^2\,^oC\text{)}$$

Calculation Table (For Vertical Condenser):

S.No	Q_W (W)	Q_S (W)	Q (W)	ΔT_m (°C)	U (W/m^2°C)	h_o (W/m^2°C)

Calculations (For Horizontal Condenser):

$$T_h = \frac{T_1 + T_2}{2} \ (^oC)$$

$$T_W = \frac{T_4 + T_5}{2} \ (^oC)$$

$$T_f = \frac{T_W + T_h}{2} \ (^oC)$$

Find the properties of condensate (ρ, k, μ, C_p) at temperature T_f from data book.

ρ = _____ (kg/m^3)

k = _____ (W/m °C)

μ = _____ (kg/m-sec)

C_p = _____ (J/kg °C)

find the property of steam (λ, ρ_s) at pressure P and temperature T_h from data book.

λ = _____ (J/ kg)

ρ_s = _____ (kg/m^3)

Find the properties of water (C_{pw}, ρ_w) at temperature T_W from data book.

C_{pw} = _____ (J/kg °C)

ρ_w = ______ (kg/m^3)

$$M_W = \frac{W \times \rho_W}{3600 \times 1000} \ (kg/sec)$$

$$Q_W = M_W \times C_{PW} \times (T_5 - T_4)(W)$$

$$M_S = \frac{V \times \rho_S}{10^6 \times t} \text{ (kg/sec)}$$

$$Q_S = M_S \times \lambda \quad \text{(W)}$$

$$Q = \frac{Q_S + Q_W}{2} \quad \text{(W)}$$

$$\Delta T = T_h - T_W \quad (^{o}C)$$

$$\Delta T_1 = T_1 - T_5 \; (^{o}C)$$

$$\Delta T_2 = T_2 - T_4 \; (^{o}C)$$

$$\Delta T_m = \frac{\Delta T_1 - \Delta T_2}{\ln(\Delta T_1 / \Delta T_2)} \; (^{o}C)$$

$$A = N\pi DL \quad (m^2)$$

$$U = \frac{Q}{A\,\Delta T_m} \quad (W/m^{2\,o}C)$$

$$\lambda_s = \lambda + 0.68 C_P (T_W + T_h) \text{ (J/ kg)}$$

$$h_o = 0.729 \left(\frac{k^3 \rho (\rho - \rho_s) g \, \lambda_s}{N D \Delta T \mu} \right)^{1/4} \quad (W/m^{2\,o}C)$$

CALCULATION TABLE (FOR HORIZONTAL CONDENSER):

S.No	Q_W (W)	Q_S (W)	Q (W)	ΔT_m (°C)	U (W/m²°C)	h_o (W/m²°C)

NOMENCLATURE:

Nom	Column Heading	Units	Type
A	Area of heat transfer	m^2	Calculated
C_p	Specific heat of water at film temperature	kJ/kg °C	Calculated
C_{pw}	Specific heat of water at mean temperature of water	kJ/kg °C	Calculated
D	Diameter of tube	m	Given
g	Acceleration due to gravity	m/sec^2	Given
h_o	Film coefficient	W/m^2 °C.	Calculated
k	Thermal conductivity at film temperature	W/m °C	Calculated
L	Length of tube	m	Given
M_s	Mass flow rate of condensing steam	kg/sec	Calculated
M_w	Mass flow rate of water	kg/sec	Calculated
N	Number of tube	-	Given
P	Pressure of steam	kg/cm^2	Measured
Q	Average heat transfer	W	Calculated
Q_w	Heat gain by water	W	Calculated
Q_s	Heat loss from steam	W	Calculated
T_1	Steam inlet temperature for horizontal and vertical condenser	°C	Measured
T_2	Steam outlet temperature for horizontal condenser	°C	Measured
T_3	Steam outlet temperature for vertical condenser	°C	Measured
T_4	Cold water inlet temperature for vertical or horizontal condenser	°C	Measured
T_5	Cold water outlet temperature for horizontal condenser	°C	Measured
T_6	Cold water outlet temperature for vertical condenser	°C	Measured
T_f	Film temperature	°C	Calculated
T_h	Mean temperature of steam	°C	Calculated
T_w	Mean temperature of water	°C	Calculated
t	Time	sec	Measured
U	Overall heat transfer coefficient	W/m^2 °C.	Calculated
V	Volume of condensing steam	ml	Measured
W	Flow rate of water	LPH	Measured
	Latent heat of condensate at mean temperature of steam	J/Kg	Measured

▭	Viscosity of condensate at film temperature	Kg/m-sec	Calculated
▭	Density of condensate at film temperature	Kg/m^3	Calculated
▭ ▭	Density of condensate at mean temperature of steam	Kg/m^3	Calculated
▭ ▭	Density of water at mean temperature of water	Kg/m^3	Calculated
Δ ▭	Mean temperature difference of steam and water	℃	Calculated
Δ ▭ 1	Inlet temperature difference	℃	Calculated
Δ ▭ 2	Outlet temperature difference	℃	Calculated
Δ ▭ ▭	Log mean temperature difference	℃	Calculated

PRECAUTION AND MAINTENANCE

1. Never run the apparatus if power supply is less than 200 volts and more than 230 volts.
2. Never switch ON mains power suplly before ensuring that all ON/OFF switches given on the panel are at OFF position.
3. Operator selector switch OFF temperature indicator gently.
4. Always keep the apparatus free from dust.

TROUBLESHOOTING:

1. **If electric panel is not showing the input on the mains light, check the main supply.**

Experiment No. 9

Aim: To determine swept volume of compressor, volumetric efficiency, compression ratio and isothermal efficiency of Double stage reciprocating compressor.

Introduction:

Air compressor is a device, which sucks the air from the atmosphere and Compresses it and delivers in reservoir tank. It compresses the air by means of a reciprocating piston, which reciprocates in a stationary cylinder. It can be single stage or multi stage. In single stage compression, air from the atmospheric pressure is compressed to the desired discharge in a single operation.

In two-stage compression, air is partially compressed in low-pressure cylinder. This air is passed through cooler between first stage and second stage so that air inlet of second stage so that air at inlet of second stage is at lower temperature than the first stage outlet. This is done to reduce the work of compression in second stage. Final compression is completed in second stage i.e. in high- pressure cylinder. Also, the compressors are provided with clearance volume, two stage compressors can achieve higher volumetric efficiency than single stage compressors, because of lower compression per stage.

As the compressed air is used in a wide range in industrial, domestic, aeronautics fields etc. so compressors are applied in wide range. Compressors are used where the air is required at high pressure.

Description:

Single and double stage air compressor test rig consists of a reservoir tank, two cylinders and pistons driven by AC motor. Thermometers are provided at inlet of low-pressure cylinder and outlet of high-pressure cylinder. Two more thermometers are provided before and after the intercooler. To find out the inlet volume of air, an orifice meter is provided. To stream line the intake, a diaphragm base manifold is provided. Pressure guage is provided at reservoir tank. Safety valve and auto power cut-off switch is provided for the safety factor.

Experimental Procedure (Single Stage):

1. Close the outlet valve of tank and also close the valves 1,2,3 and 6.
2. Now open the valves 7,4 and 5 and start the compressor. The air will be compressed in Single cylinder i.e. low-pressure cylinder.

3. Let the receiver pressure rise up to around 2 kg/cm^2. Now open the delivery valve so that constant delivery pressure is achieved.
4. Wait for some time and see that delivery pressure remain constant. Now note down the pressure.
5. Record the energy meter pulses/time to find out the input H.P.
6. Record the manometer reading to find out the volume of air input.
7. Record the temperature of air at inlet of cylinder.
8. Find out the RPM of compressor with the help of RPM indicator.
9. Find out the volumetric efficiency and isothermal efficiency by given formulae.
10. Repeat the same procedure for different delivery pressure.
11. After completing the experiment stop the compressor by pressing the red button provided at the control panel.

Experimental Procedure (Double stage):

1. Close the outlet and also close the valves 2,4,5 and 7.
2. Now open the valves 1,3 and 6 and connect the continuous water supply to the intercooler for cooling the compressed air and then start the compressor.
3. Let the receiver pressure rise up to around 2 kg/cm^2. Now open the delivery valve so that constant delivery pressure is achieved.
4. Wait for some time and see that delivery pressure remain constant. Now note down the pressure.
5. Record the energy meter pulses/time to find out the input H.P.
6. Record the manometer reading to find out the volume of air input.
7. Record the temperature of air at inlet, outlet, before and after intercooler.
8. Find out the RPM of compressor with the help of RPM indicator.
9. Repeat the same procedure for different delivery pressure.
10. After completing the experiment stop the compressor by pressing the red button provided at the control panel.

Precautions:

1. Check the oil before starting the air compressor.

2. Check the proper voltage while conducting experiments.
3. Be careful while measuring the RPM.
4. Close the delivery valve of tank before starting the experiment.

Specifications:

Motor	: 2 H.P. AC Single Phase, 1440 RPM
Compressor	: Single and double stage, Single acting
Cylinder 1	: Dia 70 mm, Stroke = 70 mm
Cylinder 2	: Dia 52 mm, Stroke=70
mm Energy meter constant (EMC)	: 3200 Pulses/ kWh

Standard Data:

Low pressure cylinder 1:

d= Bore Diameter	= 70 mm
L= Length of stroke	= 70 mm
d_o= Diameter of orifice	= 8 mm
a_o= Cross-sectional area of orifice	= 5.026×10^{-5} □^{2}
d_p= Diameter of pipe	= 16 mm
a_p= Cross-sectional area of pipe	= 2.011×10^{-4} m^2
□□ =Density of water	= 1000 kg/m^3
□□= Density of air at 0°C i.e. 273 k	= 1.293
kg/m^3 C_d= Co efficient of discharge	= 0.64
EMC= Energy Meter Constant	= 3200 pulses/ kWh
P_a= Atmospheric pressure	= 1.013×10^5 N/m^2
R= Radius of swinging field dynamometer	= 265 cm

T_1= Inlet air temperature

T_2 = Temperature of air before the intercooler and outlet of first stage

T_3= Temperature of air after the intercooler and inlet of second stage

T_4= Temperature of air at outlet of second stage

P= No. of pulses of energy meter

C_p= 1.005 kJ/kg k

Formulae:

1. $\Delta P = \left(\frac{\rho_m - \rho_a}{\rho_a}\right) R$ m of air

    Where ρ_m = density of manometer fluid (water)

    ρ_a = density of air

    R= Manometer pressure difference

2. Actual volume of air

$$Q_{act} = \frac{C_d a_o \sqrt{2 \Delta P g}}{\sqrt{1 - \left(\frac{a_o}{a_p}\right)^2}}$$

Where C_d= 0.64

a_o= cross-sectional area of orifice

a_p= cross-sectional area of pipe

ρ_a = Density of air

g= 9.81 m/sec^2

3. Actual volume of air at room temperature

$$V_{rta} = V_{act} \frac{273}{273 + T_1} \quad (T_1 = \text{[illegible]})$$

4. Swept volume of compressor

$$V_s = \frac{\pi}{4} d^2 L N \times \frac{1}{60}$$

Where d= 0.07 m

L= 0.07m

N= No. of rpm

5. Volumetric efficiency

$$\square_{\square} = \frac{}{\square_{\square}} \times 100$$

6. Power Input

$$\text{H.P. Elec} = \frac{n \times 3600 \times 1.36}{E_{mc} \times t}$$

7. Shaft Horsepower as Indicated by Swinging Field Dynamometer:

$$H.P._{shaft} = \frac{2\pi NT}{4500}$$

Torque, T = F× R

Where N= RPM of motor

F= Force in spring balance in kg

R= Radius of swinging field arm

8. Compression Ratio

$$r = \frac{\text{Swept volume} + \text{Cl. volume}}{\text{Cl. volume}}$$

9. Isothermal H.P.

$$\text{Isothermal } H.P. = \frac{P_{atm} \times \log_e r \times V_a}{75}$$

10. Isothermal Efficiency

$$\eta_{iso} = \frac{\text{Isothermal } H.P.}{H.P._{shaft}} \times 100$$

11. Heat rejected to intercooler

$$h = m_a C_p (T_3 - T_2) \text{ kJ/sec}$$

Mass flow rate of air,

$$m_a = \rho_{air} V_a \text{ kg/sec}$$

For Single Stage Compressor:

Observation Table:

S.No	Delivery Pressure kg/cm^2	Differential Manometer Reading (cm)	RPM	Inlet Temp T_1	Energy meter 20 pulses/time (Sec)	Force, F (kg)
1						
2						

3						
4						
5						

Calculation Table:

S.No.	Δ□ □ □□ □□□	□□□□ m^3/sec	Swept Volume □□ □^{3}/□□□	Volumetric Efficiency □ (%)
1				
2				
3				
4				
5				

S.No.	H.P. Elec.	Torque, T	H.P. Shaft	Compression ratio, r	Isothermal H.P.	Isothermal □ (%)
1						
2						
3						
4						
5						

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For Double stage compressor:

Observation Table:

S.No	Delivery Pressure kg/cm^2	Differential Manometer Reading (cm)	RPM	Inlet Temp T_1	Energy meter 20 pulses/time (Sec)	Force, F (kg)
1						
2						
3						
4						
5						

Calculation Table:

S.No.	Δ□ □ □□ □□□	□□□□ m^3/sec	Swept Volume □□ $□^3$/□□□	Volumetric Efficiency □ (%)
1				
2				
3				
4				
5				

S.No.	H.P. Elec.	Torque, T	H.P. Shaft	Compression ratio, r	Isothermal H.P.	Isothermal □ (%)
1						
2						
3						
4						
5						

UNIVERSITY INSTITUTE OF ENGINEERING

MECHANICAL ENGINEERING

APPLIED THERMODYNAMICS LAB (MEP-254)

CAD Modeling Lab

Course Code: MEP-255

Vision and Mission of the Chandigarh University

Vision

"To be globally recognized as a Centre of Excellence for Research, Innovation, Entrepreneurship and disseminating knowledge by providing inspirational learning to produce professional leaders for serving the society"

Mission

M1: Providing world class infrastructure, renowned academicians and ideal environment for Research, Innovation, Consultancy and Entrepreneurship relevant to the society.

M2: Offering programs & courses in consonance with National policies for nation building and meeting global challenges.

M3: Designing Curriculum to match International standards, needs of Industry, civil society and for inculcation of traits of Creative Thinking and Critical Analysis as well as Human and Ethical values.

M4: Ensuring students delight by meeting their aspirations through blended learning, corporate mentoring, professional grooming, flexible curriculum and healthy atmosphere based on co-curricular and extra-curricular activities.

M5: Creating a scientific, transparent and objective examination/evaluation system to ensure an ideal certification.

M6: Establishing strategic relationships with leading National and International corporates and universities for academic as well as research collaborations.

M7: Contributing for creation of healthy, vibrant and sustainable society by involving in Institutional Social Responsibility (ISR) activities like rural development, welfare of senior citizens, women empowerment, community service, health and hygiene awareness and environmental protection

Vision and Mission of the Department of Mechanical Engineering

Vision

To be recognized as a center of excellence for research and innovation in Mechanical Engineering through contemporary as well as futuristic tools and technologies for serving the society at regional, national and global level

Mission

MD1: Providing quality education to the students in core and allied fields by implementing advanced pedagogies

MD2: Encouraging students towards research and development through advanced tools and technologies for providing solution to societal problems

MD3: Evolve and empower the students through core technical skills for becoming entrepreneurs and innovators

MD4: Inculcating employability and leadership skill for ensuring industry ready professional through hands on experiential learning and industrial collaboration

MD5: Developing professional and ethical standards in the mind of the young engineers by continuous learning and professional activities

1.2. State the Program Educational Objectives (PEOs)(5)

PROGRAM EDUCATION OBJECTIVES (PEOs):

PEO1: Graduates will have professional knowledge in the field of Mechanical Engineering and various other interdisciplinary domains.

PEO2: Graduates will have successful career in government services, research organizations, corporate sector, academic institutes and industries at national and international repute.

PEO3: Graduate will have compatibility of modern engineering tools and technologies for deliberating solution of various engineering problems.

PEO4: Graduate will develop skill to address the concern of society, environment and communicate effectively to lead the interdisciplinary diverse team.

PEO5: Graduates will be effectively fit for higher education, innovations, research &development, entrepreneurship and professional development.

PROGRAM OUTCOMES (POs):
Program: Bachelor of Engineering (Mechanical Engineering)
Duration: 4 years

PO1. Engineering Knowledge: Apply knowledge of mathematics, science and engineering fundamentals and Production and Industrial Engineering specialization to the solution of complex Production and Industrial Engineering problems.

PO2. Problem Analysis: Identify, formulate, research literature and analyze complex Production and Industrial Engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex Engineering problems and design system components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.

PO4. Conduct investigations of complex Engineering problems: Use research-based knowledge and research methods including analysis, interpretation of data and synthesis of information to provide valid conclusions.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. The Engineer and Society: Apply contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams and in multi disciplinary settings.

PO10. Communication: Communicate effectively on complex Engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.

PO11. Project Management and Finance: Demonstrate knowledge and understanding of Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life Long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs):

PSO1: Apply the knowledge of Production, Manufacturing and Industrial Engineering for analysis, optimization and development of mechanical system

PSO2: Apply the concepts of Design and Thermal Engineering to model, analyze and develop the mechanical components and systems

Course Objectives

- To learn fundamental of drafting and designing using 3D modeling software.
- To impart practical knowledge of designing of rivets , welding joint and material conventions.
- To Design various type of machine components such as screws, nuts, bolts, keys and coupling.
- To get familiar with the industrial deigns.

Course Outcomes

After completion of course the student will be able to:

CO1	Apply the basics concepts of CAD to read and interpret the Mechanical Engineering drawings.
CO2	Familiar with CAD software to produce machine drawings using standards codes and procedure of Limit, Fits and Tolerances
CO3	Demonstrate the detail and assembly drawing of different components utilizing advanced tool and techniques of CAD.
CO4	Conduct the experiment individual/team ethically considering social, health, safety, legal and environmental aspects.
CO5	Generate the blueprints and express the same effectively in oral and written manners through report and practical presentation.

	CHANDIGARH UNIVERSITY
	DEPARTMENT OF MECHANICAL ENGINEERING

Cad Modeling lab	**Subject Code: MEP-255**

LIST OF EXPERIMENTS

1. An introduction of CAD software and study of various tool bar options.
2. Draw a 2D figure using cad software and show the dimensions, limits, fits, tolerances, and machining symbols.
3. Draw orthographic views of double riveted zigzag lap joint and double riveted chain butt joint with two equal cover plates. Show its front view, full in section and top view in in first angle projection.
4. Draw the 2D sketch of thread sections by using Creo software, to a scale full size and give all the standard proportions.
5. Assemble the hexagonal bolt, hexagonal nut and a washer using CAD tool. Show its front view, top view and side view in third angle of projection.
6. Assembly of a Gib and cotter joint for square rod.
7. Assemble all parts of sleeve and cotter joint for square rod using software.
8. Draw orthographic views of Oldham are coupling using software.
9. Draw the orthographic views of a knuckle joint using software.
10. Draw the assembly views of screw jack by using CAD-tool Creo Software:

EXPERIMENT NO.: 1

Aim: - An introduction of CAD software and study of various tool bar options.

Objective:- An introduction of CAD software and study of various tool bar options.
Note: All the dimensions in the drawing should be (Actual dimension + 0. (last two digits of UID No. of the students)

Introduction

The Creo software is a mechanical design automation application that lets designers quickly sketch out ideas, experiment with features and dimensions, and produce models and detailed drawings. This document discusses concepts and terminology used throughout the CAD application. It familiarizes you with the commonly used functions of CAD.

3D Design

Creo uses a 3D design approach. As you design a part, from the initial sketch to the final result, you create a 3D model. From this model, you can create 2D drawings or mate components consisting of parts or sub assemblies to create 3D assemblies. You can also create 2D drawings of 3D assemblies. When designing a model using CAD, you can visualize it in three dimensions, the way the model exists once it is manufactured.

Terminology

These terms appear throughout the CAD software and documentation.

Origin

Appears as two blue arrows and represents the (0,0,0) coordinate of the model. When a sketch is active, a sketch origin appears in red and represents the (0,0,0) coordinate of the sketch. You can add dimensions and relations to a model origin, but not to a sketch origin.

Plane

Flat construction geometry. You can use planes for adding a 2D sketch, section view of a model, or a neutral plane in a draft feature.

Axis

Straight line used to create model geometry, features, or patterns. You can create an axis in different ways, including intersecting two planes. The CAD application creates temporary axes implicitly for every conical or cylindrical face in a model.

Face

Boundaries that help define the shape of a model or a surface. A face is a selectable area (planar or non planar) of a model or surface. For example, a rectangular solid has six faces.

Edge

Face Location where two or more faces intersect and are joined together. You can select edges for sketching and dimensioning.

Vertex

Point at which two or more lines or edges intersect. You can select vertices for sketching and dimensioning.

User Interface

The CAD application includes user interface tools and capabilities to help you create and edit models efficiently, including:-

Windows Functions

The CAD application includes familiar Windows functions, such as dragging and resizing windows. Many of the same icons, such as print, open, save, cut, and paste are also part of the CAD application. CAD Document Windows CAD document windows have two panels. The left panel, or Manager Pane.

Menus

You can access all CAD commands using menus. CAD menus use Windows conventions, including sub menus and check marks to indicate that an item is active. You can also use context-sensitive shortcut menus by clicking the right mouse button.

Toolbars

You can access CAD functions using toolbars. Toolbars are organized by function, for example, the Sketch or Assembly toolbar. Each toolbar comprises individual icons for specific tools, such as Rotate View, Circular Pattern, and Circle. You can display or hide toolbars, dock them around the four borders of the CAD window, or float them anywhere on your screen. The CAD software remembers the state of the toolbars from session to session. You can also add or delete tools to customize the toolbars. Tool tips display when you hover over each icon.

Command Manager

The Command Manager is a context-sensitive toolbar that dynamically updates based on the active document type. When you click a tab below the Command Manager, it updates to show the related tools. Each document type, such as part, assembly, or drawing, has different tabs defined for its tasks. The content of the tabs is customizable, similar to toolbars. For example, if you click the Features tab, tools related to features appear. You can also add or delete tools to customize the Command Manager. Tool tips display when you hover over each icon.

Shortcut Bars

Customizable shortcut bars let you create your own sets of commands for part, assembly, drawing, and sketch mode. To access the bars, you press a user-defined keyboard shortcut, by default, the S key.

Context Toolbars

Context toolbars appear when you select items in the graphics area or Feature Manager design tree. They provide access to frequently performed actions for that context. Context toolbars are available for parts, assemblies, and sketches.

Design Process

The design process usually involves the following steps:

Identify the model requirements.

Conceptualize the model based on the identified needs.

Develop the model based on the concepts.

Analyze the model.

Prototype the model.

Construct the model.

Edit the model, if needed.

Dimensions

You can specify dimensions between entities such as lengths and radii. When you change dimensions, the size and shape of the part changes. Depending on how you dimension the part, you can preserve the design intent. See Design Intent on page 23. The software uses two types of dimensions: driving dimensions and driven dimensions.

Drawings

You create drawings from part or assembly models. Drawings are available in multiple views such as standard 3 views and isometric views (3D). You can import the dimensions from the model document and add annotations such as datum target symbols.

Relevant books:

1. *Bhatt N.D; Engineering Drawing,50th Edition, Charotar Publication,2011. (Online available at the link:* https://www.pdfdrive.com/engineering-drawing-by-nd-bhatt-e43754521.html*)*
2. *Jolhe D.A; Engineering Drawing: With an Introduction to AutoCAD,2nd Edition, Tata McGraw Hill(Buy at link:* https://www.abebooks.com/9780070648371/Engineering-Drawing-Introduction-JOLHE-0070648379/plp*)*

Other Resource Material:

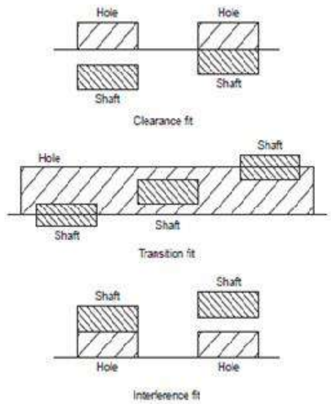
1. https://axibook.com/engineering-drawing/standard-convention-abbreviations-used-in-engineering-drawing/2019/
2. https://www.theengineerspost.com/types-of-lines/
3. https://blog.gstarcad.net/what-are-absolute-coordinates-and-relative-coordinates-in-cad-how-to-enter-coordinates-using-different-methods/

Experiment No. : 2

Topic : Draw a 2D figure using cad software and show the dimensions, limits, fits, tolerances, and machining symbols.
Note: All the dimensions in the drawing should be***(Actual dimension + 0. (last two digits of UID No. of the students)***
AIM : Draw a 2D figure using cad software and show the dimensions, limits, fits, tolerances, and machining symbols.
Theory :

Dimensioning –
A drawing of a component, in addition to providing complete shape description, must also furnish information regarding the size description. These are provided through the distances between the surfaces, location of holes, nature of surface finish, type of material, etc. The expression of these features on a drawing, using lines, symbols, figures and notes is called dimensioning. Dimension is a numerical value expressed in appropriate units of measurement and indicated on drawings, using lines, symbols, notes, etc., so that all features are completely defined.
Limit System –
Following are some of the terms used in the limit system :
Tolerance -
The permissible variation of a size is called tolerance. It is the difference between the maximum and minimum permissible limits of the given size. If the variation is provided on one side of the basic size, it is termed as unilateral tolerance. Similarly, if the variation is provided on both sides of the basic size, it is known as bilateral tolerance.
Limits -
The two extreme permissible sizes between which the actual size is contained are called limits. The maximum size is called the upper limit and the minimum size is called the lower limit.
Deviation -
It is the algebraic difference between a size (actual, maximum, etc.) and the corresponding basic size.
Actual Deviation -
It is the algebraic difference between the actual size and the corresponding basic size.
Upper Deviation -
It is the algebraic difference between the maximum limit of the size and the corresponding basic size.
Fits

The relation between two mating parts is known as a fit. Depending upon the actual limits of the hole or shaft sizes, fits may be classified as clearance fit, transition fit and interference fit.



Clearance Fit -

It is a fit that gives a clearance between the two mating parts.

Minimum Clearance -

It is the difference between the minimum size of the hole and the maximum size of the shaft in a clearance fit.

Maximum Clearance -

It is the difference between the maximum size of the hole and the minimum size of the shaft in a clearance or transition fit.

The fit between the shaft and hole in Fig. 15.10 is a clearance fit that permits a minimum clearance (allowance) value of 29.95 – 29.90 = + 0.05 mm and a maximum clearance of + 0.15 mm.

Transition Fit -

This fit may result in either an interference or a clearance, depending upon the actual values of the tolerance of individual parts.

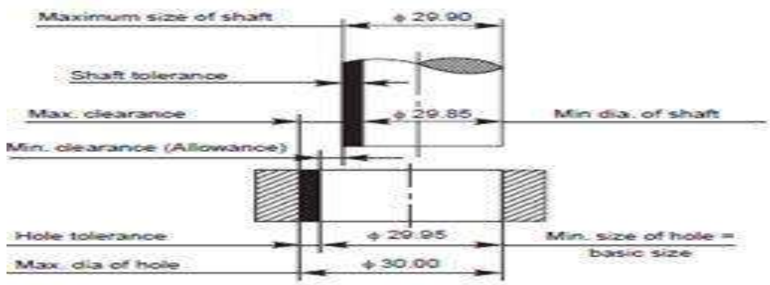
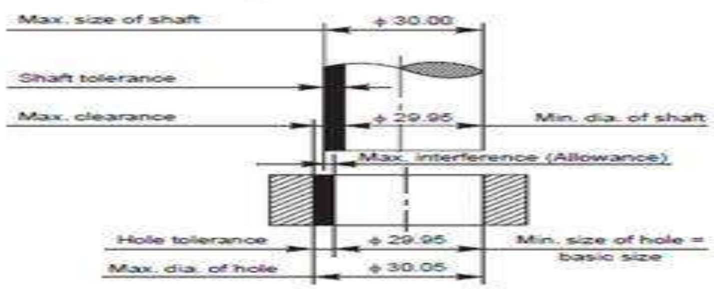
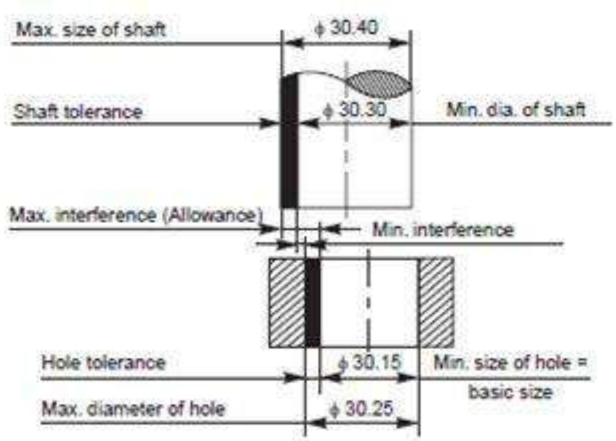


Fig. 15.10 Clearance fit



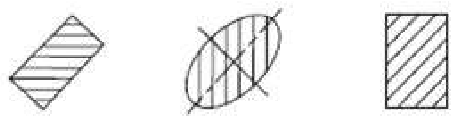
The shaft may be either smaller or larger than the hole and still be within the prescribed tolerances. It results in a clearance fit, when shaft diameter is 29.95 and hole diameter is 30.05 (+ 0.10 mm) and interference fit, when shaft diameter is 30.00 and hole diameter 29.95 (– 0.05 mm).

Interference Fit -



Hatching of Sections –

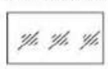
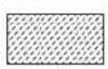
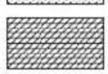
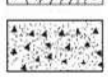
Hatching is generally used to show areas of sections. The simplest form of hatching is generally adequate for the purpose, and may be continuous thin lines (type B) at a convenient angle, preferably 45°, to the principal outlines or lines of symmetry of the sections.



Procedure –

- Select the new file and then select the drawing option.
- Open the page and then select the sheet format.
- Select your custom sheet format if already present or create a custom sheet format.
- Select the scale from the bottom at the extreme right side of the software to MMGS.
- Click on sketch and start the drawing.
- To adjust the dimensions, go to the smart dimensions option.
- Various machining symbols surface finishing, welding symbols; geometric tolerance etc. can be given in the Annotations tab.
- Written notes can be inserted in the "Note" option in annotation tab.

Conventional Representation –

Type	Convention	Material
Metals		Steel, Cast Iron, Copper and its Alloys, Aluminium and its Alloys, etc.
		Lead, Zinc, Tin, White-metal, etc
Glass		Glass
Packing and Insulating material		Porcelain, Stoneware, Marble, Slate, etc.
		Asbestos, Fibre, Felt, Synthetic resin products, Paper, Cork, Linoleum, Rubber, Leather, Wax, Insulating and Filling materials, etc.
Liquids		Water, Oil, Petrol, Kerosene, etc.
Wood		Wood, Plywood, etc.
Concrete		A mixture of Cement, Sand and Gravel

Relevant books:

1. *Bhatt N.D; Engineering Drawing,50th Edition, Charotar Publication,2011. (Online available at the link:* https://www.pdfdrive.com/engineering-drawing-by-nd-bhatt-e43754521.html*)*
2. *Jolhe D.A; Engineering Drawing: With an Introduction to AutoCAD,2nd Edition, Tata McGraw Hill(Buy at link:* https://www.abebooks.com/9780070648371/Engineering-Drawing-Introduction-JOLHE-0070648379/plp*)*

Other Resource Material:

1. https://axibook.com/engineering-drawing/standard-convention-abbreviations-used-in-engineering-drawing/2019/
2. https://www.theengineerspost.com/types-of-lines/
3. https://blog.gstarcad.net/what-are-absolute-coordinates-and-relative-coordinates-in-cad-how-to-enter-coordinates-using-different-methods/

Experiment No. : 3

Experiment No. 3

Topic : Draw orthographic views of double riveted zigzag lap joint and double riveted chain butt joint with two equal cover plates. Show its front view, full in section and top view in in first angle projection.
Note: All the dimensions in the drawing should be***(Actual dimension + 0. (last two digits of UID No. of the students)***
Aim – a) Sketch freehand all types of riveted heads and make table of welding joint symbols.
b) Draw orthographic views of double riveted zigzag lap joint and double riveted chain butt joint with two equal cover plates. Show its front view, full in section and top view in in first angle projection. Take t=12mm and D=20mm.
Theory –
Riveted Joints – Riveted joints are permanent fastenings and riveting is one of the commonly used method of producing rigid and permanent joints. Manufacture of boilers, storage tanks, etc., involve joining of steel sheets, by means of riveted joints. These joints are also used to fasten rolled steel sections in structural works, such as bridge and roof trusses.
Rivets and Riveting
Rivet –
A rivet is a round rod of circular cross-section. It consists of two parts, viz., head and shank. Mild steel, wrought iron, copper and aluminium alloys are some of the metals commonly used for rivets. The choice of a particular metal will depend upon the place of application.
Riveting –
Riveting is the process of forming a riveted joint. For this, a rivet is first placed in the hole drilled through the two parts to be joined. Then the shank end is made into a rivet head by applying pressure, when it is either in cold or hot condition.

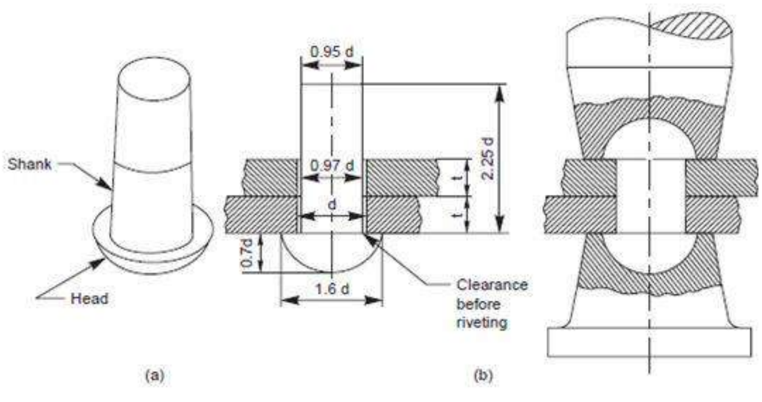
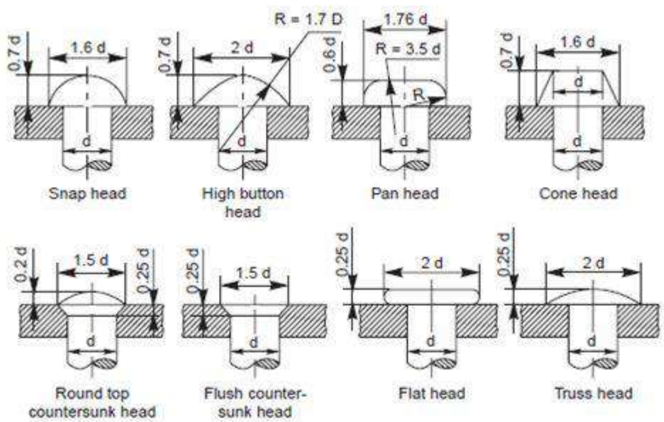


Fig. (a) Rivet Fig. (b) Riveting

Pressure may be applied to form the second rivet head, either by direct hammering or through hydraulic or pneumatic means. While forming the rivet head, the shank will bulge uniformly. Hence, a certain amount of clearance between the hole and shank must be provided before riveting (Fig. 10.1 (*b*)). Hot riveting produces better results when compared to cold riveting. This is because, after hot riveting, the contraction in the shank length tends to pull the parts together, making a tight joint.

Types of Rivet Heads –



Fasteners –

A machine element used for holding or joining two or more parts of a machine or structure is known as a fastener. The process of joining the parts is called fastening. The fasteners are of two types:

Permanent
Removable (temporary)
Riveting and welding processes are used for fastening permanently. Screwed fasteners such as bolts, studs and nuts in combination, machine screws, set screws, etc., and keys, cotters, couplings, etc., are used for fastening components that require frequent assembly and disassembly.
Screwed fasteners occupy the most prominent place among the removable fasteners. In general, screwed fasteners are used :

1. to hold parts together
2. to adjust parts with reference to each other
3. to transmit power

Procedure –

- Select the new file and then select the drawing option.
- Open the page and then select the sheet format.
- Select your custom sheet format if already present or create a custom sheet format.
- Select the scale from the bottom at the extreme right side of the software to MMGS.
- Click on sketch and start the drawing.
- To adjust the dimensions, go to the smart dimensions option.
- Various machining symbols surface finishing, welding symbols; geometric tolerance etc. can be given in the Annotations tab.

· Written notes can be inserted in the "Note" option in annotation tab.

Relevant books:

1. *Bhatt N.D; Engineering Drawing,50th Edition, Charotar Publication,2011. (Online available at the link:* https://www.pdfdrive.com/engineering-drawing-by-nd-bhatt-e43754521.html*)*
2. *Jolhe D.A; Engineering Drawing: With an Introduction to AutoCAD,2nd Edition, Tata McGraw Hill(Buy at link:* https://www.abebooks.com/9780070648371/Engineering-Drawing-Introduction-JOLHE-0070648379/plp*)*

Other Resource Material:

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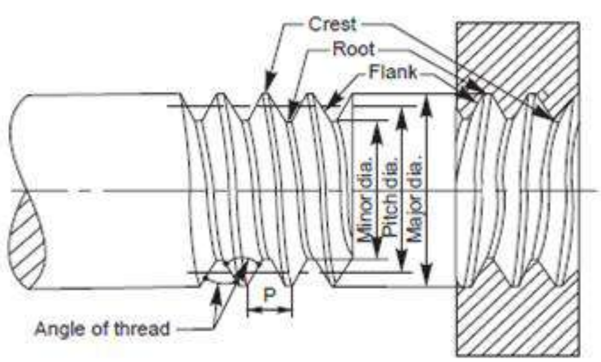
2. https://www.theengineerspost.com/types-of-lines/

https://blog.gstarcad.net/what-are-absolute-coordinates-and-relative-coordinates-in-cad-how-to-enter-coordinates-using-different-methods/

Experiment No. : 4

Topic: Draw the 2D sketch of thread sections by using Creo software, to a scale full size and give all the standard proportions.
Note: All the dimensions in the drawing should be***(Actual dimension + 0. (last two digits of UID No. of the students)***
Aim – Draw the 2D sketch of thread sections by using Creo software, to a scale full size and give all the standard proportions : ISO metric thread, BSW thread, BA thread, U.S. standard of seller's thread, Square thread Acme thread Buttress thread and Knuckle thread. Show at least four complete thread sections with all dimensions and take a pitch of thread as 40 mm.

Theory –
A screw thread is obtained by cutting a continuous helical groove on a cylindrical surface (external thread). The threaded portion engages with a corresponding threaded hole (internal thread); forming a screwed fastener. Following are the terms that are associated with screw threads –

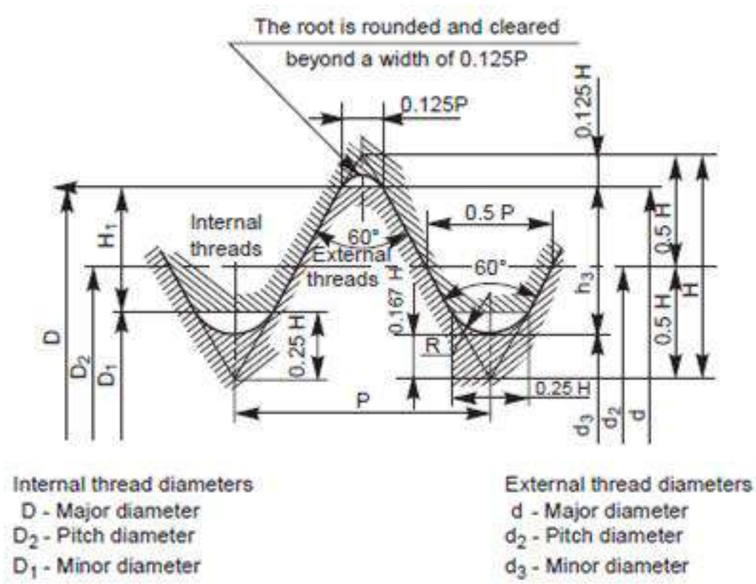


1. Major (nominal) diameter
This is the largest diameter of a screw thread, touching the crests on an external thread or the roots of an internal thread.
2. Minor (core) diameter
This is the smallest diameter of a screw thread, touching the roots or core of an external thread(root or core diameter) or the crests of an internal thread.
3. Pitch diameter
This is the diameter of an imaginary cylinder, passing through the threads at the points where the thread width is equal to the space between the threads.
4. Pitch
It is the distance measured parallel to the axis, between corresponding points on adjacent screw threads.
5. Lead
It is the distance a screw advances axially in one turn.

6. Flank
Flank is the straight portion of the surface, on either side of the screw thread.
7. Crest
It is the peak edge of a screw thread, that connects the adjacent flanks at the top.
8. Root
It is the bottom edge of the thread that connects the adjacent flanks at the bottom.
9. Thread angle
This is the angle included between the flanks of the thread, measured in an axial plane.

Forms of threads :

Bureau of Indian Standards (BIS) adapts ISO (International Organisation for Standards) metric threads which are adapted by a number of countries apart from India. The design profiles of external and internal threads are shown in Fig. 5.2. The following are the relations between the various parameters marked in the figure :



P = Pitch $d3 = d2 – 2 (H/2 – H/6)$

H = 0.86 P = d – 1.22P

D = d = Major diameter H1 = (D – D1)/2 = 5H/8 = 0.54P

$D2 = d2 = d - 0.75H$ $h3 = (d - d3)/2 = 17/24H = 0.61P$

$D1 = d2 - 2(H/2 - H/4) = d - 2H1$ $R = H/6 = 0.14P$

It may be noted from the figure that in order to avoid sharp corners, the basic profile is rounded at the root (minor diameter) of the design profile of an external thread. Similarly, in the case of internal thread, rounding is done at the root (major diameter) of the design profile.

Other Thread Profiles

Apart from ISO metric screw thread profile, there are other profiles in use to meet various applications. These profiles are shown in Fig. 5.3, the characteristics and applications of which are discussed below

V-Threads -

This thread profile has a larger contact area, providing more frictional resistance to motion.Hence, it is used where effective positioning is required. It is also used in brass pipe work.

British Standard Whitworth Thread -

This thread form is adopted in Britain in inch units. The profile has rounded ends, making it less liable to damage than sharp V-thread.

Buttress Thread –

This thread is a combination of V-and square threads. It exhibits the advantages of square thread,like the ability to transmit power and low frictional resistance, with the strength of the V-thread.It is used where power transmission takes place in one direction only such as screw press, quick acting carpenter’s vice, etc.

Square Thread -

Square thread is an ideal thread form for power transmission. In this, as the thread flank is at right angle to the axis, the normal force between the threads, acts parallel to the axis, with zero radial component. This enables the nut to transmit very high pressures, as in the case of a screw jack and other similar applications.

ACME Thread -

It is a modified form of square thread. It is much stronger than square thread because of the wider base and it is easy to cut. The inclined sides of the thread facilitate quick and easy engagement and disengagement as for example, the split nut with the lead screw of a lathe.

Worm Thread -

Worm thread is similar to the ACME thread, but is deeper. It is used on shafts to carry power to worm wheels.

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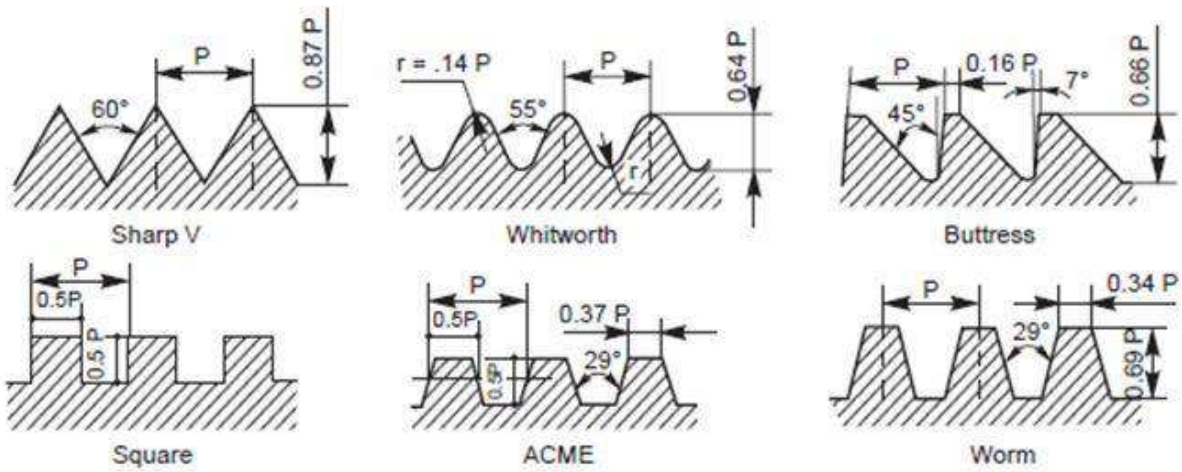

Procedure –

- Select the new file and then select the drawing option.
- Open the page and then select the sheet format.
- Select your custom sheet format if already present or create a custom sheet format.
- Select the scale from the bottom at the extreme right side of the software to MMGS.
- Click on sketch and start the drawing.
- To adjust the dimensions, go to the smart dimensions option.
- Various machining symbols surface finishing, welding symbols; geometric tolerance etc. can be given in the Annotations tab.
- Written notes can be inserted in the "Note" option in annotation tab.

Relevant books:

1. *Bhatt N.D; Engineering Drawing,50th Edition, Charotar Publication,2011. (Online available at the link:* https://www.pdfdrive.com/engineering-drawing-by-nd-bhatt-e43754521.html*)*
2. *Jolhe D.A; Engineering Drawing: With an Introduction to AutoCAD,2nd Edition, Tata McGraw Hill(Buy at link:* https://www.abebooks.com/9780070648371/Engineering-Drawing-Introduction-JOLHE-0070648379/plp*)*

Other Resource Material:

1. https://axibook.com/engineering-drawing/standard-convention-abbreviations-used-in-engineering-drawing/2019/
2. https://www.theengineerspost.com/types-of-lines/
3. https://blog.gstarcad.net/what-are-absolute-coordinates-and-relative-coordinates-in-cad-how-to-enter-coordinates-using-different-methods/

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DEPARTMENT OF MECHANICAL ENGINEERING

Cad Modeling lab	Subject Code: MEP-255

Experiment No.: 5

Topic : Assemble the hexagonal bolt, hexagonal nut and a washer using CAD tool. Show its front view, top view and side view in third angle of projection.
Note: All the dimensions in the drawing should be***(Actual dimension + 0. (last two digits of UID No. of the students)***
Aim – Draw orthogonal views by using CAD-Tool Creo Software of each of following components:

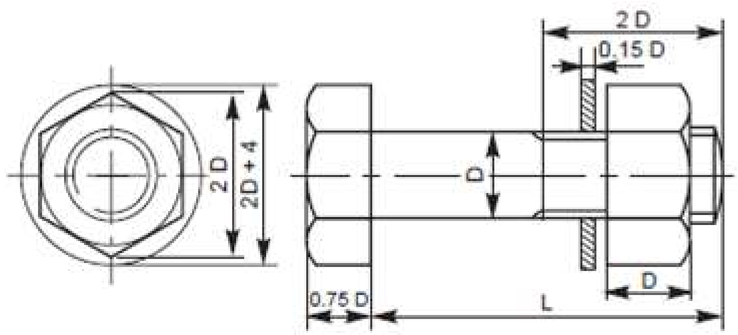
i) Standard Hexagonal nut
ii) Square nut
iii) Ring Collar Nut

Take nominal diameter D=25mm, indicate all necessary proportions in terms of D on the views.

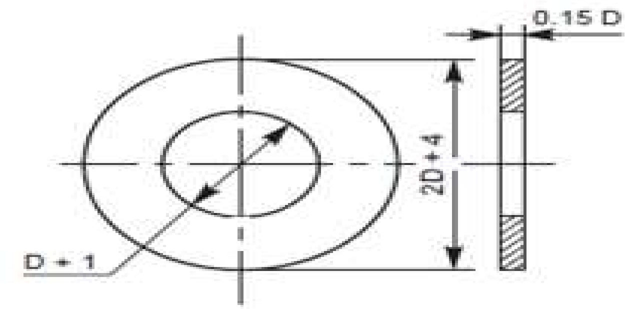
Theory – A bolt and nut in combination (Fig. 5.11) is a fastening device used to hold two parts together. The body of the bolt, called shank is cylindrical in form, the head; square or hexagonal in shape, is formed by forging. Screw threads are cut on the other end of the shank. Nuts in general are square or hexagonal in shape. The nuts with internal threads engage with the corresponding size of the external threads of the bolt.

However, there are other forms of nuts used to suit specific requirements. For nuts, hexagonal shape is preferred to the square one, as it is easy to tighten even in a limited space. This is because, with only one-sixth of a turn, the spanner can be re-introduced in the same position.

However, square nuts are used when frequent loosening and tightening is required, for example on job holding devices like vices, tool posts in machines, etc. The sharp corners on the head of bolts and nuts are removed by chamfering.



Washer – A washer is a cylindrical piece of metal with a hole to receive the bolt. It is used to give a prefect seating for the nut and to distribute the tightening force uniformly to the parts under the joint. Is also prevents the nut from damaging the metal surface under the joint.



The following steps maybe made use of to make an assemble drawing from component drawings:

- Understand the purpose, principle of operation and field of application of the given machine. This will help in understanding the functional requirements of individual parts and their location.
- Examine thoroughly, the external and internal features of the individual parts.
- Choose a proper scale for the assembly drawing.
- Estimate the overall dimensions of the views of the assembly drawing and make the outline blocks for each of the required view, leaving enough space between them, for indicating dimensions and adding required notes.
- Draw the axes of symmetry for all the views of the assembly drawing.
- Begin with the view from the front, by drawing first, the main parts of the machine and then adding the rest of the parts, in the sequence of the assembly.
- Project the other required views from the view from the front and complete the views.
- Mark the location and overall dimensions and add the part numbers in the drawing.
- Prepare the parts list.

. Add the title block.

Procedure –

- Select the new file and then select the drawing option.
- Open the page and then select the sheet format.
- Select your custom sheet format if already present or create a custom sheet format.
- Select the scale from the bottom at the extreme right side of the software to MMGS.
- Click on sketch and start the drawing.
- To adjust the dimensions, go to the smart dimensions option.
- Various machining symbols surface finishing, welding symbols; geometric tolerance etc. can be given in the Annotations tab.
- Written notes can be inserted in the “Note” option in annotation tab.

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2. *Jolhe D.A; Engineering Drawing: With an Introduction to AutoCAD,2nd Edition, Tata McGraw Hill(Buy at link:* https://www.abebooks.com/9780070648371/Engineering-Drawing-Introduction-JOLHE-0070648379/plp*)*

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2. https://www.theengineerspost.com/types-of-lines/
https://blog.gstarcad.net/what-are-absolute-coordinates-and-relative-coordinates-in-cad-how-to-enter-coordinates-using-different-methods/

Experiment No.: 6

Aim- Assembly of a Gib and cotter joint for square rod.

Note: All the dimensions in the drawing should be (Actual dimension + 0. (last two digits of UID No. of the students)

Aim – Assembly of a Gib and cotter joint for square rod. Draw the following orthographic views of the assembly by using Solid works Software:

Front View, upper half in section.

Top View.

Theory – Keys, cotters and pin joints are some examples of removable (temporary) fasteners. Assembly and removal of these joints are easy as they are simple in shape. The standard proportions of these joints are given in the figures.

Keys:

Keys are machine elements used to prevent relative rotational movement between a shaft and the parts mounted on it, such as pulleys, gears, wheels, couplings, etc. For making the joint, grooves or keyways are cut on the surface of the shaft and in the hub of the part to be mounted. After positioning the part on the shaft such that, both the keyways are properly aligned, the key is driven from the end, resulting in a firm joint. For mounting a part at any intermediate location on the shaft, first the key is firmly placed in the keyway of the shaft and then the part to be mounted is slid from one end of the shaft, till it is fully engaged with the key. Keys are classified into three types, viz., saddle keys, sunk keys and round keys.

Types of keys:

Saddle keys,

Sunk keys,

Splines,

Tangent keys, and

Round keys.

Saddle Keys:

A Saddle key is a key which fits in the keyway of the hub only.

In this case, there is no keyway on the shaft.

It is likely to slip round the shaft under load. Therefore it is used for comparatively light loads.

Resistance to slip in case of flat key is slightly more than that of hollow key

These are taper keys, with uniform width but tapering in thickness on the upper side. The magnitude of the taper provided is 1:100. These are made in two forms: hollow and flat.

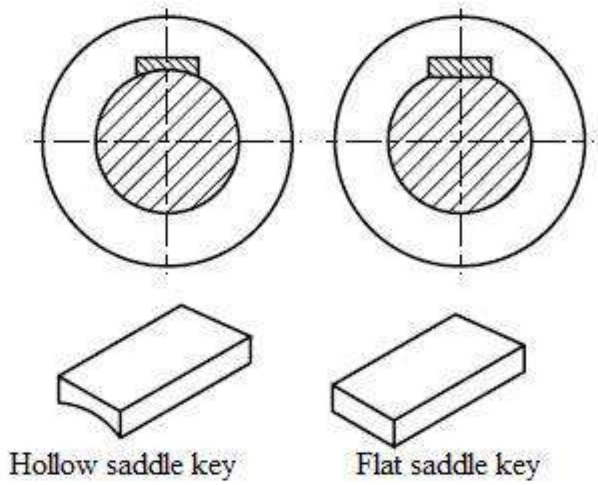
There are two types of saddle keys

Hollow saddle key.

Flat saddle key.

Use:

saddle keys are suitable for light duty or low power transmission.



Hollow Saddle Keys: A hollow saddle key has a concave shaped bottom to suit the curved surface of the shaft, on which it is used. A keyway is made in the hub of the mounting, with a tapered bottom surface. When a hollow saddle key is fitted in position, the relative rotation between the shaft and the mounting is prevented due to the friction between the shaft and key.

Flat Saddle Keys: It is similar to the hollow saddle key, except that the bottom surface of it is flat. Apart from the tapered keyway in the hub of the mounting, a flat surface provided on the shaft is used to fit this key in position. The two types of saddle keys discussed above are suitable for light duty only. However, the flat one is slightly superior compared to the hollow type. Saddle keys are liable to slip around the shaft when used under heavy loads.

Sunk Keys :

A sunk key is a key in which half the thickness of the key fits into the keyway on the shaft and the remaining half in the keyway on the hub.

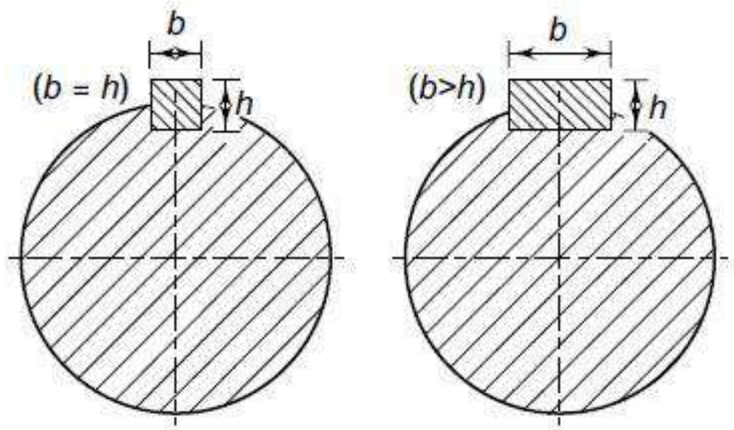
Therefore, keyways are required both on the shaft as well as the hub of the mating element.

These are the standard forms of keys used in practice, and may be either square or rectangular in cross-section. The end may be squared or rounded. Generally, half the thickness of the key fits into the shaft keyway and the remaining half in the hub keyway. These keys are used for heavy duty, as the fit between the key and the shaft is positive.

There are two types of sunk keys

Square sunk key

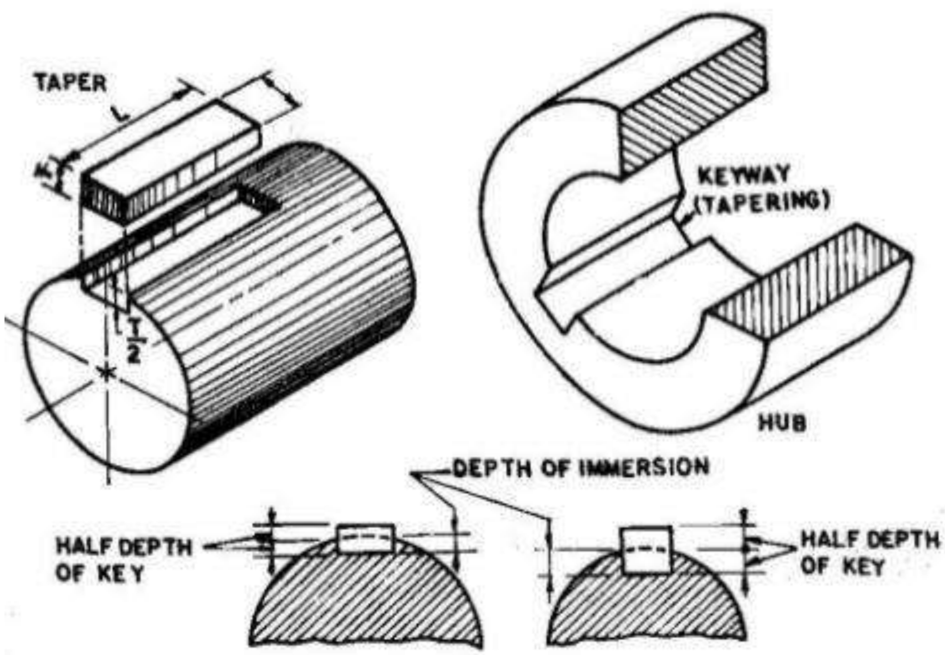
Rectangular sunk key



Square Sunk Key   Rectangular Sunk Key

Sunk keys may be classified as:
Taper key.
Parallel or Feather key.
Woodruff key.
Taper Sunk Key :
These keys are square or rectangular in cross-section, uniform in width but tapered in thickness. The bottom surface of the key is straight and the top surface is tapered, the magnitude of the taper being 1:100. Hence, the keyway in the shaft is parallel to the axis and the hub keyway is tapered.
A tapered sunk key may be removed by driving it out from the exposed small end. If this end is not accessible, the bigger end of the key is provided with a head called gib. Following are the proportions for a gib head:
If D is the diameter of the shaft, then,
Width of key, W = 0.25 D + 2 mm
Thickness of key, T = 0.67 W (at the thicker end)
Standard taper = 1:100
Height of head, H = 1.75 T
Width of head, B = 1.5 T

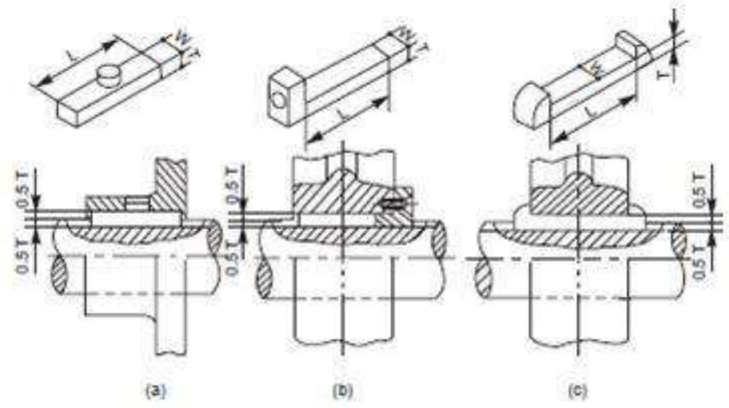
Sunk taper key



Parallel or Feather key :A parallel or feather key is a sunk key, uniform in width and thickness as well. These keys are used when the parts (gears, clutches, etc.) mounted are required to slide along the shaft; permitting relative axial movement. To achieve this, a clearance fit must exist between the key and the keyway in which it slides.

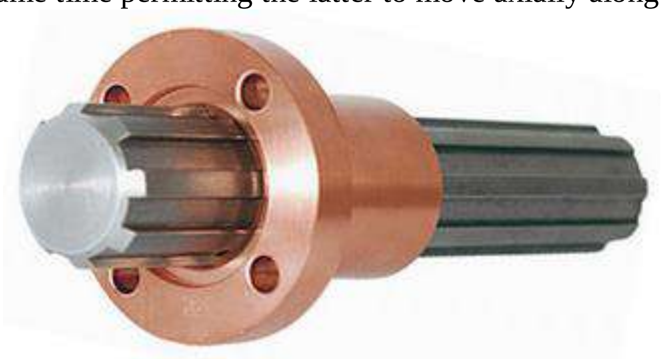
Feather Keys

The feather key may be fitted into the keyway provided on the shaft by two or more screws or into the hub of the mounting. Further these keys are of three types:
peg feather key.
single headed feather key.
double headed feather key.
Peg Feather Key :In this key, a projection known as peg is provided at the middle of the key. The peg fits into a hole in the hub of the sliding member. Once placed in a position, the key and the mounting move axially as one unit.
Single Handed Feather Key :In this, the key is provided with a head at one end. The head is screwed to the hub of the part mounted on the shaft.
Double Headed Feather Key : In this, the key is provided with heads on both ends. These heads prevent the axial movement of the key in the hub. Here too, once placed in position, the key and the mounting move as one unit.

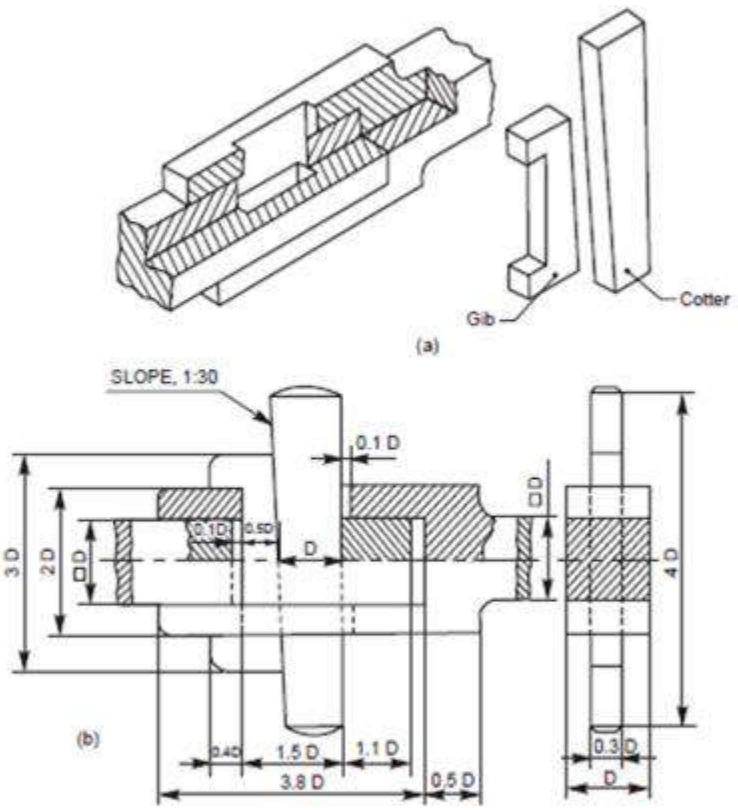


Feather keys

Splines: Splines are keys made integral with the shaft, by cutting equi-spaced grooves of uniform cross section. The shaft with splines is called a splined shaft. The splines on the shaft, fit into the corresponding recesses in the hub of the mounting, with a sliding fit, providing a positive drive and at the same time permitting the latter to move axially along the shaft .



Cotter Joint with a Gib :This joint is generally used to connect two rods of square or rectangular cross-section. To make the joint, one end of the rod is formed into a U-fork, into which, the end of the other rod fits in. When a cotter is driven-in, the friction between the cotter and straps of the U-fork, causes the straps to open. This is revented by the use of a gib. A gib is also a wedge shaped piece of rectangular cross-section with two rectangular projections called lugs. One side of the gib is tapered and the other straight. The tapered side of the gib bears against the tapered side of the cotter such that, the outer edges of the cotter and gib as a unit are parallel. This facilitates making of slots with parallel edges, unlike the tapered edges in case of ordinary cotter joint. Further, the lugs bearing against the outer surfaces of the fork, prevents the opening tendency of the straps.



Cotter joint with a gib

Procedure –
Select the new file and then select the part option.
First make the strap using line command and give right dimension using smart dimension and then use the extrude command.
Then make cotter using the line and give dimension using smart dimension .
Make one shaft using various command and the extrude command to make a hole for cotter
Save all parts then open the assembly and using Mate command complete assembly .
After making the assembly , open drawing sheet to make different views we can browse the file to the drawing option by opening a new window .
Open the page and then select the sheet format. We can also edit our sheet format by going in edit sheet format.
Precautions:
Choose A4 size sheet and set a sheet format.
Use right command to make a drawing
Measurement should be precise.

Make all orthographic view in sheet.

Relevant books:

1. Bhatt N.D; Engineering Drawing,50th Edition, Charotar Publication,2011. (Online available at the link: https://www.pdfdrive.com/engineering-drawing-by-nd-bhatt-e43754521.html)
2. Jolhe D.A; Engineering Drawing: With an Introduction to AutoCAD,2nd Edition, Tata McGraw Hill (Buy at link: https://www.abebooks.com/9780070648371/Engineering-Drawing-Introduction-JOLHE-0070648379/plp)

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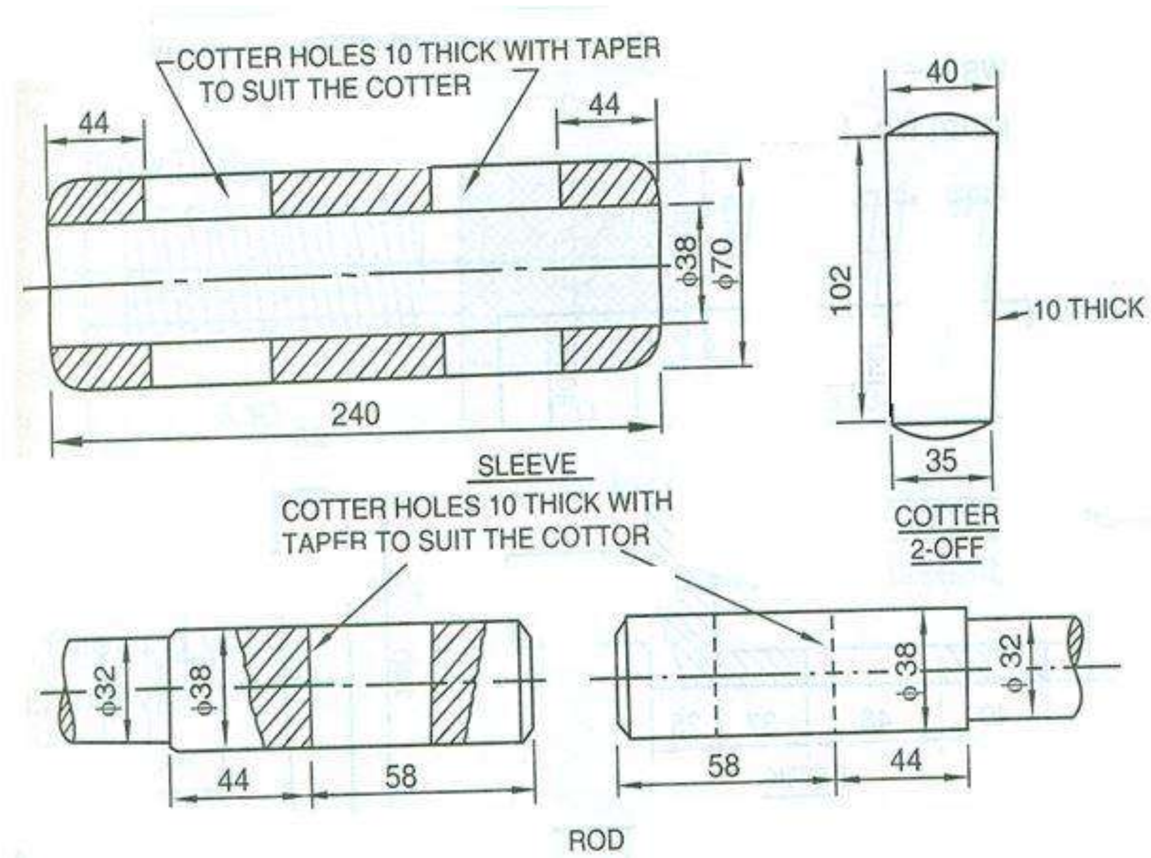
2. https://www.theengineerspost.com/types-of-lines/

https://blog.gstarcad.net/what-are-absolute-coordinates-and-relative-coordinates-in-cad-how-to-enter-coordinates-using-different-methods/

Experiment No.: 7

Aim- Assemble all parts of sleeve and cotter joint for square rod using software.
Note: All the dimensions in the drawing should be (Actual dimension + 0. (last two digits of UID No. of the students)
Aim – Assemble all parts of sleeve and cotter joint for square rod using software. Draw the following orthographic views of the assembly by using Creo Software:
Front View, upper half in section.
Top View.
Theory – Keys, cotters and pin joints are some examples of removable (temporary) fasteners. Assembly and removal of these joints are easy as they are simple in shape. The standard proportions of these joints are given below.
Cotter Joints :
Cotters are used to hold two parts together where the parts are subjected to axial forces only. A cotter is a wedge shaped piece of mild steel, often rectangular in section, tapered on one or both sides. It is usually driven in perpendicular to the axis of connecting parts. Taper on it provided to facilitate it s driving into position and withdrawal and for lateral adjustment of connecting parts.
A cotter is a flat wedge shaped piece, made of steel. It is uniform in thickness but tapering in width, generally on one side; the usual taper being 1:30. The lateral (bearing) edges of the cotter and the bearing slots are generally made semi-circular instead of straight. This increases the bearing area and permits drilling while making the slots. The cotter is locked in position by means of a screw as shown in. Cotter joints are used to connect two rods, subjected to tensile or compressive forces along their axes. These joints are not suitable where the members are under rotation. The following are some of the commonly used cotter joints:



Cotter Joint with Sleeve :

This is the simplest of all cotter joints, used for fastening two circular rods. To make the joint, the rods are enlarged at their ends and slots are cut. After keeping the rods butt against each other, a sleeve with slots is placed over them. After aligning the slots properly, two cotters are driven-in through the slots, resulting in the joint. The rod ends are enlarged to take care of the weakening effect caused by the slots. The slots in the rods and sleeve are made slightly wider than the width of cotter. The relative positions of the slots are such, that when a cotter is driven into its position, it permits wedging action and pulls the rod into the sleeve.

Cotter Joint with socket and spigot ends :

This joint is also used to fasten two circular rods. In this, the rod ends are modified instead of using a sleeve. One end of the rod is formed into a socket and the other into a spigot and slots are cut. After aligning the socket and spigot ends, a cotter is driven-in through the slots, forming the joint.

PROCEDURE :

Select the new file and then select the part option.

First make the sleeve using circle command and giveright dimension using smart dimensionand then use the extrude command.

Then make cotter using the line and give dimensionusing smart dimension .

Make two shafts using various command and the extrudecommand to make a hole for cotter

Save all parts then open the assembly and using Matecommand complete assembly .

Aftermaking the assembly , open drawing sheet to make different views we can browsethe file to the drawing option by opening a new window .

Open the page and then select the sheet format. We canalso edit our sheet format by going in edit sheet format.

Precautions:

Choose A4 sizesheet and set a sheet format.

Use right commandto make a drawing

Measurement shouldbe precise.

Make allorthographic view in sheet.

Experiment No. 8

Topic: Draw orthographic views of Oldham are coupling using software.

Note: All the dimensions in the drawing should be ***(Actual dimension + 0. (last two digits of UID No. of the students)***

Aim: Make orthographic views of Oldham's coupling and muff coupling by using software. Take diameter of shaft as 50mm.

Theory

Couplings:

A device that is used to connect two shafts together for the purpose of power transmission.

General two types of couplings are:

- Rigid: for aligned shafts
- Flexible: for non-aligned shafts

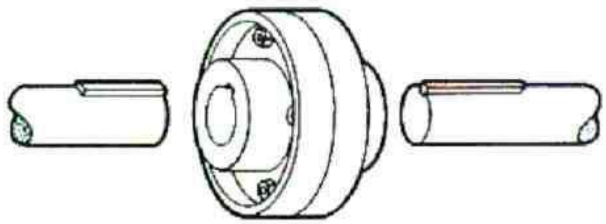
Rigid or Aligned Shaft Couplings:

Aligned shaft couplings are rigid couplings that are designed to draw two shafts together so that no motion can occur between them. General four types of rigid couplings are listed below: -

1. Flanged
2. Split Coupler
3. Keyed
4. Friction

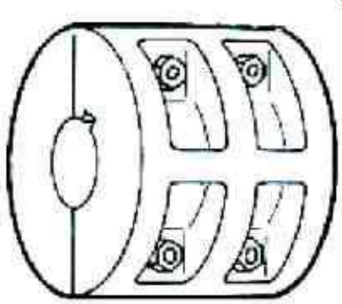
1. **Flanged Coupling**

A key is used to fix the coupling to the shaft, and then couplings are bolted together.



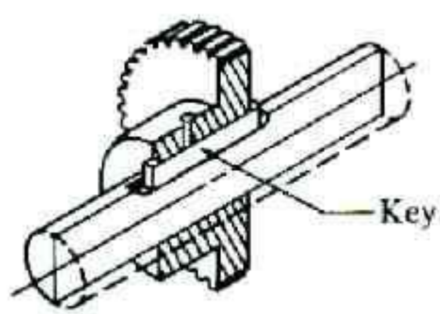
2. Split Coupler

Again, a key is used to fix the coupling and the shaft, and the two halves of the coupling are bolted together.

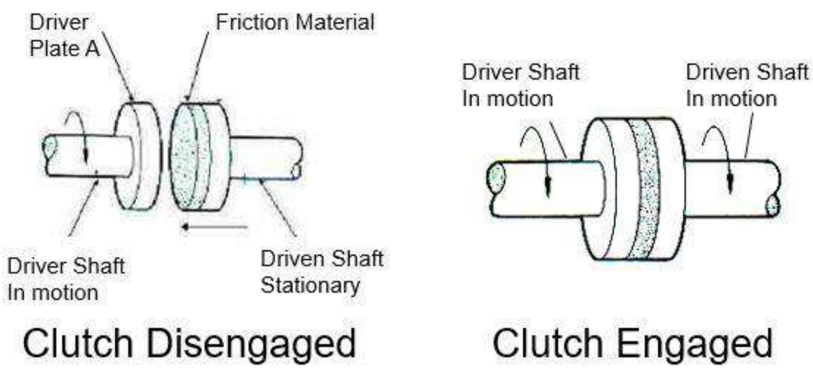


3. Keyed Coupler

Grooves are cut into the shaft and the fixed part.A key is put in the grooves to lock the two parts together.



4. **Friction Coupling**



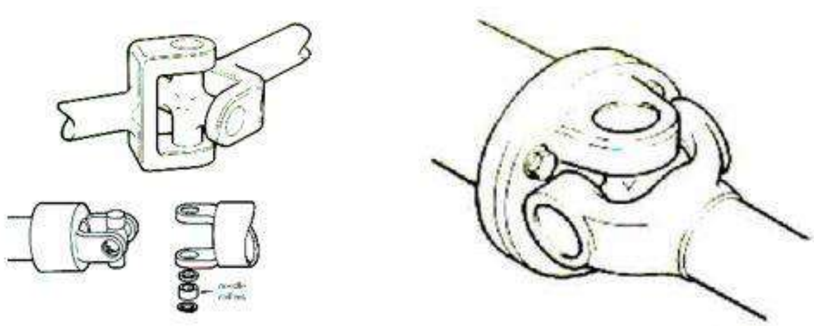
Flexible or Non-Aligned Shaft Couplings:

Used to join shafts that meet at a slight angle. Angle may still change while running due to vibration or load. General three types of flexible couplings are listed below: -

1. Universal
2. Constant Velocity
3. Flexible

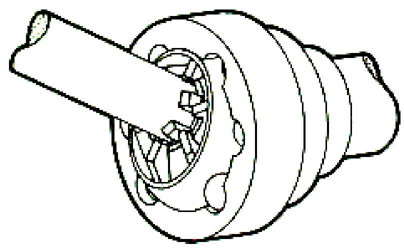
1. **Universal Joint**

Consist of two end yokes and a center bearing block. Provides for angular misalignment of up to 45 degrees.



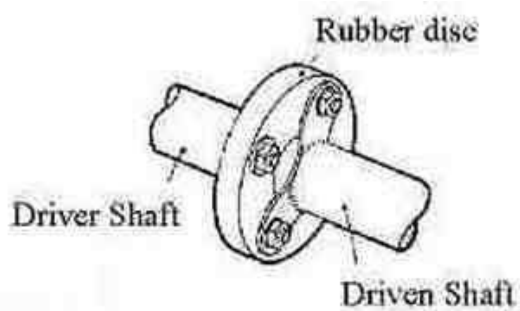
2. **Constant Velocity Joint**

Used where angles are greater than 20degreeand there is no room to use two universal joints.Driven shaft maintains a constant speed regardless of driver shaft angle.Used on driveshafts on front wheel drive cars.



3. **Flexible Coupling**

Both shafts are bolted to a rubber disc. The flexibility of the disc compensates for the change in angle. Can handle approximately 3 degree of angular misalignment.



Oldham Coupling:

It is used to connect two parallel shafts whose axes are at a small distance apart. Two flanges, each having a rectangular slot, are keyed, one on each shaft. The two flanges are positioned such that, the slot in one is at right angle to the slot in the other. To make the coupling, a circular disc with two rectangular projections on either side and at right angle to each other, is placed between the two flanges. During motion, the central disc, while turning, slides in the slots of the flanges. Power transmission takes place between the shafts, because of the positive connection between the flanges and the central disc.

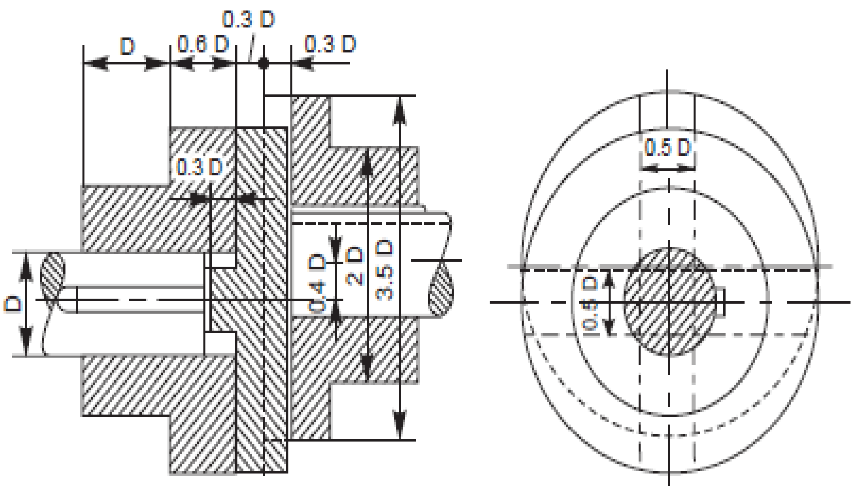
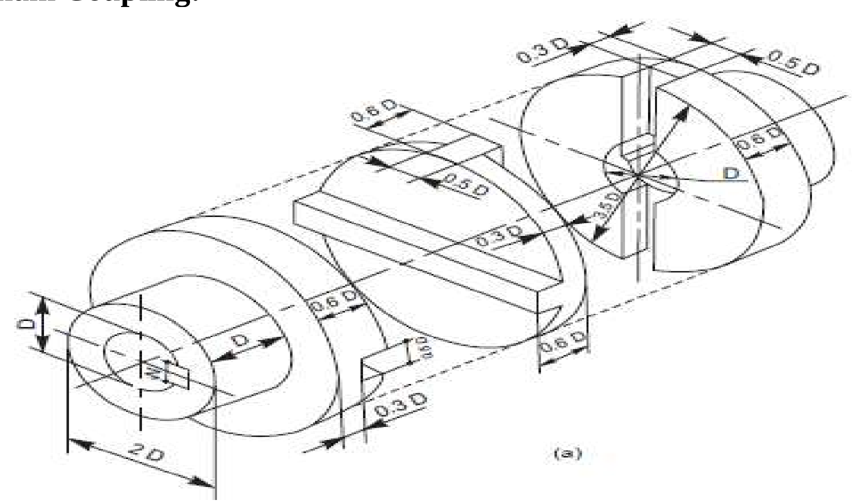


Fig: Side View of Oldham Coupling

Dimension of Oldham Coupling:



Procedure:

1. Select the new file and then select the part option.

2. Make flange, center block, shaft and key using various command like circle, line, arc, and extrude cut and various other commands and give the right dimension using smart dimension command
3. Save all parts then open the assembly and using Mate command complete assembly.
4. After making the assembly, open drawing sheet to make different views we can browse the file to the drawing option by opening a new window.
5. Open the page and then select the sheet format. We can also edit our sheet format by going in edit sheet format.

Precautions:

1. Choose A4 size sheet and set a sheet format.
2. Use right command to make a drawing
3. Measurement should be precise.
4. Make all orthographic view in sheet.

Relevant books:

1. *Bhatt N.D; Engineering Drawing,50th Edition, Charotar Publication,2011. (Online available at the link:* https://www.pdfdrive.com/engineering-drawing-by-nd-bhatt-e43754521.html*)*

2. *Jolhe D.A; Engineering Drawing: With an Introduction to AutoCAD,2nd Edition, Tata McGraw Hill(Buy at link:* https://www.abebooks.com/9780070648371/Engineering-Drawing-Introduction-JOLHE-0070648379/plp*)*

Other Resource Material:

1. https://axibook.com/engineering-drawing/standard-convention-abbreviations-used-in-engineering-drawing/2019/

2. https://www.theengineerspost.com/types-of-lines/

1. https://blog.gstarcad.net/what-are-absolute-coordinates-and-relative-coordinates-in-cad-how-to-enter-coordinates-using-different-methods/

	CHANDIGARH UNIVERSITY
	DEPARTMENT OF MECHANICAL ENGINEERING

Cad Modeling lab	Subject Code: MEP-255

Experiment No. 9

Topic: Draw the orthographic views of a knuckle joint using software.

Note: All the dimensions in the drawing should be***(Actual dimension + 0. (last two digits of UID No. of the students)***

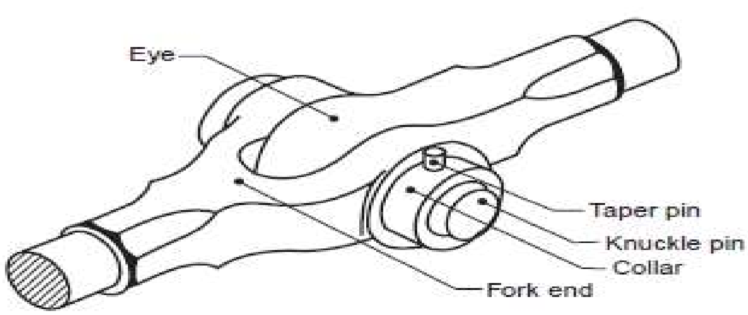
Aim: Draw the orthographic views of a knuckle joint using software.

Theory

Knuckle Joint:

It is used to connect two round rods; whose axes meet at a point.This joint allows a small angular movement of the rod relative to each other and is capable of transmitting rotary and transverse motions.

A knuckle joint is a pin joint used to fasten two circular rods. In this joint, one end of the rod is formed into an eye and the other into a fork (double eye). For making the joint, the eye end of the rod is aligned into the fork end of the other and then the pin is inserted through the holes and held in position by means of a collar and a taper pin. Once the joint is made, the rods are free to swivel about the cylindrical pin. Knuckle joints are used in suspension links, air brake arrangement of locomotives, etc.

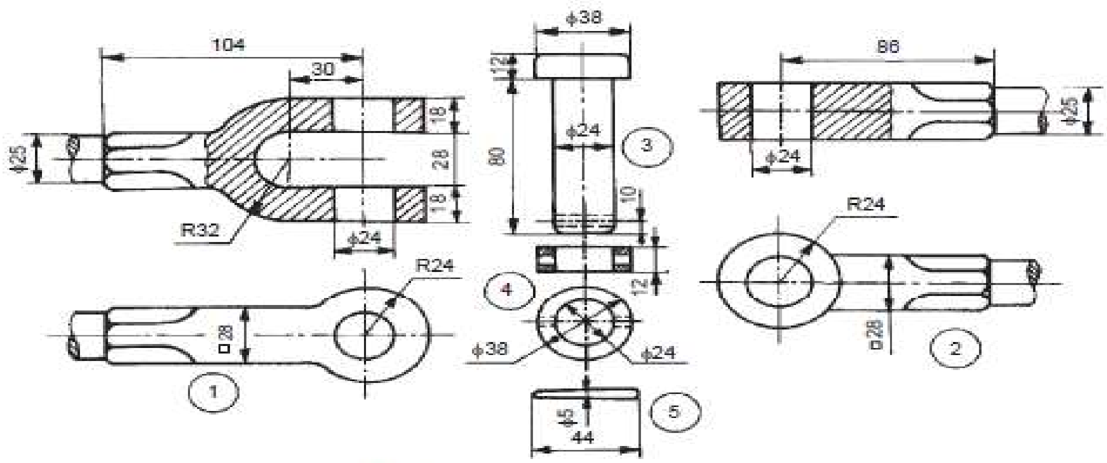


One of the rod ends is forged into shape of fork (or double eye) and other rod end is forged to the shape of the eye.The eye end is inserted between jaws of fork end, then knuckle pin is passed through them.

Knuckle Joint:

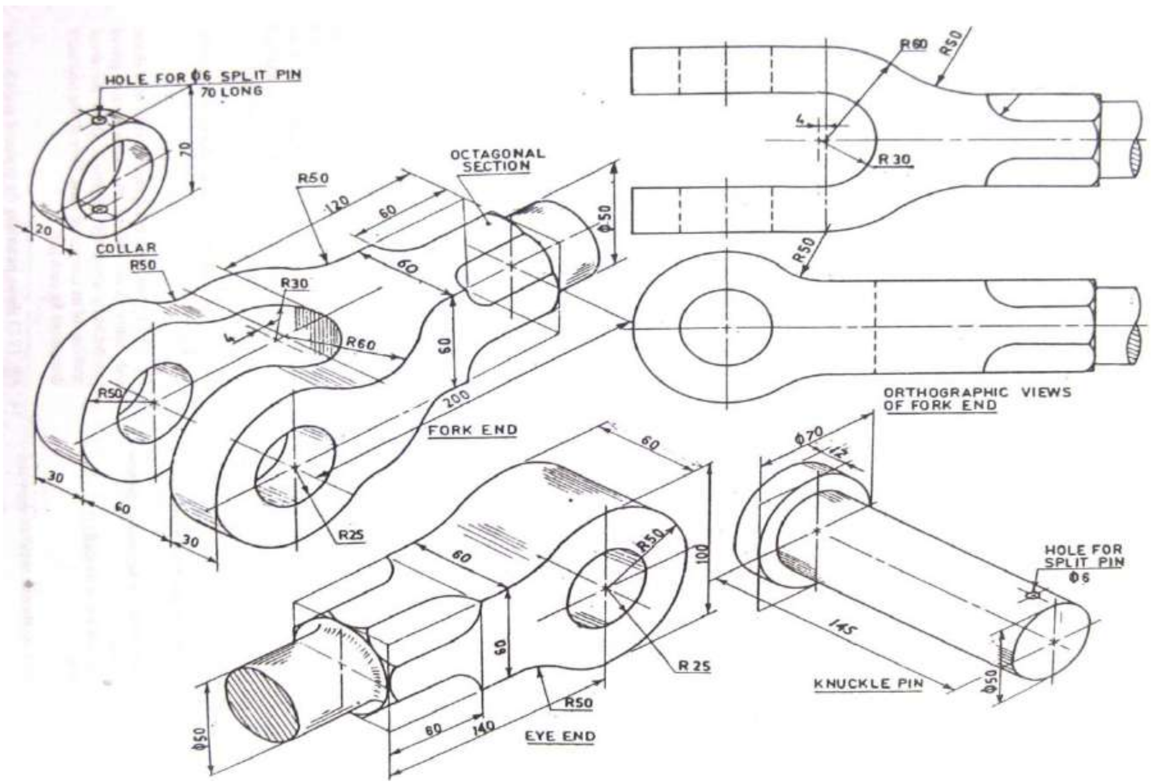
This is a pin joint and is used to connect two circular rods subjected to axial loads. Compared to a socket and spigot joint, wherein the axes of both the rods should be in the same plane; in the knuckle joint, one of the rods can be swivelled through some angle about the connecting pin, *i.e.*, the axes of the two rods could be inclined to each other.

Figure shows the details of a knuckle joint. The eye end of the rod 2 is inserted into the fork end 1 of the other rod. Then, pin 3 is inserted through the holes in the ends of the rods and held in position by the collar 4 and taper pin 5. Figure shows the assembly drawing.



Parts list

Sl. No.	Name	Matl.	Qty.
1	Fork end	Forged steel	1
2	Eye end	Forged steel	1
3	Pin	Mild steel	1
4	Collar	Mild steel	1
5	Taper pin	Mild steel	1



Procedure:

- Select the new file and then select the part option.
- Open the page and then select the sheet format.
- Select your custom sheet format if already present or create a custom sheet format.
- Select the scale from the bottom at the extreme right side of the software to MMGS.
- Click on sketch and start the drawing.
- 3D commands are available in the features tab like extrude boss/base, extrude cut etc.
- The required part is made using these commands.
- To adjust the dimensions, go to the smart dimensions option.
- Various machining symbols surface finishing, welding symbols; geometric tolerance etc. can be given in the Annotations tab.

- Written notes can be inserted in the "Note" option in annotation tab.

Assembly:

- Select new and select assembly option.
- Insert all the components required for assembly.
- Select mate option and select the appropriate mate for appropriate face, edge, point etc. of parts.
- The parts can be moved or rotated using the move tool or rotate tool.
- Complete the assembly and show different orthographic views of the assembly in a new drawing document.

Precautions:

5. Choose A4 size sheet and set a sheet format.
6. Use right command to make a drawing
7. Measurement should be precise.
8. Make all orthographic view in sheet.

Relevant books:

1. *Bhatt N.D; Engineering Drawing,50th Edition, Charotar Publication,2011. (Online available at the link:* https://www.pdfdrive.com/engineering-drawing-by-nd-bhatt-e43754521.html*)*

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2. https://www.theengineerspost.com/types-of-lines/

3. https://blog.gstarcad.net/what-are-absolute-coordinates-and-relative-coordinates-in-cad-how-to-enter-coordinates-using-different-methods/

Experiment no. 10

Topic: Draw the following assembly views of screw jack by using CAD-tool Creo Software:

i) Front view-right half in section.

ii) Top view.

Note: All the dimensions in the drawing should be***(Actual dimension + 0. (last two digits of UID No. of the students)***

Aim: Draw the following assembly views of screw jack by using CAD-tool Solid works Software:

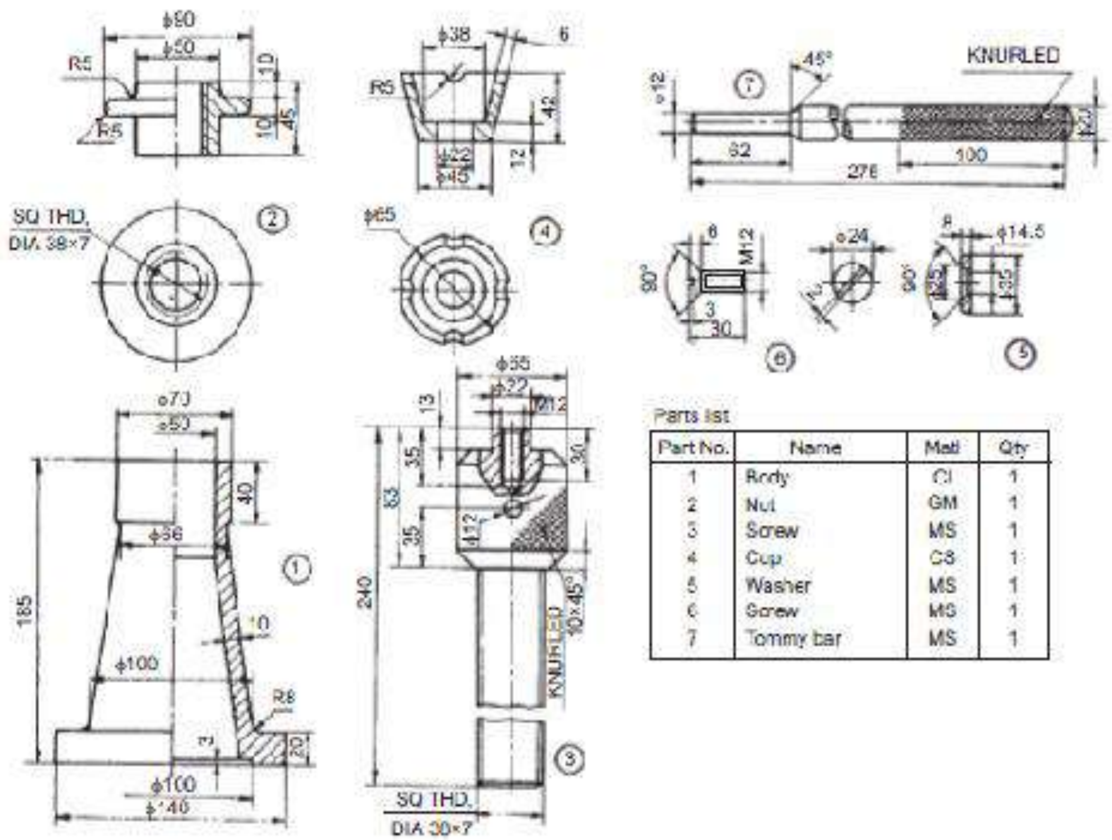
i) Front view-right half in section.

ii) Top view.

Theory

Screw Jacks

Screw jacks are used for raising heavy loads through very small heights. Figure 1 shows the details of one type of screw jack. In this, the screw 3 works in the nut 2 which is press fitted into the main body 1. The tommy bar 7 is inserted into a hole through the enlarged head of the screw and when this is turned, the screw will move up or down, thereby raising or lowering the load.



Part No.	Name	Matl	Qty
1	Body	CI	1
2	Nut	GM	1
3	Screw	MS	1
4	Cup	CS	1
5	Washer	MS	1
6	Screw	MS	1
7	Tommy bar	MS	1

Fig.1

Detail Parts of Screw Jack

Figure 2 & Figure 3 shows detailed parts of Screw jack.

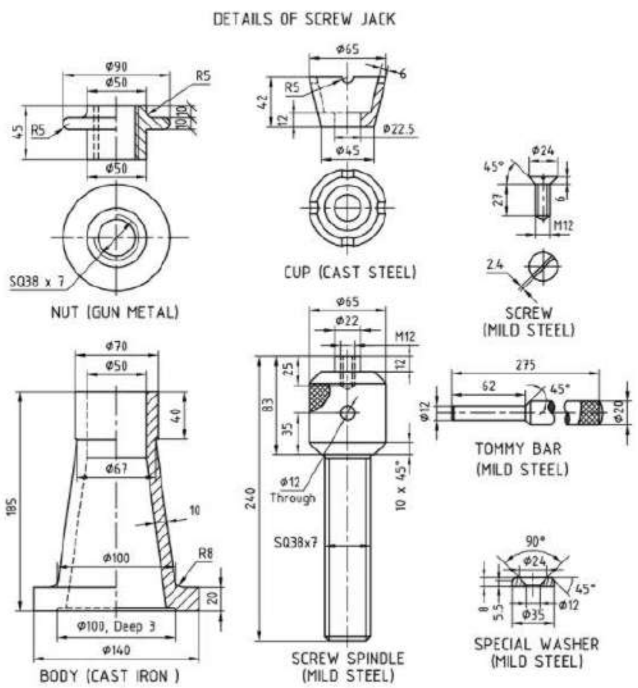


Fig.2

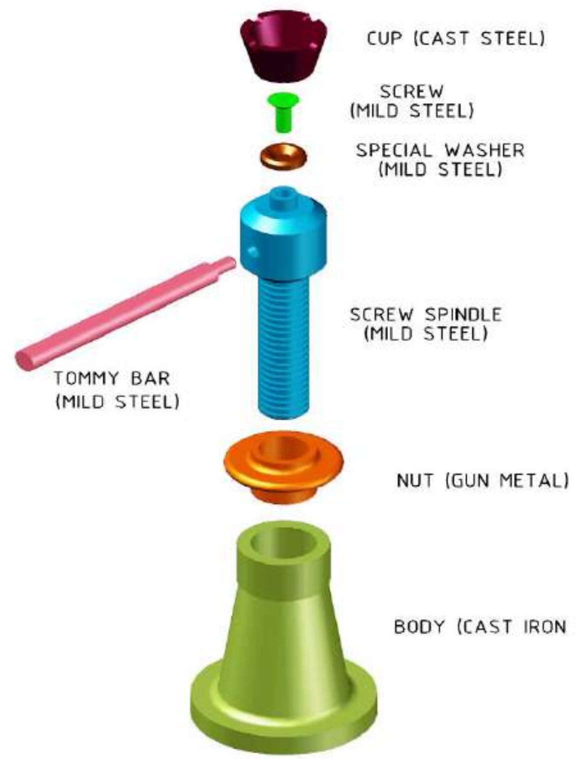


Fig.3

Final Assembly of Screw Jack

Figure 4 shows final assembly of Screw jack.

Fig.4

Procedure:

- Select the new file and then select the part option.
- Open the page and then select the sheet format.
- Select your custom sheet format if already present or create a custom sheet format.
- Select the scale from the bottom at the extreme right side of the software to MMGS.
- Click on sketch and start the drawing.
- 3D commands are available in the features tab like extrude boss/base, extrude cut etc.
- The required part is made using these commands.
- To adjust the dimensions, go to the smart dimensions option.
- Various machining symbols surface finishing, welding symbols; geometric tolerance etc. can be given in the Annotations tab.
- Written notes can be inserted in the “Note” option in annotation tab.

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- Insert all the components required for assembly.
- Select mate option and select the appropriate mate for appropriate face, edge, point etc. of parts.

- The parts can be moved or rotated using the move tool or rotate tool.
- Complete the assembly and show different orthographic views of the assembly in a new drawing document.

Precautions:

9. Choose A4 size sheet and set a sheet format.
10. Use right command to make a drawing
11. Measurement should be precise.
12. Make all orthographic view in sheet.

Relevant books:

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Design of Machine Elements Lab

Course Code: MEP - 353

Vision and Mission of the Chandigarh University

Vision

"To be globally recognized as a Centre of Excellence for Research, Innovation, Entrepreneurship and disseminating knowledge by providing inspirational learning to produce professional leaders for serving the society"

Mission

M1: Providing world class infrastructure, renowned academicians and ideal environment for Research, Innovation, Consultancy and Entrepreneurship relevant to the society.

M2: Offering programs & courses in consonance with National policies for nation building and meeting global challenges.

M3: Designing Curriculum to match International standards, needs of Industry, civil society and for inculcation of traits of Creative Thinking and Critical Analysis as well as Human and Ethical values.

M4: Ensuring students delight by meeting their aspirations through blended learning, corporate mentoring, professional grooming, flexible curriculum and healthy atmosphere based on co-curricular and extra-curricular activities.

M5: Creating a scientific, transparent and objective examination/evaluation system to ensure an ideal certification.

M6: Establishing strategic relationships with leading National and International corporates and universities for academic as well as research collaborations.

M7: Contributing for creation of healthy, vibrant and sustainable society by involving in Institutional Social Responsibility (ISR) activities like rural development, welfare of senior citizens, women empowerment, community service, health and hygiene awareness and environmental protection

Vision and Mission of the Department of Mechanical Engineering

Vision

To be recognized as a center of excellence for research and innovation in Mechanical Engineering through contemporary as well as futuristic tools and technologies for serving the society at regional, national and global level

Mission

MD1: Providing quality education to the students in core and allied fields by implementing advanced pedagogies

MD2: Encouraging students towards research and development through advanced tools and technologies for providing solution to societal problems

MD3: Evolve and empower the students through core technical skills for becoming entrepreneurs and innovators

MD4: Inculcating employability and leadership skill for ensuring industry ready professional through hands on experiential learning and industrial collaboration

MD5: Developing professional and ethical standards in the mind of the young engineers by continuous learning and professional activities

1.2. State the Program Educational Objectives (PEOs)(5)

PROGRAM EDUCATION OBJECTIVES (PEOs):

PEO1: Graduates will have professional knowledge in the field of Mechanical Engineering and various other interdisciplinary domains.

PEO2: Graduates will have successful career in government services, research organizations, corporate sector, academic institutes and industries at national and international repute.

PEO3: Graduate will have compatibility of modern engineering tools and technologies for deliberating solution of various engineering problems.

PEO4: Graduate will develop skill to address the concern of society, environment and communicate effectively to lead the interdisciplinary diverse team.

PEO5: Graduates will be effectively fit for higher education, innovations, research &development, entrepreneurship and professional development.

PROGRAM OUTCOMES (POs):
Program: Bachelor of Engineering (Mechanical Engineering)
Duration: 4 years

PO1. Engineering Knowledge: Apply knowledge of mathematics, science and engineering fundamentals and Production and Industrial Engineering specialization to the solution of complex Production and Industrial Engineering problems.

PO2. Problem Analysis: Identify, formulate, research literature and analyze complex Production and Industrial Engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex Engineering problems and design system components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.

PO4. Conduct investigations of complex Engineering problems: Use research-based knowledge and research methods including analysis, interpretation of data and synthesis of information to provide valid conclusions.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. The Engineer and Society: Apply contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams and in multi disciplinary settings.

PO10. Communication: Communicate effectively on complex Engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.

PO11. Project Management and Finance: Demonstrate knowledge and understanding of Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life Long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs):

PSO1: Apply the knowledge of Production, Manufacturing and Industrial Engineering for analysis, optimization and development of mechanical system

PSO2: Apply the concepts of Design and Thermal Engineering to model, analyze and develop the mechanical components and systems

Course Objectives

To understand the students with fundamentals of Design and Simulation using CAD and MATLB.

Course Outcomes

After completion of course the student will be able to:

CO1	Understand and apply the basic of design and simulation of machine components
CO2	Design and Simulate the various machine components such as bearing, clutch, gear box and flywheel
CO3	Conduct the experiment individual/team ethically, considering social, health, safety, legal and environmental aspects.
CO4	Analyzed the heat transfer and fluid mechanics problems through simulations
CO5	Conclude the experimental results and express the same effectively in oral and written manners through report and practical presentation.

LIST OF EXPERIMENTS

Unit-I

1. Design and Simulation of Journal Bearing
2. Design and Simulation of Disc Clutch
3. Design and Simulation of Gear Box assembly

Unit-II

4. Design and Simulation of Flywheel
5. Development of the velocity profile for laminar flow started from rest by an applied pressure gradient in a pipe.
6. Modeling the heat transfer equation as a function of thickness and thermal condition.

Unit-III

7. Design a program to compute the velocity profile of viscous fluid across the radius of pipe.
8. Develop a program to examine transient heat conduction time and temperature distributions in a semi-infinite solid.

EXPERIMENT NO.: 1

Aim: - Design and Simulation of Journal Bearing

Objective:-To understand the basics and application of Journal bearing and its design.

Theory: -

Journal or plain bearings consist of a shaft or journal which rotates freely in a supporting metal sleeve or shell. There are no rolling elements in these bearings. Their design and construction may be relatively simple, but the theory and operation of these bearings can be complex.

This article concentrates on oil and grease-lubricated full fluid film journal bearings; but first a brief discussion of pins and bushings, dry and semi-lubricated journal bearings, and tilting-pad bearings.

Low-speed pins and bushings are a form of journal bearing in which the shaft or shell generally does not make a full rotation. The partial rotation at low speed, before typically reversing direction, does not allow for the formation of a full fluid film and thus metal-to-metal contact does occur within the bearing. Pins and bushings continually operate in the boundary lubrication regime.

These types of bearings are typically lubricated with anextreme pressure (EP) grease to aid in supporting the load. Solid molybdenum disulfide (moly) is included in the grease to enhance the load-carrying capability of the lubricant.

Many outdoor construction and mining equipment applications incorporate pins and bushings. Consequently, shock loading and water and dirt contamination are often major factors in their lubrication.

Procedure:-
Draw the Split Journal Bearing in Solid works using Dimesions given in Figure:

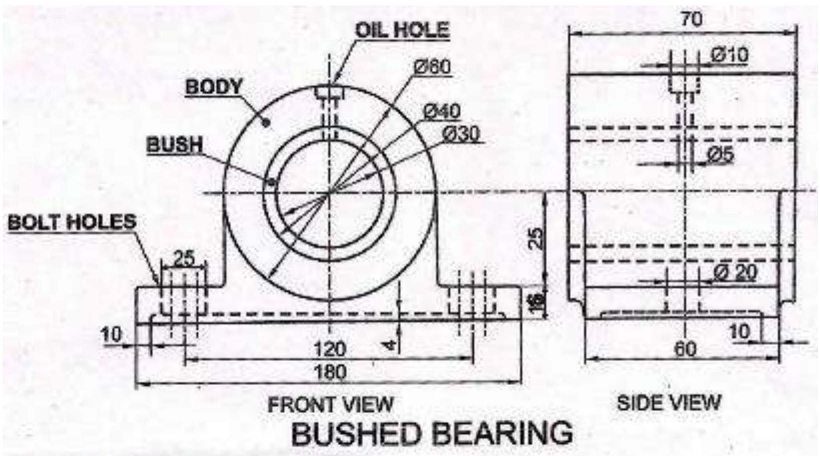


Figure 1.1 Bushed Journal Bearing

Results:

Understanding from the drawing of journal bearing on solid works

1.___________________________

2.___________________________

3.___________________________

4.___________________________

PREPARED BY CHECKED BY APPROVED BY

Experiment No. : 2

Aim: - Design and Simulation of Disc Clutch

Objective: To get knowledge Clutch and its design on solid work

Theory:
A clutch is a mechanical device that engages and disengages power transmission, especially from a drive shaft (driving shaft) to a driven shaft. The clutch acts as a mechanical linkage between the engine and transmission; and briefly disconnects, or separates the engine from the driver train, and therefore the drive wheels, whenever the pedal is depressed, allowing the driver to smoothly change gears.

In the simplest application, clutches connect and disconnect two rotating shafts (drive shafts or line shafts). In these devices, one shaft is typically attached to an engine and other to power unit (the driving member). While the other shaft (the driven member) provides output power for work and typically the motions involved are rotary, linear clutches are also possible.

In a torque-controlled drill, for instance, one shaft is driven by a motor, and the other drives a drill chuck. The clutch connects the two shafts so they may be locked together and spin at the same speed (engaged), locked together but spinning at different speeds (slipping), or unlocked and spinning at different speeds (disengaged).

Procedure:-
Draw the Disc clutch in solid works using dimesions given in figure:

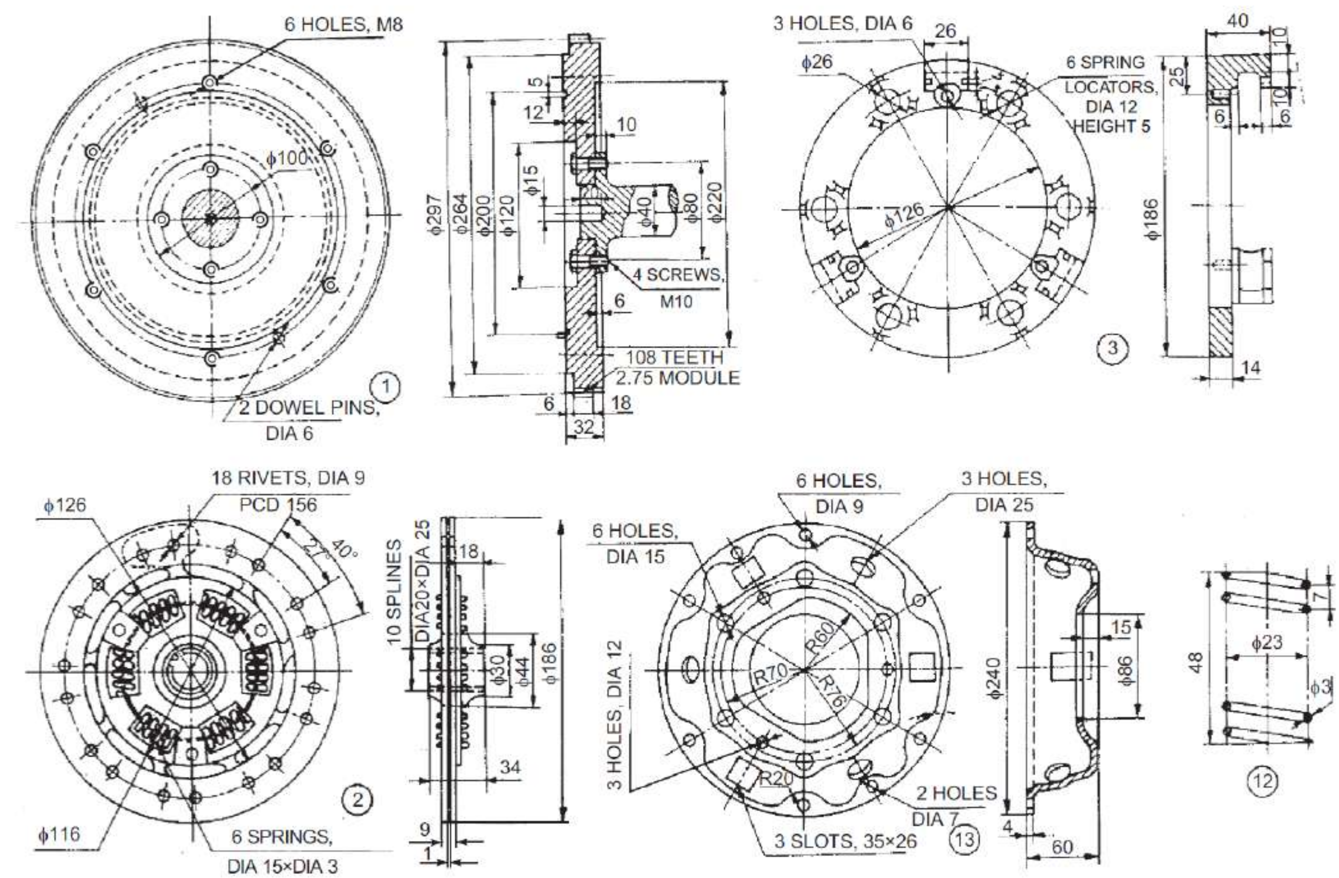


Figure 2.1 Single plate disc clutch

Results:

Understanding from the drawing of disc clutch on solid works

1.__________________________

2.__________________________

3.__________________________

4.__________________________

PREPARED BY　　　　CHECKED BY　　　　APPROVED BY

Experiment No. : 3

Aim: - Design and Simulation of Gear Box assembly

Objectives: -
Make the students familiar with the use of gear box and its types with knowledge to design a gear box on solid works.

Introduction:
Gear Box Working Principle:
A Gear Box is an assembly consisting of various gears, synchronizing sleeves, and a gear-shifting mechanism fitted inside a metal housing. The metal housing, usually made of aluminum/iron casting, accommodates all the gears in it. The gearbox is a part of the 'transmission' system as the gears play an important role in transmitting the engine power to the wheels.

How does a Gear Box work?
A gear box contains gears of different sizes. This is mainly because of the vehicle's varying demands in terms of the torque required at the wheels depending upon the road, terrain & load. E.g., if a vehicle is climbing a slope, it needs higher torque than cruising on a straight road.

The first gear is the biggest in size in a gear box and provides maximum torque output while producing minimum speed. Hence, it is used when climbing slopes. All the gears between 1st and last gear vary in size, in a decreasing ratio. Thus, it provides a varying combination in terms of pulling ability and speed. So, the vehicle could be driven smoothly without any drop in its acceleration. The gear box basically improves the vehicle's driveability in all conditions.

According to the shifting mechanism, the manufacturers further classify the automotive gear into three more categories:

1. Sliding mesh – typically used in two-wheeler/bikes
2. Constant-mesh - typically used in old generation trucks
3. Synchromesh - used in the newer generation cars & trucks

According to the shifting mechanism's location:

1. Column Shift – Gear lever mounted on the steering column, operated by hand.
2. Floor Shift - Gear lever mounted on the floor, operated by hand
3. Paddle Shifters - Gear-shifters fitted on the steering wheel, operated by fingers.

Procedure:-

Draw the constant mesh gearbox in solid works using given figure:

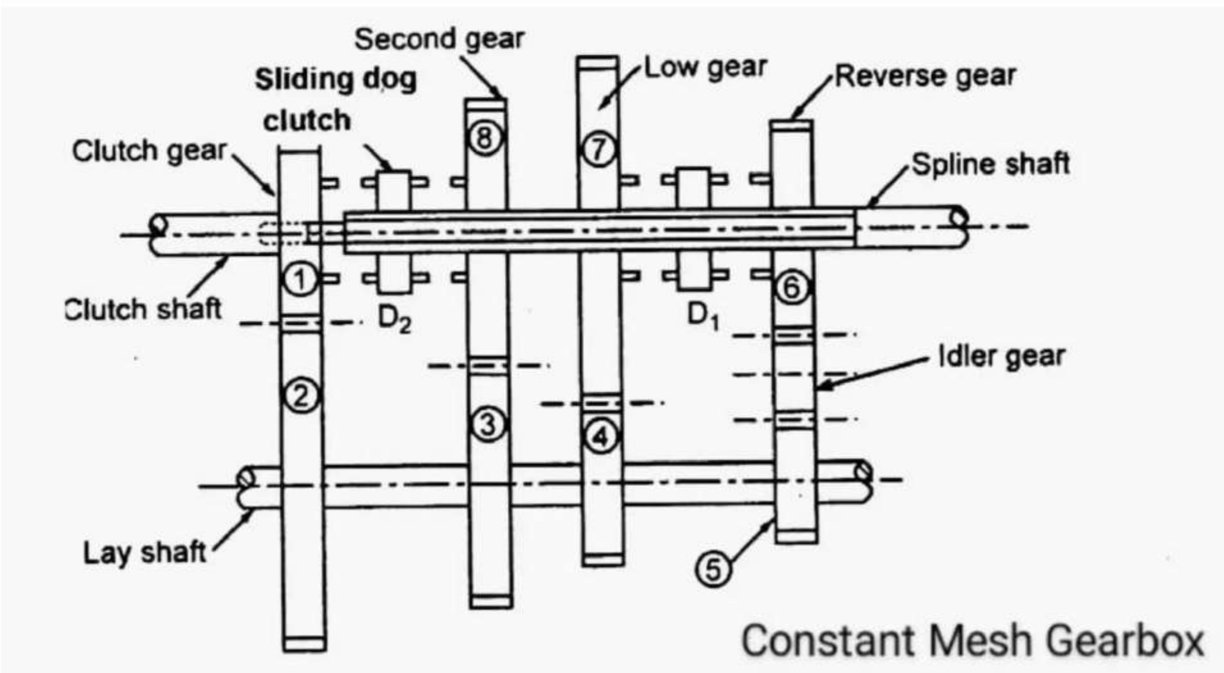


Figure 3.1 Constant Meash Gearbox

Results:

Understanding from the drawing of gear box on solid works

1.___________________________

2.___________________________

3.___________________________

4.___________________________

PREPARED BY CHECKED BY APPROVED BY

Experiment No. : 4

Aim: - Design and Simulation of Flywheel

Objectives: Make students familiar with used of flywheel and its design

Theory:

What is a flywheel?

A flywheel is essentially a very heavy wheel that takes a lot of force to spin around. It might be a large-diameter wheel with spokes and a very heavy metal rim, or it could be a smaller-diameter cylinder made of something like a carbon-fiber composite. Either way, it's the kind of wheel you have to push really hard to set it spinning. Just as a flywheel needs lots of force to start it off, so it needs a lot of force to make it stop. As a result, when it's spinning at high speed, it tends to want to keep on spinning (we say it has a lot of angular momentum), which means it can store a great deal of kinetic energy.

What's the best design for a flywheel?

It follows on from these basic laws of physics that a flywheel will store more energy if it has either a higher moment of inertia (more mass or mass positioned further from its center) or if it spins at a higher speed. And since the kinetic energy of a spinning object (E in the equation above) is related to the square of its angular velocity (ω2), you can see that speed has a much bigger effect than moment of inertia. If you take a flywheel with a heavy metal rim and replace it with a rim that's twice as heavy (double its moment of inertia), it will store twice as much energy when it spins at the same speed. But if you take the original flywheel and spin it twice as fast (double its angular velocity), you'll quadruple how much energy it stores. That's why flywheel designers typically try to use high-speed wheels rather than massive ones. (Compact, high-speed flywheels are also much more practical in things like race cars, not least because large flywheels tend to add too much weight.)

How can a flywheel retain its energy?

The laws of physics (Newton's first law of motion, to be exact) tell us that a moving object will tend to keep moving unless a force acts on it. So you might think a flywheel would keep spinning forever. The only trouble is, flywheels spin on bearings so, even when they're well lubricated, the force of friction slows them down. There's another problem too: as flywheels spin through the air, air resistance or drag slows them down as well. Modern flywheels get around these problems by being mounted on low-friction bearings and sealed inside metal cylinders so they don't lose as much energy to friction and air resistance as traditional flywheels would have done.

Procedure:-

Draw the flywheel in solid works using given figure:

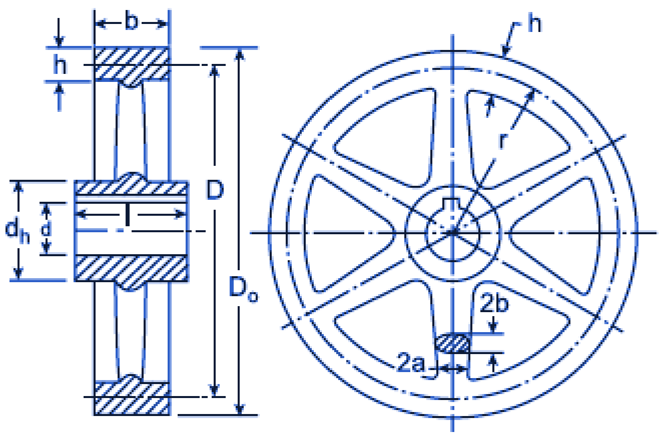


Figure 4.1 Flywheel

Results:

Understanding from the drawing of flywheel on solid works

1.__________________________

2.__________________________

3.__________________________

4.__________________________

PREPARED BY CHECKED BY APPROVED BY

Experiment No.: 5

Aim: Development of the velocity profile for laminar flow started from rest by an applied pressure gradient in a pipe.

Objective:-To plot velocity profile for laminar flow in a pipe under applied pressure gradient

Theory

Laminar Flow

In fluid dynamics, laminar flow is characterized by fluid particles following smooth paths in layers, with each layer moving smoothly past the adjacent layers with little or no mixing. At low velocities, the fluid tends to flow without lateral mixing, and adjacent layers slide past one another like playing cards. There are no cross-currents perpendicular to the direction of flow, nor eddies or swirls of fluids. In laminar flow, the motion of the particles of the fluid is very orderly with particles close to a solid surface moving in straight lines parallel to that surface. Laminar flow is a flow regime characterized by high momentum diffusion and low momentum convection.

Velocity Profile

The formula for the laminar velocity profile has to be mentioned first. The derivation of it is possible to find in every book dedicated to the fluid mechanics. The laminar velocity profile of the fluid flow governed by the pressure gradient is parabolic.

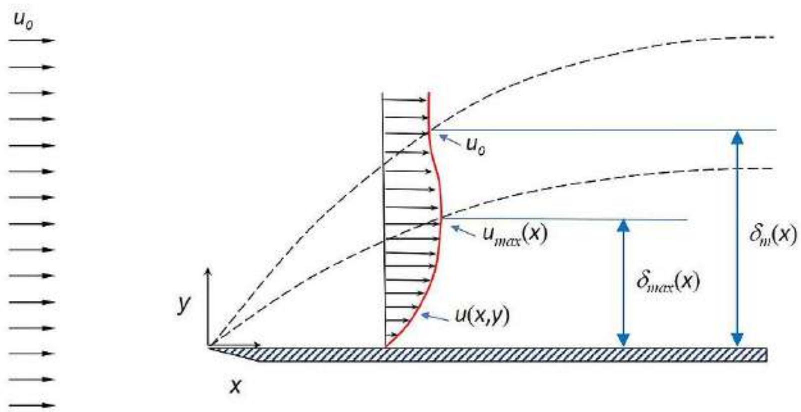


Figure 5.1 Laminar Fluid Flow over flat plate

The Bounded Boundary Layer Description

Bounded boundary layers is a name used to designate fluid flow along an interior wall such that the other interior walls induce a pressure effect on the fluid flow along the wall under consideration. The defining characteristic of this type of boundary layer is that the velocity profile normal to the wall smoothly asymptotes, without peaking, to a constant velocity value denoted as $u_e(x)$. The bounded boundary layer concept is depicted for steady flow entering the lower half of a thin flat plate 2-D channel of height H in Figure 5.1 (the flow and the plate extends in the positive/negative direction perpendicular to the x-y-plane). Examples of this type of boundary layer flow occur for fluid flow through most pipes, channels, and wind tunnels. The 2-D channel depicted in Figure 1 is stationary with fluid flowing along the interior wall with time-averaged velocity $u(x,y)$ where x is the flow direction and y is the normal to the wall. The $H/2$ dashed line is added to acknowledge that this is an interior pipe or channel flow situation and that there is a top wall located above the pictured lower wall. Figure 5.1 depicts flow behavior for H values that are larger than the maximum boundary layer thickness but less than thickness at which the flow starts to behave as an exterior flow. If the wall-to-wall distance, H, is less than the viscous boundary layer thickness then the velocity profile, defined as $u(x,y)$ at x for all y, takes on a parabolic profile in the y-direction and the boundary layer thickness is just $H/2$.

At the solid walls of the plate the fluid has zero velocity (no-slip boundary condition), but as you move away from the wall, the velocity of the flow increases without peaking, and then approaches a constant mean velocity $u_e(x)$. This asymptotic velocity may or may not change along the wall depending on the wall geometry. The point where the velocity profile essentially reaches the asymptotic velocity is the boundary layer thickness. The boundary layer thickness is depicted as the curved dashed line originating at the channel entrance in Figure 5.1. It is impossible to define an exact location at which the velocity profile reaches the asymptotic velocity. As a result, a number of boundary layer thickness parameters, generally denoted as delta (x), are used to describe characteristic thickness scales in the boundary layer region. Also of interest is the velocity profile shape which is useful in differentiating laminar from turbulent boundary layer flows. The profile shape refers to the y-behavior of the velocity profile as it transitions to $u_e(x)$.

Laminar flow in a Pipe

Laminar flow is the normal condition for blood flow throughout most of the circulatory system. It is characterized by concentric layers of blood moving in parallel down the length of a blood vessel. The highest velocity (Vmax) is found in the center of the vessel. The lowest velocity (V=0) is found along the vessel wall. The flow profile is parabolic once laminar flow is fully developed. This occurs in long, straight blood vessels, under steady flow conditions.

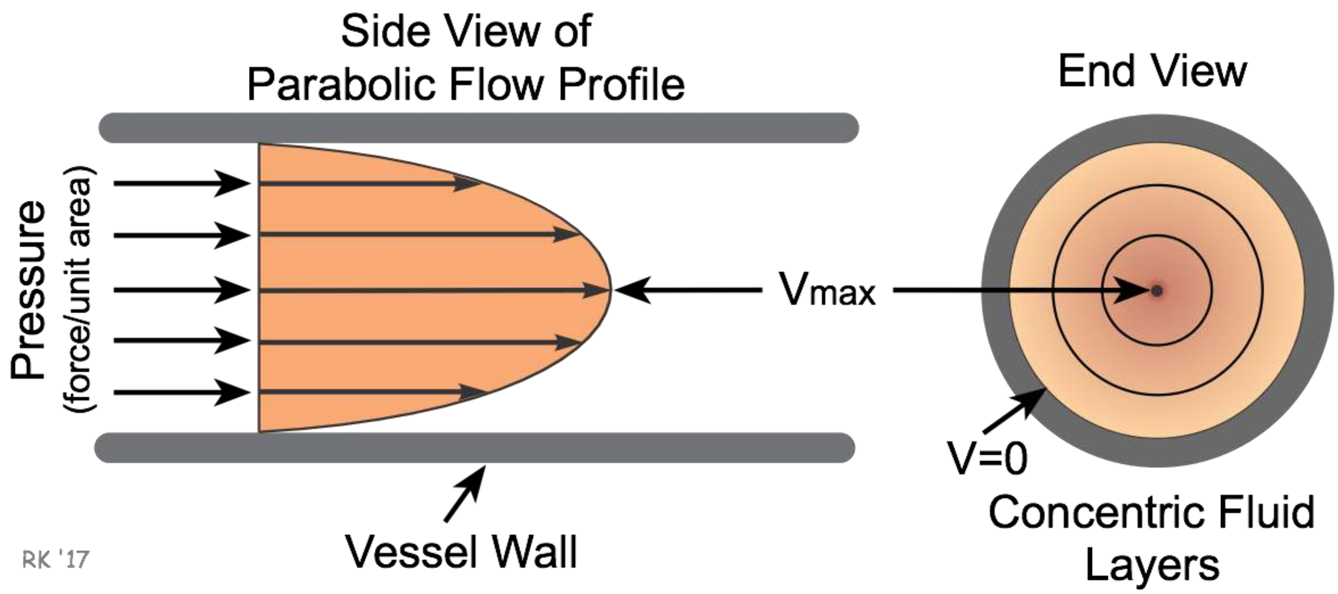


Figure 5.2: Velocity Profile

Procedure

1. Take arbitrary parameters of fluid flow in a pipe
2. Make a program in Matlab to calculate velocity value with taking different pressure input
3. Use the program to plot velocity profile for different pressure inputs

Results:

Understanding from the use of Matlab for analysis of Laminar flow in pipe

1.___________________________

2.___________________________

3.___________________________

4.___________________________

Experiment No.: 6

Aim : Modeling the heat transfer equation as a function of thickness and thermal condition.

Objective:- Explore the knowledge of heat transfer equation in finding the temperature distribution in slab

Theory:
Heat transfer processes are classified into three types.

1. Conduction
2. Convection
3. Radiation

The first is conduction, which is defined as transfer of heat occurring through intervening matter without bulk motion of the matter. Figure 1.1 shows the process pictorially. A solid (a block of metal, say) has one surface at a high temperature and one at a lower temperature. This type of heat conduction can occur, for example, through a turbine blade in a jet engine. The outside surface, which is exposed to gases from the combustor, is at a higher temperature than the inside surface, which has cooling air next to it. The level of the wall temperature is critical for a turbine blade.

Heat Conduction
When a temperature gradient exists in a body, energy will transfer from the hightemperature region to the low-temperature region by conduction. The general equations of heat conduction is given by

$$\nabla \cdot (k\nabla T) + \dot{q}_{in} = \rho c \frac{\partial T}{\partial t}$$

where T is temperature; $\dot{q}_{in}$ is energy generated per unit volume; k, ρ, and c are thermal conductivity, density and specific heat, respectively. In fire engineering, one-dimensional (1D) heat transfer is usually considered. The equation of 1D conduction is given by (ignore energy generation, thus $\dot{q}_{in} = 0$)

$$\frac{\partial^2 T}{\partial x^2} = \frac{1}{\alpha}\frac{\partial T}{\partial t}$$

where α = k/ρc is thermal diffusivity. Fourier's law states that the quantity of heat transferred per unit time per unit area is proportional to the temperature gradient, thus

$$\dot{q} = -k\frac{\partial T}{\partial x}$$

In unsteady or transient conduction, Boit number is used to determine whether a body can be treated as thermally thin or thermally thick, which is defined by

$$Bi = \frac{\delta/k}{1/h} = \frac{h\delta}{k}$$

where, δ = V/A is the characteristic length of the body, in which V and A are the body's solid volume and its surface area. In engineering calculation, if Bi < 0.1 the body is treated as thermally thin and if Bi > 0.1 the body is treated as thermally thick. For thermally thin body, the temperature gradient within the body can be ignored and lump-capacity method can be applied to temperature calculation; and for thermally thick body, the temperature gradient throughout the body cannot be ignored, as demonstrated in Figure below. In the figure, a plane wall initially at a uniform temperature Ti experiences heating when

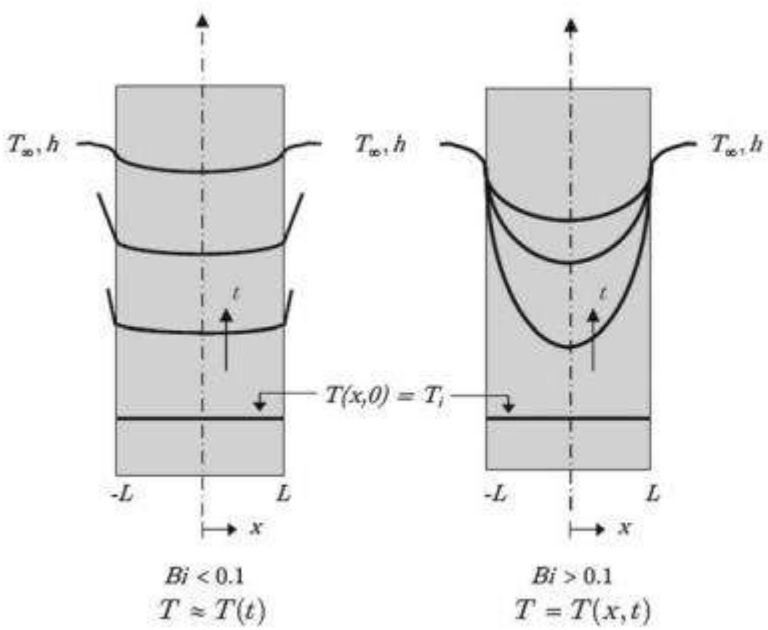


Figure 6.1 Transient temperature distributions for different Biot numbers in a plane wall symmetrically cooled by convection

Procedure

1. Take values of constant of cast iron like density, diffusivity, thermal conductivity etc and also take parameters like thickness, length, width, ambient temperature etc.
2. Make a program in Matlab to calculate the temperature variation in slab

3. Use the program to demonstrate temperature variation along the thickness of slab.

Results:

Understanding from the use of Matlab for the heat transfer equation as a function of thickness and thermal condition

1.___________________________
2.___________________________
3.___________________________
4.___________________________

Experiment No.: 7

Aim: Design a program to compute the velocity profile of viscous fluid across the radius of pipe.

Objective:-To plot velocity profile for viscous fluid over the radius of pipe at different distance from entrance of pipe

Theory:

Laminar Flow

In fluid dynamics, laminar flow is characterized by fluid particles following smooth paths in layers, with each layer moving smoothly past the adjacent layers with little or no mixing. At low velocities, the fluid tends to flow without lateral mixing, and adjacent layers slide past one another like playing cards. There are no cross-currents perpendicular to the direction of flow, nor eddies or swirls of fluids. In laminar flow, the motion of the particles of the fluid is very orderly with particles close to a solid surface moving in straight lines parallel to that surface. Laminar flow is a flow regime characterized by high momentum diffusion and low momentum convection.

Velocity Profile

The formula for the laminar velocity profile has to be mentioned first. The derivation of it is possible to find in every book dedicated to the fluid mechanics. The laminar velocity profile of the fluid flow governed by the pressure gradient is parabolic.

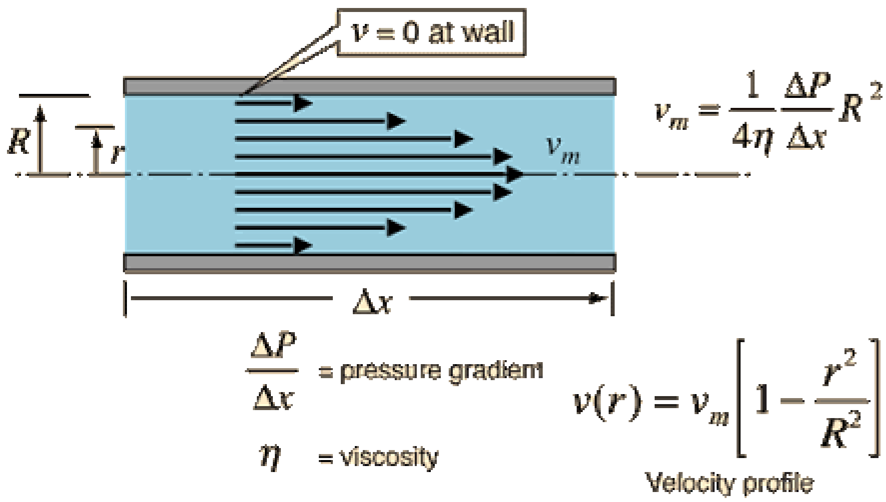


Figure 7.1 Laminar Fluid Flow in a Pipe

where R is the tube radius, v(m) is the maximal velocity or the centerline velocity of the velocity profile. It is assumed that there is only one velocity component in the tube axis direction.

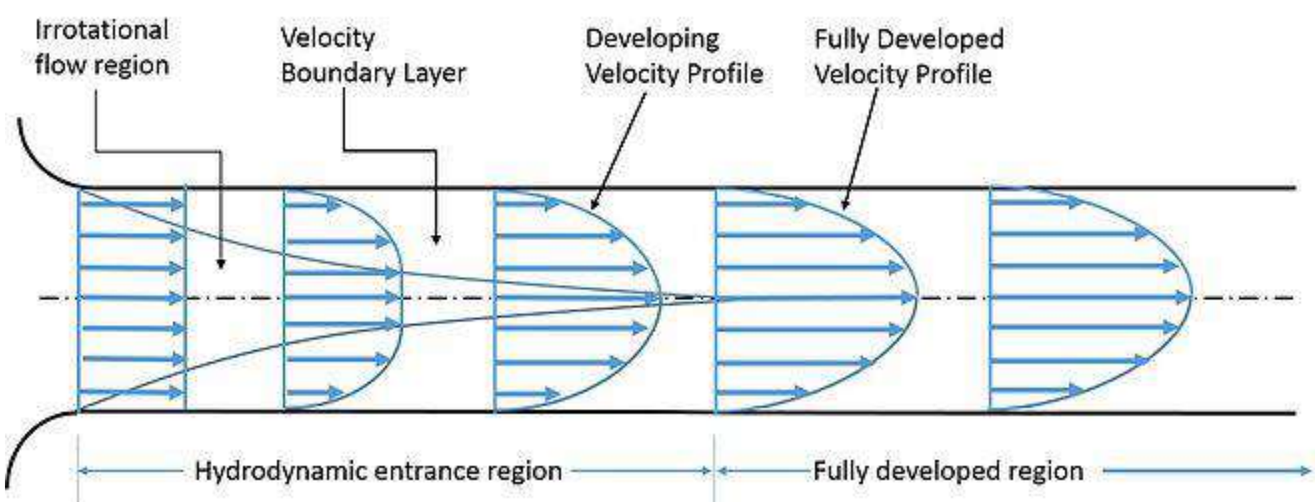


Figure 7.2 Velocity Profile of Fluid with distance from entrance in pipe

Procedure

1. Take arbitrary parameters of fluid flow in a pipe
2. Make a program in Matlab to calculate velocity value at different profile at different distance
3. Use the program to plot velocity profile

Results:

Understanding from the use of Matlab for the heat transfer equation as a function of thickness and thermal condition

1.__________________________

2.__________________________

3.__________________________

4.__________________________

Experiment No.: 8

Aim: Develop a program to examine transient heat conduction time and temperature distributions in a semi-infinite solid.

Objective:-Apply the knowledge of lumped capacity analysis and plot of temperature distribution over a body centre to its surface.

Theory:
Lumped System Analysis Interior temperatures of some bodies remain essentially uniform at all times during a heat transfer process. The temperature of such bodies are only a function of time, T = T(t). The heat transfer analysis based on this idealization is called lumped system analysis. Consider a body of arbitrary shape of mass m, volume V, surface area A, density ρ and specific heat Cp initially at a uniform temperature Ti.

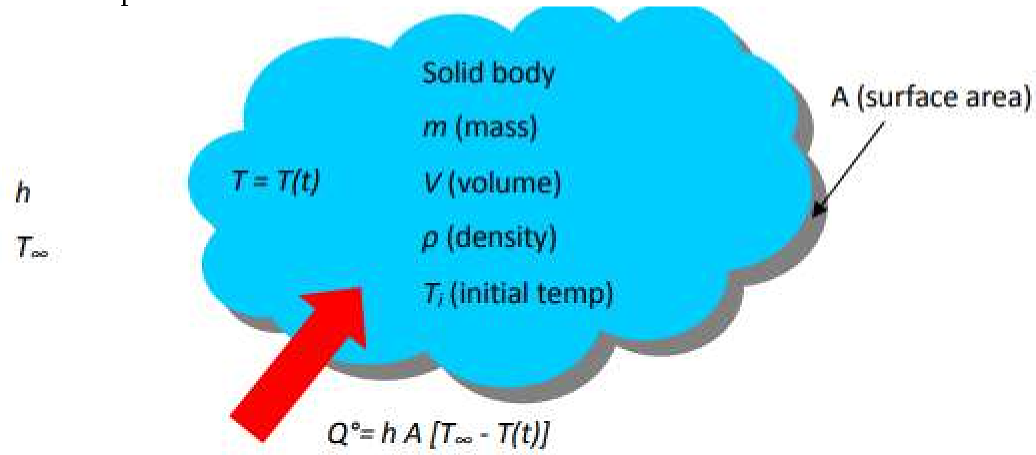


Figure 8.1 Lumped Capacity Analysis

At time t = 0, the body is placed into a medium at temperature T∞ (T∞ >Ti) with a heat transfer coefficient h. An energy balance of the solid for a time interval dt can be expressed as:

heat transfer into the body during dt = the increase in the energy of the body during dt

$$h A (T_\infty - T)\, dt = m\, C_p\, dT$$

With m = ρV and change of variable dT = d(T - T∞), we find:

$$\frac{d(T-T_\infty)}{T-T_\infty} = -\frac{hA}{\rho V C_p} dt$$

Integrating from t = 0 to T = Ti

$$\frac{T(t)-T_\infty}{T_i-T_\infty} = e^{-bt}$$

$$b = \frac{hA}{\rho V C_p} \quad (1/s)$$

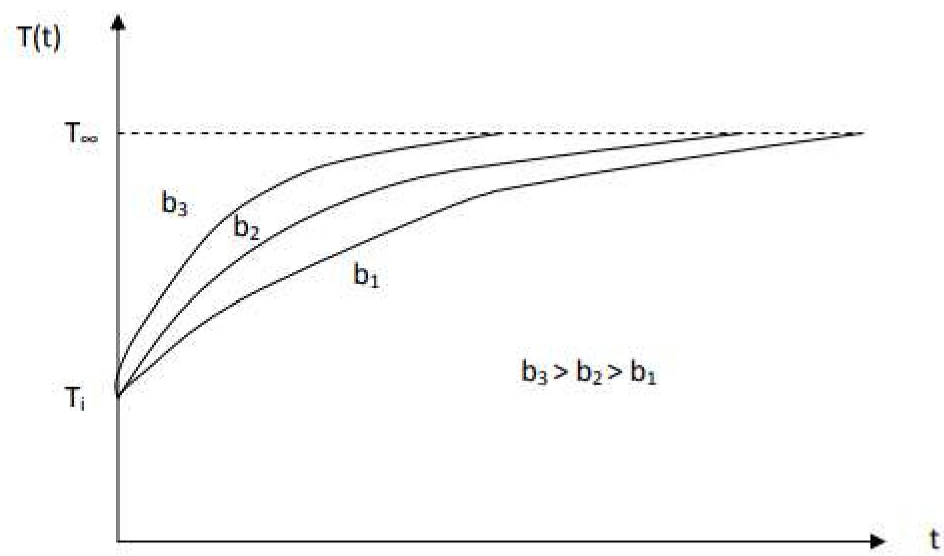


Figure 8.2 Temperature of a lump system

Using above equation, we can determine the temperature T(t) of a body at time t, or alternatively, the time t required for the temperature to reach a specified value T(t). Note that the temperature of a body approaches the ambient temperature T_∞ exponentially. A large value of b indicates that the body will approach the environment temperature in a short time. b is proportional to the surface area, but inversely proportional to the mass and the specific heat of the body. The total amount of heat transfer between a body and its surroundings over a time interval is: Q = m Cp [T(t) – Ti]

Procedure

1. Take arbitrary parameters of a thermally exposed body

2. Make a program in Matlab to calculate biot no. and its temperature distribution over surface
3. Use the program to plot temperature variation in body using different biot no. of a lump system

Results:

Understanding from the use of Matlab for the heat transfer equation as a function of thickness and thermal condition

1.__________________________

2.__________________________

3.__________________________

4.__________________________

Fluid Mechanics and Hydraulics Machine Lab

MEP-306

Vision and Mission of the Chandigarh University

Vision

“To be globally recognized as a Centre of Excellence for Research, Innovation, Entrepreneurship and disseminating knowledge by providing inspirational learning to produce professional leaders for serving the society”

Mission

M1: Providing world class infrastructure, renowned academicians and ideal environment for Research, Innovation, Consultancy and Entrepreneurship relevant to the society.

M2: Offering programs & courses in consonance with National policies for nation building and meeting global challenges.

M3: Designing Curriculum to match International standards, needs of Industry, civil society and for inculcation of traits of Creative Thinking and Critical Analysis as well as Human and Ethical values.

M4: Ensuring students delight by meeting their aspirations through blended learning, corporate mentoring, professional grooming, flexible curriculum and healthy atmosphere based on co-curricular and extra-curricular activities.

M5: Creating a scientific, transparent and objective examination/evaluation system to ensure an ideal certification.

M6: Establishing strategic relationships with leading National and International corporates and universities for academic as well as research collaborations.

M7: Contributing for creation of healthy, vibrant and sustainable society by involving in Institutional Social Responsibility (ISR) activities like rural development, welfare of senior citizens, women empowerment, community service, health and hygiene awareness and environmental protection

Vision and Mission of the Department of Mechanical Engineering

Vision

To be recognized as a center of excellence for research and innovation in Mechanical Engineering through contemporary as well as futuristic tools and technologies for serving the society at regional, national and global level

Mission

MD1: Providing quality education to the students in core and allied fields by implementing advanced pedagogies

MD2: Encouraging students towards research and development through advanced tools and technologies for providing solution to societal problems

MD3: Evolve and empower the students through core technical skills for becoming entrepreneurs and innovators

MD4: Inculcating employability and leadership skill for ensuring industry ready professional through hands on experiential learning and industrial collaboration

MD5: Developing professional and ethical standards in the mind of the young engineers by continuous learning and professional activities

1.2. State the Program Educational Objectives (PEOs)(5)

PROGRAM EDUCATION OBJECTIVES (PEOs):

PEO1: Graduates will have professional knowledge in the field of Mechanical Engineering and various other interdisciplinary domains.

PEO2: Graduates will have successful career in government services, research organizations, corporate sector, academic institutes and industries at national and international repute.

PEO3: Graduate will have compatibility of modern engineering tools and technologies for deliberating solution of various engineering problems.

PEO4: Graduate will develop skill to address the concern of society, environment and communicate effectively to lead the interdisciplinary diverse team.

PEO5: Graduates will be effectively fit for higher education, innovations, research &development, entrepreneurship and professional development.

PROGRAM OUTCOMES (POs):

Program: Bachelor of Engineering (Mechanical Engineering)

Duration: 4 years

PO1. Engineering Knowledge: Apply knowledge of mathematics, science and engineering fundamentals and Production and Industrial Engineering specialization to the solution of complex Production and Industrial Engineering problems.

PO2. Problem Analysis: Identify, formulate, research literature and analyze complex Production and Industrial Engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex Engineering problems and design system components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.

PO4. Conduct investigations of complex Engineering problems: Use research-based knowledge and research methods including analysis, interpretation of data and synthesis of information to provide valid conclusions.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. The Engineer and Society: Apply contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams and in multi disciplinary settings.

PO10. Communication: Communicate effectively on complex Engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.

PO11. Project Management and Finance: Demonstrate knowledge and understanding of Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life Long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs):

PSO1: Apply the knowledge of Production, Manufacturing and Industrial Engineering for analysis, optimization and development of mechanical system

PSO2: Apply the concepts of Design and Thermal Engineering to model, analyze and develop the mechanical components and systems

COURSE OUTCOMEs

After compeletion of this course student will be able to:

CO1	Apply the basic concepts of fluid mechanics and machinery to summarize experimental observations under different situations.
CO2	Analyze the engineering problems related to fluid kinematics, dynamics and machinery experimentally
CO3	Conduct the experiment individual/team ethically, considering social, health, safety, legal and environmental aspects.
CO4	Interpret the data and apply appropriate technique or tool for the solution of fluid mechanics and machinery related engineering problem.
CO5	Conclude the experimental results and express the same effectively in oral and written manners through report and practical presentation.

LIST OF EXPERIMENTS

1. To determine the Metacentric height of a floating vessel.
2. To verify the Bernoulli's Theorem.
3. To determine the coefficient of discharge of venture meter and Orifice meter.
4. To show the velocity and pressure variation with radius in a forced vertex flow.
5. To determine the Coefficient of velocity through a pipe flow using Pitot- Tube.
6. To determine the coefficient of discharge of Notch (V and Rectangular types).
7. To find critical Reynolds number for a pipe flow.
8. To determine the minor losses due to sudden enlargement, sudden contraction and bends.
9. Performance study of Pelton wheel.
10. Performance study of Francis turbine and axial flow turbines.
11. To study the characteristics of centrifugal pump and reciprocating pump.

EXPERIMENT NO. 1

CONTENTS

METACENTRIC HEIGHT APPARATUS

1. OBJECTIVE:

To study force balances in a static system.

2. AIM:

To determine the meta-centric height with angle of ship model

3. INTRODUCTION:

META-CENTRE:

It is defined as the point about which a body starts oscillating when the body is tilted by a small angle. The meta- centre may also be defined as the point at which the line of action of the force of buoyancy will meet the normal axis of the body when the body is given a small angular displacement. It is denoted by 'M'.

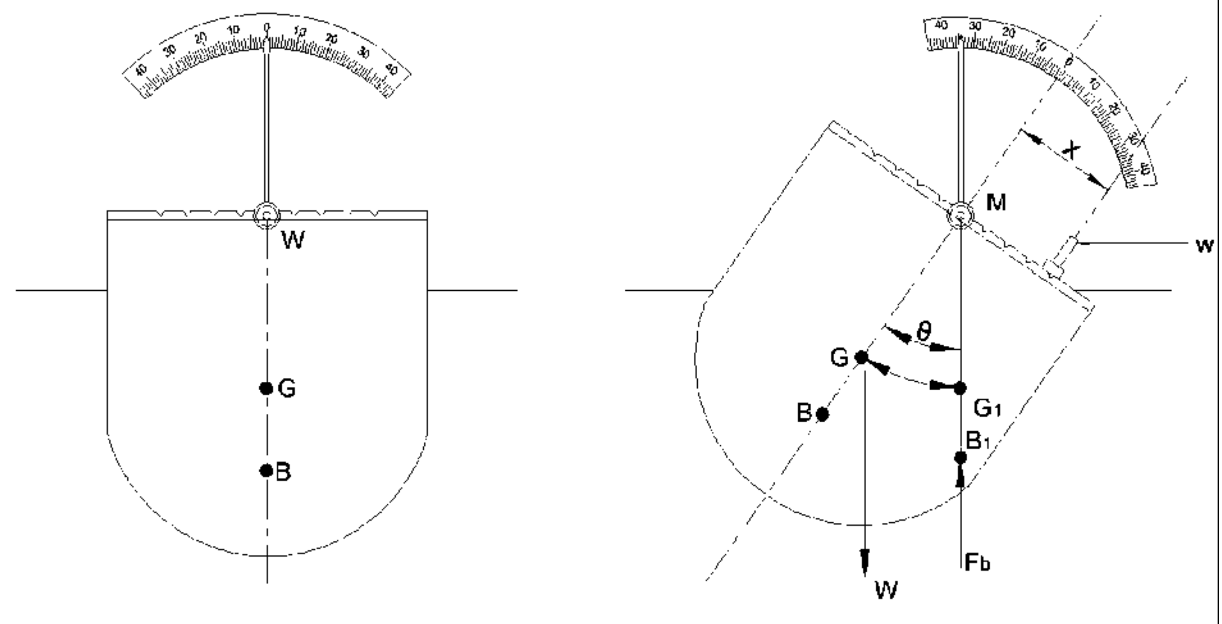
META-CENTRIC HEIGHT:

The distance between the meta-centre (M) of a floating body and the centre of gravity
(G) of the body is called meta-centric height

4. THEORY:

DETERMINATION OF META-CENTRIC HEIGHT:

For a body to be in equilibrium on the liquid surface the two forces gravity force (W) and buoyant force (F_b) must lie in the same vertical line. If the point M is above G, the floating body will be in stable equilibrium. If slight angular displacement is given to the floating body in clockwise direction, the center of buoyancy shifts from B to B_1 such that the line of action of F_b through B_1 cuts the axis at M, which is called the meta-center and the distance GM is called the meta-centric height.



METACENTRIC HEIGHT APPARATUS

The buoyant force F_b through B_1 and weight w through G constitute a couple acting in anti- clockwise direction and thus bringing the floating body in the original position.

To determine the meta-centric height of a floating body, we know the center of gravity of floating body. Place the known weight (w) over the center of the body.

The weight w is moved across the vessel towards right through a distance x. The body will be tilted. The angle of tilt θ is measured by means of a plumb line and a protractor attached on the body. The new center of gravity of the body will shift to G_1 as the weight w has been moved towards the right the center of buoyancy will change to B_1 as the body has tilted. Under equilibrium, the moment caused by the movement of the load w through a distance x must be equal to the moment caused by the shift of the center of gravity from G to G_1.Thus

The moment due to change of G,

$$GG_1 \times W = W \times GM \tan\theta$$

The moment due to movement of w,

$$\therefore \quad wx = W\,GM \tan\theta$$

Hence, $GM = \dfrac{wxW}{\tan\theta}$

W = Weight of body including w G

= Centre of gravity of body

B = Centre of buoyancy of the body M

= Meta-centre of the body

w = Applied weight

x = Distance moved by weight w

θ = Angle of tilt

5. DESCRIPTION:

A ship model is allowed to float in a small tank having water. For tilting the model, a cross bar with movable hanger is fixed on the model. By means of a pendulum the angle of tilt can be measured on a graduated arc. Pendulum and graduated arc are suitably fixed at the center of the cross bar.

6. UTILITIES REQUIRED:

Water supply (Initial fill).

Floor Drain Required.

Floor Area Required: 1 m x 0.5 m.

7. EXPERIMENTAL PROCEDURE:

STARTING PROCEDURE:

Close the valve V_1.

Fill tank ¾th with clean water and ensure that no foreign particles are there.

Float the ship model in water and wait till it became stable.

Fix known weight to be applied at the hanger.

Apply weight with hanger at any side on the slot provided.

Measure the angle of tilt by the scale provided.

Repeat the experiment for different position of weight applied.

Repeat the experiment for different weights.

CLOSING PROCEDURE:

Remove the weight with hanger from the ship model.

Drain water from tank with the help of given drain valve V_1.

8. OBSERVATION & CALCULATION:

8.1 DATA:

Weight of ship model including strips W_S =________kg

Weight of hanger W_H =_______kg

8.2 OBSERVATION TABLE:

Sr. No.	W_A (kg)	x (cm)	θ (Degree)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

8.3 CALCULATIONS:

$w = W_H + W_A$ (kg)

$W = W_S + w$ (kg)

$GM = \dfrac{wxW}{\tan\theta}$ (cm)

9. NOMENCLATURE:

Nom	Column Heading	Units	Type
GM	Metacentric height	m	Calculated
w	Wt. of hanger + applied weight	kg	Calculated
W	Total weight	kg	Calculated
W_A	Applied weight	kg	Measured
W_H	Wt. of hanger	kg	Given
W_S	Weight of ship model including strips	kg	Given
x	Distance of point (Weight applied) from centre	cm	Measured
θ	Angle of tilt	Degree	Measured

10. PRECAUTION & MAINTENANCE INSTRUCTIONS:

Always keep apparatus free from dust.

Drain the apparatus after experiment is over.

11. TROUBLESHOOTING:

Set the pointer to zero at default condition, manually if required.

Prepared By	Reviewed By	Approved By
		HOD MECHANICAL

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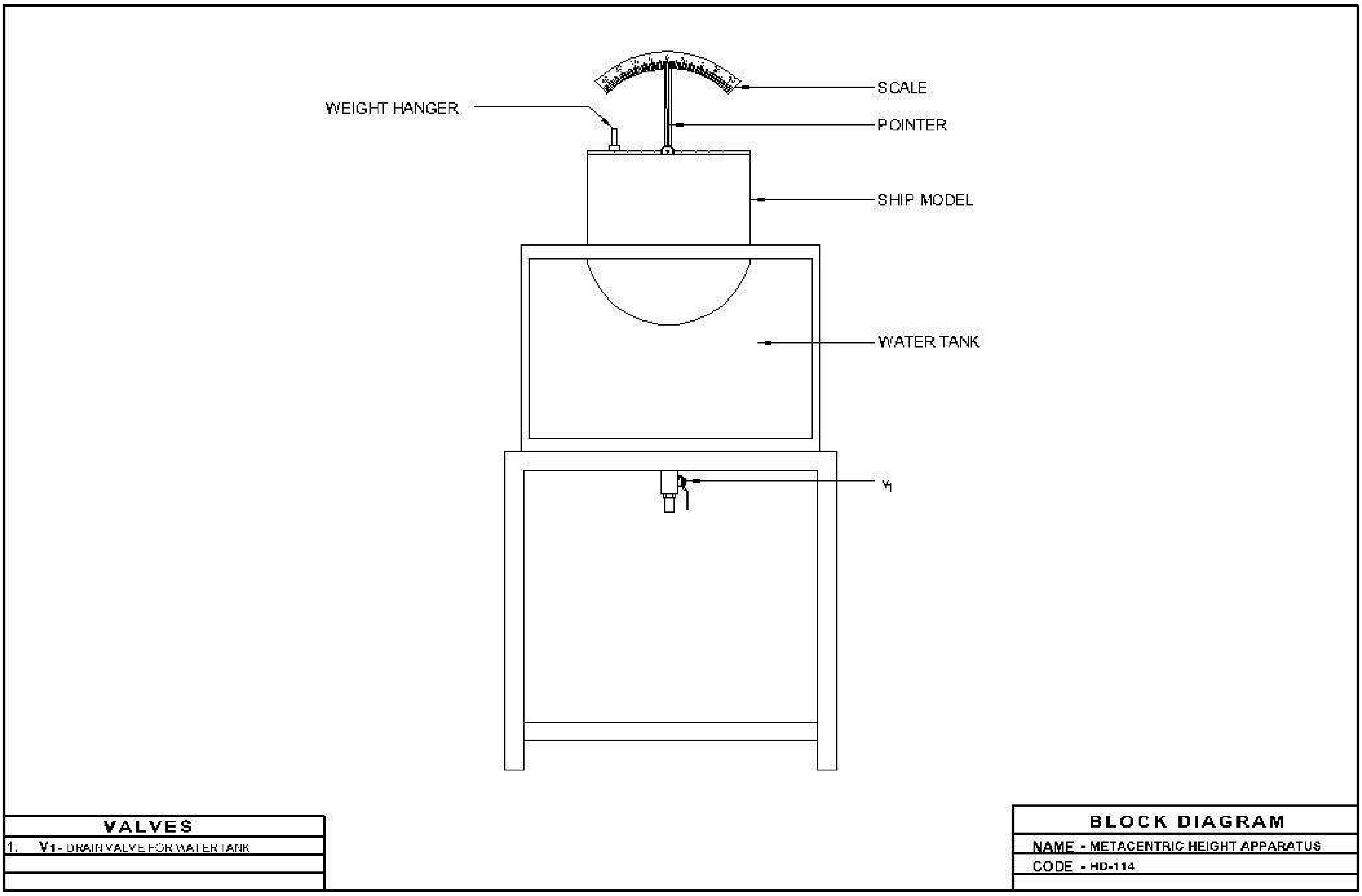
MECHANICAL ENGINEERING

FLUID MECHANICS AND HYDRAULICS MACHINE LAB(MEP-306)

BLOCK DIAGRAM



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EXPERIMENT NO.2

BERNOULLI'S THEOREM APPARATUS

1. OBJECTIVE:

To verify Bernoulli's equation experimentally.

2. AIM:

To calculate the total energy at different points

To plot the graph between total energy vs distance.

3. INTRODUCTION:

Bernoulli's theorem state that when there is a continuous connection between particles of flowing mass of liquid, the total energy at any section of flow will remain the same provided there is no reduction or addition of energy at any point.

4. THEORY:

This is the energy equation and is based on the law of conservation of energy. This equation states that at two sections of flow field the total energy remains the same. Provided that there is no loss or gain of energy between the two sections. This equation is valid only for steady flow. This equation is expressed as:

$$E = \frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2$$

5. DESCRIPTION:

The present experimental set-up for Bernoulli's Theorem is self-contained re-circulating unit. The set-up accompanies the sump tank, overhead tank, centrifugal Pump for water circulation. Control valve and by-pass valve is provided to regulate the flow of water in constant head tank. A test section made of perspex, of varying cross section is provided, which is having converging and diverging section. Piezometer tubes are fitted on this test section at specified points. The inlet of the conduit is connected to overhead tank.

Discharge through test section can be measured with the help of measuring tank .

6. Utilities Required:

Electricity Supply: Single Phase, 220 VAC, 50 Hz, 5-15 Amp. combined socket with earth connection.

Water Supply (Initial Fill).

Floor Drain Required.

Floor Area Required: 1.5 m x 0.75 m.

7. Experimental Procedure:

Starting Procedure:

Ensure that all On/Off switches given on the panel are at OFF position.

Close all the valves V_1 to V_5.

Fill sump tank with water.

Open by-pass valve V_2 given on the water supply line.

Switch On the main power supply & switch ON the pump.

Partially close by-pass valve V_2 to allow water to fill in overhead tank.

Wait until overflow occurs from overhead tank.

Regulate flow of water through test section with the help of control valve V_1 provided at the end of test section.

Ensure that the overflow still occurs; if not partially close the by-pass valve V_2 to do so.

Measure pressure head by piezometer tubes.

Measure flow rate of water using measuring tank and stop watch.

Repeat steps (8) to (11) for different flow rate of water.

CLOSING PROCEDURE:

When experiment is over, switch off pump.

Switch off power supply to panel.

Drain water from all tanks with the help of given drain valves V_3, V_4 & V_5.

8. Observation & Calculation:

8.1 Data:

Area of measuring tank A = 0.077 m^2	Acceleration due to gravity g = 9.81 m/sec^2

Sr. No. of Test points	Dia. of test point d (mm) (d_1-d_7)	Cross Sectional area at test point a (m^2) ($a_1 - a_7$)	Distance of test point from reference point S (m) ($S_1 - S_7$)
1	28.0	6.16 E-4	0.04
2	23.5	4.34 E-4	0.0785
3	18.5	2.69 E-4	0.092
4	14.0	1.54 E-4	0.1105
5	18.5	2.69 E-4	0.13585
6	23.5	4.34 E-4	0.1562
7	28.0	6.16 E-4	0.19155

8.2 Observation Table:

Sr. No	R_1 (cm)	R_2 (cm)	t (sec)	h_1 (cm)	h_2 (cm)	h_3 (cm)	h_4 (cm)	h_5 (cm)	h_6 (cm)	h_7 (cm)
1										
2										
3										
4										
5										
6										
7										

8.3 Calculations:

$$R = \frac{R_1 - R_2}{100} \text{ (m)}$$

$$Q = \frac{A \times R}{t} \text{ (m}^3\text{/sec)}$$

$V_1 = \frac{Q}{a_1}$ (m/sec)

$V_2 = \frac{Q}{a_2}$ (m/sec)

$V_3 = \frac{Q}{a_3}$ (m/sec)

$V_4 = \frac{Q}{a_4}$ (m/sec)

$V_5 = \frac{Q}{a_5}$ (m/sec)

$V_6 = \frac{Q}{a_6}$ (m/sec)

$V_7 = \frac{Q}{a}$ (m/sec)

$\frac{P_1}{\rho g} =$ $\frac{P_3}{\rho g} =$ $\frac{P_5}{\rho g} =$

$\frac{P_2}{\rho g} =$ $\frac{P_4}{\rho g} =$ $\frac{P_6}{\rho g} =$

7

$\rho g \quad \frac{h_1}{100}$ (m)

$\frac{P_7}{\rho g} = \frac{h_2}{100}$ (m)

$\frac{h_3}{100}$ (m)

$\frac{h_4}{100}$ (m)

$\frac{h_5}{100}$ (m)

$\frac{h_6}{100}$ (m)

$\frac{h_7}{100}$ (m)

$$E_1 = \frac{P_1}{\rho g} + \frac{V_1^2}{2g} \text{(m)}$$

$$E_2 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} \text{(m)}$$

$$E_3 = \frac{P_3}{\rho g} + \frac{V_3^2}{2g} \text{(m)}$$

$$E_4 = \frac{P_4}{\rho g} + \frac{V_4^2}{2g} \text{(m)}$$

$$E_5 = \frac{P_5}{\rho g} + \frac{V_5^2}{2g} \text{(m)}$$

$$E_6 = \frac{P_6}{\rho g} + \frac{V_6^2}{2g} \text{(m)}$$

$$E_7 = \frac{P_7}{\rho g} + \frac{V_7^2}{2g} \text{(m)}$$

Plot the graph E (E_1 to E_7) vs. S (S_1 to S_7)

9. NOMENCLATURE:

Nom	Column Heading	Units	Type
A	Area of measuring tank	m^2	Given
a	Cross sectional area at test point (a_1-a_7)	m^2	Given
d	Diameter of the test point (d_1-d_7)	mm	Given
E	Total energy at particular point (E_1 to E_7)	m	Calculated
g	Acceleration due to gravity	m/sec^2	given
h	Piezometric tube reading at particular point (h_1-h_7)	m	Measured
$\frac{P}{\rho g}$	Pressure energy per unit weight of fluid or pressure head at particular point $\left(\frac{P_1}{\rho g} to \frac{P_7}{\rho g}\right)$	m	Calculated

Q	Discharge through test section	m^3/sec	Calculated
R	Rise of water level in measuring tank	m	Calculated
R_1	Final level of water in measuring tank	cm	Measured

R_2	Initial level of water in measuring tank	cm	Measured
s	Distance from reference point at particular point (S_1-S_7)	m	Given
t	Time taken for R	sec	Measured
$\frac{V^2}{2g}$	Kinetic energy per unit weight or kinetic head at particular point $\left(\frac{V_1^2}{2g} to \frac{V_7^2}{2g}\right)$	m	Calculated

10. Precaution & Maintenance Instructions:

Never run the apparatus if power supply is less than 200 volts and above 230 volts.

To prevent clogging of moving parts, run pump at least once in a fortnight.

Always use clean water.

Always keep apparatus free from dust.

Drain the apparatus completely after experimentation.

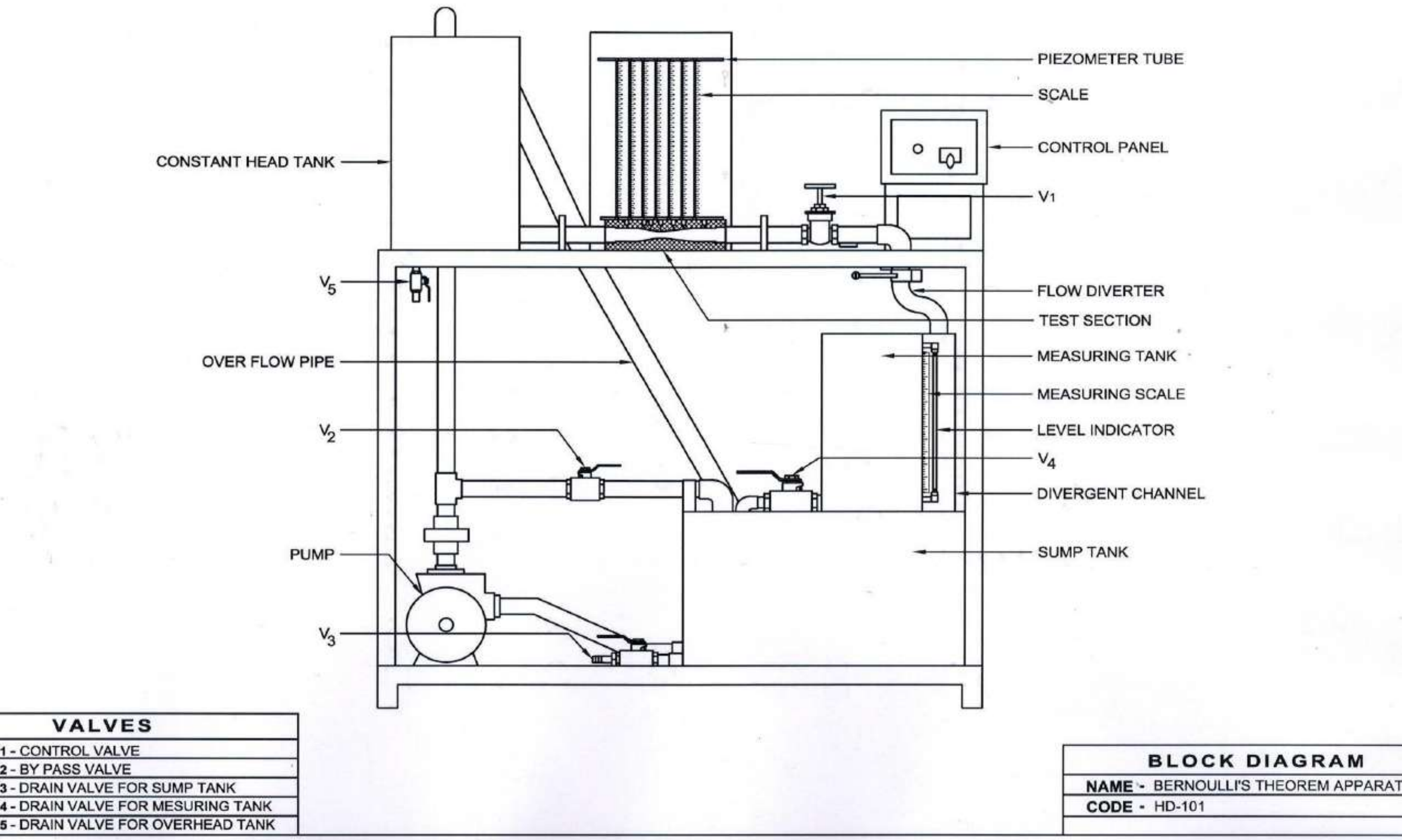
11. Troubleshooting:

If pump gets jammed, open the back cover of pump and rotate the shaft manually.

If pump gets heated up, switch off the pump for 30 minutes.

Prepared By	**Reviewed By**	**Approved By**
		HOD MECHANICAL

12. Block Diagram:



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MECHANICAL ENGINEERING
FLUID MECHANICS AND HYDRAULICS MACHINE LAB(MEP-306)

EXPERIMENT NO.3

Contents

VENTURIMETER & ORIFICEMETER SET-UP

1. OBJECTIVE:

To demonstrate the use of venturimeter & orificemeter as flow meters.

2. AIM:

To determine the co-efficient of discharge C_d for venturimeter.

To determine the co-efficient of discharge C_d for orificemeter.

3. INTRODUCTION:

If a constriction is placed in a closed channel carrying a stream of fluid, there will be increase in velocity, and hence increase in kinetic energy, at the constriction, from an energy balance, as given by Bernoulli's Theorem, there must be a corresponding reduction in pressure. Rate of discharge from the constriction can be calculated by knowing this pressure reduction, the area available for flow at the constriction, the density of fluid, and the co-efficient of discharge. The last named is defined as the ratio of actual flow to the theoretical flow.

4. THEORY:

VENTURIMETER:

A Venturimeter consists of:

1. An inlet section followed by a convergent cone.
2. A cylindrical throat.
3. A gradually divergent cone.

The inlet section of venturimeter is of the same diameter as that of the pipe, which is followed by a convergent cone. The convergent cone is a short pipe, which tapers from the original size of the pipe to that of the throat of the venturimeter. The Throat of the venturimeter is a short parallel side tube having its cross-sectional area smaller than that of the pipe. The divergent cone of the venturimeter is gradually diverging pipe with its cross-sectional area increasing from that of the Throat to the original size of the pipe. At inlet section & throat of the venturimeter, pressure taps are provided.

ORIFICEMETER:

An orifice meter consists of a flat circular plate with a circular hole called Orifice, which is concentric with the pipe axis.

5. DESCRIPTION:

The apparatus consists of a venturi meter and an orifice meter, fitted in separate pipe. Both the pipe consists of separate flow control valves and common inlet and outlet. Sump tank with centrifugal pump is provided for water circulation through pipes. The pressure tapings are provided at inlet and throat of venturi meter and inlet and outlet of orifice meter. Pressure tapings are connected to a differential manometer. Discharge is measured with the help of measuring tank & stop watch.

6. UTILITIES REQUIRED:

Electricity Supply: Single Phase, 220 V AC, 50 Hz, 5-15 Amp. combined socket with earth connection.

Water Supply (Initial Fill).

Floor Drain Required.

Floor Area Required: 1.5 m x 0.75 m.

7. Experimental Procedure:

Starting Procedure:

1. Close all the drain valves.

2. Fill sump tank ¾ with clean water and ensure that no foreign particles are there.
3. Open by-pass valve V_1.
4. Ensure that On/Off switch given on the panel is at OFF position.

5. Switch ON the main power supply and then switch on the pump.

6. Open flow control valve of desired test section (V_2 for venturi meter or V_3 for orifice meter)

7. Open the air release valve V_6 provided on the manometer, slowly to release the air from manometer.

8. When there is no air in the manometer, close the air release valves.

9. Adjust water flow rate in desired section with the help of control valve V_2 or V_3 and by pass valve V_1.

10. Record the manometer reading, in case of pressure above scale in any tube, apply air pressure by hand pump to get readable reading..

11. Measure the flow of water, discharged through desired test section, using stop watch and measuring tank.

12. Repeat experiment for different flow rates of water, operating control valve V_2 or V_3 and by-pass valve V_1.

13. When experiment is over for one desired test section, open the by-pass valve V_1 fully.

14. Then close the flow control valve V_2 or V_3 of running test section and open the control valve V_3 or V_2 of another test section.

15. Repeat the experiment for selected test section.

Closing Procedure:

1. Switch off pump.

2. Switch off power supply to panel.

3. Drain the apparatus completely by drain valves V_4 & V_5 provided.

8. Observation & Calculations:

8.1 Data:	
Acceleration due to gravity g = 9.81 m/sec^2	Area of measuring tank A = 0.077 m^2
Diameter at throat d_2 = 0.014 m	Diameter at inlet d_1 = 0.028 m

8.2 OBSERVATION TABLE:

	Test Section : Venturimeter					Test Section : Orificemeter				
Sr. No	h_1 (cm)	h_2 (cm)	R_1 (cm)	R_2 (cm)	t (sec)	h_1 (cm)	h_2 (cm)	R_1 (cm)	R_2 (cm)	t (sec)
1										
2										
3										
4										
5										

8.3 CALCULATIONS:

FOR BOTH VENTURIMETER & ORIFICEMETER :

$$R = \frac{R_1 - R_2}{100} \text{ (m)}$$

$$Q_a = \frac{A \times R}{t}, \text{ (m}^3\text{/sec)}$$

$$a_1 = \frac{\pi}{4} d_1^2 \text{ (m}^2\text{)}$$

$$a_2 = \frac{\pi}{4} d_2^2 \text{ (m}^2\text{)}$$

$$H = \frac{h_1 - h_2}{100} \text{ (m)}$$

$$Q_t = \frac{a_1 a_2 \sqrt{2gH}}{\sqrt{a_1^2 - a_2^2}} \text{ (m}^3\text{/sec)}$$

$$C_d = \frac{Q_a}{Q_t}$$

9. Nomenclature:

Nom	Column Headings	Units	Type
A	Area of measuring tank	m^2	Given
a_1	Area at inlet of venturimeter and orificemeter	m^2	Calculated
a_2	Area at throat of venturimeter and Area of orifice	m^2	Calculated
C_d	Coefficient of discharge		Calculated
d_1	Diameter at inlet of venturimeter & orifice meter	m	Given
d_2	Diameter at throat of venturimeter & dia of orifice	m	Given
g	Acceleration due to gravity	m/sec^2	Given
H	Loss of head	m of water	Calculated
h_1,h_2	Manometer reading at both points	cm	Measured
Q_a	Actual discharge	m^3/sec	Calculated
Q_t	Theoretical discharge	m^3/sec	Calculated
R	Rise of Water level in measuring tank.	m	Calculated
R_1	Final level of water in measuring tank	cm	Measured
R_2	Initial level of water in measuring tank	cm	Measured
t	Time taken for Rise of water level in measuring tank	sec	Measured

10. Precaution & Maintenance Instructions:

1. Never run the apparatus if power supply is less than 200 Volts and above 230 Volts.
2. Never fully close the flow control valve V_2 & V_3 and the by-pass valve V_1 simultaneously.
3. To prevent clogging of moving parts, run pump at least once in a fortnight.
4. Always keep apparatus free from dust.

11. TROUBLESHOOTING:

1. If pump gets jammed, open the back cover of pump and rotate the shaft manually.

2. If pump gets heated up, switch off the main power for 30 minutes and avoid closing the flow control valve and by-pass valve at a time, during operation.

Prepared By	Reviewed By	Approved By
		HOD MECHANICAL

BLOCK DIAGRAM

EXPERIMENT NO.4

Contents

FORCED VORTEX APPARATUS (VARIABLE SPEED)

1. OBJECTIVE:

To study rotating mass of fluid in forced vortex condition.

2. AIM:

To determine the surface profile of a vortex apparatus.

3. INTRODUCTION:

A mass of fluid in rotation is called a vortex. The vortex flow is of two types, Free and Forced. When a fluid is made to rotate by some external agency, is known as Forced Vortex and Free Vortex is one, which requires no external impressed contact forces to cause rotation.

4. THEORY:

Forced vortex flow is defined as the flow, in which some external torque is required to rotate the fluid mass. The fluid mass in this type of flow rotates at constant angular velocity.

Examples of forced vortex are:

- A vertical cylinder containing liquid, which is rotated about its central axis with a constant angular velocity.
- Flow of liquid inside the impeller of centrifugal pump.
- Flow of water through the runner of a turbine.

5. DESCRIPTION:

The set-up consists of an open transparent acrylic cylinder, which is free to rotate about its vertical axis. The cylinder is suitably mounted on a plate. The plate is rotated with the help of a variable speed motor so that cylinder rotates about its vertical axis. A pointer gauge mounted on graduated carriage (in X-Y co-ordinates) is provided with the apparatus. A proximity switch with RPM indicator is also provided for measuring the RPM of motor.

6. Utilities Required:

Electricity Supply: Single Phase 220 V AC, 50 Hz, 5-15 Amp. combined socket with earth connection.

Water Supply (Initial fill).

Floor Drain Required.

Floor Area Required: 1 m x 1 m.

7. Experimental Procedure:

Starting Procedure:

Fill the cylinder approximately $^{1}/_{3}{}^{rd}$ with clean water and ensure that no foreign particles are there.

Ensure that all ON/OFF switch given on the panel is at OFF position.

Switch ON the main power supply and switch ON the motor.

Increase the speed of motor slowly and keep it constant for certain vortex formed.

Record the RPM.

Record the datum depth reading of the vortex formed with pointer gauge in vertical and horizontal direction.

Move the pointer in one direction on the vortex surface and record the pointer gauge reading.

Repeat the experiment for different points on the surface.

Repeat the experiment for various speeds.

Closing Procedure:

Adjust DC Drive knob at zero.

Switch OFF the motor.

Switch OFF power supply to panel.

Drain water from cylinder by drain nut.

8. OBSERVATION & CALCULATION:

8.1 DATA:

Acceleration due to gravity g =9.81m/sec^2

8.2 OBSERVATION TABLE:

Sr. No.	N (RPM)	Z_r (cm)	R_r (cm)	Z (cm)	R (cm)
1					
2					
3					
4					

8.3 CALCULATIONS:

$$\omega = \frac{2\pi N}{60} \text{ (rad/sec)}$$

$$r = \frac{(R_r - R)}{100} \text{ (m)}$$

$$Z_C = \frac{\omega^2 r^2}{2g} \text{ (m)}$$

$$Z_A = \frac{(Z_r - Z)}{100}$$

(m)

$$\% \text{ Error} = \frac{Z_A - Z_C}{Z_A} \times 100\ (\%)$$

9. NOMENCLATURE:

Nom	Column Heading	Units	Type
g	Acceleration due to gravity	m/sec^2	Given
N	RPM of the cylinder	RPM	Measured
R	Horizontal scale reading at particular point on the vortex surface	cm	Measured
r	Difference of horizontal scale reading between particular point & at datum depth of the vortex	cm	Calculated
R_r	Horizontal scale reading of the datum depth point (at center) of the vortex	cm	Measured
Z	Vertical scale reading at particular point on the vortex surface	cm	Measured
Z_A	Actual height of particular point from deepest point	m	Calculated
Z_C	Calculated height of particular point from deepest point	m	Calculated
Z_r	Vertical scale reading of the datum depth point (at center) of the vortex	cm	Measured
ω	Angular velocity at particular point on vortex	rad/sec	Calculated

10. PRECAUTION & MAINTENANCE INSTRUCTIONS:

Never run the apparatus if power supply is less than 200 Volts and above 230 Volts

Increase the speed of the motor gradually.

Always keep apparatus free from dust.

The vortex should be visible in the cylinder means the deepest point of the “U” doesn’t touches the bottom of the cylinder.

11. TROUBLESHOOTING:

If panel is not showing input, check main supply.

If field failure (FF) indicates on the control panel and the motor is not moving, check the fuses if burnt, change it.

If overload (OL) indicates on the panel and motor stops moving, then stop the supply to motor for 15 minutes and then start it again.

Prepared By	**Reviewed By**	**Approved By**
		HOD MECHANICAL

DIAGRAM

EXPERIMENT NO.5

Contents

PITOT TUBE APPARATUS

1. OBJECTIVE:

To measure the velocity of flow at different points along the cross section in a pipe

2. AIM:

To find the point velocity at the center of a tube for different flow rates.

To find the co- efficient of pitot tube.

To plot velocity profile across the cross section of pipe.

3. INTRODUCTION:

It is a device used for measuring the velocity of flow at any point in a pipe. It is based on the principle that if the velocity of flow at a point becomes zero, there is increase in pressure due to the conversion of the kinetic energy into pressure energy. The Pitot tube consists of a capillary tube, bend at right angle. The lower end is directed in the up stream direction. The liquid rises up in the tube due to conversion of kinetic energy into pressure energy. The velocity is determined by measuring the rise of liquid in the tube.

4. THEORY:

When a Pitot Tube is used for measuring the velocity of flow in a pipe or other closed conduit the Pitot Tube may be inserted in the pipe. Since a Pitot tube measures the stagnation pressure head (or the total head) at its dipped end. The pressure head may be determined directly by connecting a differential manometer between the Pitot tube and pressure taping at the pipe surface. Consider two points 1 and 2 at the same level in such a way that point 1 is at the inlet of the pitot tube and point 2 is at the outlet. At point 1 the pressure is p_1 and the velocity of the stream is v_1. However, at point 2 the fluid is brought to rest and the energy has been converted to pressure energy. Therefore the pressure at 2 is p_2, the velocity v_2 is zero and since 1 and 2 are in the same horizontal plane, so $z_1 = z_2$.

Applying bernoulli's equation at points (1) and (2)

$$\frac{p_1}{w} + \frac{v_1^2}{2g} = \frac{p_2}{w} + \frac{v_2^2}{2g}$$

$v_2 = 0$

$$\therefore \frac{v_1^2}{2g} = \frac{p_2}{w} - \frac{p_1}{w}$$

$$v_1 = \sqrt{2g\left(\frac{p_2}{w} - \frac{p_1}{w}\right)}$$

$$v_1 = \sqrt{2gH}$$

This is theoretical velocity.

Actual velocity

$$(v_1)_{act} = C_v \sqrt{2gH}$$

Where Cv is co-efficient of Velocity of pitot tube.

5. Description:

The apparatus consists of sump tank with centrifugal pump. A pitot tube made of copper provided in the test section made of acrylic connected to pipeline with flow control valve. The pointer gauge is provided to measure the vertical position of pitot tube in test section. A manometer is provided to determine the pressure difference. Discharge is measured with the help of measuring tank and stopwatch.

6. Utilities Required:

Electricity Supply: Single Phase, 220V AC, 50Hz, 5-15 Amp. combined socket with earth connection.

Water Supply (Initial Fill).

Floor Drain Required.

Floor Area Required: 1.5 x 0.75 m.

7. Experimental Procedure:

Starting Procedure:

Close all the drain valves.

Fill sump tank ¾ with clean water and ensure that no foreign particles are there.

Open by-pass valve V_2.

Ensure that ON/OFF switch given on the panel is at OFF position.

Switch ON the main power supply and then switch ON the pump.

Open flow control valve V_1 and allow water to flow through test section by partially closing valve V_2.

Open the air release valve V_5 provided on the manometer, slowly to release the air from manometer.

When there is no air in the manometer, close the air release valve.

Set the position of pitot tube at the centre of the test section by adjusting the pointer to zero by knob provided.

Adjust water flow rate with the help of control valve V_1 and by pass valve V_2.

Record the manometer reading, in case of pressure above scale in any tube, apply air pressure by hand pump to get readable reading.

Measure the flow of water, discharged, using stop watch and measuring tank.

Repeat the experiment for different flow rates of water, operating control valve V_1 and by-pass valve V_2.

Record the manometer reading for different position of pitot tube (change by knob) at particular discharge for determination of velocity profile.

Closing Procedure:

Switch off pump.

Switch off power supply to panel.

Drain the apparatus completely by drain valves V_3 & V_4 provided.

8. Observation & Calculation:

8.1 Data:

Acceleration due to gravity g = 9.81 m/sec^2	Area of measuring tank A = 0.077 m^2
Diameter of pipe d = 0.028 m	

8.2.1 Observation Table:

For Co-efficient of Velocity:

Sr. No	h_1 (cm)	h_2 (cm)	R_1 (cm)	R_2 (cm)	t, (sec)
1					
2					
3					
4					
5					

8.2.2 Observation Table:

For Velocity Profile:

P (mm)	h_1 (cm)	h_2 (cm)	R_1 (cm)	R_2 (cm)	t, (sec)
8					
4					
0					
-4					
-8					

8.3 Calculations:

For Co-efficient of velocity

$$R = \frac{R_1 - R_2}{100} \text{ (m)}$$

$$Q_a = \frac{A \times R}{t} \text{ (m}^3\text{/sec)}$$

$$a = \frac{\pi}{4} d^2 \text{ (m}^2\text{)}$$

$$V_a = \frac{Q}{a} \text{ (m/sec)}$$

$$H = \frac{h_1 - h_2}{100}, \text{ (m)}$$

$$V_{th} = \sqrt{2gH} \text{ (m/sec)}$$

$$C_v = \frac{V_a}{V}$$

For Velocity Profile

$$R = \frac{R_1 - R_2}{100} \text{ (m)}$$

$$Q_a = \frac{A \times R}{\ } \text{ (m}^3\text{/sec)}$$

Position	$H = \frac{h_1 - h_2}{100}$, m	$V = C_v\sqrt{2gH}$, m/sec
8		
4		
0		
-4		
-8		

Use average of co-efficient of velocity calculated as C_v for velocity calculation.

Plot Graph : P vs. V

9. NOMENCLATURE:

Nom	Column Heading	Units	Type
A	Area of measuring tank	m^2	Given
a	Cross section area of pipe	m^2	Calculated

C_v	Co-efficient of pitot tube		Calculated
d	Diameter of pipe	m	Given
g	Acceleration due to gravity	m/sec^2	Given
h_1, h_2	Manometer reading at both points	cm	Measured
H	Loss of head	m of water	Calculated
P	Position of pitot tube	mm	Measured
Q	Discharge	m^3/sec	Calculated

Nom	Column Heading	Units	Type
R	Rise of water level in measuring tank	m	Calculated
R_1	Final level of water in measuring tank	cm	Measured
R_2	Initial level of water in measuring tank	cm	Measured
t	Time for rise in water level in measuring tank	sec	Measured
V	Velocity at any point	m/sec	Calculated
V_a	Actual velocity of fluid	m/sec	Calculated
V_{th}	Theoretical velocity of fluid	m/sec	Calculated

10. PRECAUTION & MAINTENANCE INSTRUCTIONS:

Never run the apparatus if power supply is less than 200 Volts and above 230 Volts

Never fully close the control valve V_1 and by pass valve V_2 simultaneously.

To prevent clogging of moving parts, run pump at least once in a fortnight.

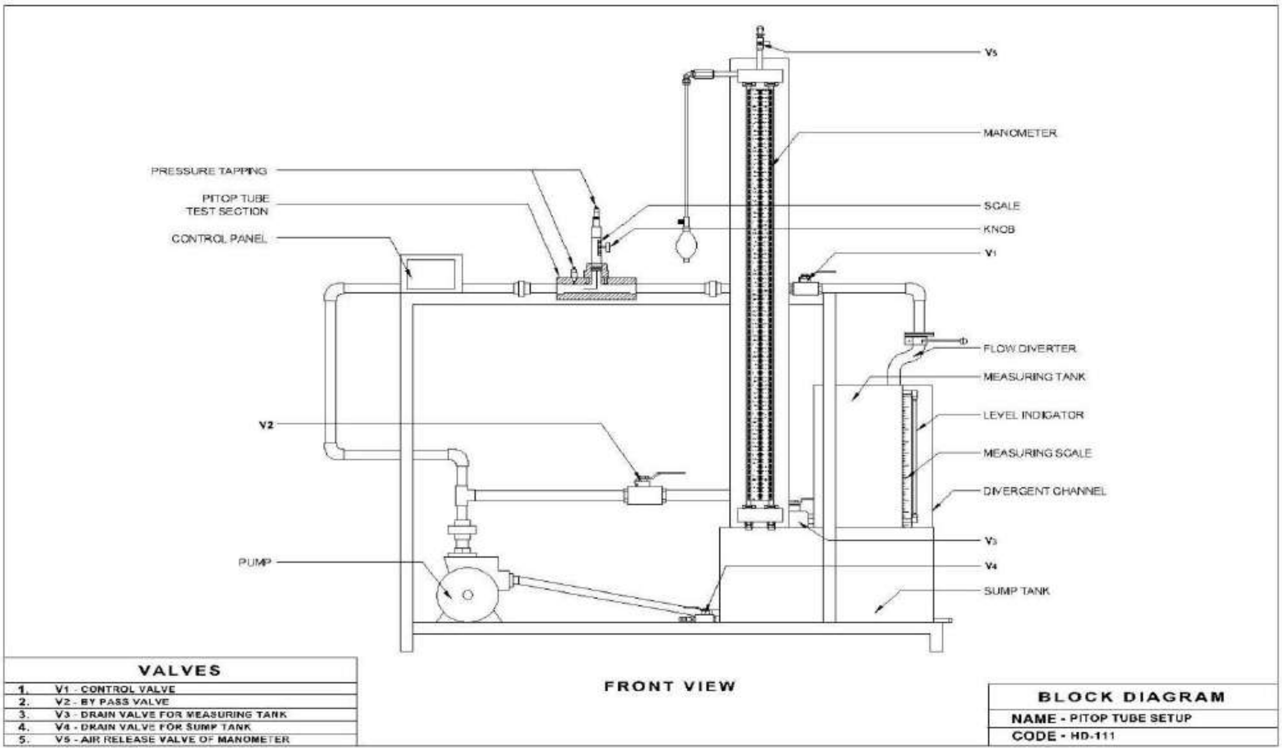
Always keep apparatus free from dust.

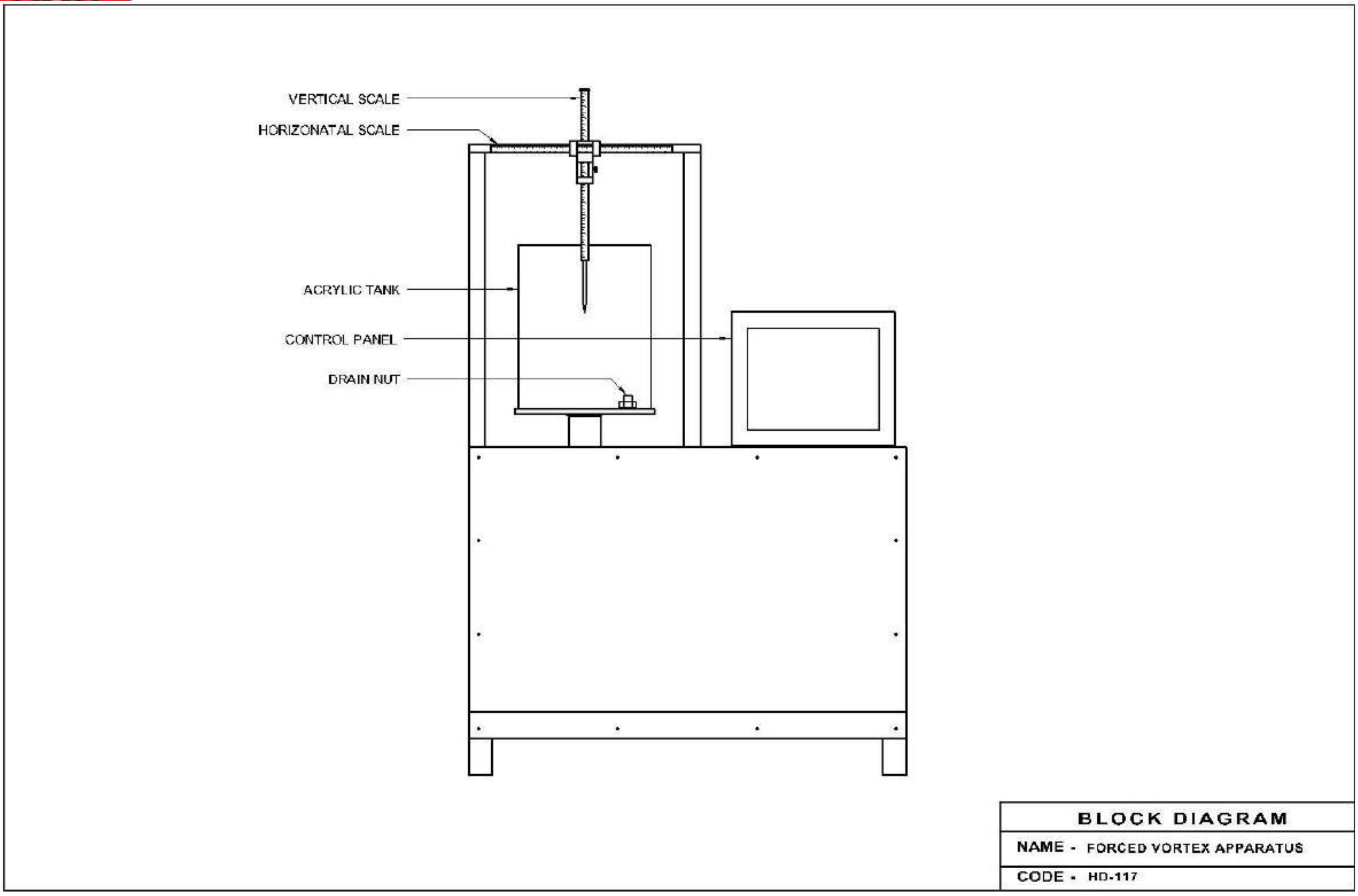
11. TROUBLESHOOTING:

If pump gets jam, open the back cover of pump and rotate the shaft manually.

If pump gets heated up, switch off the main power for 30 minutes and avoid closing the flow control valve V_1 and by-pass valve V_2 at a time, during operation.

12. BLOCK DIAGRAM:





EXPERIMENT NO.6

Contents

DISCHARGE OVER NOTCHES

1. OBJECTIVE:

To study the discharge over different type of notches.

2. AIM:

To determine the co-efficient of discharge 'C_d' of different notches:

Rectangular Notch

V Notch - 45º

V Notch - 60º

3. INTRODUCTION:

A notch is a device used for measuring the rate of a liquid through a small channel or a tank. It may be defined as an opening in the side of a tank or a small channel in such a way that the liquid surface in the tank or channel is below the top edge of the opening. The sheet of water flowing through the notch is called Nappe or Vein. The bottom edge of a notch over which the water flows, is known as the sill or crest.

4. THEORY:

CO-EFFICIENT OF DISCHARGE:

The ratio of actual discharge Q_a over a notch to the theoretical discharge Q_t is known as co-efficient of discharge. Mathematically, co-efficient of discharge:

$$C_d = \frac{Q_a}{Q_t}$$

DISCHARGE OVER A RECTANGULAR NOTCH:

$$Q_t = \frac{2}{3} \times C_d \times L \times \sqrt{2 \times g} \times [H]^{3/2}$$

DISCHARGE OVER TRIANGULAR NOTCH:

$$Q_t = \frac{8}{15} \times C_d \times \tan\theta/2 \times \sqrt{2 \times g} \times [H]^{5/2}$$

5. DESCRIPTION:

The apparatus consists of a sump tank, pump to circulate water and a flow channel. A set of three knife edged notch plates made of brass is provided. One of them is rectangular, other is 'V' notch having angle 60^o and third is 'V' notch having angle 45^o. The notches are interchangeable. A pointer is provided to measure the height of water level over the crest of the notch. Discharge through notches can be measured by measuring tank and stop watch.

6. UTILITIES REQUIRED:

Electricity supply: Single Phase, 220 V AC, 50 Hz, 5-15 Amp. combined socket with earth connection.

Water supply (Initial Fill).

Floor Drain Required.

Floor Area required: 1.5 m x 0.75 m

7. EXPERIMENTAL PROCEDURE:

STARTING PROCEDURE:

Close all the valves provided V_1 to V_4.

Fill sump tank ¾ with clean water and ensure that no foreign particles are there.

Fix desired notch at the outlet of flow channel.

Open by-pass valve V_2.

Ensure that all On/Off Switches given on the panel are at OFF position.

Now switch ON the main power supply.

Switch on the pump.

Operate flow control valve V_1 and by pass valve V_2 to fill the flow channel up to no discharge occurs through notch.

Fully open bypass valve V_2 and close the flow control valve V_1 and wait for level of water in flow channel becomes stable.

Measure the height of water level at no flow condition (crest height).

Regulate flow of water through channel with the help of flow control valve V_1 and by pass valve V_2.

Record the height of water level in the channel with the help of pointer Gauge.

Measure flow rate using measuring tank and stop watch.

Repeat the experiment for different flow rates.

Repeat the experiment for other notches.

Closing Procedure:

When experiment is over, Switch off pump.

Switch off power supply to panel.

Open bypass valve V_2 and flow control valve V_1.

Drain water from all tanks with the help of provided drain valves V_3 & V_4.

8. Observation & Calculation:

8.1 Data:	
Acceleration due to gravity g	= 9.81 m/sec^2
Area of measuring tank A	= 0.077 m^2
V–Notch 45^o,θ	= 0.7854 Radian
V–Notch 60^o,θ	= 1.0472 Radian
Rectangular Notch Length L	= 0.070 m

8.2.1 Observation Table : V – Notch
h_o =_______cm

Sr. No	h (cm)	R_1 (cm)	R_2 (cm)	t (sec)
1				
2				
3				
4				

8.2.1 Observation Table : V – Notch

h_o =_______cm

Sr. No	h (cm)	R_1 (cm)	R_2 (cm)	t (sec)
1				
2				
3				
4				

8.2.1 Observation Table : V – Notch

h_o =_______cm

Sr. No	h (cm)	R_1 (cm)	R_2 (cm)	t (sec)
1				
2				
3				
4				

8.3 Calculations:

$$H = \frac{h - h_o}{100}, \text{ m}$$

$$R = \frac{R_1 - R_2}{100}, \text{ m}$$

$$Q = \frac{A \times R}{t}, \text{ m}^3/\text{sec}$$

$$C_d = \frac{3Q}{2L\sqrt{2g} \times (H)^{3/2}}$$ (For rectangular notch)

$$C_d = \frac{15Q}{8 \times \tan\left(\frac{\theta}{2}\right) \times \sqrt{2g} \times (H)^{5/2}}$$ (For triangular notch)

9. Nomenclature:

Nom	Column Heading	Units	Type
A	Area of measuring tank,	m^2	Given
C_d	Co-efficient of discharge for rectangular notch and triangular notch.		Calculated
g	Acceleration due to gravity,	m/sec^2	Given
H	Water head over crest, m	m	Calculated
h	Liquid level flow at particular height, cm	cm	Measured
h_o	Crest height, cm	cm	Measured
L	Width of the rectangular notch in meter, m	m	Given
Q	Actual discharge, m^3/sec	m^3/sec	Calculated
R	Rise of water level in measuring tank, cm	m	Calculated
R_1	Final level of water in measuring tank, cm	cm	Measured
R_2	Initial level of water in measuring tank, cm	cm	Measured
t	Time for R, sec	sec	Measured
θ	Angle of V- notch, Radian.	Radian	Given

10. Precaution & Maintenance Instructions:

Never run the apparatus if power supply is less than 200 volts and above 230 volts.

Never switch on main power supply before ensuring that all the on/off switches given on the panel are at off position.

Never fully close the flow control valve V_1 and by pass valve V_2 simultaneously.

If apparatus is not in use for more than one month, drain the apparatus completely.

Always keep the apparatus free from dust.

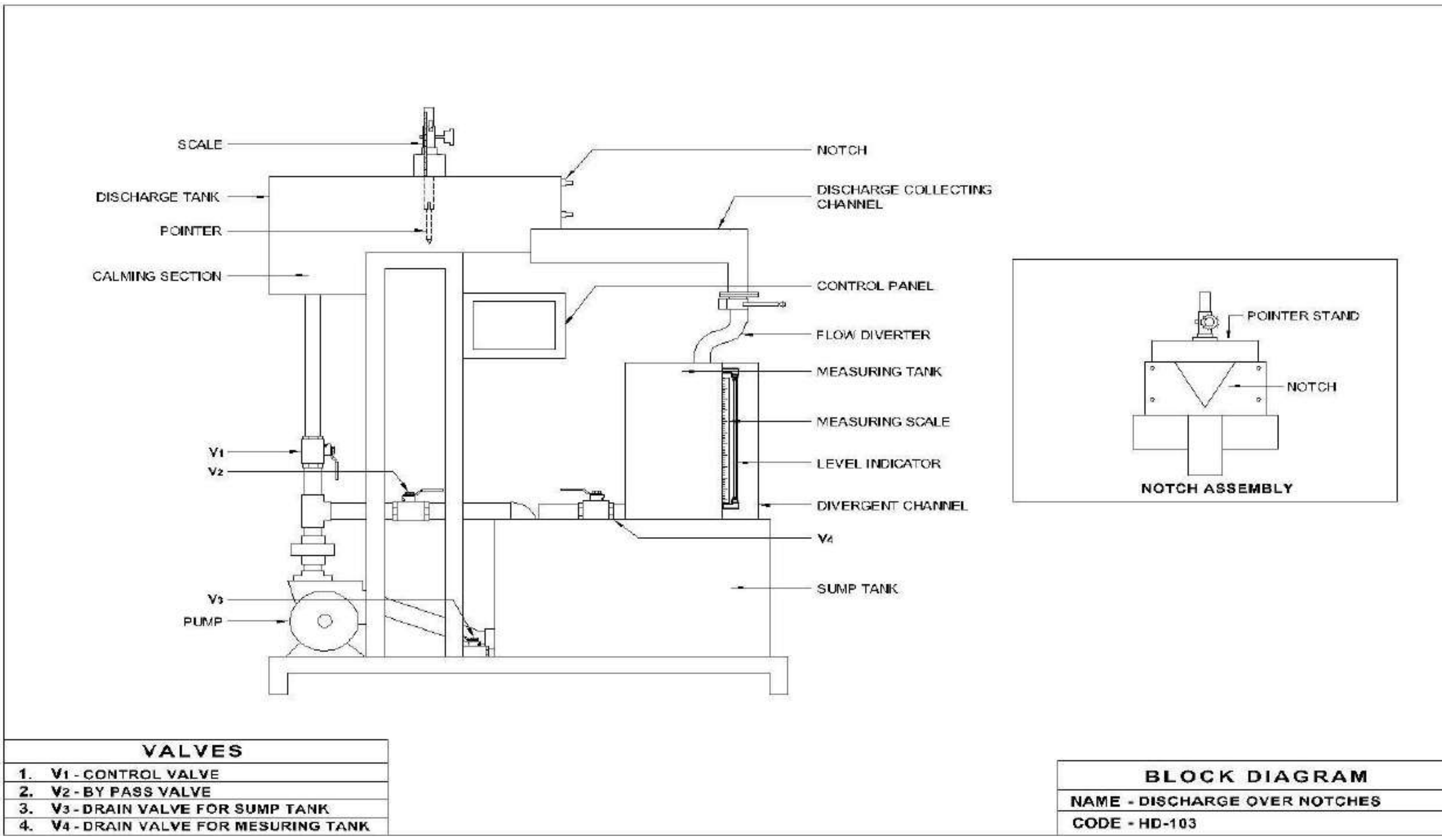
11. Troubleshooting:

If pump gets jam, open the back cover of pump and rotate the shaft manually.

If pump gets heated up, switch off the main power for 30 minutes. Avoid closing the flow control valve V_1 and by pass valve V_2 at a time.

Prepared By	Reviewed By	Approved By
		HOD MECHANICAL

BLOCK DIAGRAM:



EXPERIMENT NO.7

Contents

REYNOLD'S APPARATUS

1. OBJECTIVE:

To study different types of flow.

2. AIM:

To determine the Reynold's Number.

3. INTRODUCTION:

From an engineering viewpoint, many variables that affect velocity profile cannot be evaluated for all possible flow meters and for all pipe conditions. For this reason, steady flow and a fully developed flow profile as defined by a newtonian, homogeneous fluid, are initially assumed. Co-efficient variation can then be predicted with the dimensionless reynolds number. This number has been found to be an acceptable correlating parameter that combine the effects of viscosity, density and pipeline velocity.

4. THEORY:

In reynolds experiments, the ratio of inertia to viscous forces was observed to be dimensionless and related to viscosity, average pipeline velocity, and geometrically similar boundary conditions. For a homogeneous newtonian fluid, this dimensionless ratio is R_e is expressed as:

$$R_e = \frac{DV\rho}{\mu} \quad \text{----------------- (1)}$$

Where, $v = \frac{\mu}{\rho}$

$$R_e = \frac{DV}{v}$$

------------------ (2)

Where,

ρ	=	Density of fluid in kg/m^3
V	=	Average velocity of fluid flow in m/sec.
D	=	Diameter of glass tube in m

μ = Viscosity of fluid in N-sec/m^2

ν = Kinematic viscosity of fluid, m^2/sec

R_e < 2100 for laminar flow

R_e > 4000 for turbulent flow

R_e = 2100-4000 in transition zone

When the dye filament flows in the reynolds experiment, it indicates critical state of flow, and the corresponding reynolds number is called the critical reynolds number $R_e \approx 2000$, beyond which the flow is in transition state and then becomes turbulent.

Depending upon the relative magnitudes of viscous and inertial forces, flow can occur in two different manners. Laminar flow is defined as a line, which lies in the direction of flow at every point at a given instant. Transition flow is defined as a flow in which the streamlines needs not be straight as the flow steady as long as this criterion is fulfilled. Eddies generated in the initial zone of instability spread rapidly throughout the fluid, thereby producing a disruption of the entire flow pattern. The result is fluid turbulence superimposed upon the primary motion of translation, producing what is called turbulent flow.

5. DESCRIPTION:

The apparatus consists of sump tank with centrifugal pump, a glass tube with one end having bell mouth entrance connected to a constant head tank. At the other end of the glass tube a valve is provided to regulate flow. Flow rate of water can be measured with the help of measuring cylinder and stop watch, supplied with the set-up. A needle is introduced centrally in the bell mouth. Dye is fed to the needle from a small container, placed at the top of constant head tank, through polythene tubing.

6. UTILITIES REQUIRED:

Electricity Supply: Single Phase 220 V AC, 50Hz, 5-15 Amp. combined socket with earth connection.

Water Supply (Initial Fill).

Floor Drain Required.

Floor Area Required: 1.5 m x 0.75 m

Chemical Required: Dye ($KMnO_4$) - 10 gm

7. Experimental Procedure:

Starting Procedure:

Close all the valves V_1 to V_5.

Fill sump tank 3/4 with clean water and ensure that no foreign particles are there.

Prepare dye solution ($KMnO_4$ in water) in a beaker. Put this solution in Dye vessel after ensuring that there are no solid particles in solution.

Open by pass valve V_2.

Ensure that On/Off switch given on the panel is at OFF position.

Switch ON the main power supply and then switch on the pump.

Open control valve V_1 for water supply to constant head tank, partially close by pass valve V_2 and wait till overflow occurs.

Regulate minimum flow of water through glass tube by partial opening of control valve V_3 provided at the end of tube.

Then adjust the flow of dye through needle by knob, so that a fine colour thread is observed.Note the flow pattern observed (laminar, transition or turbulent).Measure flow Rate using measuring cylinder and stop watch.Repeat the experiment for different flow rate.

Closing Procedure:

Switch off pump.

Switch off power supply to panel.

Drain the apparatus completely by drain valves V_4 & V_5.

8. Observation & Calculations:

8.1 Data:	
Kinematic viscosity of water at ambient temp. ν	= 1.01E-06 m^2/sec
Dia. of glass tube d	= 0.010 m

8.2 Observation Table:

Sr. No.	t (sec)	V_o (ml)	Observed Flow Type (Laminar/Transition/Turbulant)
1			
2			
3			
4			
5			

8.3 Calculations:

$$Q = \frac{V_o \times 10^{-6}}{t} \ (m^3/sec)$$

$$a = \frac{\pi}{4} d^2 \ (m^2)$$

$$V = \frac{Q}{a} \ (m^3/sec)$$

$$Re = \frac{d \times V}{\nu}$$

9. Nomenclature:

Nom	Column Headings	Units	Type
a	Cross-sectional area of glass tube	m^2	Calculated
d	Diameter of glass tube	m	Given
Q	Discharge	m^3/sec	Calculated
R_e	Reynold's number		Calculated
t	Time taken for V_o	sec	Measured
V	Average velocity of fluid flow	m/sec	Calculated
V_o	Volume of water collected in measuring cylinder	ml	Measured
ν	Kinematic viscosity of water	m^2/sec	Given

10. Precaution & Maintenance Instructions:

Never run the apparatus if power supply is less than 200 Volts and above 230 Volts.

Conduct the experiment when water gets stable.

Always use clean water.

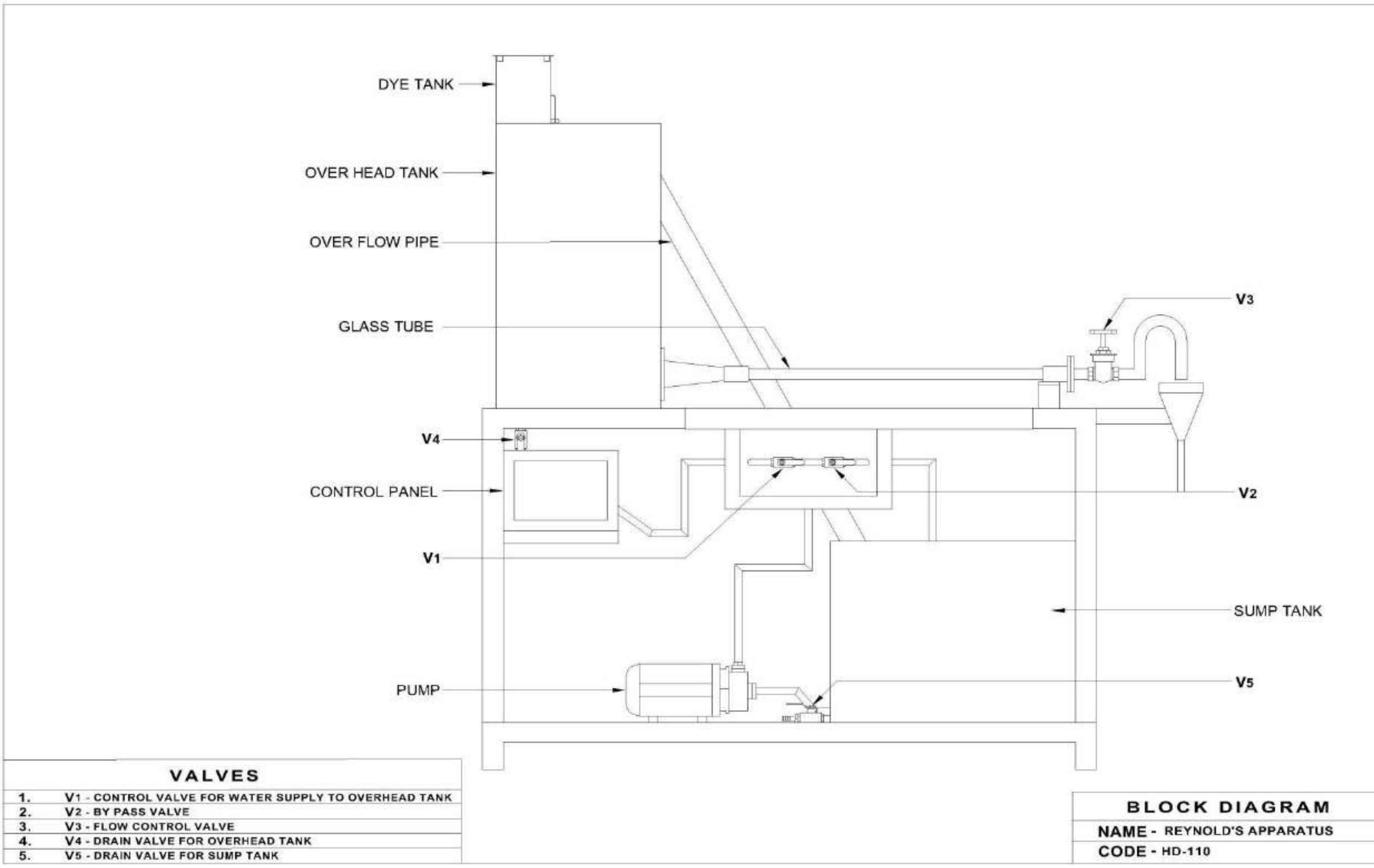
To prevent clogging of moving parts, run pump at least once in a fortnight.

11. Troubleshooting:

If dye blocks the needle, remove the needle by disconnecting it from constant head tank and pass air at some pressure through it.

Prepared By	Reviewed By	Approved By
		HOD MECHANICAL

BLOCK DIAGRAM



EXPERIMENT NO.8

Contents

Losses Due To Pipe Fittings, Sudden Enlargement & Contraction

1. Objective:

To study the losses of head due to various fittings in pipelines.

2. Aim:

To determine the loss of head in the fittings at the various water flow rates. To determine the loss co-efficient for the pipefittings.

3. Introduction:

Loss of head due to change in cross-section, bends, elbows, valves and fittings of all types fall into the category of minor losses in pipe lines. In long pipe lines the friction losses are much larger than these minor losses and hence the latter are often neglected. But, in shorter pipelines their consideration is necessary for the correct estimate of losses.

4. Theory:

When there is any type of bend in pipe, the velocity of flow changes, due to which the separation of the flow from the boundary and also formation of eddies, takes place. Thus the energy is lost. The losses of head due to fittings in pipe:

$$h_L = K_L \frac{V^2}{2g}$$

The minor losses in contraction can be expressed as:

$$h_L = K_L \frac{V_1^2}{2g}$$

The minor losses in enlargement can be expressed as:

$$h_L = K_L \frac{(V_1 - V_2)^2}{2g}$$

Where

h_L = Minor loss or head loss K_L

= Loss coefficient

V = Velocity of fluid.

V_1 = Velocity of fluid in pipe of small Diameter. V_2

= Velocity of fluid in pipe of large Diameter.

5. DESCRIPTION:

The apparatus consist of two pipes with different fittings. Bend, sudden expansion, sudden contraction and elbow are provided at pipe 1. Ball valve and gate valve are provided at pipe 2. Pressure tapings are provided at inlet and outlet of these fittings at suitable distance. A differential manometer fitted in the line gives head loss due to fittings. Supply to the pipeline is made through centrifugal pump, which deliver water from sump tank. The flow of water in pipes can be regulated by the valve provided at the end for pipe 1 and gate valve fitting for pipe 2. Discharge is measured with the help of measuring tank and stop watch.

6. UTILITIES REQUIRED:

Electricity Supply: Single Phase, 220 V AC, 50 Hz, 5-15 Amp. combined socket with earth connection.

Water Supply (Initial Fill).

Floor Drain Required.

Floor Area Required: 1.5 m x 0.75 m.

7. EXPERIMENTAL PROCEDURE:

STARTING PROCEDURE:

Close all the valves provided (V_1 to V_7).

Fill sump tank ¾ with clean water and ensure that no foreign particles are there.

Open by-pass valve V_1.

Connect the pressure taps of related test section to manometer.

Ensure that On/Off Switch given on the panel is at OFF position.

Switch ON the main power supply and switch ON the pump.

Open flow control valve V_2 of pipe 1 for bend, sudden enlargement, sudden contraction and elbow fitting or gate valve V_3 and ball valve V_4 of pipe 2 for ball valve & gate valve fitting.

Open Valve V_7 provided on the Manometer, slowly to release the air in manometer.

When there is no air in the manometer, close air release valve V_7.

Record the manometer reading, in case of pressure above scale in any tube apply air pressure by hand pump to get readable reading.

Measure the flow of water, discharged through desired test section, using stop watch and measuring tank.

Repeat same procedure for different flow rates of water, operating control valve (V_2 or V_3, V_4) and by pass valve V_1.

Repeat the experiment for other fittings of selected pipe.

When experiment is over for fittings of selected pipe, open the by-pass valve V_1 fully. Then close the flow control valve of pipe and open the control valve of other pipe (V_3, V_4 or V_2) and by pass valve V_1.

Repeat same procedure for selected test section and so on.

Closing Procedure:

When experiment is over, Switch off pump

Switch off power supply to panel.

Drain the apparatus completely with the help of drain valves provided (V_5 & V_6).

8. Observation & Calculations:

8.1 Data:

Area of measuring tank A = 0.077 m^2	Small pipe diameter d_1 = 0.016 m
Acceleration due to gravity g = 9.81 m/sec^2	Large pipe diameter d_2 = 0.028 m

8.2 OBSERVATION TABLE:

Sr. No.	h_1 (cm)	h_2 (cm)	R_1 (cm)	R_2 (cm)	t (sec)	Sr. No.	h_1 (cm)	h_2 (cm)	R_1 (cm)	R_2 (cm)	t (sec)
Sudden Contraction						**Sudden Expansion**					
1						1					
2						2					
3						3					
Bend						**Elbow**					
1						1					
2						2					
3						3					
Ball Valve						**Gate Valve**					
1						1					
2						2					
3						3					

8.3 CALCULATIONS:

$$R = \frac{R_1 - R_2}{100} \text{ (m)}$$

$$Q = \frac{A \times R}{t} \text{ (m}^3\text{/sec)}$$

$$a_1 = \frac{\pi}{4} d_1^2 \text{ (m}^2\text{)}$$

$$a_2 = \frac{\pi}{4} d_2^2 \text{ (m}^2\text{)}$$

$$V_1 = \frac{Q}{a_1}$$

$$V_2 = \frac{Q}{a_2}$$

2

(m/sec)

(m/sec)

2

(m)

$$h_L = \frac{h_1 - h_2}{100}$$

$$K_L = \frac{2g\,h_L}{V_1^2}$$ ***(For sudden contraction, Band, Elbow, Ball Valve, Gate valve)***

$$K_L = \frac{2g\,h_L}{(V_1 - V_2)^2}$$ ***(For sudden enlargement)***

9. Nomenclature:

Nom	Column Headings	Units	Type
A	Area of measuring tank	m^2	Given
a_1	Cross-sectional area of Small diameter Pipe	m^2	Calculated
a_2	Cross-sectional area of Large diameter Pipe	m^2	Calculated
d_1	Small diameter of pipe	m	Given
d_2	Large diameter of pipe	m	Given
g	Acceleration due to gravity	m/sec^2	Given
h_1, h_2	Manometric reading at both points	cm	Measured
h_L	Head loss	m of water	Calculated
K_L	Loss coefficient.		Calculated
Q	Discharge	m^3/sec	Calculated
R	Rise of water level in measuring tank	m	Calculated
R_1	Final level of water in measuring tank	cm	Measured
R_2	Initial level of water in measuring tank	cm	Measured
t	Time taken for R	sec	Measured
V_1	Velocity of fluid in pipe of small diameter	m/sec	Calculated
V_2	Velocity of fluid in pipe of large diameter	m/sec	Calculated

10. Precaution & Maintenance Instructions:

Never run the apparatus if power supply is less than 200 Volts and above 230 Volts.

Never fully close the flow control valves (V_2 or V_3, V_4) and by-pass valve V_1 simultaneously.

To prevent clogging of moving parts, Run Pump at least once in a fortnight.

11. Troubleshooting:

If pump gets jammed, open the back cover of pump and rotate the shaft manually.

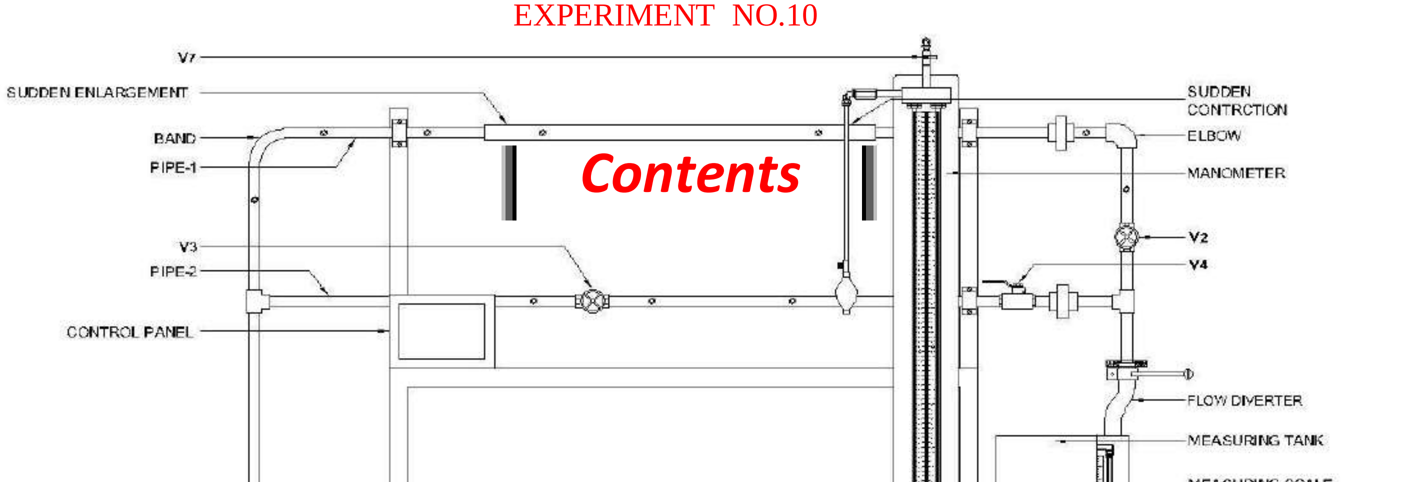
If pump gets heated up, switch off the main power for 30 minutes, avoid closing the flow control valve (V_2 or V_3, V_4) and by-pass valve V_1 simultaneously, during operation.

Prepared By	**Reviewed By**	**Approved By**
		HOD MECHANICAL

BLOCK DIAGRAM

EXPERIMENT NO.10

Contents



MECHANICAL ENGINEERING
FLUID MECHANICS AND HYDRAULICS MACHINE LAB(MEP-306)

Francis Turbine Test Rig (Output Power 1 kW)

1. Objective:

To study the operation of a Francis Turbine.

2. Aim:

To determine the output power of Francis Turbine.

To determine the efficiency of the Francis Turbine.

3. Introduction:

Francis Turbine, named after James Bichens Fransis, is a reaction type of turbine for medium high to medium low heads and medium small to medium large quantities of water. The reaction turbine operates with its wheel submerged in water. The water before entering the turbine has pressure as well as kinetic energy. The moment on the wheel is produced by both kinetic and pressure energies. The water leaving the turbine has still some of the pressure as well as kinetic energy.

4. Theory:

Originally the Francis turbine was designed as a purely radial flow type reaction turbine but modern Francis turbine is a mixed flow type in which water enters the runner radially inwards towards the centre and discharges out axially. It operates under medium heads and requires medium quantity of water.

5. Description:

The present set-up consists of a runner. The water is fed to the turbine by means of Centrifugal Pump, radially to the runner. The runner is directly mounted on one end of a central SS shaft and other end is connected to a brake arrangement. The circular window of the turbine casing is provided with a transparent acrylic sheet for observation of flow on to the runner. This runner assembly is supported by thick cast iron pedestal. Load is applied to the turbine with the help of brake drum arrangement so that the efficiency of the turbine can be calculated. A draft tube is fitted on the outlet of the turbine. The set-up is complete with guide mechanism. Pressure and vacuum gauges are fitted at the inlet and outlet of the turbine to measure the total supply head on the turbine.

6. Utilities Required:

Electricity Supply: Three Phase, 440 V AC, 50 Hz, 32 Amp. MCB 4 Pole, with earth connection.

Water supply (Initial Fill)

Floor Drain Required.

Floor Area Required: 2 m x 1 m

Tachometer for RPM measurement

Mercury for manometer: 250 gms.

7. Experimental Procedure:

Starting Procedure:

Close the drain valve V_7.

Fill sump tank ¾ with clean water and ensure that no foreign particles are there.

Fill manometer fluid i.e. Hg. in manometer by opening the valves of manometer and one PU pipe from pressure measurement point of pipe.

Connect the PU pipe back to its position and close the valves of manometer.

Ensure that there is no load on the brake drum.

Switch ON the Pump with the help of starter.

Open the air release valve V_5 & V_6 and valves for pitot tube V_3 & V_4 provided on the manometer, slowly to release the air from manometer. This should be done very carefully.

When there is no air in the manometer, close the air release valves V_5 & V_6.

Now turbine is in operation.

Apply load on load pan and make the pan to be lifted fro bore by hand wheel.

Partially open valve V_8 for cooling of brake drum.

Note the manometer reading, pressure gauge reading and vacuum gauge reading.

Note the RPM of the turbine.

Note the spring balance readings.

Repeat the same experiment for different load.

Regulate the discharge by regulating the guide vanes position.

Repeat the experiment for different discharge.

Closing Procedure:

When the experiment is over, first remove load from dynamometer.

Close the ball valves provided on manometer.

Switch OFF Pump with the help of starter.

Switch OFF main power supply.

Drain water from sump tank by drain valve V_7.

8. Observation & Calculation:

8.1 Data:	
Co-efficient of pitot tube C_v = 0.98	Diameter of pipe D = 0.08 m
Density of water ρ_w = 1000 kg/m^3	Diameter of rope d_R = 0.01 m
Density of manometer fluid (Hg)ρ_m=13600 kg/m^3	Diameter of brake drum d_B = 0.2 m

Acceleration due to gravity g = 9.81 m/sec^2	Weight of hanger W_3 =________kg
	Weight of rope W_4 =________kg

8.2 Observation Table:

S.No	N(RPM)	h_1(cm)	h_2(cm)	W_1(kg)	W_2(kg)	P_d(kg/cm^2)	P_S(mm Hg)
1							
2							
3							
4							
5							

8.3 Calculations:

$$H = 10\left(P_d + \frac{P_s}{760}\right) \text{ (m of water)}$$

$$A = \frac{\pi}{4} D^2 \text{ (m}^2\text{)}$$

$$h = \frac{h_1 - h_2}{100} \text{ (m)}$$

$$V = C_V \times \sqrt{2gh \times \left(\frac{\rho_m}{\rho_w} - 1\right)} \text{ (m/sec)}$$

$$Q = V \times A \text{ (m}^3\text{/sec)}$$

$$E = \frac{\rho_w \times g \times Q \times H}{1000}$$

(kW)

$$T = (W_1 + W_3 + W_4 - W_2) \times g \times R_e \text{ (N m)}$$

$$R_e = \frac{d_B + 2d_R}{2} \text{ (m)}$$

$$E_o = \frac{2 \times \pi \times N \times T}{60 \times 1000}$$

(kW)

$$\eta = \frac{E_o}{E_i} \times 100 \text{ (\%)}$$

9. Nomenclature:

Nom	Column Heading	Units	Type
A	Cross-sectional area of pipe	m^2	Given
C_v	Co-efficient of pitot tube		Given
D	Diameter of pipe	m	Given
d_B	Diameter of brake drum	m	Given
d_R	Diameter of rope	m	Given
E_i	Input power	kW	Calculated
E_o	Output power	kW	Calculated
g	Acceleration due to gravity	m/sec^2	Given
H	Total head	m	Calculated
h	Differential pressure of manometer	m	Calculated
h_1, h_2	Manometer reading at both points	cm	Measured
N	RPM of runner shaft	RPM	Measured
P_d	Delivery pressure	kg/cm^2	Measured
P_S	Suction pressure	mm of Hg	Measured
Q	Discharge	m^3/sec	Calculated
R_e	Equivalent radius	m	Calculated
T	Torque	N m	Calculated
V	Velocity of water	m/sec	Calculated
W_1	Applied weight	kg	Measured
W_2	Dead weight (obtain from spring balance)	kg	Measured
W_3	Weight of hanger	kg	Given
W_4	Weight of rope	kg	Given
ρ_m	Density of manometer fluid (Hg)	kg/m^3	Given
ρ_w	Density of water	kg/m^3	Given
η	Turbine efficiency	%	Calculated

10. Precaution & Maintenance Instructions:

Never run the apparatus if power supply is less than 390 Volts and above 420 Volts

To prevent clogging of moving parts, run pump at least once in a fortnight.

Always use clean water.

11. Troubleshooting:

If pump does not lift the water, the revolution of the motor may be reverse. Change the electric connection to change the revolutions.

If panel is not showing input, check the main supply.

Prepared By	**Reviewed By**	**Approved By**
		HOD MECHANICAL

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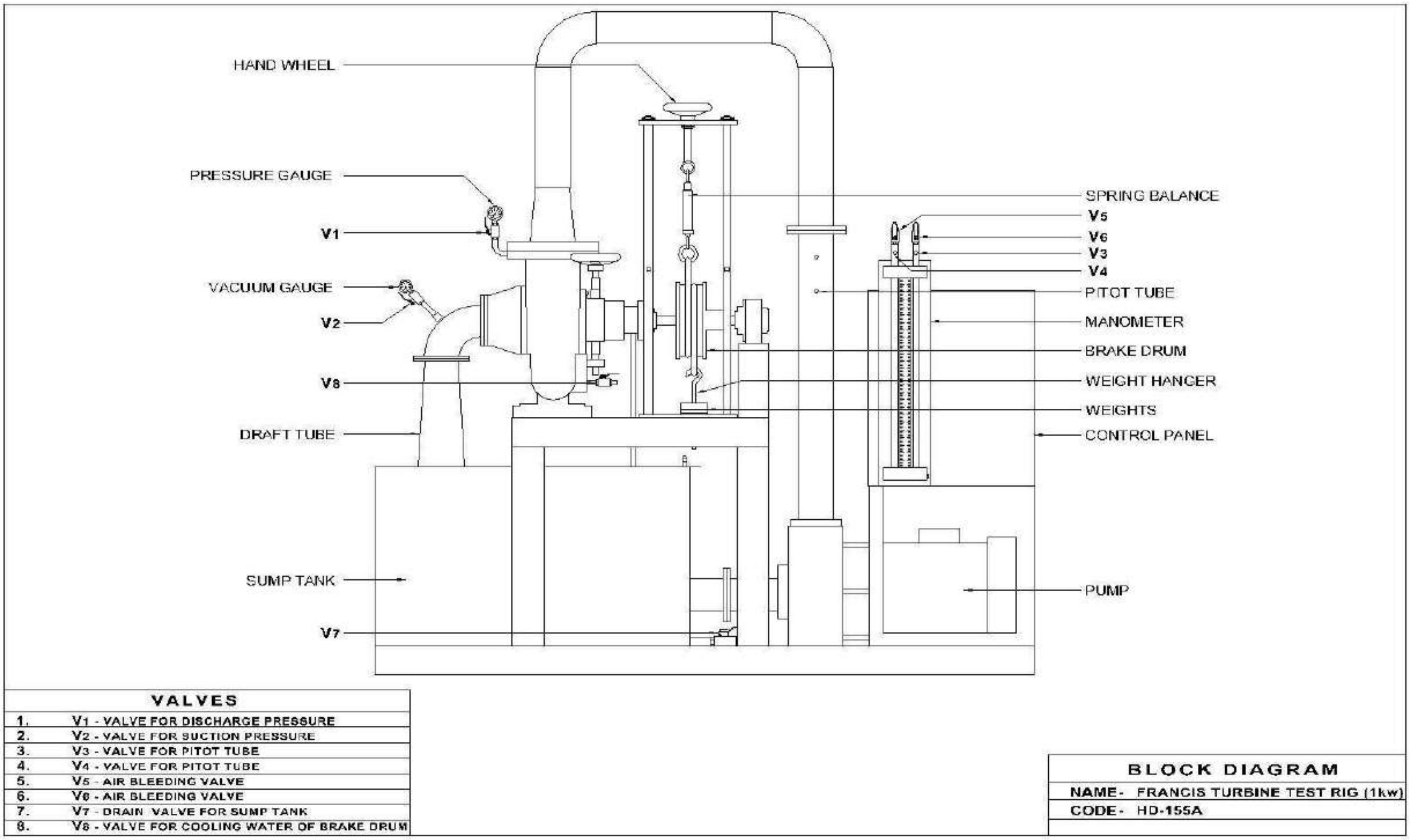


EXPERIMENT NO.10

Contents

FRANCIS TURBINE TEST RIG (OUTPUT POWER 1 kW)

12. OBJECTIVE:

To study the operation of a Francis Turbine.

13. AIM:

To determine the output power of Francis Turbine.

To determine the efficiency of the Francis Turbine.

14. INTRODUCTION:

Francis Turbine, named after James Bichens Fransis, is a reaction type of turbine for medium high to medium low heads and medium small to medium large quantities of water. The reaction turbine operates with its wheel submerged in water. The water before entering the turbine has pressure as well as kinetic energy. The moment on the wheel is produced by both kinetic and pressure energies. The water leaving the turbine has still some of the pressure as well as kinetic energy.

15. THEORY:

Originally the Francis turbine was designed as a purely radial flow type reaction turbine but modern Francis turbine is a mixed flow type in which water enters the runner radially inwards towards the centre and discharges out axially. It operates under medium heads and requires medium quantity of water.

16. DESCRIPTION:

The present set-up consists of a runner. The water is fed to the turbine by means of Centrifugal Pump, radially to the runner. The runner is directly mounted on one end of a central SS shaft and other end is connected to a brake arrangement. The circular window of the turbine casing is provided with a transparent acrylic sheet for observation of flow on to the runner. This runner assembly is supported by thick cast iron pedestal. Load is applied to the turbine with the help of brake drum arrangement so that the efficiency of the turbine can be calculated. A draft tube is fitted on the outlet of the turbine. The set-up is complete with guide mechanism. Pressure and vacuum gauges

are fitted at the inlet and outlet of the turbine to measure the total supply head on the turbine.

17. Utilities Required:

Electricity Supply: Three Phase, 440 V AC, 50 Hz, 32 Amp. MCB 4 Pole, with earth connection.

Water supply (Initial Fill)

Floor Drain Required.

Floor Area Required: 2 m x 1 m

Tachometer for RPM measurement

Mercury for manometer: 250 gms.

18. Experimental Procedure:

Starting Procedure:

Close the drain valve V_7.

Fill sump tank ¾ with clean water and ensure that no foreign particles are there.

Fill manometer fluid i.e. Hg. in manometer by opening the valves of manometer and one PU pipe from pressure measurement point of pipe.

Connect the PU pipe back to its position and close the valves of manometer.

Ensure that there is no load on the brake drum.

Switch ON the Pump with the help of starter.

Open the air release valve V_5 & V_6 and valves for pitot tube V_3 & V_4 provided on the manometer, slowly to release the air from manometer. This should be done very carefully.

When there is no air in the manometer, close the air release valves V_5 & V_6.

Now turbine is in operation.

Apply load on load pan and make the pan to be lifted fro bore by hand wheel.

Partially open valve V_8 for cooling of brake drum.

Note the manometer reading, pressure gauge reading and vacuum gauge reading.

Note the RPM of the turbine.

Note the spring balance readings.

Repeat the same experiment for different load.

Regulate the discharge by regulating the guide vanes position.

Repeat the experiment for different discharge.

Closing Procedure:

When the experiment is over, first remove load from dynamometer.

Close the ball valves provided on manometer.

Switch OFF Pump with the help of starter.

Switch OFF main power supply.

Drain water from sump tank by drain valve V_7.

19. Observation & Calculation:

8.1 Data:

Co-efficient of pitot tube C_v = 0.98	Diameter of pipe D = 0.08 m
Density of water ρ_w = 1000 kg/m^3	Diameter of rope d_R = 0.01 m
Density of manometer fluid (Hg)ρ_m=13600 kg/m^3	Diameter of brake drum d_B = 0.2 m
Acceleration due to gravity g = 9.81 m/sec^2	Weight of hanger W_3 =________kg
	Weight of rope W_4 =________kg

8.2 Observation Table:

S.No	N(RPM)	h_1(cm)	h_2(cm)	W_1(kg)	W_2(kg)	P_d(kg/cm^2)	P_S(mm Hg)
1							
2							
3							
4							
5							

8.3 Calculations:

$$H = 10\left(P_d + \frac{P_S}{760}\right) \text{ (m of water)}$$

$$A = \frac{\pi}{4} D^2 \text{ (m}^2\text{)}$$

$$h = \frac{h_1 - h_2}{100} \text{ (m)}$$

$$V = C_V \times \sqrt{2gh \times \left(\frac{\rho_m}{\rho_w} - 1\right)} \text{ (m/sec)}$$

$$Q = V \times A \text{ (m}^3\text{/sec)}$$

$$E = \frac{\rho_w \times g \times Q \times H}{\quad}$$

1000 (kW)

$$T = \left(W_1 + W_3 + W_4 - W_2\right) \times g \times R_e \text{ (N m)}$$

$$R_e = \frac{d_B + 2d_R}{2} \text{ (m)}$$

$$E_o = \frac{2 \times \pi \times N \times T}{60 \times 1000} \text{ (kW)}$$

$$\eta = \frac{E_o}{E_i} \times 100 \text{ (\%)}$$

20. Nomenclature:

Nom	Column Heading	Units	Type
A	Cross-sectional area of pipe	m^2	Given
C_v	Co-efficient of pitot tube		Given
D	Diameter of pipe	m	Given
d_B	Diameter of brake drum	m	Given
d_R	Diameter of rope	m	Given
E_i	Input power	kW	Calculated
E_o	Output power	kW	Calculated
g	Acceleration due to gravity	m/sec^2	Given
H	Total head	m	Calculated
h	Differential pressure of manometer	m	Calculated
$h_{1,}h_2$	Manometer reading at both points	cm	Measured
N	RPM of runner shaft	RPM	Measured
P_d	Delivery pressure	kg/cm^2	Measured
P_S	Suction pressure	mm of Hg	Measured
Q	Discharge	m^3/sec	Calculated
R_e	Equivalent radius	m	Calculated
T	Torque	N m	Calculated
V	Velocity of water	m/sec	Calculated
W_1	Applied weight	kg	Measured
W_2	Dead weight (obtain from spring balance)	kg	Measured
W_3	Weight of hanger	kg	Given
W_4	Weight of rope	kg	Given
ρ_m	Density of manometer fluid (Hg)	kg/m^3	Given
ρ_w	Density of water	kg/m^3	Given
η	Turbine efficiency	%	Calculated

21. Precaution & Maintenance Instructions:

Never run the apparatus if power supply is less than 390 Volts and above 420 Volts

To prevent clogging of moving parts, run pump at least once in a fortnight.

Always use clean water.

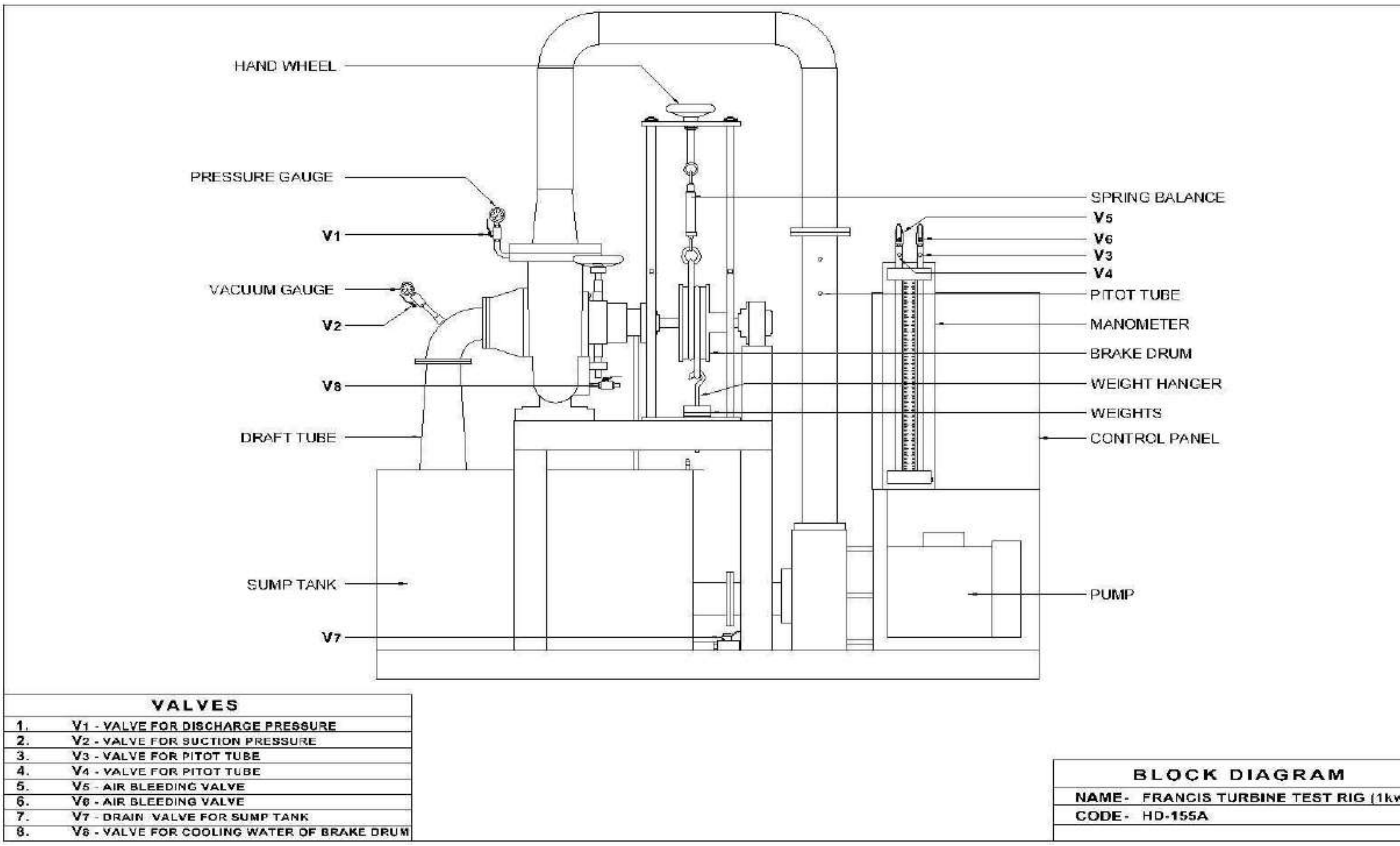
22. Troubleshooting:

If pump does not lift the water, the revolution of the motor may be reverse. Change the electric connection to change the revolutions.

If panel is not showing input, check the main supply.

Prepared By	Reviewed By	Approved By
		HOD MECHANICAL

Block Diagram



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EXPERIMENTNO.11

Contents

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CENTRIFUGAL PUMP TEST RIG (VARIABLE SPEED)

1. OBJECTIVE:

Study of centrifugal pump characteristics.

2. AIM:

To determine;

Power input

Shaft output

Discharge

Total head

Pump output

Overall efficiency

Pump efficiency

2. 2 To plot the following performance characteristics:

Head Vs Discharge

Pump efficiency Vs Discharge

3. INTRODUCTION:

The hydraulic machines, which convert the mechanical energy into hydraulic energy, are called pumps. The hydraulic energy is in the form of pressure energy. If the mechanical energy is converted into pressure energy by means of centrifugal force acting on the fluid, the hydraulic machine is called centrifugal pump.

4. THEORY:

The centrifugal pump acts as a reversed of an inward radial flow reaction turbine. This means that the flow in centrifugal pumps is in the radial outward directions. The centrifugal pump works on the principle of forced vortex flow, which means that an external torque rotates a certain mass of liquid, the rise in pressure head of the rotating liquid takes place. The rise in pressure head at any point of the rotating liquid is proportional to the square of tangential velocity of (i.e. rise in pressure head = $V^2/ 2g$ or

$\omega^2 r^2/2g$) the liquid at that point. Thus at the outlet of the impeller where radius is more, the rise in pressure head will be more and the liquid will be discharged at the outlet with a high- pressure head. Due to this high-pressure head, the liquid can be lifted to a high level.

Centrifugal Pump is a mechanical device, which consists of a body, impeller and a rotating mean i.e. motor, engine etc. Impeller rotates in a stationary body and sucks the fluid through its axes and delivers through its periphery. Impeller has an inlet angle, outlet angle and peripheral speed, which affect the head and discharge.Impeller is rotated by motor or i.c. engine or any other device.

5. Description:

Centrifugal Pump Test Rig consists of a sump, a centrifugal pump, a DC motor and measuring tank. To measure the head, pressure and vacuum gauges are provided. To measure the discharge, a measuring tank is provided. Flow diversion system is provided to divert flow from sump tank to measuring tank and from measuring tank to sump tank. A valve is provided in pipeline to change the flow rate.

6. Utilities Required:

Electricity Supply: Single Phase, 220 VAC, 50 Hz, 5-15 Amp. combined socket with earth connection.

Water Supply (Initial Fill).

Floor Drain Required.

Floor Area Required: 2 m x 1 m

7. Experimental Procedure:

Starting Procedure:

Clean the apparatus and make all tanks free from dust.

Close the drain valves V_5 & V_6.

Fill sump tank ¾ with clean water and ensure that no foreign particles are there.

Open flow control valve V_1 given on the water discharge line and control valve V_2 given on suction line.

Ensure that all ON/OFF switches given on the panel are at OFF position. Switch on the motor.

Set the desired RPM of pump with the speed control knob provided at the control panel.

Operate the flow control valve V_1 to regulate the flow of water discharged by the pump.

Operate the control valve V_2 to regulate the suction of the pump.

Record discharge pressure by means of Pressure Gauge, provided on discharge line. (Partially close valve V_3 in case of fluctuation.)

Record suction pressure by means of Vacuum Gauge, provided at suction of the pump. (Partially close valve V_4 in case of fluctuation.)

Record the time for 10-20 pulses by means of energy meter and stop watch.

Measure the discharged water by using measuring tank and stop watch.

Repeat the same procedure for different discharge with constant speed.

Repeat the same procedure for different speeds of pump.

CLOSING PROCEDURE:

When experiment is over, open valve V_1 provided on discharge line.

Reduce the RPM of the pump with the help of DC Drive to Zero.

Switch OFF the pump.

Switch OFF power supply to panel.

Drain the tanks by valve V_5 & V_6.

8. Observation & Calculation:

8.1 Data:

Acceleration due to gravity g = 9.81 m/sec^2	Area of measuring tank A = 0.128 m^2
Energy meter constant EMC = 3200 Pulses/kW hr	Density of water P_w = 1000 kg/m^3
Height of pressure gauge from suction of pump h_{pg} = 1 m	Motor efficiency ηm = 0.8

8.2 Observation Table:

S.No.	N (RPM)	P_d (kg/cm^2)	P_S (mmHg)	R_1 (cm)	R_2 (cm)	t (sec)	P	t_p (sec)
1								
2								
3								
4								
5								

8.3 Calculations:

$$E_i = \frac{P}{t_p} \times \frac{3600}{EMC} \text{ (kW)}$$

$$E_S = E_i \times \eta_m \text{ (kW)}$$

$$R = \frac{R_1 - R_2}{100} \text{ (m)}$$

$$Q = \frac{A \times R}{t}$$

(m^3/sec)

$$H = 10 \times \left[P_d + \frac{P_s}{760} \right] + h \quad \text{(m of water)}$$

pg

$$E_o = \frac{\rho \times g \times Q \times H}{1000} \text{ (kW)}$$

$$\eta_o = \frac{E_o}{E_i} \times 100(\%)$$

$$\eta_p = \frac{E_o}{E_s} \times 100\ (\%)$$

9. Nomenclature:

Nom	Column Heading	Units	Type
A	Area of measuring tank	m^2	Given
EMC	Energy meter constant	Pulses/ kW hr	Given
E_i	Pump input	kW	Calculated
E_S	Shaft output	kW	Calculated
E_o	Pump output	kW	Calculated
g	Acceleration due to gravity	m/sec^2	Given
H	Total Head	m	Calculated
h_{pg}	Height of pressure gauge from suction of pump	m	Given
N	Speed of Pump	RPM	Measured
P	Pulses of energy meter		Measured
P_d	Delivery pressure	kg/cm^2	Measured
P_S	Suction pressure	mm of Hg	Measured
Q	Discharge	M^3/sec	Calculated
R	Rise of water level in measuring tank	M	Calculated
R_1	Final level of water in measuring tank	cm	Measured
R_2	Initial level of water in measuring tank	cm	Measured
t	Time taken by R	sec	Measured
t_p	Time taken by P	sec	Measured
ρ	Density of water	kg/m^3	Given
η_p	Pump efficiency	%	Calculated

η_o	Overall efficiency	%	Calculated
η_m	Motor efficiency		Given

10. PRECAUTION & MAINTENANCE INSTRUCTIONS:

Never run the apparatus if power supply is less than 200 Volts and above 230 Volts

Never fully close the delivery line valve V_1.

To prevent clogging of moving parts, run pump at least once in a fortnight

11. TROUBLESHOOTING:

If pump does not lift the water, open the air vent provided on the pump to remove the air from pump.

If still water is not lifting the revolution of the DC motor may be reverse. Change the electric connection of motor to change the revolutions.

If panel is not showing input, check the main supply.

If field failure (FF) indicates on the control panel and the motor is not moving, check the fuses if burnt, change it.

If overload (OL) indicates on the panel and motor stop moving, open the valve at suction and discharge line to reduce load and restart motor after 5-10 minutes.

Prepared By	Reviewed By	Approved By

		HOD MECHANICAL

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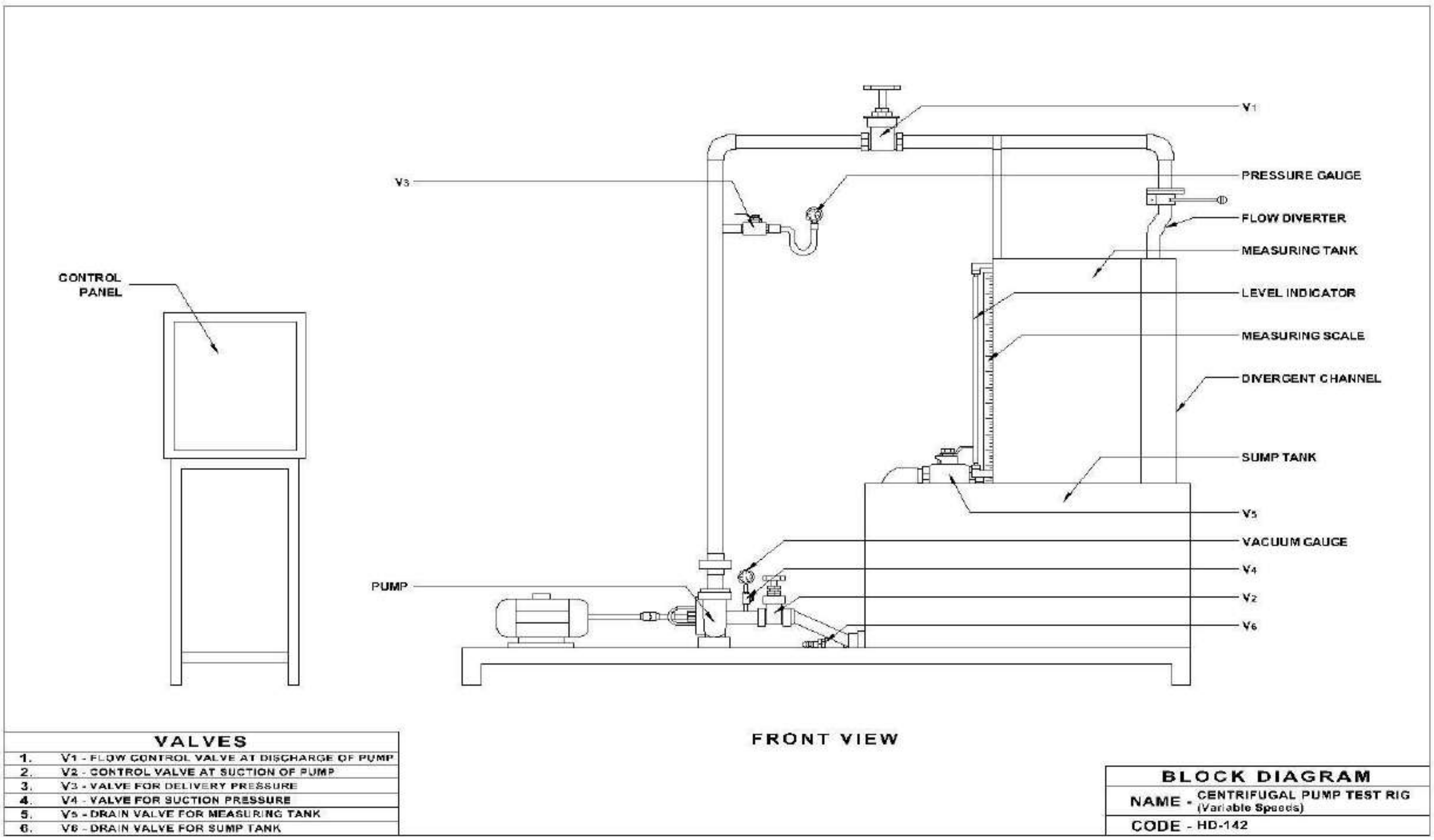
BLOCK DIAGRAM



CHANDIGARH UNIVERSITY Discover. Learn. Empower.	DEPARTMENT OF MECHANICAL ENGINEERING
HEAT AND MASS TRANSFER LAB	Subject Code: **(MEP-327)**

HEAT TRANSFER LAB

COURSE CODE: MEP – 327

CHANDIGARH UNIVERSITY Discover. Learn. Empower.	DEPARTMENT OF MECHANICAL ENGINEERING
HEAT AND MASS TRANSFER LAB	Subject Code: **(MEP-327)**

Vision and Mission of the Chandigarh University

Vision

"To be globally recognized as a Centre of Excellence for Research, Innovation, Entrepreneurship and disseminating knowledge by providing inspirational learning to produce professional leaders for serving the society"

Mission

M1: Providing world class infrastructure, renowned academicians and ideal environment for Research, Innovation, Consultancy and Entrepreneurship relevant to the society.

M2: Offering programs & courses in consonance with National policies for nation building and meeting global challenges.

M3: Designing Curriculum to match International standards, needs of Industry, civil society and for inculcation of traits of Creative Thinking and Critical Analysis as well as Human and Ethical values.

M4: Ensuring students delight by meeting their aspirations through blended learning, corporate mentoring, professional grooming, flexible curriculum and healthy atmosphere based on co-curricular and extra-curricular activities.

M5: Creating a scientific, transparent and objective examination/evaluation system to ensure an ideal certification.

M6: Establishing strategic relationships with leading National and International corporates and universities for academic as well as research collaborations.

M7: Contributing for creation of healthy, vibrant and sustainable society by involving in Institutional Social Responsibility (ISR) activities like rural development, welfare of senior citizens, women empowerment, community service, health and hygiene awareness and environmental protection

	DEPARTMENT OF MECHANICAL ENGINEERING
HEAT AND MASS TRANSFER LAB	Subject Code: **(MEP-327)**

Vision and Mission of the Department of Mechanical Engineering

Vision

To be recognized as a center of excellence for research and innovation in Mechanical Engineering through contemporary as well as futuristic tools and technologies for serving the society at regional, national and global level

Mission

M1: Providing quality education to the students in core and allied fields by implementing advanced pedagogies

M2: Encouraging students towards research and development through advanced tools and technologies for providing solution to societal problems

M3: Evolve and empower the students through core technical skills for becoming entrepreneurs and innovators

M4: Inculcating employability and leadership skill for ensuring industry ready professional through hands on experiential learning and industrial collaboration

M5: Developing professional and ethical standards in the mind of the young engineers by continuous learning and professional activities

1.2 .State the Program Educational Objectives (PEOs)(5)

PROGRAM EDUCATION OBJECTIVES (PEOs):

PEO1: Mechanical Engineering graduates will have professional knowledge in the field of Mechanical Engineering and its allied branches.

PEO2: Graduates will have successful career in government services, research organizations, academic institutes and industries at national and international repute.

PEO3: The graduates will be capable of utilizing modern tools and technologies for deliberating solutions to engineering problems.

PEO4: Graduate will be able to identify the concern for Society, environment and communicate effectively while leading the interdisciplinary diverse team under divergent needs.

PEO5: To produce graduates adaptable for higher education, research and development, creativity, innovations, entrepreneurship and professional development.

Program Outcome (POs)

PO1: Ability to apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.

PO2: Ability to identify, formulate, research literature and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

PO3: Ability to design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.

PO4: Ability to conduct investigation into complex problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.

PO5: Ability to create, select and apply appropriate techniques, resources and modern engineering and IT tools, including prediction and modelling, to complex engineering activities, with an understanding of the limitations.

PO6: Ability to apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.

PO7: Ability to recognize and incorporate the diversity and commonalities of engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.

PO8: Ability to apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

PO9: Ability to function effectively as an individual and as member or leader in a diverse teams and interdisciplinary settings.

PO10: Ability to communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

PO11: Ability to demonstrate knowledge and understanding of the engineering and management principles and also apply these principles to one's own work as member and leader to the teams to manage projects and interdisciplinary teams.

PO12: Ability to recognize the need for, and have the preparations and ability to engage in Independent and lifelong learning in the broadest context of technological change

CHANDIGARH UNIVERSITY Discover. Learn. Empower.	**DEPARTMENT OF MECHANICAL ENGINEERING**
HEAT AND MASS TRANSFER LAB	Subject Code: **(MEP-327)**

Program Specific Outcomes:

PSO1: Apply the knowledge of Production and Manufacturing concepts for analysis and development of Mechanical systems.

PSO2: Apply the Principle of Design and Thermal Engineering to construct various components and systems.

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HEAT AND MASS TRANSFER LAB	Subject Code: **(MEP-327)**

HEAT TRANSFER LAB

Course Objectives

The objective of this lab is to provide a Fundamental Understanding of the Principles of Heat Transfer Due to Convection, Conduction, Radiation and the Principles of Thermal Design of Heat Exchanger.
Also Determining the Thermal Conductivity of Materials Course Outcomes

After completion of course the student will be able to:

CO1	Apply the basic concepts of heat transfer mode under different situations.
CO2	Analyze the engineering problems related to conductive, convective and radiation heat transfer.
CO3	Conduct the experiment individual/team ethically, considering social, health, safety, legal and environmental aspects.
CO4	Interpret the data and apply appropriate technique or tool for the solution of heat transfer related engineering problem.
CO5	Conclude the experimental results and express the same effectively in oral and written manners through report and practical presentation.

LIST OF EXPERIMENTS

1. To determine the thermal conductivity of metal bar.
2. To determine the thermal conductivity of insulating powder.
3. To analyze the conduction heat transfer in composite wall.
4. To demonstrate experimentally convection heat transfer in natural convection.
5. To examine the convection heat transfer in forced convection.
6. To analyze the radiation heat transfer by black body.
7. To analyze the conduction heat transfer from pin fin.
8. To demonstrate experimentally heat transfer through lagged pipe.
9. To examine the heat transfer phenomenon in parallel/ counter arrangement.
10. To find out Stefan Boltzmann constant experimentally.

THERMAL CONDUCTIVITY OF INSULATIING POWDER

1. OBJECTIVE: Study of conduction heat transfer through insulating powder.

2. AIM: To determine Thermal Conductivity of Insulating Powder

3. INTRODUCTION:

In many heat transfer equipments, heat loss to surroundings is to be minimized to achieve maximum economy. In such cases they are lagged by materials of lower thermal conductivity, which are referred as insulators. Because of demand of such insulating materials, many industries have come up to produce such material. Preference is given to produce materials having lower and lower thermal conductivities. Also their material is available in different shapes, sizes and forms of powders. Powders have the advantage that they can take any complicated shape between any two confirming surfaces. In addition its conductivity will be much lower than that of the Basic solid from which the powder has been made. This is because of a very large number of air spaces in between particles, which have much lower thermal conductivity values. Thermal conductivity of such material is a complicated function of the Geometry of the particles, particle thermal conductivity, the nature of heat transfer, conduction, convection and radiation in air spaces, which is determined by the air space size and temperature level etc. Thus it is very difficult quantity to estimate and almost in all practical cases it is measured experimentally. The set-up provided is one such apparatus to find the thermal conductivity values.

4. THEORY:

Consider the transfer of heat by conduction through the wall of hollow sphere formed by the insulating powdered layer packed between two thin copper spheres.

Let r_i = radius of inner sphere in meter

r_o = radius of outer sphere in meter

T_i = average temperature of the inner surface in ºC

T_o = average temperature of the outer surface in ºC

Where,
$$T_i = \frac{T_1 + T_2 + T_3 + T_4}{4}$$

and
$$T_o = \frac{T_5 + T_6 + T_7 + T_8 + T_9 + T_{10}}{6}$$

From the Experimental values of q, T_i and T_o, the unknown thermal conductivity k can be determined as:

$$k = \frac{q(r_o - r_i)}{4\pi r_i r_o (T_i - T_o)}$$

5. DESCRIPTION:

The apparatus consists of two thin walled concentric spheres of copper of different size. The small inner copper sphere houses the heating coil. The insulating Powder (**ASBESTOS**) is packed between the two spheres. The power given to the heating coil is measured by Voltmeter and Ammeter and can be varied by using Dimmerstat. There are ten (T_1 to T_{10}) Thermocouples embedded on the copper spheres, T_1 to T_4 (4 Nos.) are embedded on the inner sphere and rest T_5 to T_{10} (6 Nos.) on the outer sphere. Thermal Conductivity of Insulating Powder can be finding out by taking the temperature reading of these thermocouples. Assume that Insulating Powder is an isotropic material and the value of Thermal Conductivity to be constant. The apparatus assumes one dimensional radial heat conduction across the powder and thermal conductivity can be determined.

6. UTILITIES REQUIRED:

Electricity Supply: 1 Phase, 220 V AC, 2 Amp.

Table for set-up support (optional)

7. EXPERIMENTAL PROCEDURE:

1. Switch on the main power supply 220 AC single phase, 50 Hz.
2. Increase slowly the input to heater by the dimmerstat starting from zero volt position.
3. Adjust the heat input by Voltmeter and Ammeter.
4. Thermocouple readings are taken at frequent intervals (say once in 10 minutes) till consecutive readings are same indicating that steady state has been reached.
5. Note down the readings in the observation table.

8. SPECIFICATION:

Radius of the inner copper sphere, r_i	:	50mm
Radius of the outer copper sphere, r_o	:	100mm
Voltmeter	:	0-500 V
Ammeter	:	0-2 A
Temperature Indicator	:	0-200ºC.
Dimmerstat	:	0-2A, 0-230 V

Heater coil-Strip Heating Element Sandwiched between mica sheets

Thermocouples No. T_1 to T_4 embedded on the inner sphere to measure T_i

Thermocouples No. T_5 to T_{10} embedded on the outer sphere to measure T_o

Insulating Powder-Plaster of Paris commercially available powder and packed between the two spheres.

9. FORMUALE:

1. Heat input, $Q = V * I$ **,** Watt

2. Thermal conductivity of insulating power:

$$K = \frac{Q(r_o - r_i)}{4\pi r_o r_i (T_i - T_o)}, Watt/m -{}^{O} C$$

There is a possibility of getting abrupt result if the supply voltage is fluctuating or if the input is not adjusted till the satisfactory steady state condition reached.

10. OBSERVATIONS & CALCULATIONS:

DATA:

Radius of inner sphere	r_i	=	50 mm
Radius of outer sphere	r_o	=	100 mm

OBSERVATIONS:

1.	Voltmeter reading	(V)	=	V
2.	Ammeter reading	(I)	=	A
3.	Heater Input	Q	=	V x I Watts

INNER SPHERE:

Thermocouple No	T_1	T_2	T_3	T_4	Mean temperature $T_i = \frac{T_1 + T_2 + T_3 + T_4}{4}$
Temperature °C					

OUTER SPHERE:

Thermocouple No	T_1	T_2	T_3	T_4	T_5	T_6	Mean temperature $T_o = \frac{T_5 + T_6 + T_7 + T_8 + T_9 + T_{10}}{6}$
Temperature °C							

CALCULATIONS:

Calculate the value of k by using the equation

$$k = \frac{Q(r_o - r_i)}{4\pi r_i r_o (T_i - T_o)}$$

11. NOMENCLATURE:

r_i = Inner Radius (meters)

r_o = Outer Radius (meters)

T_i = Inside surface temperature °C

T_o = Outside surface temperature °C

Q = Heat Input.

V = Voltmeter reading.

I = Ammeter reading

12. PRECAUTIONS & MAINTENANCE INSTRUCTIONS:

1. Use the stabilize A.C. Single Phase supply only.
2. Never switch on mains power supply before ensuring that all the ON/OFF switches given on the panel are at OFF position.
3. Voltage to heater starts and increases slowly.
4. Keep all the assembly undisturbed.
5. Never run the apparatus if power supply is less than 180 volts and above than 240 volts.
6. Operate selector switch of temperature indicator gently.
7. Always keep the apparatus free from dust.

There is a possibility of getting abrupt result if the supply voltage is fluctuating or if the satisfactory steady state condition is not reached**.**

13. TROUBLESHOOTING:

1. If electric panel is not showing the input on the mains light. Check the fuse and also check the main supply.
2. If D.T.I displays "1" on the screen check the computer socket if loose tight it.
3. If temperature of any sensor is not displays in D.T.I check the connection and rectify that.
4. Voltmeter showing the voltage given to heater but ampere meter does not. Tight the heater socket & switch if ok it means heater burned.

HEAT TRANSFER THROUGH COMPOSITE WALL

1. OBJECTIVE: Study of conduction heat transfer in composite wall.

2. AIM: To determine total thermal resistance and thermal conductivity of composite wall

To plot the temperature profile along the composite wall.

3. INTRODUCTION:

When a temperature gradient exists in a body, there is an energy transfer from the high temperature region to the low temperature region. Energy is transferred by conduction and heat transfer rate per unit area is proportional to the normal temperature gradient:

$$\frac{q}{A} \approx \frac{\partial T}{\partial X}$$

When the proportionality constant is inserted,

$$q = -kA\frac{\partial T}{\partial X}$$

Where q is the heat transfer rate and $\partial T/ \partial X$ is the temperature gradient in the direction of heat flow. The positive constant k is called thermal conductivity of the material.

4. THEORY:

A direct application of Fourier's law is the plane wall. Fourier's equation:

$$\mathbf{q = \frac{-kA}{\Delta X}(T_2 - T_1)}$$

When the thermal conductivity is considered constant. The wall thickness is ΔX, and T_1 and T_2 are surface temperatures. If more than one material is present, as in the multiplayer wall, the analysis would proceed as follows:

The temperature gradients in the three materials (A, B, C), the heat flow may be written

$$q = -k_A A \frac{\Delta T_A}{\Delta X_A} = -k_B A \frac{\Delta T_B}{\Delta X_B} = -k_C A \frac{\Delta T_C}{\Delta X_C}$$

The heat flow must be same through all sections. Solving these three equations simultaneously, the heat flow is written as

$$q = \frac{T_C - T_A}{\Delta X_A / K_A A + \Delta X_B / k_B A + \Delta X_C / k_C A}$$

5. DESCRIPTION:

The Apparatus consists of a heater sandwiched between two asbestos sheets. Three slabs of different material are provided on both sides of heater, which forms a composite structure. A small press- frame is provided to ensure the perfect contact between the slabs. A Variac is provided for varying the input to the heater and measurement of input power is carried out by a Digital Voltmeter & Digital Ammeter. Temperatures Sensors are embedded between inter faces of the slab, to read the temperature at the surface. The experiment can be conducted at various values of power input and calculations can be made accordingly.

6. UTILITIES REQUIRED:

Electricity Supply: 1 Phase, 220 V AC, 2 Amp.

Table for set-up support (optional)

7. EXPERIMENTAL PROCEDURE:

1. Start the supply of heater by varying the dimmerstat.
2. Adjust the power input at the desired value.
3. Take readings of all the temperature sensors after steady temperatures are achieved and rate of rise is negligible.
4. Note down readings in the observation table.

8. SPECIFICATION:

Slab Sizes:

Cast Iron : Diameter = 300 mm, Thickness = 25 mm.

Bakelite : Diameter = 300 mm, Thickness = 21 mm.

Press Wood : Diameter = 300 mm, Thickness = 19 mm.

Heater : Nichrome heater (750Watt) wounded on mica and insulated with mica and asbestos is provided.

Control Panel : The control panel consists of Digital voltmeter (0-500 V), Digital Ammeter (0-2.0 Amps), Digital temperature indicator with multi channel switch, Variac (2.0 Amps @ 220VAC) to control the heat input to the heater.

Temp sensors : RTD PT-100 type (8 nos.)

Whole assembly is fitted on a MS powder coated base plate to give the setup more strength and rigidness.

9. FORMULAE:

1. Heat input,

$$Q = V * I$$ **, Watt**

2. Heat Flux

$$q = \frac{Q}{A}$$ **, Watt/m²**

3. Total thermal resistance,

$$R_t = \frac{\Delta T}{q}$$ **, °C-m²/Watt**

4. Thermal conductivity of composite wall,

$$K_{eff} = \frac{q * \Delta X}{\Delta T}$$ **, Watt/m-°C**

Where $\Delta X = X_1 + X_2 + X_3$ **, m**

10. OBSERVATION & CALCULATIONS:

Slab Sizes:

Cast Iron : Diameter = 300 mm, Thickness = 25 mm.

Bakelite : Diameter = 300 mm, Thickness = 21 mm.

Press Wood : Diameter = 300 mm, Thickness = 19 mm.

Thermal conductivity,

Cast Iron = k_1 = 52 W /m - ^oC

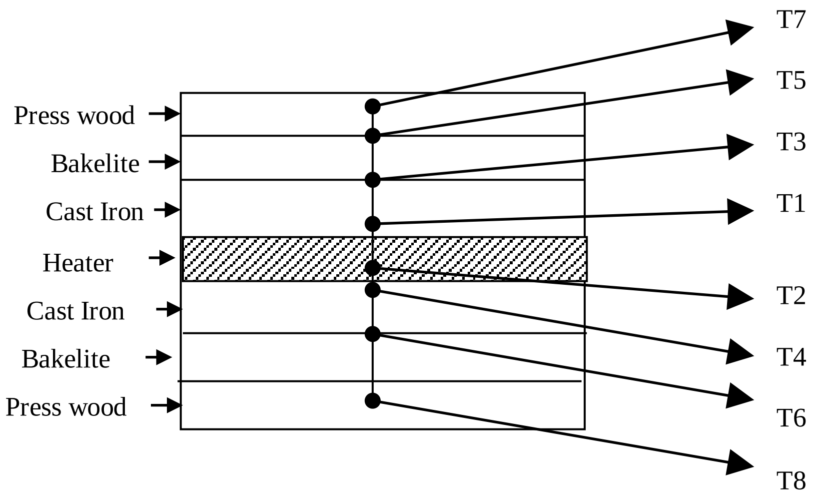
Bakelite = k_2 = 1.4 W /m - ^oC

Press Wood = k_3 = 0.12 W /m - ^oC

OBSERVATION TABLE:

Voltage V	Amperage A	Heat input W=V*I	Temperature sensors readings							
			T_1 ^oC	T_2 ^oC	T_3 ^oC	T_4 ^oC	T_5 ^oC	T_6 ^oC	T_7 ^oC	T_8 ^oC
			At x=0		At x= 25mm		At x= 46mm		At x=65mm	

CALCULATION:



Heat supplied, W = (V X I) Watt

Since the heater is positioned at the centre and similar slabs are fixed on either side, Therefore amount of heat transferred to the RHS of the composite slab will be

Q = -------- W / 2

Considering the one set of composite surface (top surface)

Interface temperature = T1, T3, T5, T7

Heat transfer area of each plate, A = $\frac{\pi}{4}D^2$ (Where D = Plate dia.)

$\therefore$ Heat flux q = $\frac{Q}{A}$

$$q = k\frac{\Delta T}{\Delta X} = \frac{\Delta T}{R_t}$$

Where

$R_t = -\frac{\Delta T}{q}$ = Total thermal resistance of the composite plate.

or $$R_t = \frac{T_1 - T_7}{q} = \frac{\Delta X}{K_{effective}}$$

$$\therefore \quad K_{eff} = \frac{\Delta X}{R_t} = \frac{\sum x_i}{R_t} = \frac{x_1 + x_2 + x_3}{R_t}$$

To plot the temp. profile,

Distance	0	25	46	65
Avg. Temp.				

At distance 0, average temp. = $(T_1 + T_2)/2$

At distance 20, average temp. = $(T_3 + T_4)/2$

At distance 36, average temp. = $(T_5 + T_6)/2$

At distance 48.7, average temp. = $(T_7 + T_8)/2$

Plot the graph of distance Vs average temp.

11. NOMENCLATURE:

Q	=	Heat supplied by the heater
q	=	Heat flux
T_1 & T_2	=	Interface temperature of cast Iron and heater.
T_3 & T_4	=	Interface temp. of cast Iron and bakelite
T_5 & T_6	=	Interface temp. of bakelite and press wood
T_7 & T_8	=	Top surface temp. of press wood
ΔT	=	$T_1 - T_7$
X_1	=	Cast Iron thickness.

X_2	=	Bakelite thickness.
X_3	=	Press wood thickness.
R_t	=	Total thermal resistance of composite wall.
K_{eff}	=	Thermal conductivity of composite wall.

12. PRECAUTIONS & MAINTENANCE INSTRUCTIONS:

8. Use the stabilize A.C. Single Phase supply only.
9. Never switch on mains power supply before ensuring that all the ON/OFF switches given on the panel are at OFF position.
10. Voltage to heater starts and increases slowly.
11. Never run the apparatus if power supply is less than 180 volts and above than 230 volts.
12. Operate selector switch of temperature indicator gently.
13. Always keep the apparatus free from dust.

There is a possibility of getting abrupt result if the supply voltage is fluctuating or if the satisfactory steady state condition is not reached.

13. TROUBLESHOOTING:

5. If electric panel is not showing the input on the mains light. Check the fuse and check the main supply.
6. If D.T.I displays "1" on the screen check the computer socket if loose tight it.
7. If temperature of any sensor is not displays in D.T.I, check the connection and rectify that.

HEAT TRANSFER THROUGH LAGGED PIPE

1. OBJECTIVE: To study the heat transfer through the insulating medium.

2. AIM: To determine heat flow rate through the lagged pipe for known value of thermal conductivity of lagging material.

To determine the effective thermal conductivity of lagged pipe.

To plot the temperature distribution across the lagging material.

3. INTRODUCTION:

When a temperature gradient exists in a body, there is an energy transfer from the high temperature region to the low temperature region. Energy is transferred by conduction and heat transfer rate per unit area is proportional to the normal temperature gradient:

$$\frac{q}{A} \approx \frac{\partial T}{\partial X}$$

When the proportionality constant is inserted,

$$q = -kA\frac{\partial T}{\partial X}$$

Where q is the heat transfer rate and $\partial T/ \partial X$ is the temperature gradient in the direction of heat flow. The positive constant k is called thermal conductivity of the material.

4. THEORY:

Consider a long cylinder of inside radius r_i, and length L. We expose this cylinder to a temperature differential T_i - T_O and see what the heat flow will be. For a cylinder with length very large compared to diameter, it may be assumed that the heat flow in a radial direction, so that the only space coordinate needed to specify the system is ‘r’. In cylindrical system the Fourier’s law is written

$$q = -kA_r \frac{dT}{dr}$$

$$A_r = 2\pi rL$$

$$q = -2\pi krL \frac{dT}{dr}$$

With the boundary conditions

T = Ti at r = ri

T = To at r = ro

The solution to equation is

$$q = \frac{2\pi kL(T_i - T_o)}{\ln(r_o/r_i)}$$

And the isothermal resistance in this case is

$$R_{th} = \frac{\ln(r_o/r_i)}{2\pi kL}$$

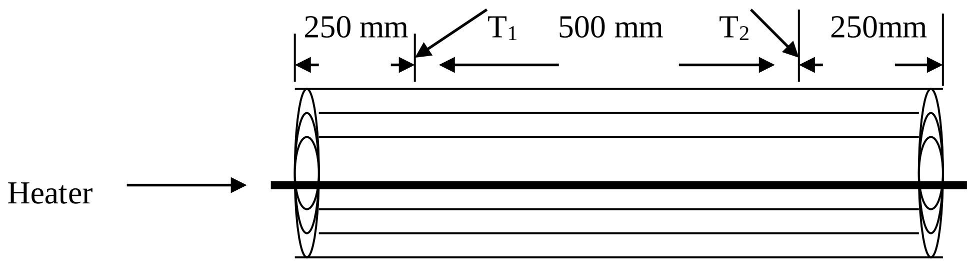
The thermal – resistance concept may be used for multiple – layer cylindrical walls just as it was used for plane walls. For the two-layer system the solution is

$$q = \frac{2\pi kL(T_1 - T_3)}{\ln(r_2/r_1)/k_A + \ln(r_3/r_2)/k_B}$$

5. DESCRIPTION:

The apparatus consist of three concentric pipe mounted on suitable stands. The inside pipe consists of the heater. Between first two cylinders the insulating material with which lagging is to be done is asbestos and in second and third pipe is wooden dust.

The Thermocouples are attached to the surface of cylinders appropriately to measure the temperatures. The input to the heater is varied through a dimmer stat and measured on a voltmeter, ammeter. The experiments can be conducted at various values of input and calculations can be made accordingly.



6. UTILITIES REQUIRED:

Electricity Supply: 1 Phase, 220 V AC, 2 Amps.

Table for set-up support (optional)

7. EXPERIMENTAL PROCEDURE:

1. Start the supply of heater & by varying dimmerstat adjusts the input for desired values by using voltmeter and ammeter.
2. Take readings of all the 6 thermocouples at the interval of 10 minutes until the said steady state is reached.
3. Note down steady state readings in observation table.

(Assumptions: The Pipe is so long as compared with diameter that heat flows in radial direction only in middle half section.)

8. SPECIFICATION:

Inner pipe	=	5 cm Dia (Approx)
Middle pipe	=	10 cm Dia (Approx)
Outer Pipe	=	15 cm Dia (Approx)
Temp. Sensor position of T_1 & T_2	=	25 cm from each end. Similarly for T_3, T_4, T_5, T_6

Heater

Nichrome wire heater with control unit capacity of 440 watts Max.

Heater control Unit	2 Amps.
Single phase Dimmerstat	1 No
Voltmeter	0-500 V
Ammeter	0-2.0 Amps.
Temperature Indicator for thermocouples	
Range 0-200 °C	1 Nos

9. FORMULAE:

1. **Heat input,** $Q = V * I$ **, Watt**
2. **Theoretical heat flow rate through the composite cylinder (for two insulating layers)**

$$Q = \frac{2\pi L(T_i - T_o)}{[ln(R_2 / R_1)/k_1] + [ln(R_3 / R_2)/k_2]} \text{, Watt}$$

3. **From known value of heat flow rate, value of combined thermal conductivity, k_{eff} of lagging material can be calculated:**

$$Q = \frac{2\pi L k_{eff}(T_i - T_o)}{ln(R_3 / R_1)} \text{ , Watt}$$

4. **Effective Thermal Conductivity of Lagged Pipe,**

$$k_{eff} = \frac{Q\, ln(R_3 / R_1)}{2\pi L(T_i - T_o)} \text{, Watt/m-}^{O}\text{C}$$

5. **To plot the temperature distribution use formula: -**

$$\frac{T - T_i}{T_o - T_i} = \frac{ln(R / R_1)}{ln(R_3 / R_1)}$$

Thus the plot of T Vs R (Thickness) can be made for different values of R.

10. OBSERVATION & CALCULATION:

DATA:

Radius of Innermost pipe	=	25 mm
Radius of Middle pipe	=	50 mm
Radius of Outermost pipe	=	75 mm
Length of pipes, L	=	1000 mm
Material filled in Inner Annulus	=	Asbestos
Material filled in Outer Annulus	=	Sawdust
Thermal Conductivity of Asbestos	=	0.26 W/m ^{o}C
Thermal Conductivity of Sawdust	=	0.069 W/m ^{o}C

OBSERVATION TABLE:

S. No.	Volt-meter V	Reading Ammeter I	q = heat supplied = V x I W	Thermocouple Readings					
				T_1	T_2	T_3	T_4	T_5	T_6

CALCULATION:

Mean Readings:

Inside, $\mathbf{T_i = \frac{T_1 + T_2}{2}}$, ^{O}C

Middle, $\mathbf{T_m = \frac{T_3 + T_4}{2}}$, ^{O}C

Outside, $\mathbf{T_o = \frac{T_5 + T_6}{2}}$, ^{O}C

Heat supplied, Q = V x I, W

Calculate Q_{the} and $k_{eff.}$

Plot Temperature Profile

11. NOMENCLATURE:

k = Thermal conductivity of material.

A = Heat transfer area.

q = heat transfer rate

r_i = inside radius of the pipe.

r_o = outside radius of the pipe.

T_i = inside temperature of the pipe

T_o = outside temperature of the pipe

L = Length of the pipe.

R = Isothermal Resistance.

12. PRECAUTIONS & MAINTENANCE INSTRUCTIONS:

14. Use the stabilize A.C. Single Phase supply only.
15. Never switch on mains power supply before ensuring that all the ON/OFF switches given on the panel are at OFF position.
16. Voltage to heater starts and increases slowly.
17. Keep all the assembly undisturbed.
18. Never run the apparatus if power supply is less than 180 volts and above than 240 volts.
19. Operate selector switch of temperature indicator gently.
20. Always keep the apparatus free from dust.
21. There is a possibility of getting abrupt result if the supply voltage is fluctuating or if the satisfactory steady state condition is not reached.

13. TROUBLESHOOTING:

8. If electric panel is not showing the input on the mains light. Check the fuse and also check the main supply.
9. If D.T.I displays “1” on the screen check the computer socket if loose tight it.
10. If temperature of any sensor is not displays in D.T.I check the connection and rectify that.
11. Voltmeter showing the voltage given to heater but ampere meter does not. Tight the heater socket & switch if ok it means heater burned.

HEAT TRANSFER IN NATURAL CONVECTION

1. OBJECTIVE: Study of convection heat transfer in natural convection conditions.

2. AIM: To find out the heat transfer co-efficient of vertical cylinder in natural convection.

3. INTRODUCTION:

Convection is defined as process of heat transfer by combined action of heat conduction and mixing motion. Convection heat transfer is further classified as Natural Convection and Forced Convection.

If the mixing motion takes place due to density difference caused by temperature gradient, then the process of heat transfer is known as heat transfer by Natural or Free Convection. If the mixing motion is induced by some external means such as a pump or blower then the process is known as heat transfer by Forced Convection.

4. THEORY:

Natural convection phenomenon is due to the temp. Difference between the surface and the fluid and is not created by any external agency. The Setup is designed and fabricated to study the natural convection phenomenon from a vertical cylinder in terms of average heat transfer coefficient.

The heat transfer coefficient is given by.

$$h = \frac{Q_a}{A(T_s - T_a)} \text{ Kcal/ m}^2 \text{ hr °C}$$

5. DESCRIPTION:

The apparatus consists of a brass tube fitted in a rectangular duct in a vertical fashion. The duct is open at the top and bottom and forms an enclosure and serves the purpose of undisturbed surrounding. One side of it is made up of glass/Acrylic for visualization. A heating element is kept in the vertical tube, which heats the tube surface. The heat is lost from the tube to the surrounding air by natural convection. Digital Temperature Indicator measures the temperature at the different points with the help of seven temperature sensors. The heat input to the heater is measured by Digital Ammeter and Digital voltmeter and can be varied by a dimmerstat.

6. UTILITIES REQUIRED:

Electricity Supply: 1 Phase, 220 V AC, 2 Amp.
Table for set-up support (optional)

7. EXPERIMENTAL PROCEDURE:

Starting Procedure:

1. Clean the apparatus and make it free from Dust, first.
2. Ensure that all On/Off Switches given on the Panel are at OFF position.
3. Ensure that Variac Knob is at ZERO position, given on the panel.
4. Now switch on the Main Power Supply (220 V AC, 50 Hz).
5. Switch on the Panel with the help of Mains On/Off Switch given on the Panel.
6. Fix the Power Input to the Heater with the help of Variac, Voltmeter and Ammeter provided.
7. After 30 Minutes record the temperature of Test Section at various points in each 5 Minutes interval.

8. If Temperatures readings are same for three times, assume that steady state is achieved.
9. Record the final temperatures.

Closing Procedure:

1. When experiment is over, Switch off heater first.
2. Adjust Variac at Zero.
3. Switch off the Panel with the help of Mains On/Off Switch given on the Panel.
4. Switch off Power Supply to Panel.

8. SPECIFICATION:

Dia of the tube	=	38 mm.
Length of the tube	=	500 mm.
Size of duct	=	700x300x700 mm.
Temperature Sensors	=	RTD PT-100 type.
No. of RTD Temperature Sensors	=	8 Nos.
Digital Voltmeter	=	0 to 500 V.
Digital Ammeter	=	0 to 2.0 Amps.
Dimmerstat	=	2 Amps/220 V.
Temperature Indicator	=	Digital Temperature Indicator 0 to 200°C with multi channel switch.

9. FORMULAE:

1. Heat Transfer Co-efficient

$$\mathbf{h = \frac{q}{A(T_s - T_a)}} \text{ Watt / m}^2\ {}^\circ\text{C}$$

2. Heat Input

$$\mathbf{q = V * I} \text{ Watt}$$

3. Heat transfer Area

$$\mathbf{A = \pi dL} \ \ m^2$$

4. Mean Surface Temperature

$$\mathbf{T_s = \frac{T_1 + T_2 + T_3 + T_4 + T_5 + T_6 + T_7}{7}} \ \ ^\circ C$$

10. OBSERVATION & CALCULATIONS:

Outer diameter of Cylinder, d = 38 mm.

Length of Cylinder, L = 500 mm.

Area of heat transfer, A = 0.5969 m^2

Run No.	V	I	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8 ambient °C
1.	104	0.722	61.7	73.5	83.0	98.0	115.1	123.6	112.8	29.5

CALCULATION:

Amount of heat transferred, Q = ------- Watt.

Average surface temp. Ts = 95.38 ^{O}C

Heat transfer coefficient, h = 2.52 Watt/ m^2 °C

11. PRECAUTIONS & MAINTENANCE INSTRUCTIONS:

22. Use the stabilize A.C. Single Phase supply only.
23. Never switch on mains power supply before ensuring that all the ON/OFF switches given on the panel are at OFF position.
24. Voltage to heater starts and increases slowly.

25. Keep all the assembly undisturbed.
26. Never run the apparatus if power supply is less than 180 V and above than 240 V.
27. Operate selector switch of temperature indicator gently.
28. Always keep the apparatus free from dust.

    There is a possibility of getting abrupt result if the supply voltage is fluctuating or if the satisfactory steady state condition is not reached**.**

12. TROUBLESHOOTING:

12. If electric panel is not showing the input on the mains light. Check the fuse and also check the main supply.
13. If D.T.I displays "1" on the screen check the computer socket if loose tight it.
14. If temperature of any sensor is not displays in D.T.I check the connection and rectify that.
15. Voltmeter showing the voltage given to heater but ampere meter does not. Tight the heater socket & switch if ok it means heater burned.

HEAT TRANSFER IN FORCED CONVECTION

1. OBJECTIVE: Study of convection heat transfer in forced convection.

2. AIM: To find surface heat transfer co-efficient for a pipe flowing heat by force convection for air flowing through it, for different air flow rates and heat flow rates.

3. INTRODUCTION:

Convection is defined as process of heat transfer by combined action of heat conduction and mixing motion. Convection heat transfer is further classified as Natural Convection and Forced Convection.

If the mixing motion takes place due to density difference caused by temperature gradient, then Natural or Free Convection knows the process of heat transfer as heat transfer. If the mixing motion is induced by Forced Convection knows some external means such as a pump or blower.

4. THEORY:

Air flowing into the heated pipe with very high flow rate the heat transfer rate increases. The temperature taken by the cold air from the bulk temperature and rises its temperature. Thus, for the tube the total energy added can be expressed in terms of a bulk-temperature difference by

$$\mathbf{q = \dot{m} C_P (T_{b2} - T_{b1})}$$

Bulk temperature difference in terms of heat transfer co-efficient

$$\mathbf{q = hA(T_{b2} - T_{b1})}$$

A traditional expression for calculation of heat transfer in fully developed turbulent flow in smooth tubes is that recommended by Dittus and Boelter

$$\mathbf{Nu_d = 0.023\,Re_d^{0.8}\,Pr^n}$$

if n = 0.4 for heating of the fluid
0.3 for cooling of the fluid

5. DESCRIPTION:

The apparatus consists of blower unit fitted with the test pipe. The test section is surrounded by nichrome wire heater. Four Temperature Sensors are embedded on the test section and two temperature sensors are placed in the air stream at the entrance and exit of the test section to measure the air temperature. Test Pipe is connected to the delivery side of the blower along with the Orifice to measure flow of air through the pipe. Input to the heater is given through a dimmerstat and measured by volt and amps meters. It is to be noted that only a part of the total heat supplied is utilized in heating the air. A temperature indicator is provided to measure temperature of pipe wall in the test section. Airflow is measured with the help of Orifice meter and the water manometer fitted on the board.

Temperature sensors:

T_1	=	Air inlet temp.
T_2, T_3, T_4, T_5	=	Surface temperature of test section
T_6	=	Air outlet temp.

6. UTILITIES REQUIRED:

Electricity Supply: 1 Phase, 220 V AC, 02 Amp.

Floor area of 1.2 m x 0.5 m

7. EXPERIMENTAL PROCEDURE:

Starting Procedure:

1. Clean the apparatus and make it free from Dust.
2. Put Manometer Fluid (Water) in Manometer connected to Orificemeter.
3. Ensure that all On/Off Switches given on the Panel are at OFF position.
4. Ensure that Variac Knob is at ZERO position, given on the panel.
5. Now switch on the Main Power Supply (220 V AC, 50 Hz).
6. Switch on the Panel with the help of Mains On/Off Switch given on the Panel.
7. Fix the Power Input to the Heater with the help of Variac, Voltmeter and Ammeter provided.
8. Switch on Blower by operating Rotary Switch given on the Panel.
9. Adjust Air Flow Rate with the help of Air Flow Control Valve given in the Air Line.
10. After 30 Minutes record the temperature of Test Section at various points in each 5 Minutes interval.
11. If Temperatures readings are same for three times, assume that steady state is achieved.
12. Record the final temperatures.
13. Record manometer reading.

Closing Procedure:

1. When experiment is over, Switch off heater first.
2. Switch off Blower.
3. Adjust Variac at Zero.
4. Switch off the Panel with the help of Mains On/Off Switch given on the Panel.
5. Switch off Power Supply to Panel.

8. SPECIFICATION:

Length of test section	=	500 mm
I.D. of Test section	=	28 mm
O.D. of Test Section	=	32 mm
No. of RTD Temperature sensors	=	6 Nos.
Orifice Diameter	=	17 mm
Orifice pipe inside diameter	=	28 mm
Dimmerstate	=	2 Amps 220 Volts.

Digital temperature indicator with multi-channel switch Digital voltmeter & Digital Ammeter are also provided.

9. FORMULAE:

1. $U = \dfrac{Q_a}{A(T_s - T_a)}$ Watt/m² °C

2. $\Delta H = R\left(\dfrac{\rho w}{\rho a} - 1\right)$ m of air

3. $Q = \dfrac{C_o \dfrac{\pi}{4} d_p^{\,2} d_o^{\,2} \sqrt{2g\Delta H}}{\sqrt{d_p^{\,2} - d_o^{\,2}}}$, m^3/s **(Where, C_o = 0.62 mm)**

4. $Q_a = m\, C_p\, (T_6 - T_1)$

5. $m = Q^* \rho_a$ kg/s

10. OBSERVATION & CALCULATIONS:

Inner dia of test section, D_i = 28 mm

Outer diameter of test section, D_o = 32 mm=0.032m

Cross section area of pipe in m² = $8.0424\text{x}10^{-4}$

Area of test section, A = 500 mm =0.5m =0.0502m²

Diameter of orifice, d_o = 17 mm=0.017m

Cross section area of orifice in m² = $2.2698\text{x}10^{-4}\text{m}^2$

Diameter of orifice pipe, d_p = 28 mm

Specific heat of air, Cp = 1003.2 J/kg ^{O}C

Density of air, ρ_a = 1.225 kg/m^3

Density of water, ρ_w = 1000 kg/m^3

Average temperature of air, T_a $= \frac{T_1 + T_6}{2}$ °C

Average surface temperature, T_s $= \frac{T_2 + T_3 + T_4 + T_5}{4}$ °C

Manometer reading R = -------- meters.

OBSERVATION TABLE:

V VOLT	I AMPS	T_1 ^{0}C	T_2 ^{0}C	T_3 ^{0}C	T_4 ^{0}C	T_5 ^{0}C	T_6 ^{0}C	Manometer Reading (cm.)

CALCULATIONS:

Calculate, ΔH = 12.22

Volumetric flow rate of air, Q = 3.0161×10^{-3}

Mass flow rate of air, m = 3.6947×10^{-3}

Amount of heat transferred with air,

Q_a = 22.23 watt

Average temperature of air, T_a = 36.6 ° C

Average surface temperature of air, T_s = 55.6 °C

Heat transfer coefficient, U = 23.31

NOMENCLATURE:

m = mass flow rate of air.

ΔH = meter of air

A = area of test section, m^2

C_p = Specific heat of air.

ΔT = Temp. Rise in air °C.

Q_a = rate of heat transfer to air

U = heat transfer co-efficient.

C_o = Co-efficient of discharge of orifice.

h = Difference of water level in manometer in meters.

ρ_w = Density of water, kg/m^3

ρ_a = Density of air at inlet temperature kg/m^3

11. PRECAUTIONS & MAINTENANCE INSTRUCTIONS:

29. Use the stabilize A.C. Single Phase supply only.

30. Never switch on mains power supply before ensuring that all the ON/OFF switches given on the panel are at OFF position.
31. Voltage to heater starts and increases slowly.
32. Keep all the assembly undisturbed.
33. Never run the apparatus if power supply is less than 180 volts and above than 240 volts.
34. Operate selector switch of temperature indicator gently.
35. Always keep the apparatus free from dust.

There is a possibility of getting abrupt result if the supply voltage is fluctuating or if the satisfactory steady state condition is not reached.

12. TROUBLESHOOTING:

16. If electric panel is not showing the input on the mains light. Check the fuse and also check the main supply.
17. If D.T.I displays “1” on the screen check the computer socket if loose tight it.
18. If temperature of any sensor is not displays in D.T.I check the connection and rectify that.
19. Voltmeter showing the voltage given to heater but ampere meter does not. Tight the heater socket & switch if ok it means heater burned.

HEAT TRANSFER FROM A PIN FIN

1. OBJECTIVE: Study of heat transfer conduction from a pin fin.

2. AIM:,To study the temperature distribution along the length of a pin fin under free and forced convection heat transfer.

3. INTRODUCTION:

Extended surfaces or fins are used to increase the heat transfer rate from a surface to a fluid wherever it is not possible to increase the value of the surface heat transfer coefficient or the temperature difference between the surface and the fluid. The use of this is very common and they are fabricated in a variety of shapes circumferential fins around the cylinder of a motorcycle engine and fins attached to condenser tubes of a refrigerator are few familiar examples.

4. THEORY:

It is obvious that a fin surface stick out from primary heat transfer surface. The temperature difference with surrounding fluid will steadily diminish as one moves out along the fin. The design of the fins therefore requires knowledge of the temperature distribution in the fin. The main object of this experimental set up is to study the temperature distribution in a simple pin fin.

Fin effectiveness = ε = tan h mL /mL

The temperature profile within a pin fin is given by:

$\theta / \theta_o = [T-T_f] / [T_b - T_f] = [\cosh m (L-x) + H \sinh m (L-x)] / [\cosh mL + H \sinh mL]$

Where T_f is the free stream temp. of air; T_b is the temp. of fin at its base; T is the temp. Within the fin at any x; L is the length of the fin and D is the fin diameter. m is the fin parameter defined as:

Fin parameter $m = \sqrt{[h C / (k_b A)]}$

$B = 1/ [Tmf + 273.15]$, 1/K

Velocity of air = $V' = Q$ / cross-sectional area of duct

$$Q = \frac{Co (\pi /4) d^2 \sqrt{[2g \Delta H]}}{\sqrt{(1-\beta^4)}} \; m^3/s \quad (\text{at temp} = T_f)$$

$$\text{Where } \beta = \frac{dp}{do}$$

Velocity of air at T_{mf} may be calculated from:

$V = V' [Tmf + 273.15] / [T_f + 273.15]$

5. DESCRIPTION:

A brass fin of circular cross section is fitted across a long rectangular duct. The other end of the duct is connected to the suction side of a blower and the air flows past the fin perpendicular to its axis. One end of the fin projects outside the duct and is heat by a heater. RTD PT-100 type temperature sensors measure temperatures at five points along the length of the fin. An orifice meter, fitted on the delivery side of the blower, measures the flow rate of air.

6. UTILITIES REQUIRED:

Electricity Supply: 1 Phase, 220 V AC, 2 Amps.

Table for set-up support (optional)

7. EXPERIMENTAL PROCEDURE:

NATURAL CONVECTION:

1. Start heating the fin by switching on the heater element and adjust the voltage on dimmerstat (Increase slowly from 0 onwards)
2. Note down the Temp. Sensors readings No.1 to 5.
3. When steady state is reached, record the final readings of Temperature Sensor No.1 to 5 and also the ambient temperature reading Temperature Sensor No 6.
4. Repeat the same experiment at different heat input.

FORCED CONVECTIONS:

1. Start heating the fin by switching on the heater and adjust dimmerstat voltage.
2. Start the blower and adjust the flow rate of air with the help of fly valve provided on the pipe.
3. Note down the Temperature Sensor readings (1) to (5) at a time interval of 5 minutes.
4. When the steady state is reached, record the final readings (1) to (5) and also record the ambient temperature readings by (6)
5. Repeat the same experiment at different heat input and at different flow rate of air.

8. SPECIFICATION:

Duct size	= 150 mm x 100 mm x 1000 mm
Diameter of the fin	= 12.7 mm, Length of the fin: 150 mm
Diameter of the Orifice	= 26 mm
Diameter of the delivery pipe (Int.)	= 52 mm

Temperature Indicator = 0-200°C, RTD PT-100 type

RTD PT-100 type Sensors = 6 Nos.

Temperature Sensor No.6 reads ambient temperature in the inside of the duct.

Thermal conductivity of fin material (Brass) = 95 Kcal /hr- m- °C

Centrifugal blower with Single-phase motor.

Dimmerstat for heat input control 230 V, 2 Amps.

Heater suitable for mounting at the fin end outside the duct.

Voltmeter 0- 500V.

Ammeter 0- 2 A.

9. OBSERVATIONS & CALCULATIONS:

Diameter of pipe, D_P = 52 mm

Diameter of orifice, D_O = 26 mm

Coefficient of discharge of Orifice meter, C_d = 0.64

Experiment	Power input, w = v * i	Fin temperature, °C					Ambient air temp, $T_f = T_6$, oC	Manometer Reading, Δh m of water
		T_1 (x =2.5 cm)	T_2 (x = 5 cm)	T_3 (x = 7.5 cm)	T_4 (x = 10 cm)	T_5 (x = 12.5 cm)		
Free convection								
Forced convection								

Properties of air

Density of air, ρ = 1.093 kg / m^3

Viscosity of air, μ = $19.61*10^{-6}$ kg /m-s

Kinematic viscosity, ν = $17.95 *10^{-6}$ m^2 / s

Thermal conductivity, k= $28.215 *10^{-3}$ Watt / m–°C

Specific heat, C_p = 1003.2 J / kg - °C

Free Convection:

Mean temp. of the fin, T_m = $(T1 + T_2 + T_3 + T_4 + T_5) / 5$

Ambient air temp., T6 = $\mathbf{T_f}$ = 32.3 °C

Mean fluid temp., Tmf = $(Tm + T_f) /2$

β = 1/ (Tmf + 273.15)

ΔT = $T_m - T_f$

Fin dia., D = $12.7 X 10^{-3}$ m

Grashoff No. G_r = $(g \beta D^3 \Delta T) / \nu^2$

Prandtl number, P_r = .698

Using the correlation for free convection:

Nusselt No., N_u = $0.53 (G_r * P_r)^{1/4}$ = $h D / k_{air}$

Free convective heat transfer coeff. h = $N_u * k_{air} / D$, Watt/m^2-°C

Fin parameter, m = $\sqrt{\ }$ hC / k_b A, m

Perimeter, C = πD, m

Cross- sectional area of fin, A = $\pi D^2 / 4$, m^2

Fin dia., D = $12.7 X 10^{-3}$ m

Fin length, L = $125 X 10^{-3}$ m

Fin effectiveness, ε = tanh mL / m L

Parameter, H = h / k_b m

Theoretical temperature profile within the fin =

$\theta / \theta_0 = (T - T_f) / (T_b - T_f) = [\cosh m (L - x) + H \sinh m (L - x)] / [\cosh mL + H \sinh mL]$

Taking base temp., $T_b = T_1$

Forced convection:

Orifice coefficient C_o = 0.64

Volumetric flow rate of air, Q = $\dfrac{Co\,(\pi/4)\, D_P^2 D_O^2 \sqrt{[2g\,\Delta H]}}{\sqrt{[D_P^4 - D_O^4]}}$, m^3/s

ΔH = $[h\,(\rho_w/\rho_a - 1)]/100$, m of air

Velocity of air, V = Q / a (at ambient fluid temp.), m/s

Velocity of air at mean fluid temp. (T_{mf}), V_1 = V x (T_{mf} + 273.15) / (T_f + 273.15), m/s

R_e = $D\, V_1\, \rho / \mu$

Using the correlation for force convection:

Nusselt No., N_u = $0.615\,(R_e)^{0.466}$

N_u = $h\,D / k_{air}$

Heat transfer co-eff. h = $N_u * k_{air} / D$, Watt/m^2-^{O}C

Fin parameter, m = $\sqrt{hC / k_b A}$, m

10. NOMENCLATURE:

K_b = thermal conductivity of brass fin

C = perimeter

T_m = Fin mean temperature.

T_f = Fin temperature at any point.

x = distance of the sensor at base of the fin.

g = Acc. due to gravity.

D = Fin diameter

Gr = Grashoff's number

Pr = Prandtl number

Nu = Nusselt number

K_{air} = Air conductivity at mean temp.

h = heat transfer coefficient.

m = fin parameter

A = X-sectional area of fin.

L = Fin length.

ε = Fin effectiveness

ρ = the density of air, kg/m^3

μ = the dynamic viscosity of air, kg/ m-h

ν = the kinematic viscosity of air, m^2 /h

Cp = the specific heat of air, kcal/kg-ºC

k = the thermal conductivity of air, kcal / h-m ºC

Q = volumetric flow rate of air through the duct m^3 /s

Co = the orifice coeff. = 0.64

D = the orifice dia., m

ρ_w = the density of water (manometer fluid = 1000 kg/m^3)

ΔH = the orifice manometer reading, m

v = velocity of air at T_{mf}

Tmf = fluid mean temp.

11. PRECAUTIONS & MAINTENANCE INSTRUCTIONS:

36. Use the stabilize A.C. Single Phase supply only.
37. Never switch on mains power supply before ensuring that all the ON/OFF switches given on the panel are at OFF position.
38. Voltage to heater starts and increases slowly.

39. Keep all the assembly undisturbed.
40. Never run the apparatus if power supply is less than 180 volts and above than 240 volts.
41. Operate selector switch of temperature indicator gently.
42. Always keep the apparatus free from dust.

There is a possibility of getting abrupt result if the supply voltage is fluctuating or if the satisfactory steady state condition is not reached**.**

12. TROUBLE SHOOTING:

20. If electric panel is not showing the input on the mains light. Check the fuse and also check the main supply.
21. If D.T.I displays “1” on the screen check the computer socket if loose tight it.
22. If temperature of any sensor is not displays in D.T.I check the connection and rectify that.
23. Voltmeter showing the voltage given to heater but ampere meter does not. Tight the heater socket & switch if ok it means heater burned.

PARALLEL FLOW/COUNTER FLOW HEAT EXCHANGER

1. OBJECTIVE: To study the heat transfer phenomena in parallel / counter flow arrangements.

2. AIM: To calculate overall heat transfer coefficient for both type of heat exchanger.

3. INTRODUCTION:

Heat Exchangers are devices in which heat is transferred from one fluid to another. The necessity for doing this arises in a multitude of industrial applications. Common examples of heat exchangers are the radiator of a car, the condenser at the back of a domestic refrigerator and the steam boiler of a thermal power plant.

Heat Exchangers are classified in three categories:

1) Transfer Type.
2) Storage Type.
3) Direct Contact Type.

4. THEORY: A transfer type of heat exchanger is one on which both fluids pass simultaneously through the device and heat is transferred through separating walls. In practice most of the heat exchangers used are transfer type ones.

The transfer type exchangers are further classified according to flow arrangement as -

1. **Parallel flow** in which fluids flow in the same direction.
2. **Counter flow** in which they flow in opposite direction and
3. **Cross flow** in which they flow at right angles to each other.

A simple example of transfer type of heat exchanger can be in the form of a tube type arrangement in which one of the fluids is flowing through the inner tube and the other through the annulus surroundings it. The heat transfer takes place across the walls of the inner tube.

5. DESCRIPTION:

The apparatus consists of a tube in tube type concentric tube heat exchanger. The hot fluid is hot water which is obtained from an insulated water bath using a magnetic drive pump and it flow through the inner tube while the cold fluid is cold water flowing through the annuals.

The hot water flows always in one direction and the flow rate of which is controlled by means of a valve. The cold water can be admitted at one of the end enabling the heat exchanger to run as a parallel flow apparatus or a counter flow apparatus. This is done by valve operations.

RTD PT-100 type sensors measure the temperature. For flow measurement Rotameters are provided at the inlet of hot and cold water supply. The readings are recorded when steady state is reached.

6. UTILITIES REQUIRED:

Water supply 10 lit/min (approx.)
Drain.
Electricity Supply: 1 Phase, 220 V AC, 3 kW.
Floor area 2 m x 0.6m

7. EXPERIMENTAL PROCEDURE:

1. Put water in bath and switch on the heaters.
2. Adjust the required temperature of hot water using DTC.
3. Adjust the valve. Allow hot water to recycle in bath by switching on the magnetic pump.

4. Start the flow through annulus and run the exchanger either as parallel flow or counter flow unit.
5. Adjust the flow rate on cold water side by rotameter provided.
6. Adjust the flow rate on hot water side by rotameter provided.
7. Keeping the flow rates same, wait till the steady state conditions are reached.
8. Record the temperatures on hot water and cold water side and the flow rates accurately.
9. Repeat the experiment with a counter flow under identical flow conditions.

8. SPECIFICATION:

Inner Tube	:	Material = SS, ID = 9.5 mm, OD = 12.7 mm
Outer tube	:	Material = SS, ID = 28 mm, OD = 33.8mm
Length of the heat Exchanger	:	L = 1.13 m
Temperature Controller	:	Digital, Range: 0-200°C
Temperature Indicator	:	Digital Range: 0-200°C & least count 0.1°C with Multi channel switch.
Temperature Sensors	:	RTD–PT-100 type. (5 Nos.)
Flow measurement	:	Rotameter (2 No.)
Water Bath	:	Material: SS insulated with ceramic wool and powder coated MS outer Shell fitted with heating elements.
Pump	:	FHP magnetic drive pump (Max operating temp. 85°C).

10. FORMULAE:

1. **Rate of heat transfer from hot water,**

$$Q_h = M_h C_{ph}\left(T_{hi} - T_{ho}\right), \text{ Watt}$$

2. **Rate of heat transfer to cold water,**

$$Q_c = M_c C_{pc}\left(T_{co} - T_{ci}\right), \text{ Watt}$$

3. **Average heat transfer,**

$$Q = \frac{Q_h + Q_c}{2}, \text{ Watt}$$

4. **LMTD,**

$$\Delta T_m = \frac{\Delta T_2 - \Delta T_1}{ln\frac{\Delta T_2}{\Delta T_1}}, \text{ }^{o}C$$

Where: ΔT_1 = $T_{hi} - T_{Ci}$ (for parallel flow)

= $T_{hi} - T_{Co}$ (for counter flow)

And ΔT_2 = $T_{ho} - T_{Co}$ (for parallel flow)

= $T_{ho} - T_{Ci}$ (for counter flow)

- Note that in a special case of Counter Flow Exchanger exists when the heat capacity rates C_c & C_h are equal, then $T_{hi} - T_{co} = T_{ho} - T_{ci}$ thereby making $\Delta T_i = \Delta T_o$. In this case LMTD is of the form 0/0 and so undefined. But it is obvious that since ΔT is constant throughout the exchanger, hence

$$\Delta T_m = \Delta T_i = \Delta T_o$$

(acc. to ref. Fundamental of Engineering Heat & Mass Transfer by R.C. Sachdeva, Pg. 499)

5. Overall heat transfer coefficient,

$$U_i = \frac{Q}{A_i \Delta T_m}$$ **, Watt/m2-^{O}C**

$$U_o = \frac{Q}{A_o \Delta T_m}$$ **, Watt/m2-^{O}C**

10. OBSERVATION & CALCULATION:

DATA:

Inside heat transfer area, A_i = $7.088 * 10^{-5}$ m^2

Outside heat transfer area, A_o = $61.575 * 10^{-5}$ m^2

OBSERVATION TABLE:

FOR PARALLEL FLOW:

S. No.	Hot water side			Cold water side		
	Flow rate	T_{hi} °C	T_{ho} °C	Flow rate	T_{ci} °C	T_{co} °C
1						
2						

FOR COUNTER FLOW:

S. No.	Hot water side			Cold water side		
	Flow rate	T_{hi} °C	T_{ho} °C	Flow rate	T_{ci} °C	T_{co} °C
1						
2						

CALCULATIONS:

CASE I: Counter Flow

Mass flow rate of Hot water:-

Average temp. = ----------°C

M_H = ---------- kg/hr.

ρ_H = ---------- kg/m^3

C_{pH} = --------- J/kg°K

Mass flow rate of Cold water

Average temp. = ----------°C

M_C = ---------- kg/m

ρ_C = ----------- kg/m^3

C_{pc} = --------- J/kg°K

Heat Flow Rate

Q_H = M_H x C_{pH} x ΔT = ----------- W

Q_C = M_C x C_{pC} x ΔT = -------- W

Effectiveness of HE, ε = $\frac{Q_{actual}}{Q_{max}} x100\%$

Q_{actual} = $\frac{\mathbf{Q_C + Q_h}}{\mathbf{2}}$ = -------------- kW

Q_{max} = $M_h\ Cp_h\ (Th_i - Tc_i)$ = ----------------kW

L.M.T.D. for Counter Flow = $\frac{(T_{hi} - T_{Co}) - (T_{ho} - T_{Ci})}{ln[(T_{hi} - T_{Co})/(T_{ho} - T_{Ci})]}$

U_o = $\frac{Q}{A_o xLMTD}$ = ------------- W/m^2°C

Ui = $\frac{Q}{A_i xLMTD}$ = ------------ W/m^2°C

CASE II: Parallel Flow

Mass flow rate of Hot water:-

Average temp. = ----------°C

M_H = ---------- kg/hr.

ρ_H = ---------- kg/m^3

C_{pH} = --------- J/kg°K

Mass flow rate of Cold water

Average temp. = ----------°C

M_C = ---------- kg/m

ρ_C = ----------- kg/m^3

C_{pc} = --------- J/kg°K

Heat Flow Rate

Q_h = $M_h \times C_{Ph} \times \Delta T$ = -------- W

Q_C = $M_C \times C_{Pc} \times \Delta T$ = -------- W

Effectiveness of HE, ε = $\frac{Q_{actual}}{Q_{max}} x100\%$

Q_{actual} = $\frac{Q_C + Q_h}{2}$ = ------------kW

Q_{max} = $M_h\, Cp_h\, (Th_i - Tc_i)$ = ------------- W

L.M.T.D. for Parallel Flow = $\frac{(T_{h_i} - T_{C_i}) - (T_{h_o} - T_{C_o})}{\ln[(T_{h_i} - T_{C_i})/(T_{h_o} - T_{C_o})]}$

U_o = $\frac{Q}{A_o xLMTD}$ = -------------W/m^2°C

U_i = $\frac{Q}{A_i xLMTD}$ = ------------- W/m^2°C

11. NOMENCLATURE:

Q_h = heat loss by the hot water, W

M_h = mass flow rate of the hot water

C_{ph} = specific heat of hot fluid at mean temperature.

T_{ho} = outlet temperature of the hot water

T_{hi} = inlet temperature of the hot water

ΔT_m = Log mean temperature difference.

Q_c = heat gained by the cold water

M_c = mass flow rate of the cold water

C_{pc} = specific heat of cold fluid at mean temperature

T_{co} = outlet temperature of the cold water

T_{ci} = inlet temperature of the cold water

Q = average heat transfer from the system

U = overall heat transfer coefficient.

U_i = Inside overall heat transfer coefficient.

A_i = πr_i^2 X-sectional area of inner pipe.

U_o = outside overall heat transfer coefficient.

A_o = πr_i^2 X-sectional area of outer pipe.

12. PRECAUTIONS AND MAINTENANCE INSTRUCTION:

43. Never switch on mains power supply before ensuring that all the ON/OFF switches given on the panel are at OFF position.
44. Keep all the assembly undisturbed.
45. Never run the apparatus if power supply is less than 180 volts and above than 230 volts.
46. Operate selector switch of temperature indicator gently.
47. Always keep the apparatus free from dust.
48. Don’t switch ON the heater before filling the water into the bath.

13. TROUBLESHOOTING:

24. If electric panel is not showing the input on the mains light. Check the fuse and also check the main supply.
25. If D.T.I displays “1” on the screen check the computer socket if loose tight it.
26. If temperature of any sensor is not displays in D.T.I check the connection and rectify that.

TEFAN BOLTZMANN APPARATUS

1. OBJECTIVE: Study of Radiation heat transfer by black body.

2. AIM: To find out the Stefan Boltzmann constant.

3. INTRODUCTION: All substances at all temperature emit thermal radiation. Thermal radiation is an electromagnetic wave and does not require any material medium for propagation. All bodies can emit radiation and have also the capacity to absorb all of a part of the radiation coming from the surrounding towards it.

4. THEORY: The most commonly used law of thermal radiation is the Stefan Boltzmann law which states that thermal radiation heat flux or emissive power of a black surface is proportional to the fourth power of absolute temperature of the surface and is given by

$$\frac{Q}{A} = E_b = \sigma T^4 \; (W/m^2 K^4)$$

The constant of proportionally is called the Stefan Boltzmann constant and has the value of 5.67×10^{-8} $W/m^2 K^4$. The Stefan Boltzmann law can be derived by integrating the Planck's law over the entire spectrum of wavelength from 0 to ∞. The objective of this experimental set up is to measure the value of this constant fairly closely, by an easy arrangement.

5. DESCRIPTION: The apparatus is centered on a flanged copper hemisphere B fixed on a flat non-conducting plate A. The outer surface of B is enclosed in a metal water jacket used to heat B to some suitable constant temperature.

One RTD PT-100 type Temperature Sensor is attached to the inner wall of hemisphere B to measure its temperature and to be read by a temperature indicator.

The disc D, which is mounted in an insulating bakelite sleeves S is fitted in a hole drilled in the centre of the base plate A. A Chromel-Alumel Temperature Sensor is used to measure the temperature of D i.e. T_D. The Temperature Sensor is mounted on the disc to study the rise of its temperature.

6. UTILITIES REQUIRED:

Electricity Supply: 1 Phase, 220 V AC, 2 kW.
Table for set-up support

7. EXPERIMENTAL PROCEDURE:

1. Heat the water in the tank by the immersion heater upto a temperature of about below 90 °C.
2. The disc D is removed before pouring the hot water in the jacket.
3. The hot water is poured in the water jacket.
4. The hemispherical enclosure B and A will come to some Uniform temperature in a short time after filling the hot water in the jacket. The thermal inertia of hot water is quite adequate to prevent significant cooling in the time required to conduct the experiment.
5. The disc. D is now inserted in A at a time when its temperature is T_D.
6. Start noting the temperature change for every five second for a minute.

8. SPECIFICATION:

Hemispherical enclosure dia	=	200 mm
Suitable sized Water jacket for hemisphere.		
Base plate, Bakelite diameter	=	250 mm.
No. of Temperature Sensor mounted on B	=	1
No. of Temperature Sensor mounted on D	=	1
Temperature indicator digital	=	0-199.9^{o}C RTD PT-100 type

Immersion water heater of suitable capacity and tank for hot water. 1.5 KW

The surface of B and A forming the enclosure are blacked by using lamp black to make their absorptivity to be approximately unity. The copper surface of the disc D is also blacked.

9. FORMULAE:

1. **Stefan Boltzmann constant**, σ = $\frac{ms(dT/dt)_{t=0}}{A_D(T^4 - T_D^4)}$, Watt/m^2-k^4

10. OBSERVATION & CALCULATION:

DATA:

Test disc dia = 20 mm

Mass of test disc, m = 5.1 gm

Specific heat of the test disc, s. = 418 J/kg -°C

OBSERVATION TABLE:

Time t (sec.)	Temperature T_D in °C
5	
10	
15	
20	
25	
30	

CALCULATION:

The radiation energy falling on D from the enclosure is given by:

$E = \sigma A_D (T)^4$ -------- (i)

The emissivity of the disc D is assumed unity, (Black disc). The radiant energy disc D is emitting into enclosure will be

$E_1 = A_D T_D^4 \sigma$ -------- (ii)

Net heat input to disc. D per unit time is given by (i) - (ii)

$E - E_1 = A_D (T^4 - T_D^4)\sigma$ ------- (iii)

If the disc D has a mass m and specific heat s then a short time after D is inserted in A.

$m\,s\,(dT/dt)_{t=0} = \sigma A_D (T^4 - T_D^4)$

or

$$\sigma = \frac{ms(dT/dt)_{t=0}}{A_D(T^4 - T_D^4)}$$

In this equation $(dT/dt)_{t=0}$ denotes the rate of rise of temperature of the disc D at the instant when its temperature is T_D and will vary with time . It is clearly measured at time t = 0 before heat conducted from A to D begins to have any significant effect. This is obtained from plot of temperature rise of D w.r.t. time and obtaining its slope at t = 0 when temperature is T_D. This will be the required value of dT/dt at t = 0. The Temperature Sensor mounted on disc is to be used for this purpose.

Note that the disc D with its sleeve is placed quickly in position and start recording the temperature at fixed time intervals. The whole process must be completed in 30 seconds of time. Longer disc D is left in position the greater is the probability of errors due to heat conduction form A to D.

T temperature of enclosure in ºC = ------

T temperature of enclosure in °K = ------

Temp. Of disc D at the instant

When it is inserted (T_D) in °K= -------

Temperature time response of the disc. Note down the temperature T_D at the time interval of 5 second. Plot the graph of T against as shown in figure.

Obtain from the graph

(dT/dt) at t = 0 = ------ °C/sec.

Value of σ can be obtained by using (3)

$$\sigma = \frac{ms(dT/dt)_{t=0}}{A_D(T^4 - T_D^4)}$$

11. NOMENCLATURE:

A_D	=	Area of disc D.
T	=	Temp. Of enclosure
T_D	=	Temperature. Of disc
m	=	mass of disc
s	=	specific heat of the disc material.

12. PRECAUTIONS & MAINTENANCE INSTRUCTIONS:

1. Always use clean water and heater should be completely dipped in the water before switch ON the heater.
2. Always take the reading for the first min. of the disc while fixing.
3. Use the stabilize A.C. Single Phase supply only.
4. Never switch on mains power supply before ensuring that all the ON/OFF switches given on the panel are at OFF position.
5. Voltage to heater should be constant.
6. Keep all the assembly undisturbed.
7. Never run the apparatus if power supply is less than 180 V and above than 240 V.

8. Operate selector switch of temperature indicator gently.
9. Always keep the apparatus free from dust.
10. Don't switch ON the heater before filling the water into the bath.

There is a possibility of getting abrupt result if the supply voltage is fluctuating or if the satisfactory steady state condition is not reached.

13. TROUBLESHOOTING:

27. If electric panel is not showing the input on the mains light. Check the fuse and also check the main supply.
28. If D.T.I displays "1" on the screen check the computer socket if loose tight it.
29. If temperature of any sensor is not displays in D.T.I check the connection and rectify that.

THERMAL CONDUCTIVITY OF METAL ROD

1. OBJECTIVE: Study of conduction heat transfer in metal rod.

2. AIM: To determine the thermal conductivity of metal bar.

3. INTRODUCTION:

Thermal conductivity of a substance is a physical property, defined as the ability of a substance to conduct heat. Thermal conductivity of material depends on chemical composition; state of matter, crystalline structure of a solid, the temperature, pressure and weather or not it is a homogeneous material.

4. THEORY:

The heater will heat the bar on its one end and heat will be conducted through the bar to the other end. Since the rod is insulated from outside, it can be safely assumed that the heat transfer along the copper rod is mainly due to axial conduction and at steady state the heat conducted shall be equal to the heat absorbed by water at the cooling end. The heat conducted at steady state shall create a temperature profile within the rod. (T = f (x))The steady state heat balance at the rear end of the rod is:

Heat absorbed by cooling water,

$$Q = MC_p \Delta T$$

Heat conducted through the rod in axial direction:

$$Q = -kA\frac{dT}{dX}$$

at steady state

$$Q = -kA\frac{dT}{dX} = MC_p\Delta T$$

So thermal conductivity of rod may be expressed as,

$$k = \frac{MC_p\Delta T}{-A\left(\frac{dT}{dX}\right)}$$

5. DESCRIPTION:

The apparatus consists of a metal bar, one end of which is heated by an electric heater while the other end of the bar projects inside the cooling water jacket. The middle portion of the bar is surrounded by a cylindrical shell filled with the asbestos insulating powder. The temperature of the bar is measured at different section. The heater is provided with a dimmerstat for controlling the heat input. Water under constant head conditions is circulated through the jacket and its flow rate and temperature rise are noted by two temperature sensors provided at the inlet and outlet of the water.

6. UTILITIES REQUIRED:

Electricity Supply: 1 Phase, 220 V AC, 2 Amps.

Water supply.

Drain.

Table for set-up support (optional)

7. EXPERIMENTAL PROCEDURE:

Starting Procedure:

1. Connect cold water supply at inlet of the Cooling Chamber.
2. Connect outlet of the Cooling Chamber to drain.
3. Ensure that all on / Off Switches given on the Panel are at OFF position.
4. Ensure that Variac Knob is at ZERO position, given on the panel.
5. Start water supply at constant head.
6. Now switch on the Main Power Supply (220 V AC, 50 Hz).
7. Switch on the Panel with the help of Mains On/Off Switch given on the Panel.
8. Fix the Power Input to the Heater with the help of Variac, Voltmeter and Ammeter provided.
9. After 30 Minutes start recording the temperature of various points at each 5 Minutes interval.
10. If Temperatures readings are same for three times, assume that steady state is achieved.
11. Record the final temperatures.
12. Record then flow rate of cooling water with the help of measuring cylinder and stopwatch.

Closing Procedure:

1. When experiment is over, Switch off heater first.
2. Adjust Variac at Zero.
3. Switch off the Panel with the help of Mains On/Off Switch given on the Panel.
4. Switch off Power Supply to Panel.
5. Stop cold water supply.

8. SPECIFICATION:

Length of the Metal Bar	:	450mm
Dia of the Metal Bar	:	25mm
Effective Test length of the bar	:	231mm
Total no. of temperature sensors in the setup	:	9 Nos.
No. of Temp. Sensors mounted on bar	:	7 Nos.
No. of Temp. Sensors mounted on water jacket	:	2 Nos.
Type of Temperature Sensors	:	RTD PT-100
Heater	:	Nichrome heater
Cooling Jacket Dia	:	100mm
Length of cooling jacket	:	75mm
Dimmer stat for heater coil	:	2Amp, 230VAC
Digital Voltmeter	:	0 to 500 Volts
Digital Ammeter	:	0 to 2.0 Amps.
Temperature indicator	:	Digital Temperature Indicator 0°C to 199.9°C and least count 0.1°C with multi-channel switch.

9. FORMULAE:

1. Heat gained by water,

$$Q = MCp(T_9 - T_8), \text{ Watt}$$

2. Thermal conductivity of metal rod,

$$K = \frac{MC_p \Delta T}{-A\left\{\frac{dT}{dX}\right\}}, \text{ Watt/m-}^{O}\text{C}$$

10. OBSERVATION & CALCULATION

OBSERVATION TABLE:

Temp. Sensor No. →	1	2	3	4	5	6	7	8	9
Steady state temp →									

Temp Sensor No. along the axis	Distance from leading edge (hot end) of the rod , X (mm)
T_1	33
T_2	66
T_3	99
T_4	132
T_5	165
T_6	198
T_7	231

T_8 is the inlet temp. Of cold water

T_9 is the outlet temp. Of cold water

CALCULATIONS:

Heat gained by water (at Steady state) $Q = M \times C_p x (T_8 - T_7)$ Kcal/hr.

Heat transfer area for axial conduction $A = (\pi /4) D^2$

D is the diameter of copper rod

Plot T vs X. Draw a smooth curve through all the points and obtain the slope dT/dX at x=L or using least square method fit the T vs X data to a polynomial (Express the data as $T = A_0 + A_1 x + A_2 x^2$) and thus obtain the slope dT/dX at x=L. Express the slope in ^oC /m. Calculate the value of thermal conductivity of metal bar, k from:

$k = M.C_p \Delta T / [-A \{dT/ dX\}]$

11. NOMENCLATURE:

k	=	thermal conductivity of metal bar
M	=	mass flow rate of cooling water
C_p	=	Specific heat of water at mean temp. Of inlet & outlet of cooling water, J/kg-^{O}C
ΔT	=	temp. rise of cooling water = $(T_9 - T_8)$
A	=	X-sectional area of the metal bar
dT/ dX	=	slope of the graph b/w temp. Vs length of the bar

12. PRECAUTIONS & MAINTENANCE INSTRUCTIONS:

49. Use the stabilize A.C. Single Phase supply only.
50. Never switch on mains power supply before ensuring that all the ON/OFF switches given on the panel are at OFF position.
51. Voltage to heater should be increased slowly.
52. Never run the apparatus if power supply is less than 180 volts and above than 230 volts.
53. Operate selector switch of temperature indicator gently.
54. Always keep the apparatus free from dust.

There is a possibility of getting abrupt result if the supply voltage is fluctuating or if the satisfactory steady state condition is not reached**.**

13. TROUBLESHOOTING:

30. If electric panel is not showing the input on the mains light. Check the fuse and also check the main supply.
31. If D.T.I displays “1” on the screen check the computer socket if loose tight it.
32. If temperature of any sensor is not displays in D.T.I check the connection and rectify that.

CHANDIGARH UNIVERSITY Discover. Learn. Empower.	**DEPARTMENT OF MECHANICAL ENGINEERING**
HEAT AND MASS TRANSFER LAB	Subject Code: **(MEP-327)**

<u>EMMISIVITY MEASUREMENT APPARATUS</u>

Aim: To measure the emmisivity of the gray body (plate) at different temperature and plot the variation of emmisivity with surface temperature.

Apparatus Used: Emmisivity measurement apparatus: The experimental set up consists of two circular aluminum plates identical in size provide with heater coils at the bottom as shown in figure.

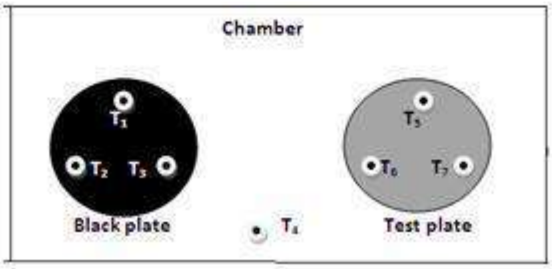


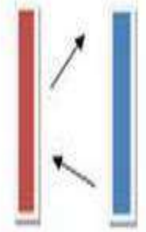
Fig: Emmisivity Apparatus

It is kept in an enclosure so as to provide undisturbed natural convection surroundings. The heat input to the heaters is varied by two regulators and is measured by an ammeter and voltmeter. Each plate is having three thermocouples; hence an average temperature is taken. One thermocouple is kept in the enclosure to read the chamber temperature. One plate is blackened by a layer of enamel black paint to form the idealized black surface whereas the other plate is the test plate. The temperatures of the plates are measured by using thermocouples.

Theory:

Emissivity of a surface is defined as ratio of the radiation emitted by the surface to the radiation emitted by the black body at the same temperature. If a sample is replaced by a black body of temperature of same area at same temperature, under thermal equilibrium, the emissivity of the body is equal to the absorptivity.

Consider two flat infinite plates, surface A and surface B, both emitting radiation towards one another. Surface B is assumed to be an ideal emitter, $\varepsilon B = 1$.



Surface A will emit radiation according to Stefan's Boltzmann law as

$$E_A = \varepsilon_A \sigma T_A^4 \qquad (1)$$

And will receive radiation as

$$G_A = \alpha_A \sigma T_B^4 \qquad (2)$$

Net heat flow from surface A will be

$$Q = \varepsilon_A \sigma T_A^4 = \alpha_A \sigma T_B^4 \qquad (3)$$

Now suppose that the two surfaces are at exactly same temperature then, $\varepsilon A = \alpha A$
Emissivity of surface will depend on the material of which it is composed.
The radiation emitted per unit area per unit time from the surface of a body is called its emissive power. The ratio of emissive power of a body to the emissive power of a black body is called emissivity.

Heat emitted by the black body, $Q_b = \varepsilon_b \sigma (T_b^4 - T_c^4)$ (4)

Heat emitted by the test plate, $Q_p = \varepsilon_p \sigma (T_p^4 - T_c^4)$ (5)

ε_b Emissivity of the black plate.

ε_p Emissivity of the test plate

σ Stefan-Boltzmann constant = 5.67×10^{-8} W m^{-2}K^{-4}

T_b Black body temperature in Kelvin

T_c Chamber temperature in Kelvin

T_p Test plate temperature in Kelvin

$Q_b = Q_p$ since input power to the two plates is same and conduction heat loss are also same.

Emissivity, $\varepsilon_p = \varepsilon_b \dfrac{T_b^4 - T_c^4}{T_p^4 - T_c^4}$ (6)

The same amount of power input is given to both test plate and black plate. After achieving steady state temperature for black plate, it continuously emits radiations and this radiation is completely absorbed by the test plate. But its emit radiation is slightly less than the black body because emissivity depends on nature of the material.

Procedure:

1. Adjusting the voltage and corresponding current given as input power.
2. Tuning Switch- Used to turn either Black plate (BP) or Test plate (TP) and thereby can change the corresponding voltage and current for both the plates.
Note: Power should be given for both the plates must be same.
3. Power on button- Using this button we can switch on the power when all the initial adjustments were done.
4. Temperature indicator should be reaching steady.
5. Note down the T_1 to T_7 temperature on thermocouples in degree Celsius.

Observations & Calculations:

Voltmeter Reading (V)	Ammeter Reading (A)	Black body temperature (K)			Average temperature (T_b) K	Test plate temperature (K)			Average Test plate Temperature (T_p) K	Chamber Temperature (T_4) K
		T_1	T_2	T_3		T_5	T_6	T_7		

Heat emitted by the black body, $Q_b = \varepsilon_b \sigma (T_b^4 - T_c^4)$ W

Heat emitted by the test plate, $Q_p = \varepsilon_p \sigma (T_p^4 - T_c^{4})$ W

ε_b Emissivity of the black plate and it is equal to 1

ε_p Emissivity of the test plate

σ Stefan-Boltzmann constant = 5.67×10^{-8} W m^{-2}K^{-4}

$$T_b = \frac{(T_1 + T_2 + T_3)}{3} = ...K$$

$$T_p = \frac{(T_5 + T_6 + T_7)}{3} = ...K$$

$$T_c = ...K$$

$Q_b = Q_p$ since input power to the two plates is same and conduction heat loss are also same.

Emissivity of the specimen plate, $\varepsilon_p = \varepsilon_b \dfrac{T_b^4 - T_c^4}{T_p^4 - T_c^4}$

Hence the emmisivity of the gray body (plate) at different temperature is ________.

Industrial Automation and Robotics LAB

Course Code: MEP - 354

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M1: Providing world class infrastructure, renowned academicians and ideal environment for Research, Innovation, Consultancy and Entrepreneurship relevant to the society.

M2: Offering programs & courses in consonance with National policies for nation building and meeting global challenges.

M3: Designing Curriculum to match International standards, needs of Industry, civil society and for inculcation of traits of Creative Thinking and Critical Analysis as well as Human and Ethical values.

M4: Ensuring students delight by meeting their aspirations through blended learning, corporate mentoring, professional grooming, flexible curriculum and healthy atmosphere based on co-curricular and extra-curricular activities.

M5: Creating a scientific, transparent and objective examination/evaluation system to ensure an ideal certification.

M6: Establishing strategic relationships with leading National and International corporates and universities for academic as well as research collaborations.

M7: Contributing for creation of healthy, vibrant and sustainable society by involving in Institutional Social Responsibility (ISR) activities like rural development, welfare of senior citizens, women empowerment, community service, health and hygiene awareness and environmental protection

Vision and Mission of the Department of Mechanical Engineering

Vision

To be recognized as a center of excellence for research and innovation in Mechanical Engineering through contemporary as well as futuristic tools and technologies for serving the society at regional, national and global level

Mission

MD1: Providing quality education to the students in core and allied fields by implementing advanced pedagogies

MD2: Encouraging students towards research and development through advanced tools and technologies for providing solution to societal problems

MD3: Evolve and empower the students through core technical skills for becoming entrepreneurs and innovators

MD4: Inculcating employability and leadership skill for ensuring industry ready professional through hands on experiential learning and industrial collaboration

MD5: Developing professional and ethical standards in the mind of the young engineers by continuous learning and professional activities

1.2. State the Program Educational Objectives (PEOs)(5)

PROGRAM EDUCATION OBJECTIVES (PEOs):

PEO1: Graduates will have professional knowledge in the field of Mechanical Engineering and various other interdisciplinary domains.

PEO2: Graduates will have successful career in government services, research organizations, corporate sector, academic institutes and industries at national and international repute.

PEO3: Graduate will have compatibility of modern engineering tools and technologies for deliberating solution of various engineering problems.

PEO4: Graduate will develop skill to address the concern of society, environment and communicate effectively to lead the interdisciplinary diverse team.

PEO5: Graduates will be effectively fit for higher education, innovations, research &development, entrepreneurship and professional development.

PROGRAM OUTCOMES (POs):

Program: Bachelor of Engineering (Mechanical Engineering)

Duration: 4 years

PO1. Engineering Knowledge: Apply knowledge of mathematics, science and engineering fundamentals and Production and Industrial Engineering specialization to the solution of complex Production and Industrial Engineering problems.

PO2. Problem Analysis: Identify, formulate, research literature and analyze complex Production and Industrial Engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex Engineering problems and design system components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.

PO4. Conduct investigations of complex Engineering problems: Use research-based knowledge and research methods including analysis, interpretation of data and synthesis of information to provide valid conclusions.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. The Engineer and Society: Apply contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams and in multi disciplinary settings.

PO10. Communication: Communicate effectively on complex Engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.

PO11. Project Management and Finance: Demonstrate knowledge and understanding of Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life Long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs):

PSO1: Apply the knowledge of Production, Manufacturing and Industrial Engineering for analysis, optimization and development of mechanical system

PSO2: Apply the concepts of Design and Thermal Engineering to model, analyze and develop the mechanical components and systems

Course Objectives

- Focuses on equipment, work systems, machinery, and automation systems for today's manufacturing environment
- To provide students the opportunity to acquire hands-on experience in the use of the engineering equipment, systems, and tools in the lab
- To understand working and construction of hydraulic and pneumatic circuits

To understand, diagnose an automated system.

Course Outcomes

After completion of course the student will be able to:

CO1	Apply the basic concepts of automation and its components
CO2	Design hydraulic & pneumatic circuit integrated with PLC
CO3	Classify the FMS, develop and execute the CNC program for machining the component on lathe and milling machines
CO4	Inspect the the various features of industrial Robot and its applications considering social, health, safety, legal and environmental aspects.
CO5	Conclude the experimental results and express the same effectively in oral and written manners through report and practical presentation.

LIST OF EXPERIMENTS

1. Design and Assembly of Pneumatic Logic Circuit Utilizing single and double Acting Cylinders
2. Design and assembly of Hydraulic Logic Circuit Utilizing Single and Double Acting Cylinder

   Implementation of various basic logic gates VIZ. OR, AND,NOT and NAND.
3. To familiarize with microprocessor based PLC and its industrial applications
4. Demonstration of robotics arm and its applications
5. To Exhibit the working of Flexible Manufacturing system
6. To perform tool and work offset in case of CNC Lathe and Milling
7. To develop and execute a program for CNC turning & perform simulation on software
8. To develop and execute a program for CNC Mill& perform simulation on software
9. To execute a program on vertical CNC Mill in Machine on Lathe Machine.

EXPERIMENT NO.: 1

Aim: - Design and Assembly of Pneumatic Logic Circuit Utilizing single and double Acting Cylinders .

Objective:-To operate 3/2 single solenoid with single acting cylinder and 5/2 single solenoid with double acting cylinder.

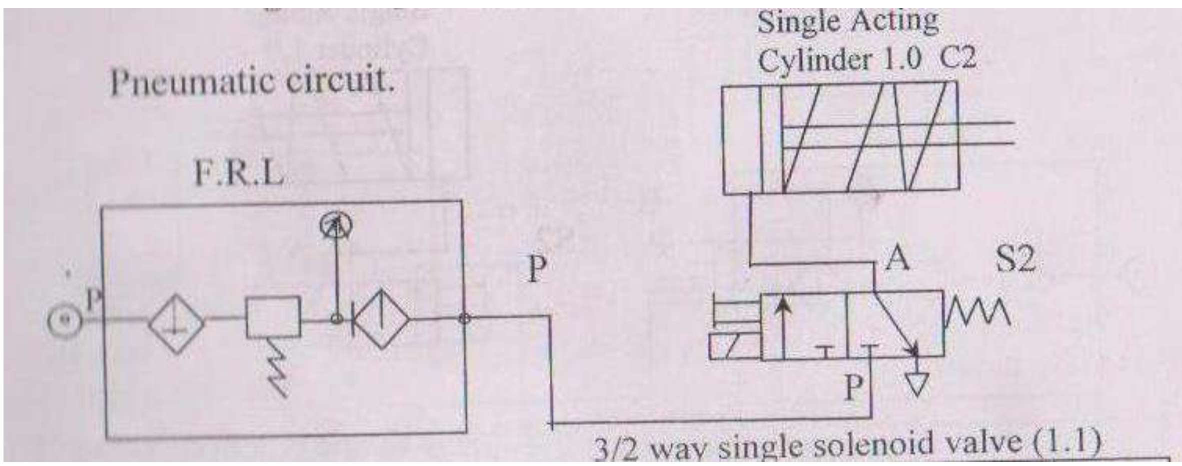


Fig 1: Operation of single acting cylinder

Theory: -

Air Pressure Regulator: Pneumatic equipment is designed to operate properly at certain pressure. A regulator will provide a constant set flow of air pressure at its outlet. An air lined regulator is specialized control valve which reduces upstream supply pressure lend to a specified constant downstream pressure. The size of the regulator is determined by the downstream flow and pressure requirement.

Compressor: As the crankshaft pulls the piston down an increasing volume is formed within the housing. This action causes the trapped air in the piston bar to expand reducing its pressure. When pressure differential becomes high enough the inlet valve opens allowing the spring to push the piston down

Safety Relief Valve: Maximum pressure developed by a compressor is designed to regulate by a controlled system which senses the discharged or tank pressure. When pressure differential in case of emergency such as failure of control system to function properly by a positive displacement compressor system is generally equipped of safety relief valve.

F.R.L Unit: F.R.L unit stands for "Filter regulator and lubrication" This unit ensures that air supply is clean and dry. The pressure is at its correct level and fine particles of oil are carried in the air to lubricate wearing parts between valve cylinder and tools.

Direction Control Valves: Direction control valves are designed to direct the flow of fluid at desired time to the point in fluid power station where it will do work. Directional control valves are intermediators which supply pressurized fluid from component as pump to an actuator as per requirement.

Procedure:-

1. Make wiring sequence as given above
2. Connect compressor to F.R.L.
3. Connect pressure line to"P" to "P" of solenoid (S2).
4. Vary the pressure by knob provided on F.R.L.
5. Make power supply ON.
6. As soon as the power supply is ON, when solenoid S2 becomes ON it extend the position rod of S.A. Cylinder and when S4 becomes of it retract position rod of S.A. cylinder automatically.
7. The sequence of task is repeated continuously because the timer is set in a stable mode.

Theory:-The Double Acting Cylinder (DAC)

DAC has two ports to allow air in, one for outstroke (extend) and one for in-stroke (retract). Through both the ports air is supplied and exited. During extension, air is supplied from the piston-side and exited from the rod-end. During retraction, air is supplied from the piston rod-end and exited from the piston-side. Figure 1 shows photograph of DAC. The blue pipes connect both the ports of the cylinder to the actuator ports of the DCV. The direction of air flow in the connecting pipe and hence into and from the cylinder will be decided by the DCV. When any of the actuator ports is linked to the respective pressure port of the DCV, air is supplied to the DAC to actuate it, either to extend or to retract. During both extension and retraction, when one port of the DAC is linked to the respective pressure port of the DCV via its actuator port, the other port of the DAC will always be linked to the respective exhaust port of the DCV via its other actuator port. The DAC extends when pressurized air is supplied from piston-side and it stays in that position until there is an opposing signal / pressure from the rod-end which causes it to retract. Both sides can be pressured, unlike the SAC where only one side (piston-side) could be pressurized

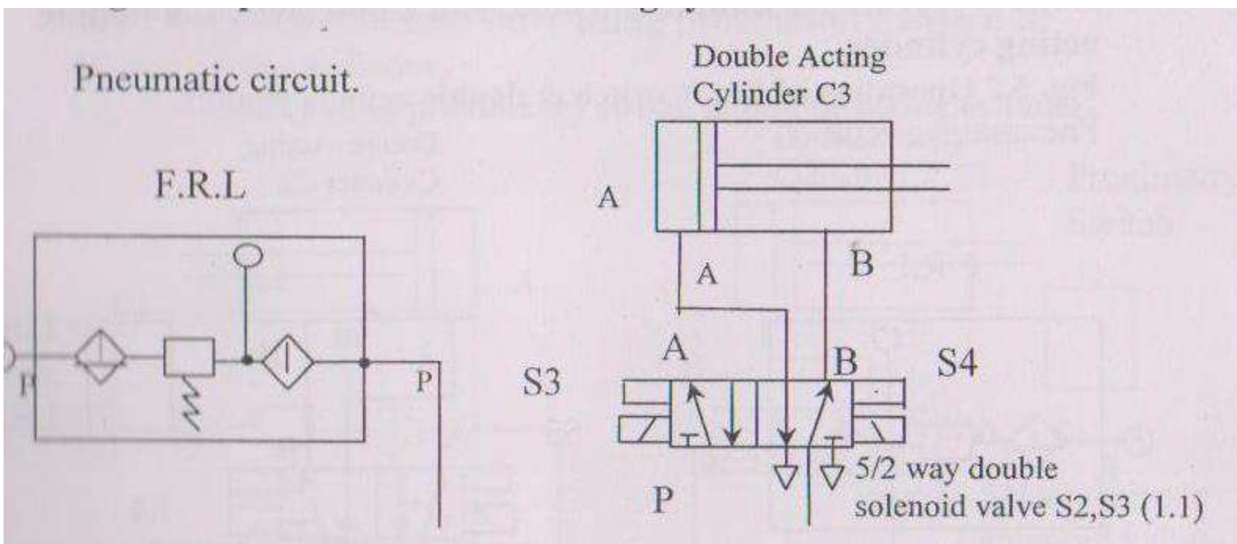


Fig: Operation of double acting cylinder

Procedure:-

1. Make wiring sequence as given above
2. Connect compressor to F.R.L.
3. Connect pressure line to ”P” to “P” of solenoid(S3& S4).
4. Connect “A” port of solenoid to “A” port of D.A. cylinder.
5. Connect “B” port of solenoid to “B” port of D.A. cylinder.
6. Vary the pressure by knob provided on F.R.L.
7. Make power supply ON.

8. As soon as the power supply is ON, when solenoid S2 becomes ON it extend the position rod of S.A. Cylinder and when S4 becomes of it retract position rod of D.A.(C3) cylinder automatically.
9. The sequence of task is repeated continuously because the timer is set in a stable mode.

Experiment No. : 2

Aim: - Design and assembly of Hydraulic Logic Circuit Utilizing Single and Double Acting Cylinder.

Objective:

1) To study the operation of working element Double acting cylinder.
2) To study the working of 4/3 way directional control valve.

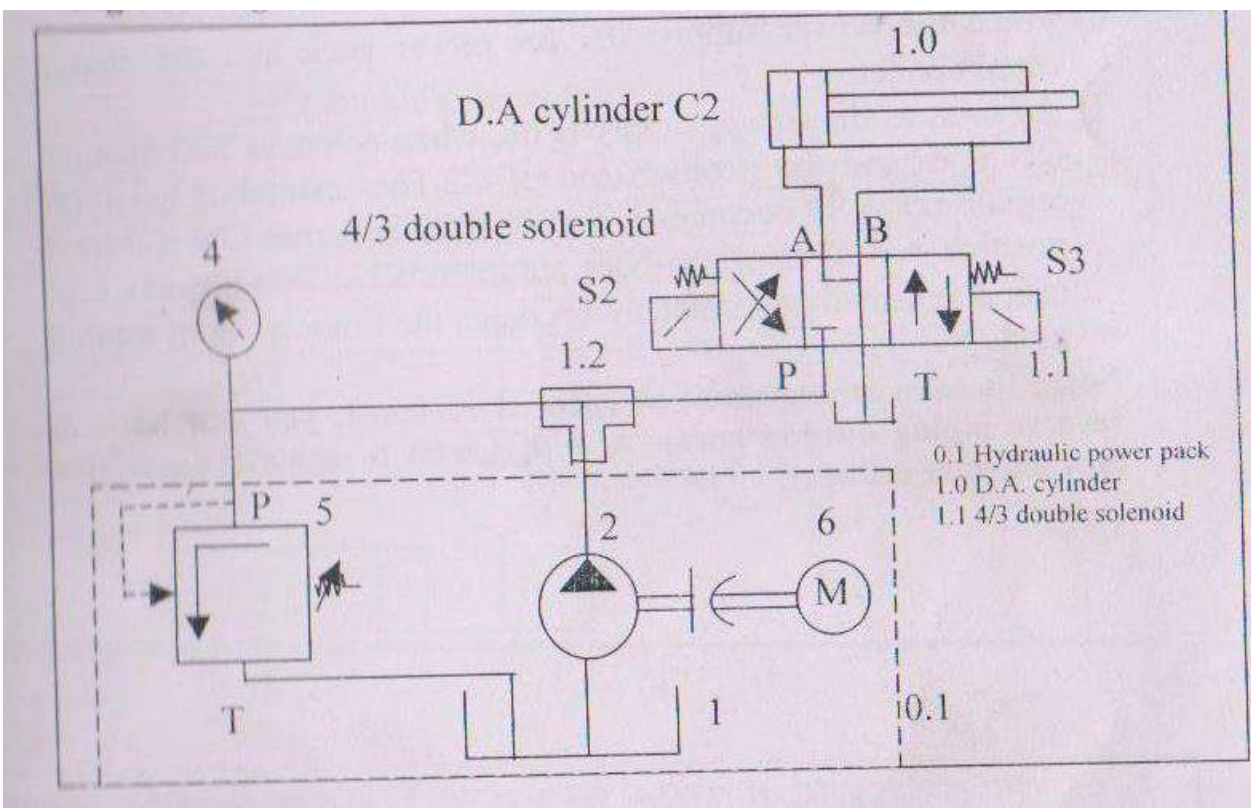


Fig: Diagram of double solenoid with double acting cylinder

Theory:

The hydraulic fluid reservoir holds excess hydraulic fluid to accommodate volume changes from cylinder extension and contraction, temperature driven expansion and contraction and leaks. The reservoir is also designed to aid in separation of air from the fluid.

Pump: The pump is used to draw the fluid and supply to the rest of the system. It is the pump that imparts power to the fluid and hence the system. The power of this hydraulic machine is proportional to that of the pump.

Common types of hydraulic pumps for hydraulic machinery applications are:
Gear pump: Cheap, durable, simple, less efficient because they are constant displacement and suitable for large pressure below 200 bar.
Vane pump: Cheap and simple, reliable, good for higher flow-low pressure output.

Pressure Relief Valve: It is used to bleed the fluid from the system into the reservoir when the pressure in the system exceeds the safe level. These valve are used in several machinery on the return circuit to maintain a small amount of pressure for brakes, pilot lines etc.

Hydraulic Hose: Hydraulic hose is graded by pressure temperature and fluid compatibility. A rubber interior is surrounded by multiple layers of the woven wire and rubber. The exterior is designed for abrasion resistance.

Hydraulic Pipe: Is thick enough to have threads cur into it for connections. It is rarely used for high pressure systems which prefer hoses.

Direction control valve: DCV is the valve that controls the direction of flow of the fluid in and out of the cylinder and connects the cylinder to the pump and the reservoir. These are generally designed to be stock able with one valve for each hydraulic cylinder and one fluid input, supplying all the valves in the stock.
Direction control valve can be actuated by spring, push button lever, solenoid or by the combination of these.

Procedure:-

1. Make the wiring sequence as given above.
2. Connect the solenoid DC valve (S2, S3) "P" to power pack".
3. Connect "T" of power pack to "T" of solenoid.
4. Connect "A" port of solenoid DC valve (S2, S3) to "A" port of double acting cylinder (C2).
5. Connect "B" port of solenoid DC valve (S2, S3) to "B" port of D.A. cylinder (C2).
6. Make the power supply ON for power pack and the power supply panel.
7. As soon as the power supply is ON, when solenoid S2 becomes ON it extends the position rod of C2. This extending position remain up to S3 becomes ON it retract the position rod of D.A. cylinder automatically. This sequence of task is repeated continuously becomes the timer is set in a stable mode.

Experiment No. : 3

Aim: - Implementation of various basic logic gates VIZ. OR, AND,NOT and NAND.

Objectives: -
- Understand the function of each logic gate and how it being used in the industrial automation field.
- Be able to draw the electrical wiring diagram and construct the hardware connections.

Introduction:
Automation is the use of control systems (such as numerical control, programmable logic control, and other application information technology (such as computer aided technology) to control industrial machinery and process, in order to reduce the need of human's intervention.
There are many advantages of using automation in industrial, some of those advantages are:
1- Replace human operations in tedious task.
2- Replace human operations in dangerous environments (fire, nuclear facilities, under the water .etc).
3- Make tasks that beyond human capability.
4- Economy improvements.

Theory:
A logic gate is an elementary building block of a digital circuit. Most logic gates have two inputs and one output. At any given moment, every terminal is in one of the two binary conditions low (0) or high (1), represented by different voltage levels. The logic state of a terminal can, and generally does, change ften, as the circuit processes data. In most logic gates, the low state is approximately zero volts (0 V), while the high state is approximately five volts positive (+5 V). There are seven basic logic gates: AND, OR, XOR, NOT, NAND, NOR, and XNOR. In this experiment we will discuss and implement each of Them.

Basic Logic Gates:

AND gate:
The AND gate is so named because, if 0 is called "false" and 1 is called "true," the gate acts in the same way as the logical "and" operator. Figure 1 illustration and table show the circuit symbol and logic combinations for an AND gate. (In the symbol, the input terminals are at left and the output terminal is at right.) The output is "true" when both inputs are "true." Otherwise, the output is "false."

Truth table:

Input 1	Input 2	Output
0	0	0
0	1	0
1	0	0
1	1	1

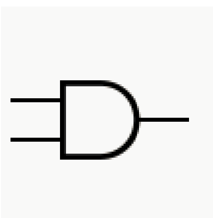


Figure (1): AND logic gate, Distinctive shape

OR gate:

The OR gate gets its name from the fact that it behaves after the fashion of the logical inclusive "or." The output is "true" if either or both of the inputs are "true." If both inputs are "false," then the output is "false". See figure2.

Truth table:

Input 1	Input 2	Output
0	0	0
0	1	1
1	0	1
1	1	1

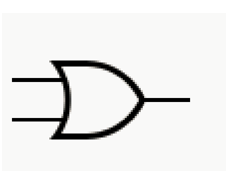


Figure (2): OR logic gate, a. Distinctive shape

Inverter gate:

A logical inverter, sometimes called a NOT gate to differentiate it from other types of electronic inverter devices, has only one input. It reverses the logic state shown in figure3.

Truth Table:

Input 1	Input 2
0	1
1	0

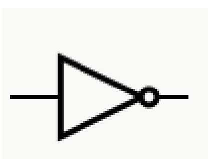


Figure (3): NOT logic gate, a. Distinctive shape

NAND gate:

The NAND gate operates as an AND gate followed by a NOT gate. It acts in the manner of the logical operation "and" followed by negation. The output is "false" if both inputs are "true." Otherwise, the output is "true”. See figure4

Input 1	Input 2	Output
0	0	1
0	1	1
1	0	1
1	1	0

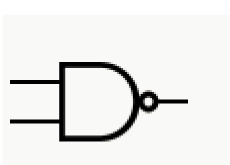


Figure (4): NAND logic gate, a. Distinctive shape

Procedure:

Part 1:
For each logic gate
1. Draw the wiring diagram representing the inputs as switches and output as LEDs.
2. Construct the drawn connection of yours.

Part 2:
Construct the connections to achieve the followings:
A- When push button PB1 is activated and push button PB2 (manual stop) is deactivated, LED1 turns on.
B- When PB1 or PB2 or both are activated and PB3 (manual stop) deactivated, then LED1 turns on, else LED1 must be off.
C- When PB1 and PB2 are activated and PB3 (manual stop) is deactivated, then LED1 turns on, and LED2 (emergency indicator) turns off. but at the moment the manual stop being activated (PB3) , LED1 and LED2 will be toggled.

Part 3:
Application in industrial field and automation:
Entrance Control Systems (access control system): In the entrance and exit of parking, there is a sensor before the barriers to detect movement of cars and automatically control the barriers. Draw electrical wiring diagram for such system in order to detect any car and opened the barrier then closed it.
- Make a connection in order to build such system use LEDs to simulate the barrier and switch for sensor.

Figure: barrier.
Hint: you need two sensors, before and after the barrier to ensure that the car is completely lift.

In the report:

Part 2:
A- The following Truth table must be filled

PB1	PB2	LED1
0	0	
0	1	
1	0	
1	1	

B- The following Truth table must be filled

PB1	PB2	PB3(manual Stop)	LED1
0	0	0	
0	1	0	
1	0	0	
1	1	0	

PB1	PB2	PB3(manual Stop)	LED1
0	0	1	
0	1	1	
1	0	1	
1	1	1	

C- The following Truth table must be filled

PB1	PB2	PB3(Manual Stop)	LED1	LED2
0	0	0		
0	1	0		
1	0	0		
1	1	0		

PB1	PB2	PB3(Manual Stop)	LED1	LED2
0	0	1		
0	1	1		
1	0	1		
1	1	1		

Experiment No. : 4

Aim: - To familiarize with microprocessor based PLC and its industrial applications.

Objectives:

- Using PLC "hard ware and soft ware" in building and controlling automatic systems.

- Implement complete system by using hardware in the laboratory.

Industrial Application:

Design and implement a Robot machine as below:

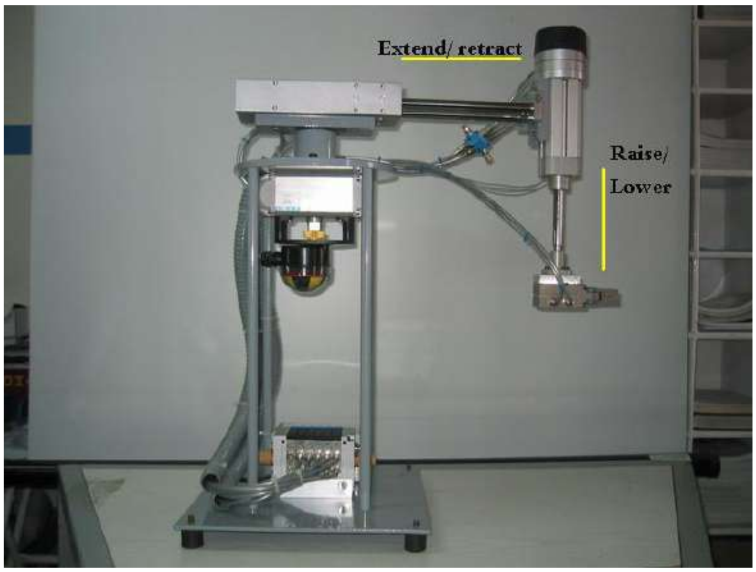


Fig: Industrial Robot

Robot is a mechanical or virtual intelligent agent that can perform tasks automatically or with guidance. It defines as a programmable and automatically controlled machine that imitates the actions or appearance of an intelligent creature, usually a human. See figure 1

American National Standards Institute (ANSI) defines an industrial robot as "a reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through various programmed motions for the performance of a variety of tasks". Figure 1 represents one of industrial robot that will be used in our experiment.

An industrial robot can be classified according to the following main characteristic:
1- Number of axes of motion "degree of freedom".
2- Kinematic structure.
3- Maximum speed.
4- Accuracy.
5- Drive train (actuators, remote vs. direct-drive).

In general, the most important classification is depending on kinematic structure and the coordinate frame, and then industrial robot can be divided into three types:
a- Cartesian robots.
b- SCARA robots.
c- Articulated robot.

A- Cartesian coordinate Robot:

It is also called a rectilinear "linear" robot. That has three principle linear axes to be controlled. Also these axes have a right angle between each other.
Figure 2 represents a kinematic diagram of such robot.

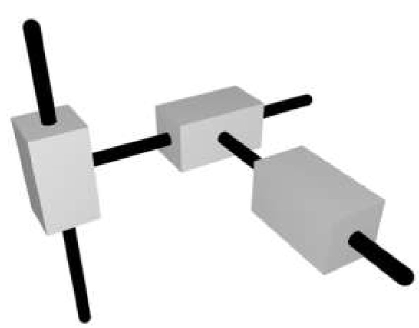


Figure 2: kinematic Diagram for Cartesian Robot

This type of industrial robots are widely used in CNC machine "computer numerical control machine" where a pen or router translates across an x-y plane while a tool is raised and lowered onto a surface of the work pieces to create a precise design. see figure 3

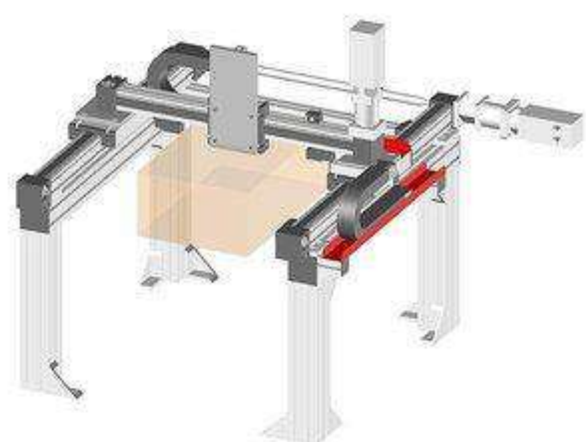


Figure 3: Cartesian Robot in CNC Machine.

B- SCARA Robot:

SCARA robot stands for Selective Compliant Assembly Robot Arm. It is primarily cylindrical in design. See figure 4 which represent the kinematic diagram of such robots.

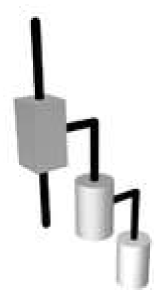


Figure 4: kinematic Diagram for SCARA Robot.

In such robot 'X', 'Y' and the 'Theta-Z' movements are obtained with three parallel-axis rotary joints. Figure 5 represent that more clearly.

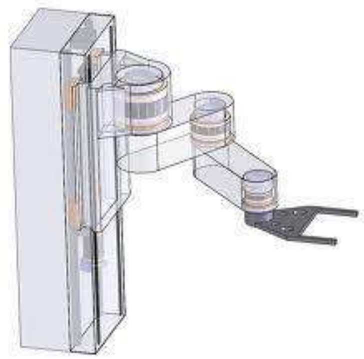


Figure 5: SCARA Robot axes of motion

By virtue of the SCARA's parallel-axis joint layout, the arm is slightly compliant in the X-Y direction but rigid in the 'Z' direction, hence the term: Selective Compliant. This is advantageous for many types of assembly operations, e.g., inserting a round pin in a round hole without binding.
This one of industrial robots is generally faster and cleaner than Cartesian coordinate one. On the other hand it can be more expensive and the controlling software requires inverse kinematics for linear interpolated moves.

C- Articulated robot:
This robot design with rotary joints. Those allow the robot to access its workspace. Usually the joints are arranged in a "chain", so that one joint supports another further in the chain. It can be arranged from simple two-jointed structures to systems with 10 or more interacting joints. See figure 6

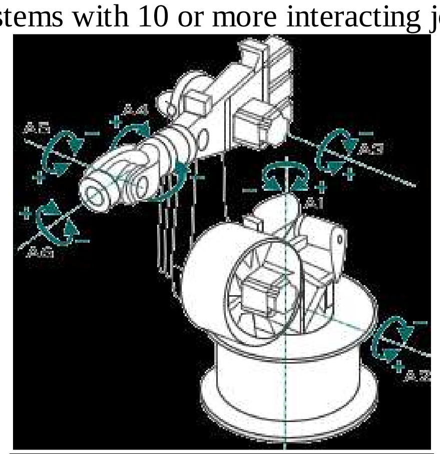


Figure 6: Articulated Robot Kinematic Diagram

Each joint is called an axis and provides an additional degree of freedom, or range of motion. Industrial robots commonly have four or six axes. The rotary joints in such robot are powered by a variety of means, including electric motors. See figure 7

Figure 7: Articulated Industrial Robot

Procedure:

Implement and control the industrial robot in the laboratory by using LOGO PLC kit in order to do some funny movements and offer candy to guests.
The robot is a pneumatic actuated robot that can do the followings:
1- Extend / Retract." "Linear movement".
2- Move Up / Down. "Linear movement".
3- Rotate the robot body left / right.
4- Rotate the gripper clockwise CW /counter clock wise CCW.
5- Open/Close the gripper.

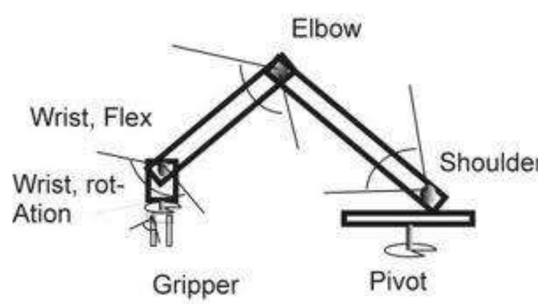
Experiment No.: 5

Aim: Demonstration of robotic arm and its applications .

Parameters

- **Number of axes** – two axes is required to reach any point in a plane; three axes are required to reach any point in space. To fully control the orientation of the end of the arm (i.e. the wrist) three more axes (yaw, pitch, and roll) are required. Some designs (e.g. the SCARA robot) trade limitations in motion possibilities for cost, speed, and accuracy.
- Degrees of freedom which is usually the same as the number of axes.
- Working envelope – the region of space a robot can reach.
- Kinematics – the actual arrangement of rigid members and joints in the robot, which determines the robot's possible motions. Classes of robot kinematics include articulated, Cartesian, parallel and SCARA.
- Carrying capacity or payload – how much weight a robot can lift.
- Speed – how fast the robot can position the end of its arm. This may be defined in terms of the angular or linear speed of each axis or as a compound speed i.e. the speed of the end of the arm when all axes are moving.
- Acceleration - how quickly an axis can accelerate. Since this is a limiting factor a robot may not be able to reach its specified maximum speed for movements over a short distance or a complex path requiring frequent changes of direction.
- Accuracy – how closely a robot can reach a commanded position. When the absolute position of the robot is measured and compared to the commanded position the error is a measure of accuracy. Accuracy can be improved with external sensing for example a vision system or Infra-Red. See robot calibration. Accuracy can vary with speed and position within the working envelope and with payload (see compliance).
- Repeatability - how well the robot will return to a programmed position. This is not the same as accuracy. It may be that when told to go to a certain X-Y-Z position that it gets only to within 1 mm of that position. This would be its accuracy which may be improved by calibration. But if that position is taught into controller memory and each time it is sent there it returns to within 0.1mm of the taught position then the repeatability will be within 0.1mm.

- Motion control – for some applications, such as simple pick-and-place assembly, the robot need merely return repeat ably to a limited number of pre-taught positions. For more sophisticated applications, such as welding and finishing (spray painting), motion must be continuously controlled to follow a path in space, with controlled orientation and velocity.
- **Power source** – some robots use electric motors, others use hydraulic actuators. The former are faster, the latter are stronger and advantageous in applications such as spray painting, where a spark could set off an explosion; however, low internal air-pressurization of the arm can prevent ingress of flammable vapors as well as other contaminants.
- **Drive** – some robots connect electric motors to the joints via gears; others connect the motor to the joint directly (direct drive). Using gears results in measurable 'backlash' which is free movement in an axis. Smaller robot arms frequently employ high speed, low torque DC motors, which generally require high gearing ratios; this has the disadvantage of backlash. In such cases the harmonic drive is often used.
- **Compliance -** this is a measure of the amount in angle or distance that a robot axis will move when a force is applied to it. Because of compliance when a robot goes to a position carrying its maximum payload it will be at a position slightly lower than when it is carrying no payload. Compliance can also be responsible for overshoot when carrying high payloads in which case acceleration would need to be reduced.



End-of-arm Tooling or end effectors,

The most essential robot peripheral is the end effectors, or end-of-arm-tooling (EOT). Common examples of end effectors include welding devices (such as MIG-welding guns, spot-welders, etc.), spray guns and also grinding and deburring devices (such as pneumatic disk or belt grinders, burrs, etc.), and grippers (devices that can grasp an object, usually electromechanical or pneumatic). Another common means of picking up an object is by vacuum. End effectors are frequently highly complex, made to match the handled product and often capable of picking up an array of products at one time. They may utilize various sensors to aid the robot system in locating, handling, and positioning products.

Controlling Movement For a given robot the only parameters necessary to completely locate the end effectors (gripper, welding torch, etc.) of the robot are the angles of each of the joints or displacements of the linear axes (or combinations of the two for robot formats such as SCARA). However there are many different ways to define the points. The most common and most convenient way of defining a point is to specify a Cartesian coordinate for it, i.e. the position of the 'end effectors' in mm in the X, Y and Z directions relative to the robot's origin. In addition, depending on the types of joints a particular robot may have, the orientation of the end effectors in yaw, pitch, and roll and the location of the tool point relative to the robot's faceplate must also be specified. For a jointed arm these coordinates must be converted to joint angles by the robot controller and such conversions are known as Cartesian Transformations which may need to be performed iteratively or recursively for a multiple axis robot. The mathematics of the relationship between joint angles and actual spatial coordinates is called kinematics.

Robotic end effectors

Robot end effectors: - In robotics, an **end effectors** is the device at the end of a robotic arm, designed to interact with the environment. The exact nature of this device depends on the application of the robot. In the strict definition, which originates from serial robotic manipulators, the end effector means the last link (or end) of the robot. At this endpoint the tools are attached. In a wider sense, an end effector can be seen as the part of a robot that interacts with the work environment. This does not refer to the wheels of a mobile robot or the feet of a humanoid robot which are also not end effectors—they are part of the robot's mobility. End effectors may consist of a gripper or a tool. The gripper can be of two fingers, three fingers or even five fingers.

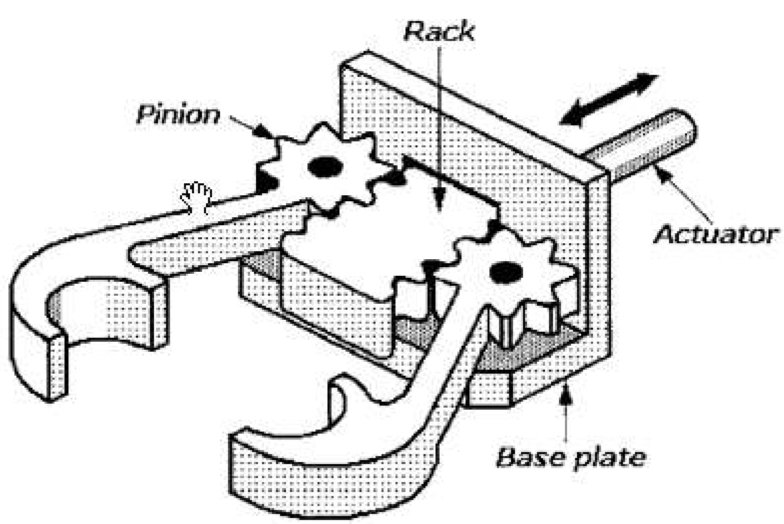
The end effectors that can be used as tools serve various purposes. Such as, Spot welding in an assembly, spray painting where uniformity of painting is necessary and for other purposes where the working conditions are dangerous for human beings. Surgical robots have end effectors that are specifically manufactured for performing surgeries.

When referring to robotic pretension there are four general categories of robot grippers, these are:

1. Impactive – jaws or claws which physically grasp by direct impact upon the object.
2. Ingressive – pins, needles or hackles which physically penetrate the surface of the object (used in textile, carbon and glass fiber handling).
3. Astrictive – suction forces applied to the objects surface (whether by vacuum, magneto– or electro adhesion).
4. Contiguities – requiring direct contact for adhesion to take place (such as glue, surface tension or freezing).

Mechanism of gripping: Generally, the gripping mechanism is done by the grippers or mechanical fingers. The number of fingers can be two, three or even as high as five. Though in the industrial robotics due to less complication, two finger grippers are used. The fingers are also replaceable. Due to gradual wearing, the fingers can be replaced without actually replacing the grippers. There are two mechanisms of gripping the object in between the fingers (due to simplicity in the two finger grippers, in the following explanations, two finger grippers are considered).

Shape of the gripping surface: The shape of the gripping surface on the fingers can be chosen according to the shape of the objects that are lifted by the grippers. For example, if the robot is designated a task to lift a round object, the gripper surface shape can be a negative impression of the object to make the grip efficient, or for a square shape the surface can be plane.



Force required to grip the object : Though there are numerous forces acting over the body that has been lifted by the robotic arm, the main force acting there is the frictional force. The gripping surface can be made of a soft material with high coefficient of friction so that the surface of the object is not damaged. The robotic gripper must withstand not only the weight of the object but also acceleration and the motion that is caused due to frequent movement of the object. To find out the force required to grip the object, the following formula is used

$$F = \mu W n$$

where:

F is the force required to grip the object,
μ is the coefficient of friction,
n is the number of fingers in the gripper and
W is the weight of the object.

But the above equation is incomplete. The direction of the movement also plays an important role over the gripping of the object. For example, when the body is moved upwards, against the gravitational force, the force required will be more than towards the gravitational force. Hence, another term is introduced and the formula becomes:

$$F = \mu W n g$$

Here, the value of g should not be taken as the acceleration due to gravity. In fact, here g stands for multiplication factor. The value of g ranges from 1 to 3. When the body is moved in the horizontal direction then the value is taken to be 2, when moved against the gravitational force then 3 and along the gravitational force, i.e., downwards, 1.

Application: The end effector of an assembly line robot would typically be a welding head, or a paint spray gun. A surgical robot's end effector could be a scalpel or others tools used in surgery. Other possible end effectors are machine tools, like a drill or milling cutters. The end effector on the space shuttle’s robotic arm uses a pattern of wires which close like the aperture of a camera around a handle or other grasping point.

CHANDIGARH UNIVERSITY

DEPARTMENT OF MECHANICAL ENGINEERING

Industrial Automation and Robotics Laboratory	Subject Code: MEP-354

PREPARED BY CHECKED BY APPROVED BY

Experiment No.: 6

Aim : To exhibit the working of flexible manufacturing system (FMS)

FMC Layout

The layout for flexible manufacturing cell (FMC) in Chandigarh University has been shown in Figure 1. The entire system has been developed by Hytech Industries, Pune. The system comprises of a number of physical and control systems. The automated guided vehicle (AGV) is initially homed at a point near the automatic storage/retrieval system (Figure 1). To perform a particular operation, the workpiece pallet is called using the master controller and is placed on the AGV. The AGV carries the workpiece pallet in the fixed path towards the robot as shown in the layout (Figure 1). The AGV rests at the machine loading/unloading position. The robot picks the workpiece and places it in either CNC lathe or mill, which depends upon the final processing requirement. The program to be followed by robot is selected from the robot controller. A number of paths can be chosen which will lead to perform any machining operation on the workpiece. After the final machining is done, the workpiece is picked by the robot and placed on the AGV. The AGV travel backs to the starting point from where it initially rested. The robotic arm of ASRS unit now picks the pallet and places it on the finished rack.

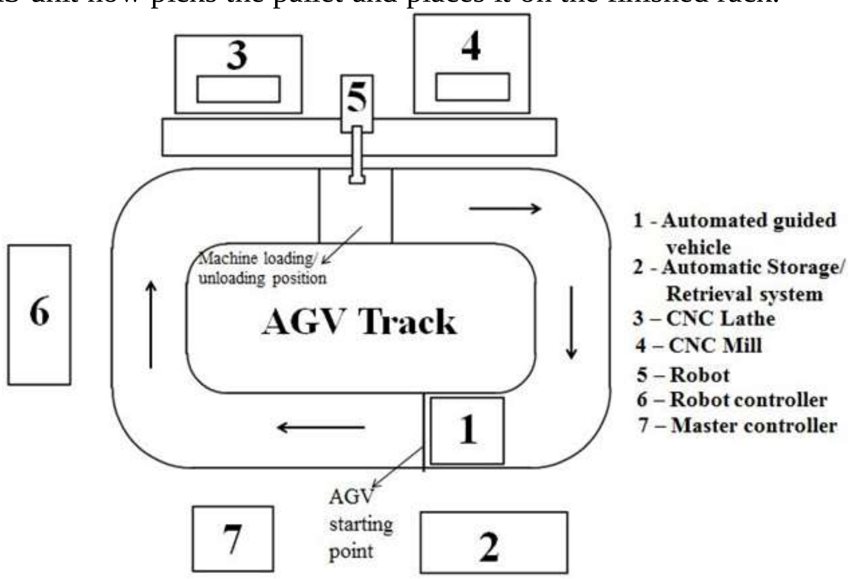


Figure 1.Schematic layout of the flexible manufacturing cell

FMC ELEMENTS

The FMC elements comprise of the physical and the control elements which are discussed as follows:

Automated guided vehicle (AGV)

The automated guided vehicle used in FMC is programmed on the basis of two mechanisms. Firstly, the number of rotations to the wheel is specified. If the wheel has to take right turn, the left hand side wheel will take fewer rotations compared to the right hand side wheel. The programming for AGV is done by the inbuilt touch panel where numeric values are entered. The path to be travelled by AGV can be broken into a number of sections. Once one section is travelled by AGV, indication to travel the next section would be given by reflective strips which are the part of second programming mechanism. Two photo sensors are provided for each wheel of AGV so that the color strips can be detected. AGV will stop at the position where the programmed path ends or when the sensor detects red colored strip. Whichever condition approaches first, the AGV shall execute the path of next section. Initial referencing of the vehicle is must before starting the programmed path. The positional accuracy of this AGV is 10 mm. A proximity sensor is installed at the front of AGV so that it stops in case any obstacle is encountered. A conveyor belt is installed at the top of a machine. The conveyor facilitates in handling the workpiece from the robotic arm of Automatic storage/Retrieval system.

CNC Lathe

The CNC lathe comprises of 8 tool turret station which can perform variety of operations like threading, boring, turning facing etc. A spindle speed of 6000 rpm can be achieved in this machine.

CNC Mill

This machine is a three axis milling machine to which a 4th axis can also be integrated. The three axes program can be converted into 4th axes by converting Y axis (linear) into A axis (Rotary). Thus with the help of this feature, complex profiles can be easily developed without the use of expensive CAM software. A pneumatic vice has been attached to the machine which provides the flexibility to hold a variety of rectangular and cylindrical workpieces. This machine is equipped with précised linear motion guideways which have a resolution of 1 micron.

Automatic Storage and Retrieval system (ASRS)

The ASRS system is used to store the raw and final workpieces for both CNC lathe and mill. A total number of 16 racks are present which are equally divided for both raw and finished workpieces. A robotic arm which is an integral part of the ASRS systems transfers the pallets placed in the racks to the AGV. Part programming is done on the master controller PC for locating the pallet and precisely placing it on a AGV.

Robot

Various operations like, picking, placing, machine unloading/loading, palletizing, object identification, object stacking etc. can be performed by this robot. The robot has 6 axis which can be programmed through G and M codes. A positional accuracy of 10 micron is easily achievable in this robot. The robot is equipped with a probing sensor which is used to detect the exact position of workpiece. The probing photo sensor emits light and measures the exact position of workpiece by detecting the amount of light reflected back towards it. The whole robotic arm unit is mounted on a conveyor which can travel in a range of 3 to 5 m.

Control system

The installed FMC system can be operated on two modes, individual mode and FMC mode. In FMC mode, the communication between machines has to be established. The communication between machines is established by using the robot controller panel. G and M codes are used to program the robot, CNC Mill and CNC Lathe. The Control system of the machines is PLC based which has been developed by CutViewer, United Kingdom.

Experiment No.: 7

Aim: To perform work offset in case of CNC Mill

Theory: It is difficult to place a vise in the exact same position on the machine each time, the distance from Home to the WCS(Work Coordinate System) is usually not known until the vice is set and aligned with the machine. Machine set up is best done after the program is completely written, because the programmer may change his mind during the CAM process, rendering any pre-planned setup obsolete. To complicate matters further, different tools extend out from the machine spindle different lengths, also a value difficult to determine in advance. For example, a long end mill extends further from the spindle face than a stub length drill. If the tool wears or breaks and must be replaced, it is almost impossible to set it the exact length out of the tool holder each time. Therefore, there must be some way to relate the Machine Coordinate system(MCS) to the part WCS and take into account varying tool lengths. This is done using Work Offsets. There are many offsets available on CNC machines. Understanding how they work and to correctly use them together is essential for successful CNC machining. In Hytech CNC Machine, there are various work offsets from G54 to G 59.3. That means offset of 8 different workpieces can be stored in the controller. It is always recommended to take the work offset before running the program if the operator is not sure about the exact dimensions of the workpiece.

Procedure 1:

Step 1: Mount the workpiece in the vice
Step 2: Move the tool exactly to the point which you want to consider as 0,0,0 (X:0, Y:0 and Z:0). For example, if you want the work offset exactly at the center of the workpiece, move x and y axes in such a way that tool is exactly at the center of the workpiece. Now move the Z Axis in such a way that the tool tip will touch the top surface of the workpiece. We suggest you to define the upper surface of the material as Z=0, such that a negative Z value goes into the material.
Step 3: Go to Coordinates Tab
Step 4: Select the desired work offset, say for example G54

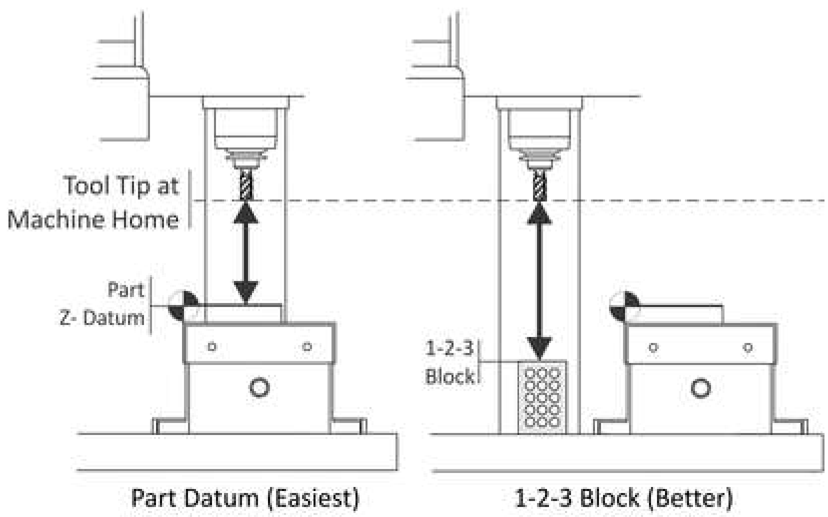
Procedure 2:

Step 1: Mount the workpiece in the vice
Step 2: Move the tool exactly to the point which you want to consider as 0,0,0 (X:0, Y:0 and Z:0). For example, if you want the work offset exactly at the center of the workpiece, move x and y axes in such a way that tool is exactly at the center of the workpiece. Now move the Z Axis in such a way that the tool tip will touch the top surface of the workpiece. We suggest you to define the upper surface of the material as Z=0, such that a negative Z value goes into the material.
Step 3: Go to 'MDI'
Step 4: Type following command and press enter. G10 L20 P1 x0 y0 z0
G10 : Coordinate system origin setting
L20 P1 : Corresponds to G54. Similarly,
L20 P2 corresponds to G55 and so on.
X0 Y0 Z0 : Current position of the tool. If tool is jogged to any other position, coordinates will change accordingly.

Aim: To perform tool offset in case of CNC Mill

TOOL OFFSET theory

Every tool loaded into the machine is of different length. In fact, if a tool is replaced due to wear or breaking, the length of its replacement will likely change because it is almost impossible to set a new tool in the holder in exactly the same place as the old one. The CNC machine needs some way of knowing how far each tool extends from the spindle to the tip. This is accomplished using a Tool Length Offset (Tool Offset). In its simplest use, the Tool Offset is found by jogging the spindle with tool from the machine home Z-position to the part Z-zero position, as shown on the far left in Figure 1.



The tool is jogged to the part datum Z and the distance travelled is measured. This value is entered in the TLO register for that tool. Problems with this method include the need to face mill the part to the correct depth before setting tools. The second method is much preferable as compared to other method. All tools are set to a known Z-position, such the top of a precision 1-2-3 block resting on the machine table. This makes it very easy to reset tools if worn or broken.

How to take Tool Offset?

The various tools in the ATC have various diameters as well as various lengths. During the lifetime of the machine, user might have to change the tools which might have different tool length / diameter than the original tool. To cater this variation, we can enter the tools details in tool offset.

Step 1: Go to Tools Tab. Clear all of the values currently present in the tool table.
Step 2: Select tool 1. For this you can command "T1 M6" in MDI.

Step 3: Move the edge of this tool to a machine position whose machine coordinate values are known. For example, you can move this tool exactly at the center of the work piece. At this point, we will note the machine coordinate values. For tools offset of Milling machine, Z Axis value is of prime importance. The edge of the tools is expected to touch the top of the workpiece. In this case, enter the machine coordinate value of Z axis in tools table in Z offset column as shown below. Also, enter the diameter of the tool. As soon as you click on the save changes button, Machine coordinate value will change to 0

Step 4: Select next tool, say for example tool no. 2. The same will be shown on the operate screen as shown below. Always cross check that the tool commanded and the tool loaded in the spindle are the same. That means when operate window shows tool 2, the same tool should be present in the spindle.
Step 5: Repeat the same procedure that you carried out for Tool no.1 for all tools.

AIM: - To perform work offset in case of CNC lathe.

THEORY - The work piece coordinate systems defined through G54 to G59 or G54 P{1 ... 93} can be changed with the following two processes.

- Data inputting from Coordinates Tab
- with the program commands G10 or G50 (setting actual value)

Format Modified by G10: G10 L2 Pp X (U)... Z(W)... ;
p=0: External workpiece work offset p=1 to 6: The value of the workpiece work offset corresponds to the workpiece coordinate system G54 to G59 (1 = G54 to 6 = G59)
X, Z: Absolute setting data of the workpiece coordinate system offset.
U, W: Incremental setting data of the workpiece coordinate system offset.
Modified by G50: G50 X... Z... ;

Explanations

Modified by G10:
G10 can be used to change each workpiece coordinate system individually. If the work offset with G10 is to be written only when the G10 block is executed on the machine (main run block), then MD20734 $MC_EXTERN_FUNCTION_MASK, Bit 13 must be set. An internal STOPRE is executed in that case with G10. The machine data bits affect all G10 commands in the ISO Dialect T and ISO Dialect M.
Modified by G50:
By specifying G50 X... Z..., a workpiece coordinate system that was selected earlier with a G command G54 to G59 or G54 P{1 ...93}, can be shifted and thus a new workpiece coordinate system can be set. If X and Z are programmed incrementally, the workpiece coordinate system is defined in such a way that the current tool position matches the total of the specified incremental value and the coordinates of the previous tool position (shift of coordinate system).
Finally, the value of the coordinate system shift is added to each individual value of the workpiece work offset. To put it another way: All workpiece coordinate systems are shifted systematically by the same value.

PROCEDURE:

The various commands used: -
1. Home the tool by pressing the F8 button.
2. Open the Job pad and slowly bring the tool towards the work piece such that the tool overlaps the work piece position.
3. Now bring the tool in contact with the work piece such that the paper between tool and the work piece gets stucked in between.
4. As the outer diameter is touched. Open the MDI button and write,

g10 l20 p1 x25

Where 25 is the diameter of the work piece measured by Vernier calliper
5. Now bring the tool away from the work piece in z direction without changing the x coordinates.

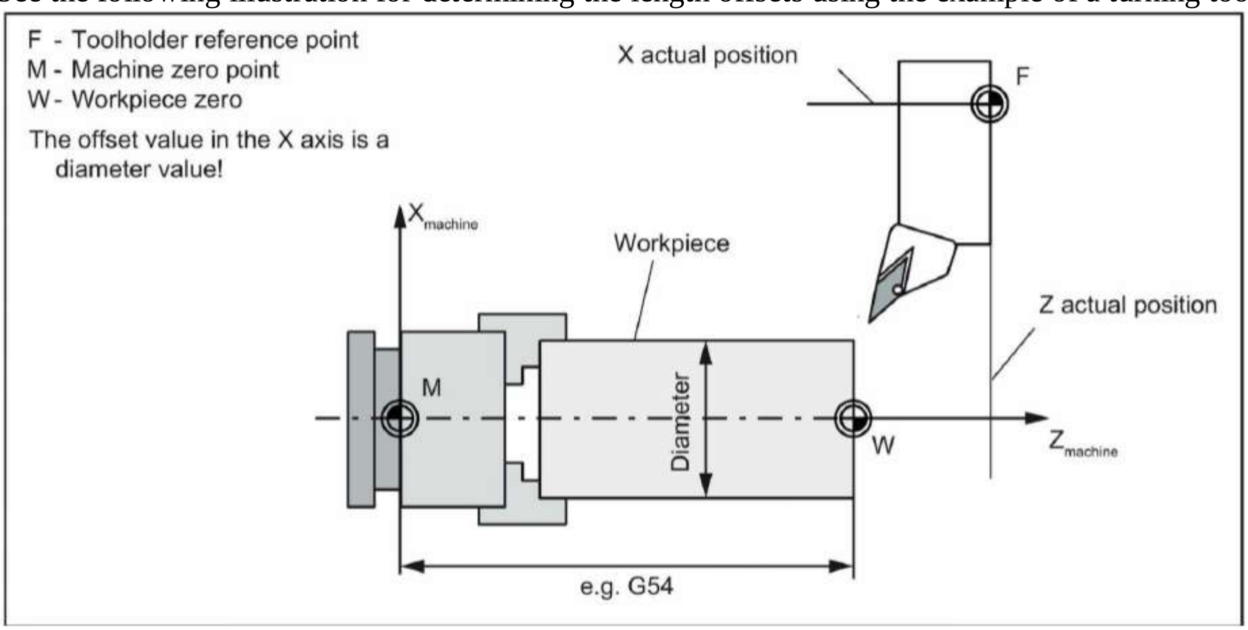
6. The tool should be brought to the center by entering the command,

g0 g91 x -25

7. The tool will now come in front of work piece face where the cutting edge point will coincide with the center of the work piece face.
8. Keep the paper in between tool and the work piece and slowly move the tool in contact of work piece.
9. The place where paper gets fixed, stop the movement of jog pad and enter the command g10 l20 p1 z0
10. On the software screen all the coordinates would be displayed zero.

AIM: To perform tool offset in case of CNC lathe

The geometries of the machining tool must be taken into consideration when you execute a part program. These are stored as tool offset data in the tool list. Each time the tool is called, the control considers the tool offset data. You can determine the tool offset data, including the length, radius and diameter by either measuring the tool or entering the values in the tool list.
As per the actual position of the point F (the machine coordinate) and the reference point, the control system can calculate the offset value assigned to the lengths for the X and Z axes.
See the following illustration for determining the length offsets using the example of a turning tool:



Measuring the tool in the X direction:
1. Select the desired operating area.

2. Switch to "JOG" mode.

3. Move the current activated tool to the position whose coordinates are known to the user.

4. Open the manual tool (Tools) tab.
5. In X Offset column, enter the value in such a way that the work coordinate reflect the exact position of the tool.

Measuring the tool in Z direction
1. Select the desired operating area.
2. Switch to "JOG" mode.
3. Move the current activated tool to the position whose coordinates are known to the user.
4. Open the manual tool (Tools) tab.
5. In Z offset column, enter the value in such a way that the work coordinate reflect the exact position of the tool.

CHANDIGARH UNIVERSITY	
DEPARTMENT OF MECHANICAL ENGINEERING	
Mechanical Measurement and Metrology Laboratory	**Subject Code: MEY-255**

Mechanical Measurement
and
Metrology Lab

Course Code: MEY - 255

Vision and Mission of the Chandigarh University
Vision

"To be globally recognized as a Centre of Excellence for Research, Innovation, Entrepreneurship and disseminating knowledge by providing inspirational learning to produce professional leaders for serving the society"

Mission

M1: Providing world class infrastructure, renowned academicians and ideal environment for Research, Innovation, Consultancy and Entrepreneurship relevant to the society.

M2: Offering programs & courses in consonance with National policies for nation building and meeting global challenges.

M3: Designing Curriculum to match International standards, needs of Industry, civil society and for inculcation of traits of Creative Thinking and Critical Analysis as well as Human and Ethical values.

M4: Ensuring students delight by meeting their aspirations through blended learning, corporate mentoring, professional grooming, flexible curriculum and healthy atmosphere based on co-curricular and extra-curricular activities.

M5: Creating a scientific, transparent and objective examination/evaluation system to ensure an ideal certification.

M6: Establishing strategic relationships with leading National and International corporates and universities for academic as well as research collaborations.

M7: Contributing for creation of healthy, vibrant and sustainable society by involving in Institutional Social Responsibility (ISR) activities like rural development, welfare of senior citizens, women empowerment, community service, health and hygiene awareness and environmental protection

Vision and Mission of the Department of Mechanical Engineering

Vision

To be recognized as a center of excellence for research and innovation in Mechanical Engineering through contemporary as well as futuristic tools and technologies for serving the society at regional, national and global level

Mission

M1: Providing quality education to the students in core and allied fields by implementing advanced pedagogies

M2: Encouraging students towards research and development through advanced tools and technologies for providing solution to societal problems

M3: Evolve and empower the students through core technical skills for becoming entrepreneurs and innovators

M4: Inculcating employability and leadership skill for ensuring industry ready professional through hands on experiential learning and industrial collaboration

M5: Developing professional and ethical standards in the mind of the young engineers by continuous learning and professional activities

1.2 .State the Program Educational Objectives (PEOs)(5)

PROGRAM EDUCATION OBJECTIVES (PEOs):

PEO1: Mechanical Engineering graduates will have professional knowledge in the field of Mechanical Engineering and its allied branches.

PEO2: Graduates will have successful career in government services, research organizations, academic institutes and industries at national and international repute.

PEO3: The graduates will be capable of utilizing modern tools and technologies for deliberating solutions to engineering problems.

PEO4: Graduate will be able to identify the concern for Society, environment and communicate effectively while leading the interdisciplinary diverse team under divergent needs.

PEO5: To produce graduates adaptable for higher education, research and development, creativity, innovations, entrepreneurship and professional development.

Program Outcome (POs)

PO1: Ability to apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.

PO2: Ability to identify, formulate, research literature and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

PO3: Ability to design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.

PO4: Ability to conduct investigation into complex problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.

PO5: Ability to create, select and apply appropriate techniques, resources and modern engineering and IT tools, including prediction and modelling, to complex engineering activities, with an understanding of the limitations.

PO6: Ability to apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.

PO7: Ability to recognize and incorporate the diversity and commonalities of engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.

PO8: Ability to apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

PO9: Ability to function effectively as an individual and as member or leader in a diverse teams and interdisciplinary settings.

PO10: Ability to communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

PO11: Ability to demonstrate knowledge and understanding of the engineering and management principles and also apply these principles to one's own work as member and leader to the teams to manage projects and interdisciplinary teams.

PO12: Ability to recognize the need for, and have the preparations and ability to engage in Independent and lifelong learning in the broadest context of technological change

Program Specific Outcomes:

PSO1: Apply the knowledge of Production and Manufacturing concepts for analysis and development of Mechanical systems.

PSO2: Apply the Principle of Design and Thermal Engineering to construct various components and systems.

Mechanical Measurement and Metrology Lab

Course Objectives

- Focuses on equipment, work systems, machinery, and automation systems for today's manufacturing environment
- To provide students the opportunity to acquire hands-on experience in the use of the engineering equipment, systems, and tools in the lab
- To understand working and construction of hydraulic and pneumatic circuits

To understand, diagnose an automated system.

Course Outcomes

After completion of course the student will be able to:

CO1	Apply the basic concept of automation and its components
CO2	Design hydraulic & pneumatic circuit integrated with PLC
CO3	Classify the FMS, develop and execute the CNC program for machining the component on lathe and milling machines
CO4	Inspect the the various features of industrial Robot and its applications considering social, health, safety, legal and environmental
CO5	Conclude the experimental results and express the same effectively in oral and written manners through report and practical presentation

List Of Experiments

1. Measurement of Linear dimensions using Vernier caliper, Micrometer and slip gauges.

2. Measurement of an angle with the help of sine bar and bevel protector.

3. Measurement of surface roughness of a machined plate, rod and pipe.

4. Measurement of gear elements using profile projector.

5. Measurement of effective diameter of external threads using three wire method

6. Measurement of thread element by tool makers microscope.

7. Calibration of a pressure guage with the help of a dead weight guage tester.

8. Use of stroboscope for measurement of speed of shaft.

9. Use of pitot tube to plot velocity profile of a fluid through a pipe.

10. Preparation of a thermocouple, its calibration and application for temperature measurement.

List of Equipments

S. No.	Name of Equipment/ Apparatus	Brief Specifications	Quantity	Price (Rs.)	Year of Purchase
1	Profile Projector	RPP-250	1	65800	2011
2	Profile Projector	RPP-3000	1	78800	2014
3	Tool Maker Microscope	RTM 500	2	71200	2014
4	Calibration Of Thermocouple	std	2	50400	2014
5	Dead Weight Pressure Gauge Tester	std	1	39000	2014
6	Depth Gauge And Dial Indicator	0-150 mm	1	1425	2011
7	Height gauge	0-300 mm	1	8700	2011
8	Inside Micrometer	5-30 mm	1	2600	2011
9	Outside Micrometer 25-50 MM	25-50 mm	2	5570	2015
10	Roughness Tester	TR 110	1	44838	2011
11	Dead Weight Pressure Gauge Tester	Dw-13	1	42200	2011
12	Vernier Depth Gauge	0-300mm	1	5100	2015
13	Dial Gauge	0.01--25 mm	1	1760	2015
14	Dial Gauge	0.01--25 mm	1	903	2011
15	Micrometer	0-25 mm	2	4180	2015
16	Vernier Caliper	150mm	3	6900	2015
17	Thread Gauge	Std	1	1350	2015
18	Vernier Caliper	200mm	3	9000	2015

Course Name: Measurement and Metrology Lab

Course Code: MEY-255

Course Objectives

1. To learn use of various measurement instruments such as Vernier calliper, micrometre, slip gauges, sine bar and surface roughness tester
2. To determine thread diameter using Toolmakers microscope
3. To understand the principle of stroboscope and velocity measurements using pitot tube

Course Outcomes

On the successful completion of this course, the student will be able to:

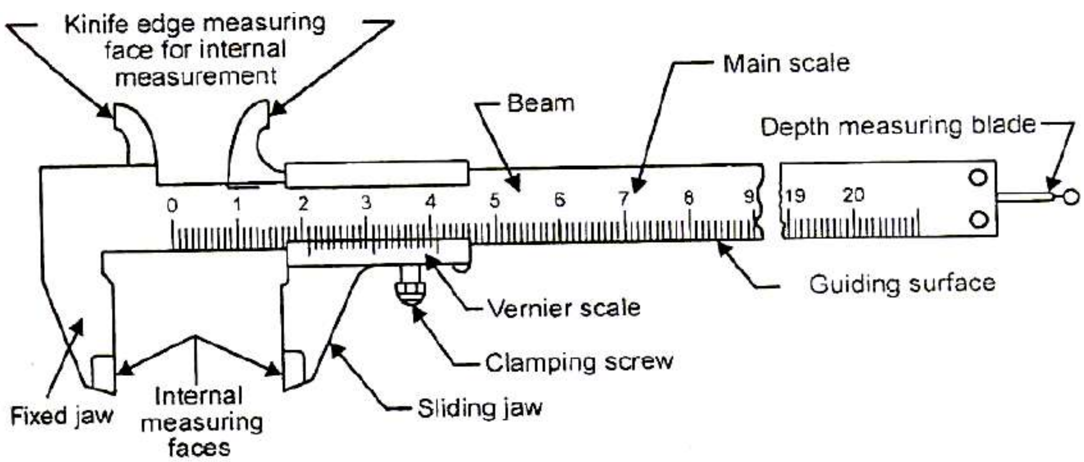
1. Measure linear dimensions using Vernier Calliper, micrometre and slip gauges
2. Calculate measure the angular dimensions using Sine Bar and Bevel protector
3. Evaluate the surface roughness and profile of gear element.
4. Determine the effective diameter of thread using different instruments
5. Calculate the speed of shaft, velocity of flowing fluid and temperature using different instruments

EXPERIMENT NO. 1

AIM: - Measurement with the help of Vernier Caliper and Micrometer.

INSTRUMENTS USED:

1. Vernier Caliper
2. Micrometer
3. Jobs



Vernier caliper—Type A.

1. VERNIER CALIPERS:

PRINCIPLE AND WORKING OF VERNIER CALIPER:

The principle of vernier calipers is based on the difference between two scales or divisions which are nearly but not exactly equal. The difference between them is utilized to determine the accuracy of measurement. It consists of two scales, Main scale which is fixed and vernier scale which move over the main scale.

The difference between the value of main scale and vernier scale division is called least count. If the value of one small division on main scale is 0.5mm and the value of one small division on the vernier scale is 0.48mm. Then the least count of instrument is given by the difference of these two values i.e. 0.02mm.

PROCEDURE:

1. First of all, check the zero error of vernier scale by closing the two jaws. In this position, the zero of vernier scale should exactly match with zero of main scale.
2. The linear dimensions may be taken by placing the work piece between fixed and movable jaw.
3. The workpiece must be exactly perpendicular to the measuring surface.
4. The internal dimensions or internal diameter should be taken by using upper measuring jaws.
5. To obtain the reading, first count the number of divisions on main scale. The vernier scale is then examined to determine which of the divisions coincides with a division on main scale. Now calculate the value as ,

   Total Reading = Main Scale reading + (Least count x Vernier scale reading)
6. Repeat this procedure three to four times, and then calculate average value.

OBSERVATIONS:

Least count (L.C.) = ……………….

S. No.	Dimension (a)			Dimension (b)		
	Main scale reading (M.S.)	**Vernier Scale Reading (V.S.)**	**Total = [M.S. + L.C. x V.S.]**	**M.S.**	**V.S.**	**Total**
1						
2						
3						

RESULT:-

The average value of dimensions is (a) = -----------------------mm

(b) = ------------------------mm

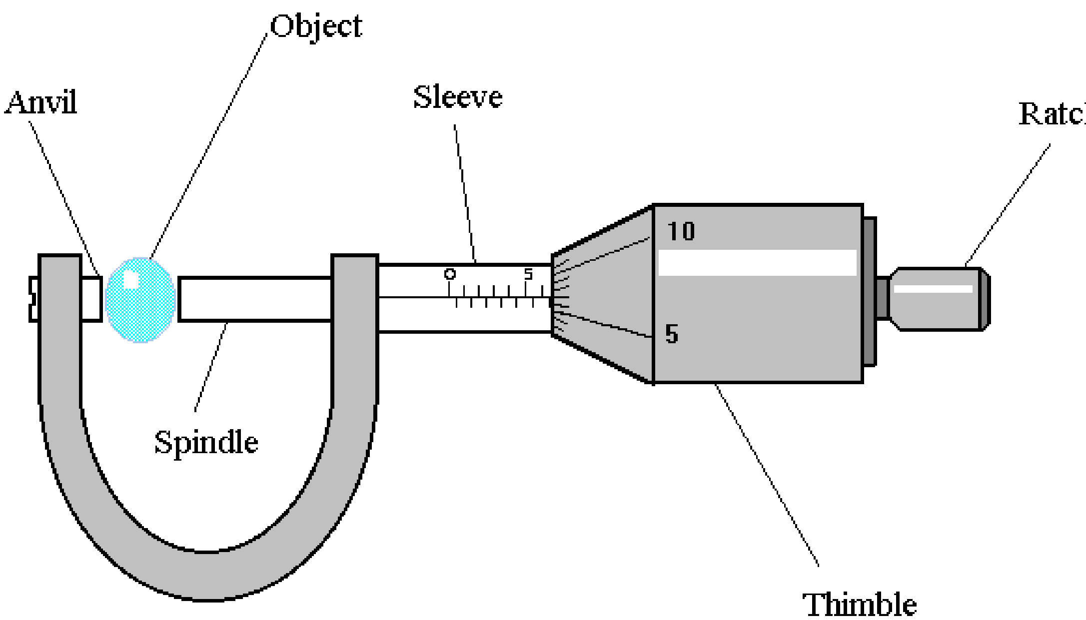
PRECAUTIONS:

1. Check the zero error of vernier before starting the experiment.
2. The parallax error must be avoided by proper positioning of observer.
3. There should not be play between sliding jaw and the beam scale.
4. The line of measurement must coincide with the line of scale.
5. While measuring outside diameters, the plane of the measuring tip of the caliper must be perpendicular to the center line of work piece, the caliper should not be tilted or twisted.
6. Do not apply excessive pressure; this may be a source of error.

2. MICROMETER:

PRINCIPLE AND WORKING OF MICROMETER:

It works on the principle of screw and nut. If we rotate screw by one rotation then it advances in axial direction by a linear distance equal to pitch of threads. If the circumference of screw is divided into a number of equal divisions, hen for one divisions or rotation, the screw will advance by a very small distance, which will be equal to (pitch/n). This is minimum amount of length that can be measured. Hence it is also called least count. Increasing number of divisions on circumference can further increase



the accuracy.

PROCEDURE:

1. Check the zero error of micrometer.
2. To measure linear dimensions, first place the workpiece between the anvil and spindle and then move the spindle and then move the spindle by rotating the thimble until the anvil and spindle touch the work surface.
3. Make the fine adjustment by using the ratchet.
4. Now note the main scale reading by counting the divisions just below reference line. Take the circular scale reading by counting the divisions, which coincides with the reference line or main scale.
   Total reading = Main scale reading + (Least count x circular scale reading).
5. Repeat this procedure three to four times and take an average reading.

OBSERVATIONS:

Least count (L.C.) = ……………….

S. No.	Dimension (a)			Dimension (b)		
	Main scale reading (M.S.)	Circular Scale Reading (C.S.R.)	Total = [M.S. + L.C. x C.S.R]	M.S.	C.S.R.	Total
1						
2						
3						

RESULT:-

The average value of dimensions is (a) = ----------------------mm

(b) = -----------------------mm

PRECAUTIONS:

1. The zero error of micrometer must be checked before starting the experiment.
2. The measuring surface of anvil and spindle must be free from dust, dirt and oils.
3. The measuring surfaces must be flat and square to the measuring spindle.
4. Use the ratchet to avoid error due to application of excessive pressure.

PREPARED BY CHECKED BY APPROVED BY

EXPERIMENT NO.2

AIM: - Measurement of angles with the help of sine bar and height gauge.

APPARATUS: - **Sine bar, surface plate, height gauge, slip gauges and dial gauge.**

THEORY: - The sine bar is one of the most widely used instruments for precision measurements of angles. It consists of a rectangular section bar of suitable grade steel having accurately ground pins of equal diameter, one at each end and lying on a line parallel to the axis of bar. The distance between the centers of these pins is arranged to be a standard, 125mm, 200mm, 250mm, 500mm etc.

The sine bar is based on the principle that in a right angled triangle the length of hypotenuse is kept constant. The sine of different angles can be obtained simply by varying the length of the perpendicular. As shown in the figure, in ΔABC, AB is the hypotenuse and if it is rotated round the point. A different length of perpendiculars BC will be obtained using the following relation:

$$\sin\theta = BC / AB = H / L$$

If AB is made 125mm the value of sine can readily be computed merely by dividing the measured height BC 125 and thus the measured height is in mm.

WORKING PRINCIPLE: - It is based on Trigonometric function Sin θ = side opposite angle / hypotenuse.

PRECAUTIONS AND CARE OF INSTRUMENT:-

(1) All the instruments should be cleaned properly.
(2) Any burrs and damage on work piece surfaces should be rectified.
(3) Zero error in any instrument likely to be checked and if so, correct it.
(4) Readings should be taken carefully.
(5) In case of circular work piece sine bar should be clamped firmly with the angle plate.

SOURCES OF ERROR:-

(1) Improper cleaning of instruments or work piece.
(2) Damaged instruments and damaged work piece surface.
(3) Improper setting of instrument.
(4) Initial error in measuring instruments.
(5) Wrong observation of height gauge measuring head.
(6) Uneven pressure at two points of reading may lead to error.

OBSERVATION TABLE:-

S. No.	H1	H2	$\sin\theta$ = H2-H1/L	θ

(a)

S.NO.	H	$\sin\theta$ = H/L	θ

(b)

PROCEDURAL STEPS:-

(1) Clean the surface plate.
(2) Clean the sine bar.
(3) Clean the work piece, and ensure that there are no damages and burrs on the surfaces of work piece.
(4) If there are any burrs remove them by means of oil stone.
(5) Place the work piece on the surface plate with taper surface facing the surface plate.

(6) Place the sine bar on tapered surface of work piece with the rollers of sine bar in upward direction.

(7) Clean the base of height gauge properly.

(8) Mount the dial indicator on the height gauge.

(9) Set the dial indicator on the height point of one of the sine bar roller and put some pressure on dial indicator.

(10) Note the reading of dial indicator and height gauge scale.

(11) Set the dial indicator on second roller of sine bar.

(12) Bring the same reading on dial indicator by adjusting the height gauge.

(13) Note the reading of height gauge at the highest point of both the rollers of sine bar.

(14) Calculate the difference of two height gauge readings which will give the height (H) of one roller with respect to other.

(15) The center distance between the two rollers is known for a standard sine bar.

(16) Divide the height in step (14) by center distance between two rollers. This will give the sine of taper angle $\sin\theta = H / L$.

(17) Using sine tables or scientific calculator the value of taper angle can be calculated.

EXPERIMENT NO.3

AIM: Measurement of surface roughness of given jobs.

INSTRUMENT REQUIRED: Surface plate, Talysurf instrument, Jobs

1. THEORY

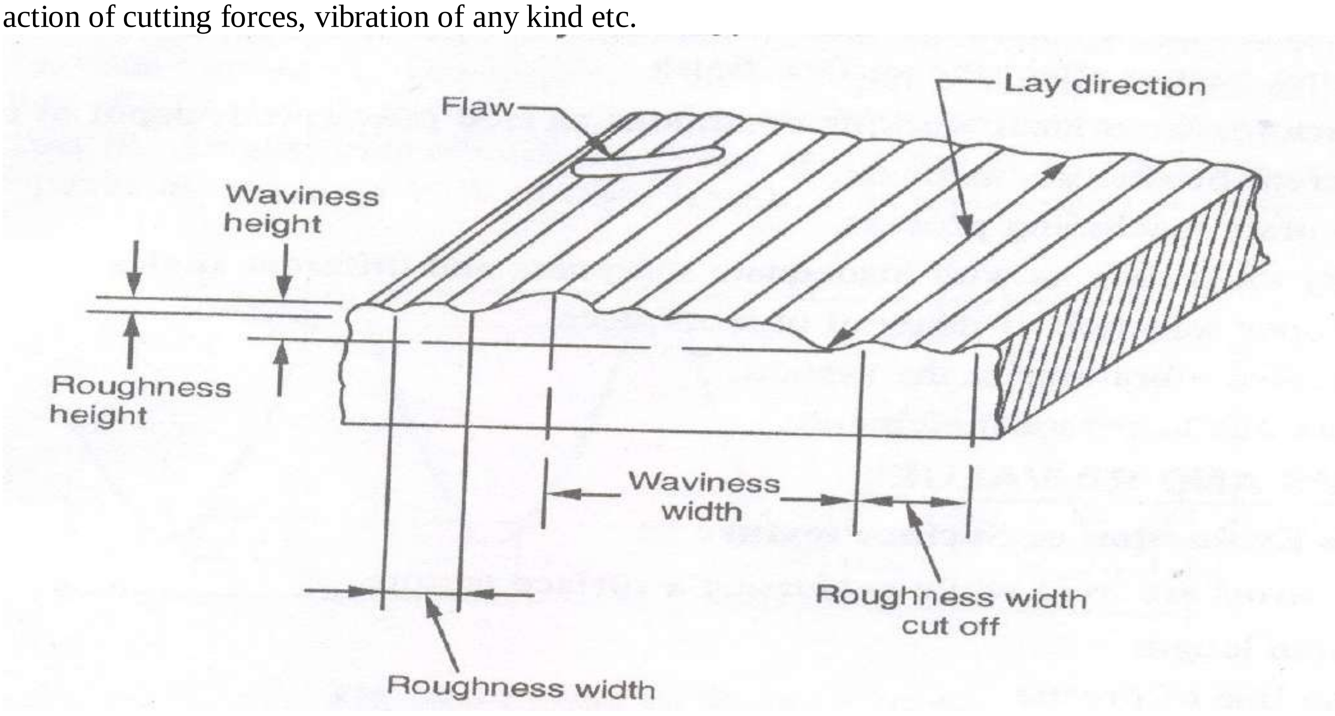
The irregularities on the surface of the part produced can be grouped into two categories:

1) Roughness and primary texture
2) Waviness and secondary texture

1) Primary surface (Roughness): The surface irregularities of small wavelength are called primary texture or roughness. These are caused by direct action of the cutting elements on the material i.e. cutting tool shape, tool feed rate or some other disturbances such as friction, wear and corrosion.

These are micro-geometrical errors in which the ratio lr / hr denoting the micro errors is less than 50, where lr = length along the surface and hr = deviation of surface from the ideal one.

2) Secondary texture (Waviness): The surface irregularities of considerable wavelength of a periodic character are called secondary texture or waviness. These irregularities results due to inaccuracies of slides, wear of guides. misalignment of centers, non linear feed motion, deformation of work under the action of cutting forces, vibration of any kind etc.



These are macro-geometrical errors; the ratio of lw / hw denoting the macro-error is more than 50. Where lw = length along the surface and hw = deviation of surface from ideal one.
Thus any finished surface can be considered as the combination of two forms of wavelength superimposed upon each other. These two forms of irregularities superimposed on each other tend to form a pattern or texture of the surface.

Factors affecting surface roughness

- Vibration
- Material of the work piece
- Type of machining
- Rigidity of the system consisting of machine tool, fixture cutting tool and work
- Type, form, material and sharpness of cutting tool
- Cutting conditions; feed, speed, depth of cut
- Types of coolant used

Evaluation of surface finish
A numerical assessment of surface finish can be carried out in a number of ways. In practice, the following three methods of evaluating primary texture of a surface are used:

1) Peak to valley height method
2) The average roughness
3) Form factor or bearing curve

1) Peak to Valley height
It measures the maximum depth of the surface irregularities over a given sample length, and largest value of the depth is accepted as a measure of roughness.
2) Average Roughness: For assessment of average roughness the following three statistical criteria are used:

a) **C.L.A. Method:** In this method, the surface roughness is measured as the average deviation from the nominal surface.
Centre line average or arithmetic average is defined as the average values of the ordinates from the mean line, regardless of the arithmetic signs of the ordinates.
C.L.A value = (h1+h2+h3+h4+…+hn) / n
C.L.A = (A1+A2+A3+…….An) / n

b) **R.M.S. Method:** In this method, the roughness is measured as the average deviation from the nominal surface. Root mean square value measured is based on the least squares. R.M.S value is defined as the square root of the arithmetic mean of the values of the squares of the ordinates of

the surface measured from a mean line. It is obtained by setting many equidistant ordinates on the mean line (y1,y2, y3,….)
and then taking the root of the mean of the squared ordinates.

Let us assume that the sample length 'L' is divided into 'n' equal parts and y1, y2, y3,………yn are the heights of the ordinates erected at these points.

RMS average =

c) **Ten Point Height Method**: In this method, the avg. difference between the five highest peaks and five lowest valleys of surface texture within the sampling length, measured from the line parallel to the mean line and not crossing the profile is used to denote the amount of surface roughness.

Mathematically,

R = ten point height of irregularities

= 1/5 [(R1 + R2 + R3 + R4 + R5) – (R6+R7+R8+R9+R10)]

This method is relatively simple method of analysis and measures the depth of surface irregularities within the sampling length. But it does not give any sufficient information about the surface, as no account is taken of frequency of the irregularities and the profile shape.

Statement of Surface Roughness

a) Surface Roughness Value: It is expressed as Ra value in microns. If a single Ra value is stated it is understood that any Ra value from zero to that stated is acceptable.

b) Limiting values: when both minimum and maximum Ra values needed to be specified these shall be expressed as

Ra 8.0/16.0 or Ra 8.0-16.0

c) Sampling length: The sampling length is indicated in parenthesis following the roughness value as follow: Ra 8.0 (2.5)

d) Lay: It is sometimes necessary to specify the direction of lay. It is expressed in accordance with the following example

Ra 1.5 lay parallel

e) Process: When it is necessary to limit the production of a surface to the use of one particular process, the process shall be stated.

Conventional Method of Designing Surface Finish

a) Roughness value Ra value in microns
b) Machining allowance in mm
c) Sampling length
d) Machining / Production method
e) Direction of lay in the symbol form as =,⊥

Direct Instrument Measurement: These are method of quantitative analysis. This method enables to determine the numerical value of the surface finish of any surface by using instrument of stylus probe type operating on electrical principles. In this instrument the output has to be amplified and amplified output is used to operate recording or indicating instrument.

Working of Surface Meter (Taylor-Hobson-Talysurf): Talysurf is a stylus and skid type instrument working on carrier modulating principle. The measurement of the instrument consists of simply pointed diamond stylus of about 0.002 mm tip radius and skid or shoe, which is drawn across the surface by means of a motorized driving unit.
In this instrument the stylus is made to trace the profile of surface irregularities and the oscillatory movement of the stylus is converted into changes into electric current by the arrangement shown in fig.1. The arm-carrying stylus forms an armature, which pivots about the centerpiece of E-shaped stamping. On two legs of (outer pole pieces) the E shaped stamping there are coils carrying the a.c. current. These two coils with other two resistances form an oscillator. As the armature is pivoted about the centre leg, any movement of the stylus causes the air gap to vary and thus the amplitude of the original a.c. current flowing in the coil is modulated. The output of the bridge thus consists of modulation only. This is further demodulated so that the current now is directly proportional to the vertical displacement of the stylus only.

Stylus type instruments generally consist of the following units:

1) Skid or shoe
2) Finely pointed stylus or probe
3) An amplifying device for magnifying the stylus movement
4) Recording device to produce a trace
5) Means for analyzing the trace.

PROCEDURE:

1. Properly set instrument and the job over the surface plate.
2. Skid or shoe is drawn slowly over the surface by motor drive. It follows the general contours of the surface and provides a datum for measurements. The stylus moves over the surface with a skid. It moves vertically up and down to surface roughness and records the micro-geometrical form of the surface. The stylus movement may be amplified by a amplifying device and recorded to produce a trace.
3. Note down the reading in terms of Ra or Ry.

OBSERVATION:

S.No.	JOB	Ra	Rz
1			
2			
3			

PRECAUTIONS:

1. The instrument and job is to be properly set over the surface plate so that stylus could move without any problem.
2. There should not be any burr on the job.
3. The job must be cleaned from any oil, dirt or dust.
4. Surface plate should be free from any oil, dust or dirt.

VIVA VOCE

1. What is the difference between primary and secondary texture?
2. What are the different methods for surface roughness measurement?
3. What is working principle of surface tester used in your lab?
4. Name the different factors, which affect surface roughness.
5. What do you mean by sampling length?
6. What is Lay?
7. Differentiate between Ra and Rz value.
8. What is Ra value of different machining processes?

EXPERIMENT NO:4

AIM: Measurement of different elements of gear using profile projector

PROFILE PROJECTOR

1. **THEORY1.1 CONSTRUCTION**

It has a swiveling turret above the stage for mounting the projection lenses. This enables different magnification to be selected fairly rapidly. The magnification available is ×10, ×20, ×50 and ×100 and illumination can be simply switched from shadow to surface by a selector on the front of the instrument. The hand wheel on the right hand side will raise or lower the stage and so position component placed on it at the focal point of the lens. A sliding hood can be positioned to prevent extraneous light shining onto the screen.

The optical system is illustrated and it can be seen that when used for shadow illumination, collimated light is transmitted up through the translucent stage, backlighting any object placed on it. Alternatively when surface illumination is selected, the light strike a half reflecting mirror placed below the projection lens, which reflects it down on onto the object on the stage. This is reflected back and when traveling in this direction, is refracted by a mirror. Whichever means of illumination is used, the lens projects the image, via. The two mirrors in the upper part of the instrument, onto the screen.

The circular screen can be swiveled and a vernier scale on its periphery can be used to measure angles on the projected image, with the aid of cross wires engraved on the surface of the screen. The stage can be moved on its longitudinal and transverse axis and micrometers control the movement.

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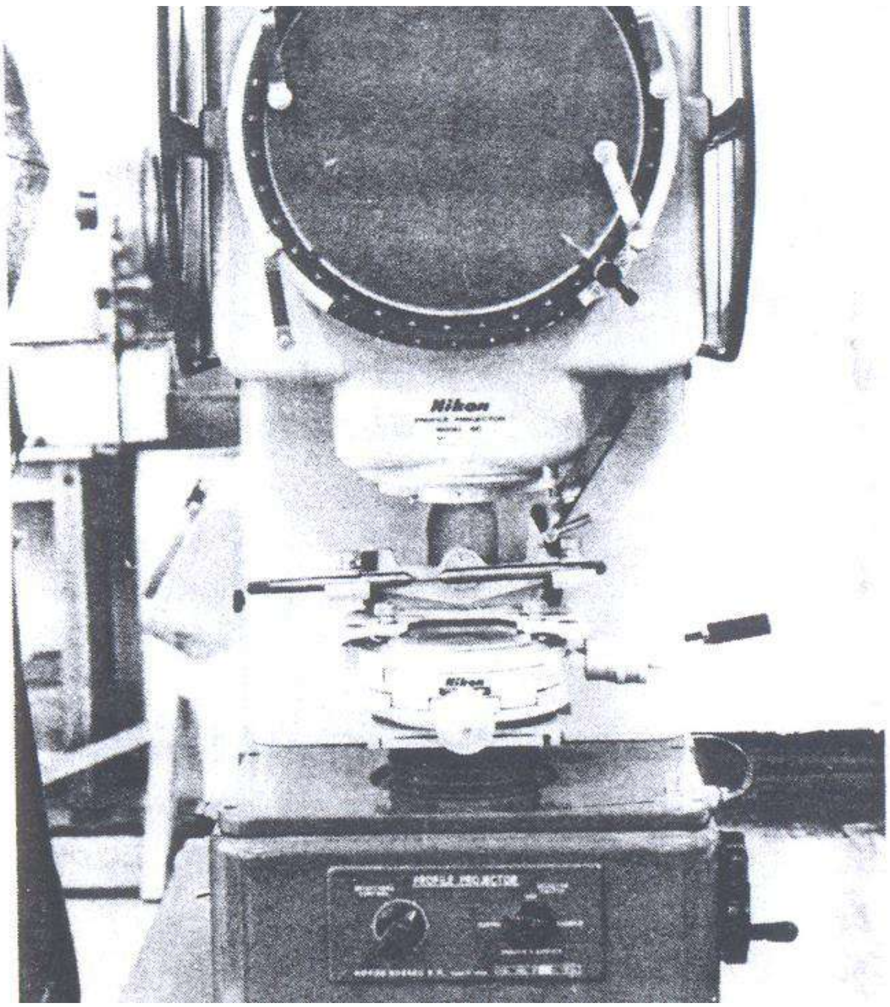
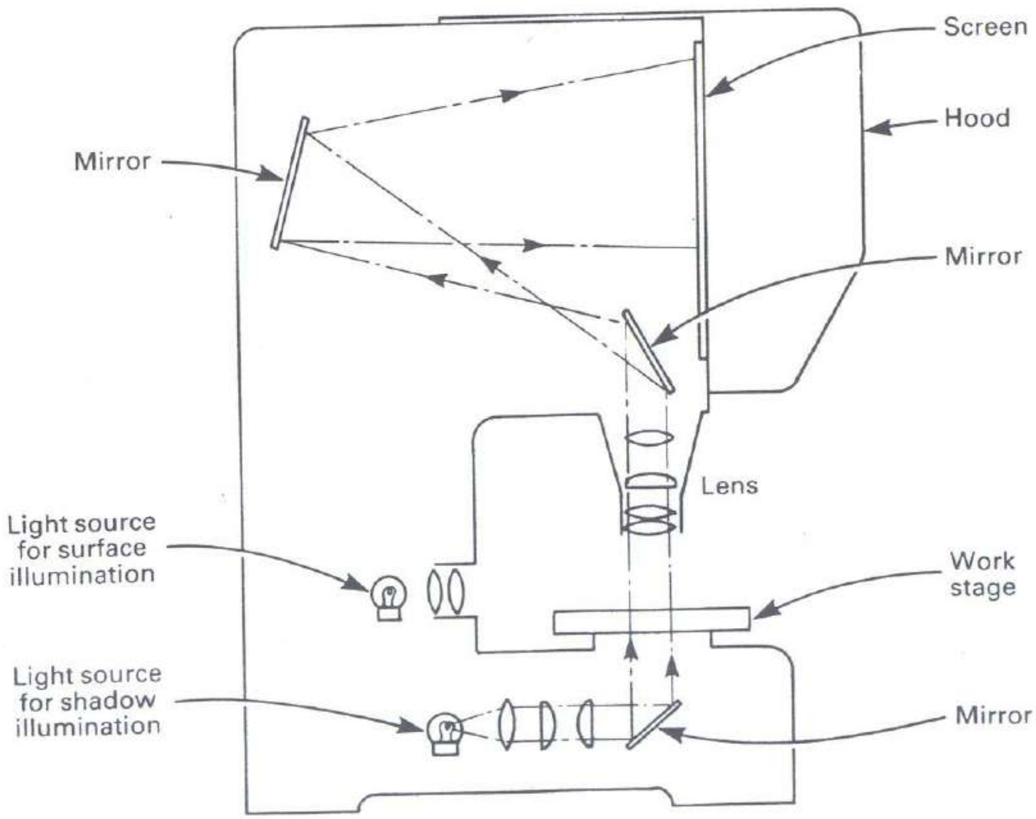
Mechanical Measurement and Metrology Laboratory	**Subject Code: MEY-255**



PROFILE PROJECTOR



The optical system of the Nikon profile projector.

1.2 WORKING PRINCIPAL:

Profile projector is an optical device, which is used for measuring linear dimensions (length, width, diameter etc) and to measure angles. The thread or gear forms can also be compared with the help of profile projector. The different types of measurements may be taken from profile projector. Some of them are as under;

i. The relative position of two points can be measured by measuring the distance traveled by worktable required to transfer a second point to the position previously occupied by first point.
ii. Thread forms can be compared with respect to standard forms marked on glass template.

iii. The angles can be measured by setting fiducially line (located on the focal plane of eyepiece) along image of the angle and taking readings from protractor scale.

2. GEAR TERMINOLOGY:

Addendum Circle: The circle, which limits the top of the gear teeth and represents its maximum diameter, is called the addendum circle.
Addendum: It is the radial height of the tooth from the pitch circle to the tip of the tooth.
Dedendum: It is the radial depth of tooth from the pitch circle to the root of the tooth.
Tooth thickness: It is the thickness of the tooth, measured along the pitch circle.
Whole depth: It is the sum of the addendum and dedendum of the tooth.
Circular Pitch: It is difference measured along the pitch circle from a point on one tooth to a corresponding point on the adjacent tooth.

Circular pitch = $(\pi * d) / T = \pi m$

d – Pitch circle diameter

T- no. of teeth

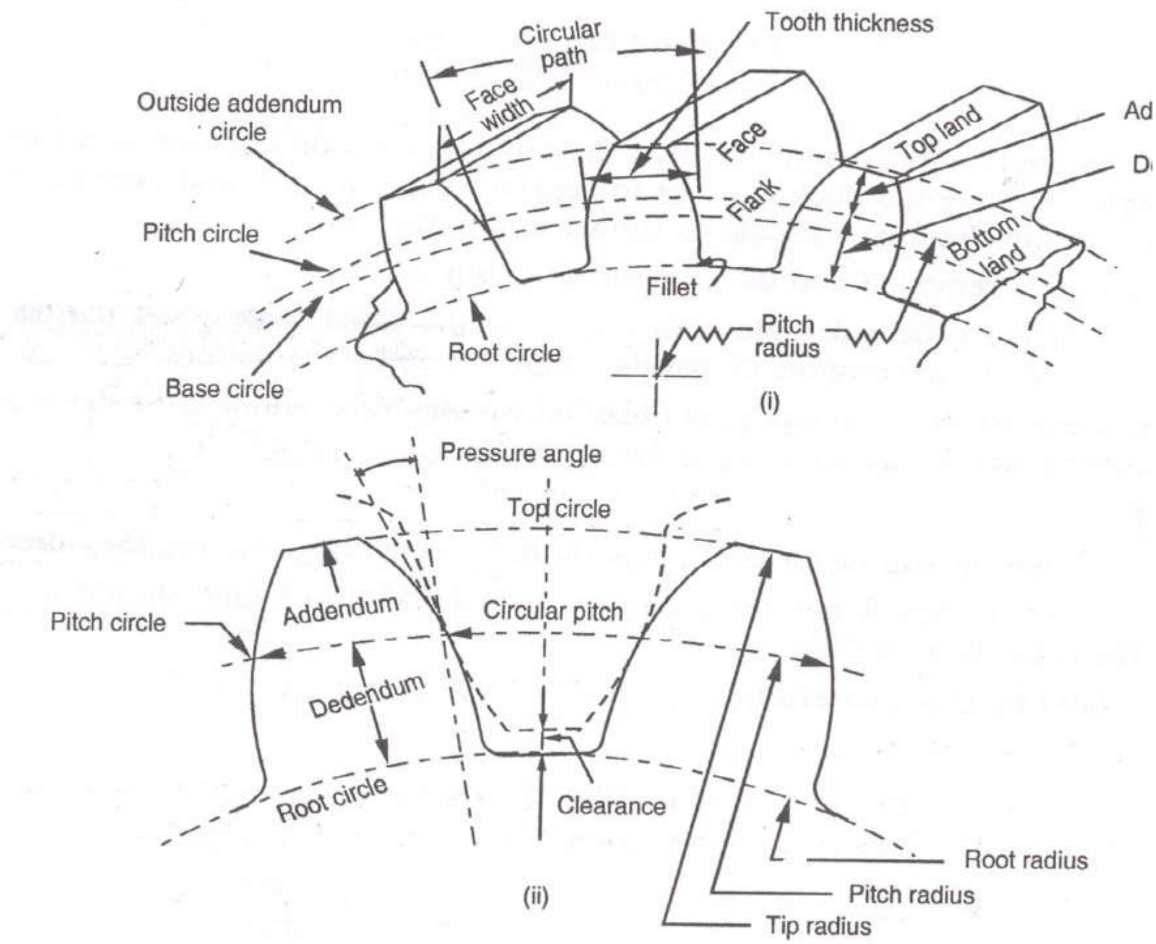
m- Module

Diametric Pitch: It is the no. of teeth per unit length of the pitch circle diameter.

Diametric Pitch = No of teeth / pitch circle diameter = T/d

Module: It is a linear distance in mm that each tooth of the gear would occupy, if the gear teeth were spaced along the pitch diameter.

Module = Pitch circle diameter / No. of teeth = d/T

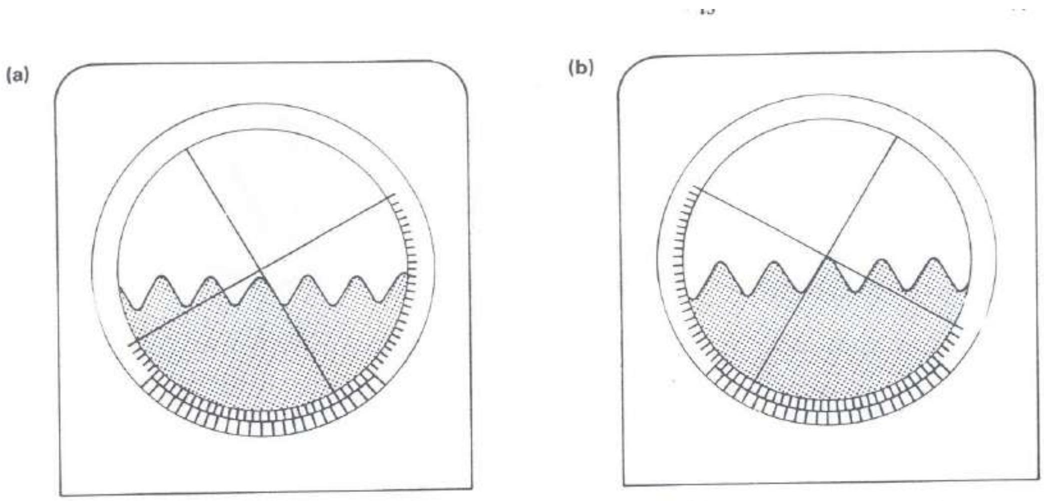


Gear terminology for spur gear

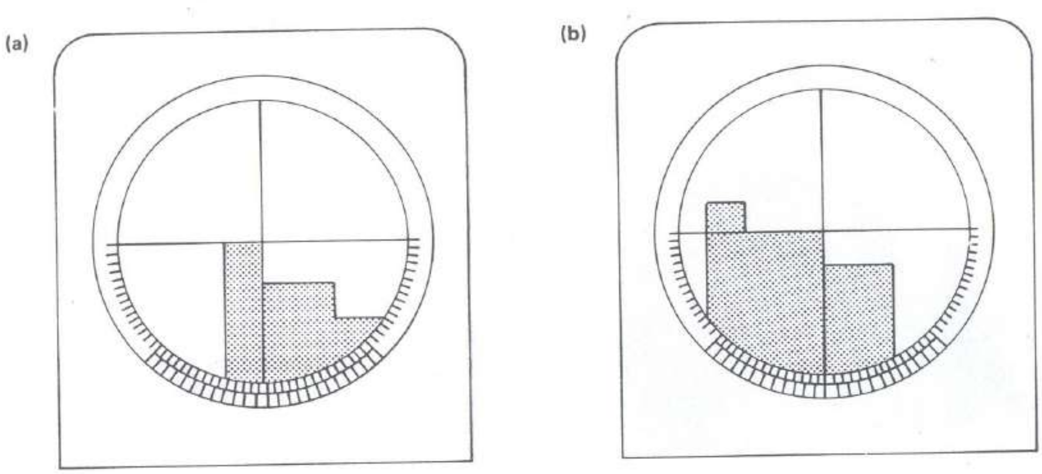
3. PROCEDURE:

1. To determine the distance between two points, first of all, set the microscope at first point. Now slide the table with the help of micrometers attached with table so that the second point occupies the position of first point. The distance between them can be measured by measuring slide of table.

2. To measure angle, set fiducially line situated in the focal plane of the eyepiece. Now turn the fiducial line and set it on the second arm of angle. The turn can be noted with the help of protractor scale attached with this. Hence angle can be measured.
3. To compare the thread form, use template. Compare the image with profile outline of standard template and measure discrepancies.



Using the Nikon profile projector to measure the flank angle of a screw thread.



4. OBSERVATION:

5. PRECAUTIONS:

1. The screw of table must be moved in one direction only while measuring to avoid backlash error.
2. Fiducially line must be properly set
3. The microscope should be handled carefully

VIVA VOCE:

1. What are the advantages of optical instrument over mechanical instrument?
2. Give the elements for specifying the gear.
3. Differentiate between diametric pitch and circular pitch.

EXPERIMENT NO. 5

AIM: To determine effective diameter of external threads using three wire method.

INSTRUMENT USED:

1. Micrometer
2. Three wires
3. Jobs (i.e. whose effective diameter is to be measured)

1. THEORY:

In this method three wires of equal and precise diameter are placed in the thread grooves at opposite sides of the screw and measuring the distance M over the outer surface of the wire with the micrometer. Out of three wires in the set two wires are placed on one side and the third on the other side. The wires are held either in hand or secured in the groove by applying grease in the thread. These wires may also be hung on through thread on a stand. This method ensures the alignment of micrometer anvil faces parallel to the thread axis. Therefore this method of measuring effective diameter is more accurate.
These wires are made of hardened steel and are lapped to sizes suitable for various pitches. For each pitch of thread there is a 'best size' wire; this is of such diameter that makes contact with the flanks of the thread on the effective diameter or pitch line.

$M = De + d\,(1 + \operatorname{cosec} \alpha/2) - p/2 \cot \alpha/2$

M = distance over the wires

De = effective diameter

R = radius of wire

d = Diameter of wire

Effective diameter:

OBSERVATION TABLE:

Specimen	$M = De + d\,(1 + \operatorname{cosec} \alpha/2) - p/2 \cot \alpha/2$	M = distance over the wires	De = effective diameter	R = radius of wire	d = Diameter of wire	Effective diameter:

2. PROCEDURE

1. The three wire method of measuring the effective diameter of a screw thread is shown in figure
2. Three wires of equal and precise diameter are placed on the thread grooved at opposite sides of screw thread.
3. Two wires are placed on one side and one wire at another side. This arrangement of setting wires ensures the alignment of micrometer anvils faces parallel to the thread axis.
4. Micrometer reading over wires is taken. Let it be M.
   Hence effective diameter is calculated as:
   $$De = M - Q$$
   Where Q is a constant, which depends upon wire diameter d and flank angle α

3. PRECAUTIONS:

1. The zero error of micrometer must be checked before using it.
2. The measuring surface of anvil and spindle must be free from dust, dirt or oil.
3. The measuring surface must be square to the measuring spindle.
4. Ensure that wire makes contact with the flanks of the thread on the effective diameter or pitch line.
5. Use ratchet to avoid error due to application of excessive diameter.

VIVA VOCE

1. What do you mean by best wire size?
2. What is the advantage of three wires method over two wires method?
3. What is the material of wires used in the measurement?
4. How three wire methods is differ from two wire method?

EXPERIMENT NO. 6

AIM: - Measurement of thread elements by Tool makers microscope

1.0 INTRODUCTION:

Tool maker Microscope is a highly precision and versatile microscope designed as per international standards and equipped with achromatic optical system to offer erect image of natural orientation and free from distortion for most diversified jobs in tool room workshop such as linear measurements in rectangular co-ordinates and angular measurements in complex works process such as electronic components, semi conductors chips small gauge, watch pars and micro components.

All mechanical and optical components have been ideally designed and constructed minimizing to severest tolerance to guarantee the highest degree of measuring accuracy and those operation.

2.0 SPECIFICATION:

Magnification	:	30 x (Standard)
Objective	:	2 x
Eye Piece	:	W.f. 15 x, with cross reticle
Field of View	:	8 mm, diameter
Working Distance	:	115 mm (approx)
Image	:	Erect Image
Observation Table	:	Monocular inclined at 30^0
Stand	:	Large and heavy base provide extra overall rigidity to the instruments.
Measuring Stage direction,	:	150 x 150 mm, size travel up to 50 mm in each equipped with zero adjustment micrometer heads having least count 0.01 mm.
Eyepiece Protractor count 6	:	Graduated 0 to 360^0 with adjustable vernier of least minutes.
Illumination	:	Built in base Transmitted from Halogen lamp and incident light from two lamps with variable separate control on front panel.

3.0 TECHNICAL DATA:

(a) MEASURING STAGE:

Stage Dimensions	:	150mm x 150mm

	Measuring range longitudinal	:	25 mm
	Measuring range transverse	:	25 mm
	Scale unit of measuring spindles	:	0.01 mm (10 microns)
(b)	**ROTATING STAGE:**		
	Diameter of mounting surface	:	125 mm
	Rotating Range	:	0-360 degree
	Vernier Reading	:	6 min.
	Diameter of glass insert	:	80 min.
(c)	**CENTER HOLDING DEVICE:**		
	Maximum distance between centers	:	100 mm
	Maximum mounting diameter	:	70 mm
	Rotation ranges horizontally	:	0-360 degree
	Scale unit of rotation	:	10 degree
	Maximum opening of rotating chuck	:	6.5 mm dia.
(d)	**DEPTH MEASURING GAUGE:**		
	Measuring range in one stroke	:	10 mm
	Scale unit	:	0.01 mm
(e)	**TRANSMITTED LIGHT ILLUMINATOR**		
	Filament Lamp	:	6V- 20 W
(f)	**INCIDENT LIGHT ILLUMINATOR**		
	Filament Lamp	:	6V-20 W
(g)	**OBSERVATION OPTICAL TUBE**		
	Standard tube length	:	160 mm
	Maximum coarse motion travel	:	200 mm
(h)	**OPTICS**		
	Super wide field eye piece	:	15 x
	Lower Power achromatic objectives	:	2 x

(i) OPTICAL COMBINATION & MAGNIFICATIONS CHART

W.F./H. Eye Piece	Achromatic Objectives
	2 x
15 X	30 x

(j) MEASURING & MICROMETER VALUES;

Insert a micrometer eyepiece in the optical tube. Length measurements in the specimen plane can be carried out with the micrometer eye piece by first observing how many divisions of the scale visible in the eye piece correspond to the specimen length to be measured, this number is then multiplied by the micrometer value M in um (1 um=0.001 mm = 1 micron).

(k) DETERMINING THE MICROMETER VALUE:

For every accurate measurement it is advisable to determine the micrometer value by means of the stage micrometer, which is graduated in 0.01 mm.

After focusing both on the eyepiece reticle and on the graduation of the stage micrometer, the eyepiece is rotated in the microscope tube so that the two distances to be measured are exactly parallel. The stage micrometer is then moved until the zero points of the two distances coincide, and the two graduations just over lap.

Now read how many divisions of the stage micrometer i.e. how many multiples of 0.01 mm correspond to 100 divisions of the eyepiece reticle. From this is very easy to calculate the micrometer value, which indicates the number of microns (um) corresponding to 1 graduation of the eyepiece scale.

(I) EXAMPLE;

Achromatic Objective	:	10x
Measuring Eye piece Micro	:	5 x
Eye piece scale	:	Stage Micrometer
100 Div	:	18 Div
1 Div	:	0.01 mm = 10 um
18 Div	:	0.18 mm = 180 um
1 Div	:	18 um = M

The micrometer value (M) is therefore 18 um.

4.0 Construction of Microscope:

BASE:

The sturdy base is rests on the three supports, two of which are adjustable for leveling the instrument. The base has built in all electrically transformers and their control panel and transmitted illuminator with green filter.

ARM:

The arm has a grove guide on which the microscope tube is vertically adjusted rack and pinion system.

FOCUSSING MECHANISM:
The course focusing movement is provided in the microscope tube separately. The coarse motion is knurled knob on both side of the tube and has the total travel of 200mm. It also locks any position by lever. This movement is characterized by its exceptionally smooth and accurate precision. The depth dial gauge can read the vertical travel or measurements up to 10 mm thickness. The thickness is being measured with the difference of two different focusing of object. The least count of gauge is 0.01.

EYE PIECE PROTRACTOR:
This unique protractor head graduated 0 to 360 degree with adjustable vernier reading to 6 minute cross line incorporated in the protractor head rotating in the optical axis of the microscope. The cross line graticule is replaceable with many other measuring reticules.

MEASURING STAGE:
The stage plate is of 150x150 mm having very smooth and precise movements in both axes with special ball racers arrangement. The travel of the stage is 25 mm in both directions with precise imported Micrometer head, least count 0.01 mm.

ROTARY STAGE:
A rotating stage is fixed in T-slots of square stage plate having 360 degree graduations on its periphery with vernier reading to 6 minute and lock screw. All types of horizontal angular measurements can be done with this stage.

ILLUMINATION SYSTEMS:
Two possible ranges of illuminating systems are provided with standard equipment to meet every application, operated through 6 volts solid state variable light control built in transformer.

1. Sub state transmitted light from a bottom source providing collimated green filter. Halogen light for viewing contours and transparent objects.
2. Surface incident illuminator for shadow free lighting, for high power examination of opaque objects.

5.0 Ray Diagram of Tool Maker Microscope:

Ray Diagram is as shown in fig.

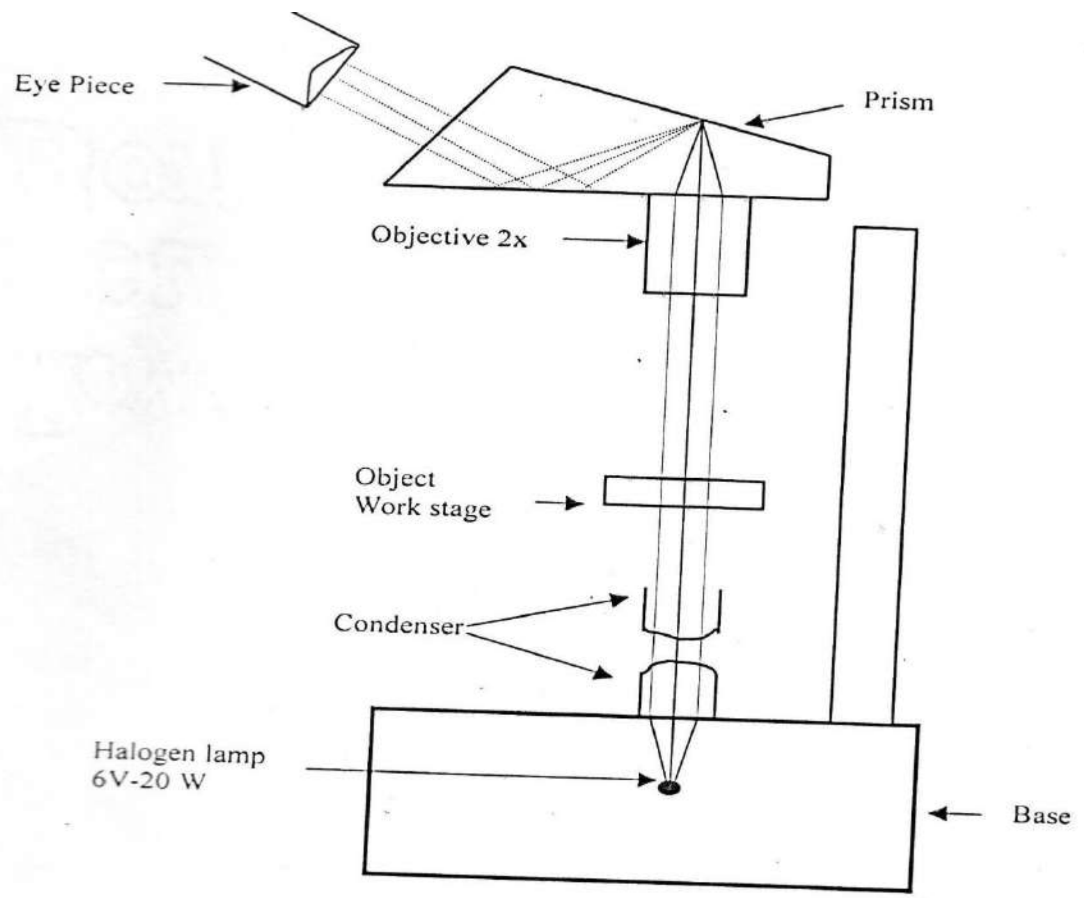
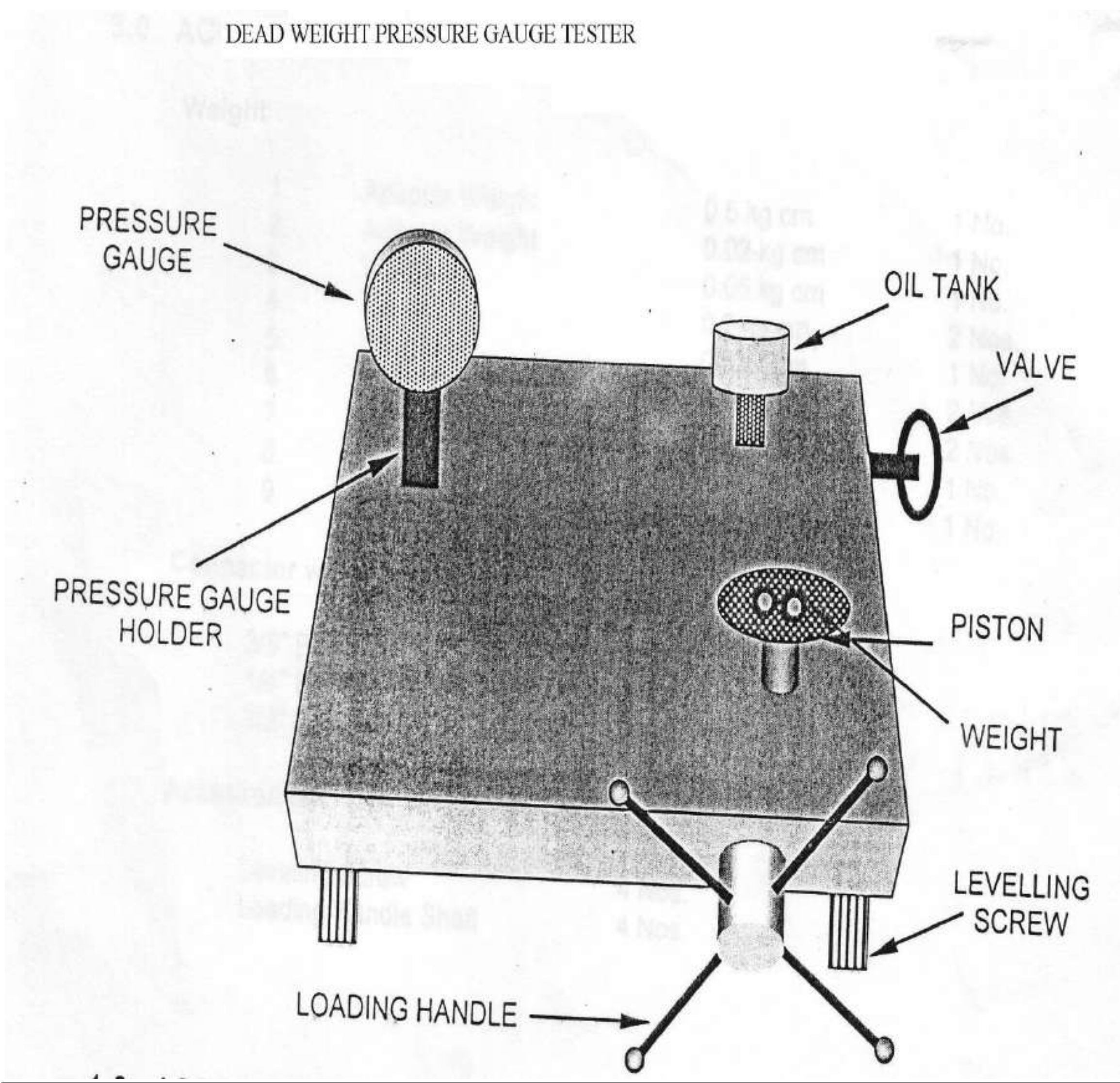


Fig 1

EXPERIMENT NO. 7

AIM: - Calibration of a pressure gauge with the help of a dead weight gauge tester



1.0 ASSEMBLY:

Place the machine on the table top (vibration free environment), connect the four labeling screw as usual. Place four handle shafts on the loading handle. Open the oil tank & fill servo grade-60 oil to tank place a spirit level on top of piston than adjust the labeling screw.

2.0 TESTING PROCEDURE:

Open the locknut for pressure gauge holder than take your required adapter place the pressure gauge on it tightly. Release the valve & wait a minute then rotate the loading handle clockwise then lock the valve. There are two type of loading adapter one for low capacity (0.1 kg cm) & another for high capacity (0.5 kg cm). Place your required loading adapter & weight on the top of piston then slowly rotate the loading handle anticlockwise & observe the reading on your pressure gauge. After completing then reset the loading handle clockwise & release the valve. Detach the pressure gauge place the locknut.

3.0 ACCESSORIES & WEIGHTS:

Weight:

1.	Adapter Weight	0.5 kg cm	1 no.
2.	Adapter Weight	0.02 kg cm	1 no.
3.	Weight	0.05 kg cm	1 no.
4.	Weight	0.2 kg cm	2 nos.
5.	Weight	0.5 kg cm	1 no.
6.	Weight	2.0 kg cm	2 nos.
7.	Weight	5.0 kg cm	2 nos.
8.	Weight	1.0 kg cm	1 no.
9.	Weight	0.1 kg cm	no.

Connector with washer:-

3/8 ’’ BSP 1 No.
1/4’’ BSP 1 No.
1/2 ’’ BSP 1 No.

Accessories:

Leveling screw 4 Nos.
Loading Handle Shaft 4 Nos.

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EXPERIMENT NO. 8

AIM: - Measurement of speed of shaft by using stroboscope.

INTRODUCTION:

Stroboscope is a source of flashing light that can be synchronized with any fast,repeating motion so as to make the moving device appear stationary or moving slowly.This is an essential tool for every technical person concerned with the study of moving parts or mechanisms.

APPARATUS:

Rotatingdisc, stroboscope,electric plug etc.

APPLICATIONS:

The two main applications of stroboscope are R.P.M. measurement and slow motion study.In industry, the main use of stroboscope is RPM measurement of revolving machinery such as motors,fans, blowers,textile machine spindles, timing adjustment,research laboratory,physics demonstration,resonance search tests,vibration studies etc.

Slow motion study is useful for observing effects, which takes place at higher speeds under dynamic conditions like vibrations,twisting of shafts,cavitation or observing print registrations while printing is being carried out etc.

DIAGRAM

Fig 1. FLASH LIGHT STROBOSCOPE

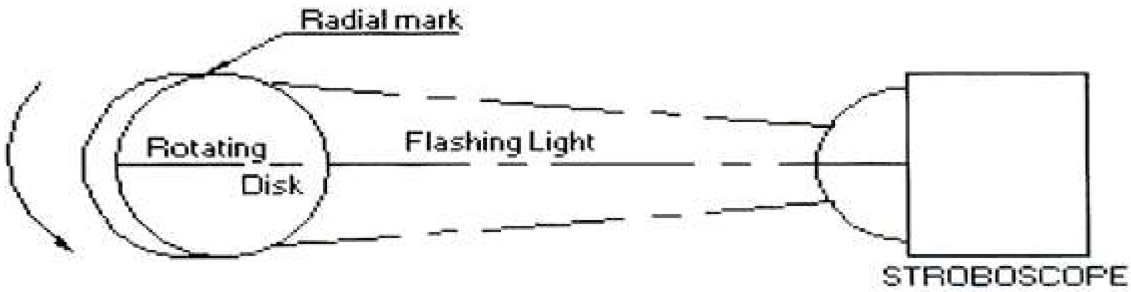
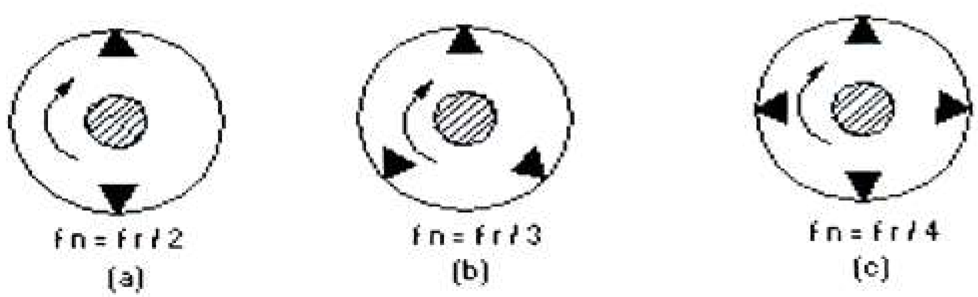


Fig 2. MULTI-IMAGES OF SINGLE MARK



DESIGN FEATURES:

I) High efficiency xenon flash tube
II) Stable integrated circuit oscillator
III) Optimum accuracy
IV) Small size
V) Bright white flash light
VI) Ease of operation
VII) Modern convenient design
VIII) Attractive finish

SPECIFICATIONS:

Flash range : 150-1800 Flashes/Min
Range division : 150- 4650 Flashes/min, 4500-18000 Flashes/Min
Flash duration : 5-10 micro sec.
Flash tube : Hard glass xenon long life 230V 50Hz.
Size : 170mm x 100mmx 65mm
Weight : Approx.1.2kg

SPEED MEASUREMENT(RPM COUNTING)

The instrument has ON/OFF switch,Range switch and Flash control knob in the centre.Connect the instrument to 230 Volts A.C.mains. If speed of revolving object is not known,then select high flashing rate by pressing the RANGE switch in down position and keeping the flash control knob in extreme clock wise position, go on reducing the flashing rate.Multiple imaging of marking on the revolving shafts will be observed.Further reduce the flash rate till single stationary image of mark is obtained.The first single image occurs, when flashing rate is equal to the RPM of revolving object.This RPM can be read on the Dial,which is calibrated in terms of RPM. In case,single image is not obtained in the higher range,then release the higher range switch to upper position and obtain the single image.

It is easier to obtain the stationary image,if light is focused on single mark available on the object,such as key way or hole or thread passing from bobbin of textile machine spindles etc. If such mark is not available, a marking made by colouredmarker is sufficient.

If user has an approximate idea of RPM of the object,it is further easy to measure exact speed.User only has to keep flashing rate near about the expected speed and then the increase or decrease the flash rate, until single image is obtained.

SLOW MOTION STUDIES:

High speed motion can be reproduced by the stroboscope at an apparently much lower speed, if the cyclic or reciprocating motion occurs at a constant rate. If the flashing rate of the stroboscope is set at speed slightly lower than the fundamental speed of the observed object, the object will appear to move slowly in the same direction, as the actual motion at speed equal to the difference between the actual speed of the object and theflashing rate of the stroboscope. Ifthe flashing rate is slightly higher than the speed of the object, the same low motion will result, but in the opposite direction. This stroboscope technique of slowing down the motion can be extremely useful in investigating the operation of device under normal operating conditions. Excessivevibrations, misalignment of parts,mode of vibrations of equipment on a shake tables, Operation of vibrating reeds,actual relation between traveler on textile spinning frame, these are a few examples of the many slow motion studies that are possible with the stroboscope.

DESCRIPTION:

Stroboscope model is a handy instrument.It has been designed to keep its functional aspects and size optimum. The smaller size of the instrument makes it easy for the operator to hold and carry his studies.

The circuit consists of an oscillator, designedusing latest integrated circuit technology and metal film resistors to make it very stable. The oscillator pulses are suitably amplified to trigger the flash tube. The oscillator frequency is adjusted using calibrated dial on the top the complete range of the instrument is divided in two parts to increase the resolution and to use the tube to its full capacity,even at lower frequency to get bright light. The xenon flash tube has been chosen because of its bright white light short light impulse.

In the present model, there are two switches (ON/OFF and range selector). Afterputting ON the instrument and selecting a proper range, only dial has to be adjusted, till the desired results are obtained. The reading from the dial gives the speed.

OBSERVATION TABLE:

Specimen	Reading 1	Reading 2	Reading 3	Final reading(average)

MAINTENANCE:

The instrument requires no maintenance at all. However, flash tubes are required to be replaced after its life is over. To make replacement easier, pin connectors are used for connecting the tube. Thus no disorderingis necessary, while changing the tube. While doing this, care must be taken to remove the supply wire from mains or battery.

PRECATIONS:

1. Do not use the instrument continuously for more than 30 minutes. It is advisable to give a break of 5 minutes. This helps in increasing the life of flash tube. This also helps in getting longer battery life.
2. Each time after use instrument,remove wire from mains.

QUESTIONS FOR VIVA:

1. What is the range of stroboscope used in our lab?
2. Can this stroboscope be used to measure r.p.m. of a fan?
3. What is difference between mechanical and electrical stroboscope?

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EXPERIMENT NO.9

AIM: To plot velocity profile of a fluid flow through a circular duct with the help of pitot tube apparatus.

APPARATUS: **Pitot tube apparatus with inclined 'U' tube differential manometer, vernier caliper, stop watch etc.**

THEORY:

The flow rate in a pipeline running full and under pressure can be computed by measuring the velocity of flow at a number of points in the cross section. Pitot tube is such an instrument used to determine the velocity of flow at a point in a pipe or a stream. Pitot static tube can be installed in a pipeline in such away that it can be traversed across the section and a series of flow velocity measurement taken. Pitot static tube in its simplest form is bent through 90^0 as shown in Fig. 1

The tube senses the stagnation pressure at its top or head and the static fluid pressure around its periphery. These two pressures are transmitted to the limbs of a manometer.

The total head of fluid can be represented by

$$p/\rho g + V^2/2g$$

i.e. the pressure head and the velocity head.

The peripheral static tapping can be represented by

$$p/\rho g$$

Where, p = Pressure intensity

V= Velocity of liquid flow.

ρ = Density of fluid

g = Acceleration due to gravity.

As these are opposed on the manometer, the differential reading is equal to the $V^2/2g$, thus enabling the velocity to be calculated. The difference in pressure is called dynamic pressure or velocity head.

Generally velocity of liquid flow V, can be measured by

$$V = C\sqrt{2gh}$$

Where 'C' takes into account the various form of losses and 'h' is the difference of pressure head.

DESCRIPTION:

The experimental set up consists of a circuit through which the fluid is circulated continuously having a pitot tube on the downstream side of the pipe. A regulating valve is provided on the downstream side of the circuit to regulate the flow. The pipe has a provision for fixing the pitot tube with gauge to fix the pitot tube at different positions across the diameter. The pitot tube is provided with two tappings, one each for stagnation pressure and static pressure. These are further connected to two limbs of 'U' tube manometer. An inclined 'U' tube manometer is provided to measure the pressure difference between two sections. A collecting tank is used to find the actual discharge through the circuit, by direct measurement of volume collected and time taken.

STANDARD DATA:

Diameter of pipe, cm	= 5cm
Area of cross section of pipe, cm^2	= 19.6375cm^2
Inclination of the manometer, θ	= 15^0
Slope of inclined manometer, $\sin 15^0$	= 0.2588
Area of collecting tank (upper)	= 40 x 40 cm^2
Diameter of pitot static tube, 'D', cm	= 0.65cm

Reading of pitot static gauge while touching bottom of conduit, h_0 = (from experiment)

Reading of pitot static gauge take on different position, h_f = (from experiment)

COEFFICIENT OF PITOT TUBE

Discharge Measurement					Manometer Reading		*Difference of head on vertical scale* $h = (h_1 - h_2)\sin\theta$ (cm)	$V = \frac{Q}{A}$	$C = \frac{V}{\sqrt{2gh}}$
S. No.	*Initial water level* *(cm)*	*Final water level* (cm)	*Time* *(sec)*	*Discharge, Q,* *(cm³/sec)*	Left limb h_2 *(cm)*	Right limb h_2 (cm)			

VELOCITY DISTRIBUTION PROFILE

S. No.	Reading of pitot static gauge h_f (cm)	$Y = h_f - h_0 + D/2$ (cm)	Manometer reading		Difference of head on vertical scale $h = (h_1 - h_2)\sin\theta$ d(cm)	$V = C\sqrt{2gh}$
			Left limb h_1 (cm)	Right limb h_2 (cm)		

PRECAUTIONS:

- Apparatus should be in leveled condition.
- Holes of pitot static tube must be free from dust and be kept open.
- There should not be any air bubble in the manometer.
- Reading must be taken in steady conditions.
- Position of pitot static tube should be varied in uniform small steps.

PROCEDURE:

1. Note down the relevant dimensions as internal diameter of pipeline, outer diameter of pitot tube and inclination of manometer, volume of collecting tank.
2. Connect pressure tapping of pitot tube to the manometer by means of flexible tubes.
3. Set the flow to full position by maintaining this amount of steady flow in the pipe circuit, there establishes a steady and uniform flow in the conduit. Time is allowed to stabilize the levels in the manometer tube.
4. The discharge flowing in the circuit is recorded together with the water level in left and right limbs of manometer tube.
5. From the reading taken above calculate discharge, velocity, coefficient of pitot tube and plot the velocity profile.
6. Change flow control valve is set at ¾ open positions. Take all the readings for different position of pitot tube again and repeat the procedure in step no. 5.
7. Repeat the experiment and get results for other discharge value like ½ & ¼ open positions.
8. Now observe the difference between the velocity profile curves.

RESULTS:

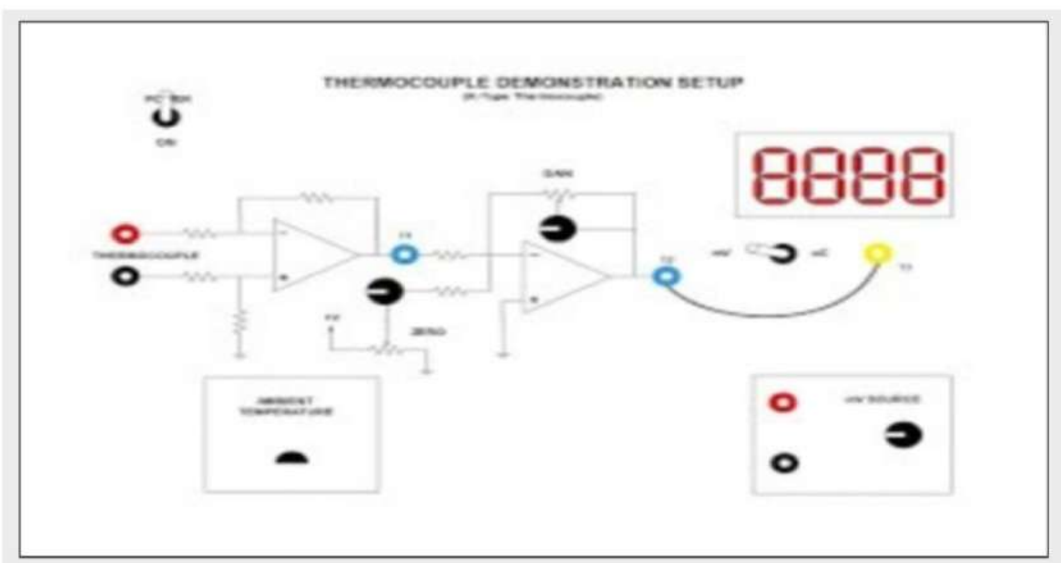
1. Draw the velocity profile i.e. plot between radial distance and velocity of flow i.e. ‘Y’ v/s ‘V’ on a simple graph paper.
2. ‘C’ lies between the 0.9 to 1.0, as the result of the small energy loss.
3. First reading of tube position is not velocity at the wall of the pipe, but at a distance of D/2 from the wall.

EXPERIMENT NO. 10

AIM: - Preparation of a thermocouple, its calibration and application for temperature measurement

Apparatus required: Beaker with water ,An immersion heater, A thermometer, A multimeter.

THEORY: The setup consists of a shielded K-type thermocouple, its signal conditioning unit, an immersion heater and a beaker. The thermocouple has two terminals which are connected to the signal conditioning unit. In the signal conditioning unit has a milli volt source that provides-10 to +25mV to calibrate the signal conditioner module for measurement of temperature directly in ^{O}C. There is a zero and gain adjustment POT provided for the calibration purpose. A 4 digit seven segment display is there for displaying the output (mV or in degree Celsius) in digital form.

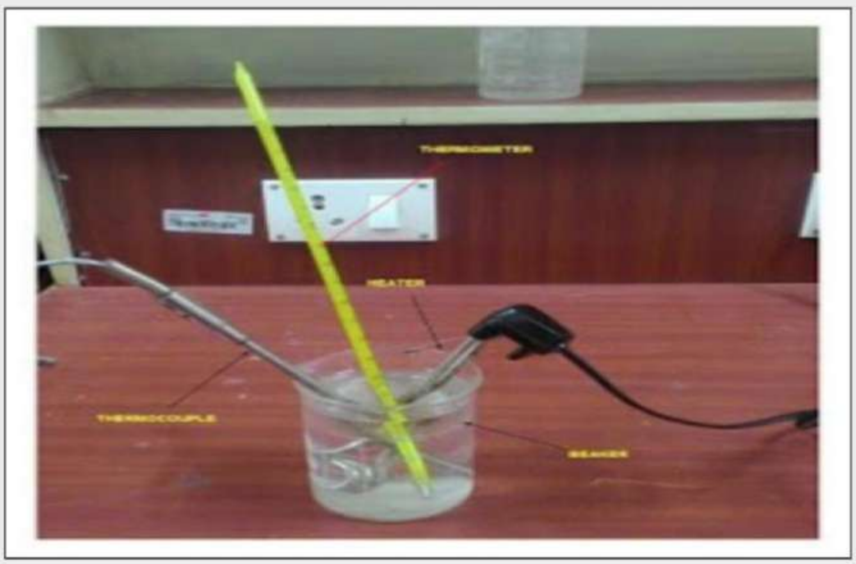


Working: The thermocouple is immersed in a hot water whose temperature is to be measured. The output of thermocouple is in mV which is directly proportional to the temperature that the thermocouple sense. The output of the thermocouple is connected to the signal conditioning unit where it is directly fed to a DC differential amplifier and then is fed to a summing amplifier. The summing amplifier has a gain and zero adjustment POT to obtain output directly in engineering unit of temperature. An LM35 IC temperature sensor is used for sensing ambient temperature that takes care of the ambient temperature compensation.

Procedure:

To get thermocouple output in mV:

Fill the water in beaker. Place an immersion heater in the beaker and keep the thermometer as well as the thermocouple in the beaker too.



Connect the output of the signal conditioner with the DPM by a patch cord (between T2 and T3). Switch ON the power. Put the toggle switch towards mV side. Set gain adjustment pot at anticlockwise. Reset minimum gain. Short the input (Thermocouple) of the setup with a patch cord and measure the output on DPM (Digital Panel Meter). It must be zero, if not adjust it to zero with the help of zero pot. Remove the input short lead and connect the I/P with a millivolt source having reading 10mV (measure with a multimeter). The reading on DPM is in mV and set it to 10.00 with gain adjustment POT. Remove the millivolt source from the input and connect the thermocouple terminals. Switch ON the heater to heat the water. The millivolt generated across the thermocouple terminals will be displayed on the DPM. Note down the reading of both thermocouple and thermometer after a fixed time interval. Plot the graph between temperature indicated by thermometer and thermocouple emf(mV).

Observation:

Sl no.	Temperature by thermometer	DPM reading (mV)

To get thermocouple output directly in degree Celsius:

Disconnect the thermocouple from the input and short again by a patch cord. Toggle the switch towards ^{O}C. note down the reading on DPM which is ambient temperature. Remove the short lead and connect the millivolt source and set the value at 4.1mV by multimeter. Adjust the DPM reading at 100 + ambient temperature with gain adjustment pot. Remove the millivolt source and connect the thermocouple and noted own there adding at different temperature position by heating the water.

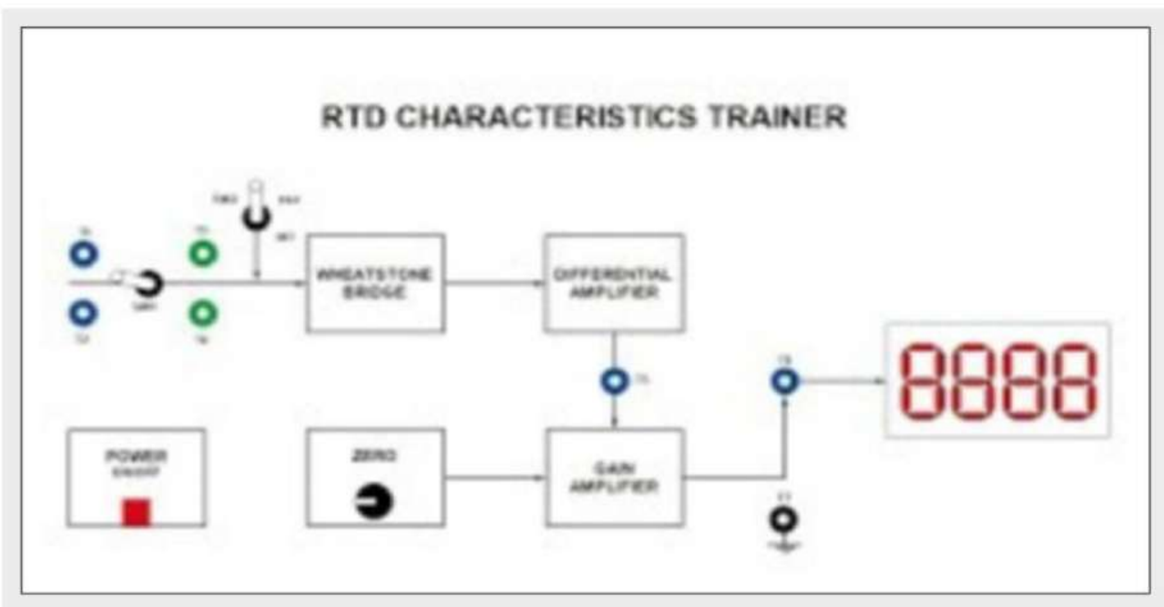
Observation:

Sl no	Temperature by thermocouple	Temperature by thermometer

TEMPERATURE MEASUREMENT USING RTD

Setup:

The setup consists of a RTD (Resistance Temperature Detector) and its signal conditioning circuit. The RTD used here is a PT 100 platinum RTD. The RTD has been shielded by stainless steel so that it can be immersed in the liquid or gas to sense the heat. The resolution of the RTD itself is 0.292 to 0.39Ω/^{O}C. The temperature range that it can measure is -200 to 850 ^{O}C. In the signal conditioning circuit, there is a Wheat stone bridge, a differential amplifier and an offset & gain adjustment circuit for calibration purpose. Two switches are there named SW1 and SW2. There is a 3 ½ digit LED display to display the temperature in ^{O}C, and some test points.



WORKING:RTD is called Resistance Temperature Detector, whose resistance changes with change in temperature. A two wire RTD called PT 100 is used here, PT 100 implies that it has a resistance of 100Ω at 0^{O}C. The RTD is placed in a temperature changing environment whose temperature is need to be measured. The two terminal of the RTD is connected to one arm of the Wheat stone bridge. When its resistance changes due to change in temperature an unbalanced output voltage is developed at the bridge output. This voltage is applied to a differential amplifier and subsequently it is processed and calibrated to display the temperature directly in ^{o}C.

PRECAUTIONS:

- Apparatus should be in leveled condition.
- Holes of pitot static tube must be free from dust and be kept open.
- There should not be any air bubble in the manometer.
- Reading must be taken in steady conditions.
- Position of pitot static tube should be varied in uniform small steps.

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CHANDIGARH UNIVERSITY

DEPARTMENT OF MECHANICAL ENGINEERING

SUBJECT : MECHANICS OF SOLID LAB	Subject Code: MEP-258

Mechanics of Solid Lab

MEP - 258

Vision and Mission of the Chandigarh University

Vision

"To be globally recognized as a Centre of Excellence for Research, Innovation, Entrepreneurship and disseminating knowledge by providing inspirational learning to produce professional leaders for serving the society"

Mission

M1: Providing world class infrastructure, renowned academicians and ideal environment for Research, Innovation, Consultancy and Entrepreneurship relevant to the society.

M2: Offering programs & courses in consonance with National policies for nation building and meeting global challenges.

M3: Designing Curriculum to match International standards, needs of Industry, civil society and for inculcation of traits of Creative Thinking and Critical Analysis as well as Human and Ethical values.

M4: Ensuring students delight by meeting their aspirations through blended learning, corporate mentoring, professional grooming, flexible curriculum and healthy atmosphere based on co-curricular and extra-curricular activities.

M5: Creating a scientific, transparent and objective examination/evaluation system to ensure an ideal certification.

M6: Establishing strategic relationships with leading National and International corporates and universities for academic as well as research collaborations.

M7: Contributing for creation of healthy, vibrant and sustainable society by involving in Institutional Social Responsibility (ISR) activities like rural development, welfare of senior citizens, women empowerment, community service, health and hygiene awareness and environmental protection

Vision and Mission of the Department of Mechanical Engineering

Vision

To be recognized as a center of excellence for research and innovation in Mechanical Engineering through contemporary as well as futuristic tools and technologies for serving the society at regional, national and global level

Mission

MD1: Providing quality education to the students in core and allied fields by implementing advanced pedagogies

MD2: Encouraging students towards research and development through advanced tools and technologies for providing solution to societal problems

MD3: Evolve and empower the students through core technical skills for becoming entrepreneurs and innovators

MD4: Inculcating employability and leadership skill for ensuring industry ready professional through hands on experiential learning and industrial collaboration

MD5: Developing professional and ethical standards in the mind of the young engineers by continuous learning and professional activities

1.2. State the Program Educational Objectives (PEOs)(5)

PROGRAM EDUCATION OBJECTIVES (PEOs):

PEO1: Graduates will have professional knowledge in the field of Mechanical Engineering and various other interdisciplinary domains.

PEO2: Graduates will have successful career in government services, research organizations, corporate sector, academic institutes and industries at national and international repute.

PEO3: Graduate will have compatibility of modern engineering tools and technologies for deliberating solution of various engineering problems.

PEO4: Graduate will develop skill to address the concern of society, environment and communicate effectively to lead the interdisciplinary diverse team.

PEO5: Graduates will be effectively fit for higher education, innovations, research &development, entrepreneurship and professional development.

PROGRAM OUTCOMES (POs):
Program: Bachelor of Engineering (Mechanical Engineering)
Duration: 4 years

PO1. Engineering Knowledge: Apply knowledge of mathematics, science and engineering fundamentals and Production and Industrial Engineering specialization to the solution of complex Production and Industrial Engineering problems.

PO2. Problem Analysis: Identify, formulate, research literature and analyze complex Production and Industrial Engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex Engineering problems and design system components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.

PO4. Conduct investigations of complex Engineering problems: Use research-based knowledge and research methods including analysis, interpretation of data and synthesis of information to provide valid conclusions.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. The Engineer and Society: Apply contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams and in multi disciplinary settings.

PO10. Communication: Communicate effectively on complex Engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.

PO11. Project Management and Finance: Demonstrate knowledge and understanding of Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life Long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs):

PSO1: Apply the knowledge of Production, Manufacturing and Industrial Engineering for analysis, optimization and development of mechanical system

PSO2: Apply the concepts of Design and Thermal Engineering to model, analyze and develop the mechanical components and systems

Objective

Industrial Automation and Robotics Laboratory

- Focuses on equipment, work systems, machinery, and automation systems for today's manufacturing environment
- To provide students the opportunity to acquire hands-on experience in the use of the engineering equipment, systems, and tools in the lab
- To understand working and construction of hydraulic and pneumatic circuits
- To understand, diagnose an automated system.

CHANDIGARH UNIVERSITY

DEPARTMENT OF MECHANICAL ENGINEERING

SUBJECT : MECHANICS OF SOLID LAB	Subject Code: MEP-258

COURSE OUTCOMEs

After compeletion of this course student will be able to:

CO1	Solve the problem related to different types of stress and strains acting on various deforming bodies.
CO2	Calculate the SFBM, shear, bending and torsional stresses acting on various types of beams, shafts and other machine components
CO3	Examine the condition of beam, shaft, cylinder, column, rim and disc under different loading conditions.
CO4	Compare the different types of beams, shafts,cylinder and sphere and other machine components
CO5	Design the different types of beam, shaft,cylinder, column, rim, disc and rotor for particular application

LIST OF EXPERIMENT

1 To perform tensile test for ductile and brittle materials and to draw stress-strain curve.

2 To perform Shear test on UTM

3 To perform compression test on UTM

4 To determine the Rockwell hardness number and Brinell hardness number of the given specimen.

5 To determine the impact strength of the given material using Charpy impact test and Izod test Machine.

6 To find stiffness of Open Coil Helical Spring.

7 To perform torsion test on Mild steel specimen

8 Determination of Bucking loads of long columns with different end conditions.

9 To perform Fatigue test on circular test piece

10 Verification of MAXWELL Reciprocal theorem

Experiment No. 1

Aim:-To perform tensile test on Mild Steel specimen using Universal Testing Machine and to draw stress-strain curve.

THEORY

Tensile tests are employed to obtain the tensile strength, elasticity and ductility of the material. This test consists in straining a test piece by tensile stress, generally to fracture. Deformation or elongation of specimen at different loads is noted and a stress-strain diagram is prepared with the help of this diagram various elastic and strength properties of material are found.

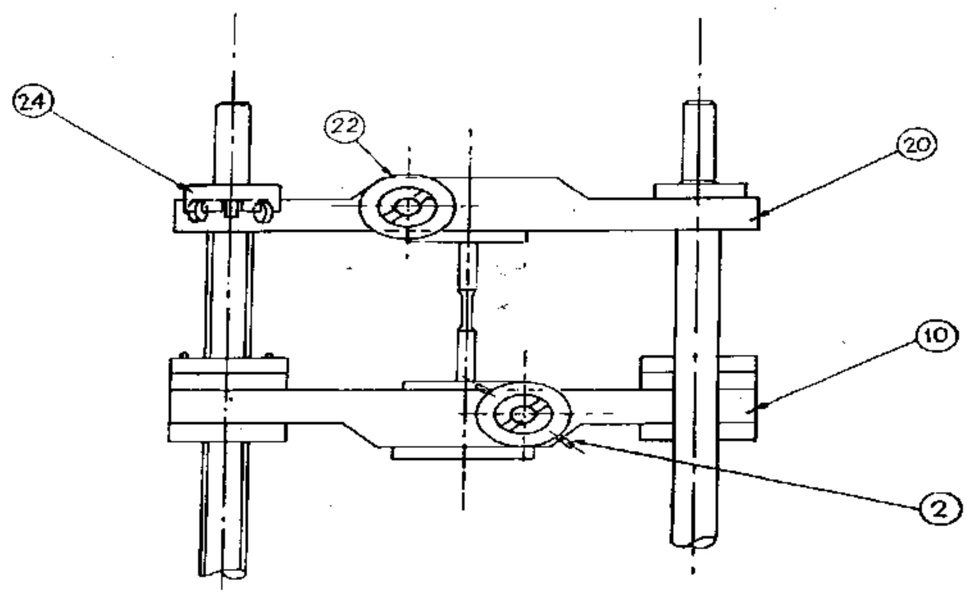
The standard form of tensile test specimen varies with the nature of the material. Acceptance tests of ductile metals are usually performed on a length of the material if it is in the form of a rod and of a strip if it is a sheet material. Brittle materials are usually formed into special shapes to permit the use of gripping devices which minimize bending and to make certain that fracture occurs within the gauge length selected.

The length of test piece between the grips of the testing machine should not be less than 9d in case of bars of dia. less than 2.5 cm., 4.5d in case of bars of dia more than 2.5 cm. The gauge length of specimen should be taken equal to 5.65 $\sqrt{S_0}$, S_o is the original cross sectional area of the specimen.

PROCEDURE

1. Prepare the specimen as explained above and draw the figure.
2. Measure the diameter of lest specimen by means of a micrometer at least at three places and determine the mean value. Also mark the gauge length with the help of a center punch.
3. Insert suitable jaws in the grips.
4. Insert the test specimen in the grip.
5. Take the initial reading on vernier scale provided in the machine.
6. Note the initial zero error in the dial of the machine.
7. Start the machine. Apply the load at the slowest speed.
8. Take the reading on vernier scale at the various load stages and record.
9. Continue applying the load till the specimen breaks and then stop the machine.
10. Take out the fractured specimen from the grips. Measure the final length in between the punch marks.
11. Record the probable yield point during test by observing the point at which pointer of load dial is stationary for MOSe time and move backward slightly

P. 4



TENSION TEST

S.No	DESCRIPTION
2	JAW LOCKING HANDLE
10	LOWER CROSS HEAD
20	UPPER CROSS HEAD
24	BEARING HOLD.
22	OPERATING HAND[illegible]

OBSERVATIONS TO BE TAKEN BY THE STUDENTS

Initial diameter of specimen, d_o =

Diameter of test specimen after fracture d_u =

Gauge length, L_o =

Final length after fracture, L_{uc} =

Initial area of cross section $A_o = \pi / 4\ d^2_o$ =

Final area of cross section, $A_u = \pi / 4\ d^2_u$ =

Probable yield point =

Type of fracture =

CALCULATIONS:

Stress = P/A_o Strain = δ / L_o

Where $(L - L_o) = \delta$

Draw the graph taking stress on Y- axis and strain on X- axis.

Ultimate Stress = $\dfrac{\text{Ultimate Load}}{A_o}$

% elongation = $\dfrac{L_u - L_o}{L_o} x100 =$

% reduction in area = $\dfrac{A_o - A_u}{A_o} x100 =$

OBSERVATION TABLE: Initial vernier reading =

Sr. No.	**Load P** 1.	Vernier reading 2.	Elongation 3.	Stress 4.	Strain 5.
01					
02					
03					
04					
05					
06					
07					
08					
09					
10					
11					
12					
13					
14					
15					
16					

For calculation of value of modulus of elasticity take any point 'x': on stress-strain curve within elastic range. Find the corresponding stress and strain i.e..x and x°

$E = \sigma_x / \varepsilon_x$

RESULTS

Ultimate Stress =
Yield stress =
Proportional Limit =
Modulus of elasticity =
Percentage elongation =
Percentage reduction of area =

DISCUSSIONS

1. Discuss the stress-strain diagram.
2. Discuss the type of fracture obtained.
3. Compare the results with standard values.

QUESTIONS

1. What is yield strength?
2. What other properties can be measure with the help of tensile test?
3. Define stress and strain.
4. Differentiate between Engineering Stress and True stress.
5. What is Hook's Law
6. Define modulus of elasticity , Poisson's ratio
7. What is the formula for calculating the gauge length?
8. What type of fracture is obtained while performing tensile test on(I) Ductile (2) Brittle Material.
9. Draw and Explain Stress- Strain diagram for Mild Steel.
10. Name the salient points on stress-strain curve.
11.

Experiment No. 3

Aim:-To Perform Compression test on UTM.

THEORY

Wood exhibits, under compressive loading, a behavior peculiar to itself It is anything but an isotropic material, being composed of cells formed by organic grains aligning themselves to form a series of tubes or columns in the direction of the grain. As a result of this structure the elastic limit is relatively low. There is no definite yield point and considerable set takes place before failure. For loads normal to the grains, the load that causes lateral collapse of the tubes or fibers (crushing) is the significant load. For loads parallel to the grain, not only the elastic strength is important but also the strength at rupture. Rupture often occurs because of collapse of the tubular fibers as columns. Various types of failure of wood loaded parallel with the grain are seen.

Crushing (plane of rupture approx. horizontal).

Wedge split.

Shearing (plane of rupture at acute angle with horizontal).

Splitting.

Shearing and splitting parallel to grain.

TEST SPECIMENS

Specimen for compression tests of wood parallel to the grain 5 cm x 5 cm x 5 cm rectangular prisms.

Compression tests perpendicular to the grain are made on nominal 5 cm x 5 cm x 5 cm. specimens.

The load is applied through a metal bearing plate placed across the upper surface at right angles to the width.

PROCEDURE

1. Measure the dimensions of the test pieces.
2. Clean the bottom and top plates of the machine.
3. Position the specimen centrally on the bottom plate and screw down the top plate into contact. Positioning of the specimen centrally is important to ensure correct application of the load.
4. Open the stop valve of the pressure gauge, to be used. Close other pressure gauge valves.
5. Open the control valve fully and start the pump running.
6. Set the loose pointer on the gauge back to zero and apply load slowly closing the control valve.

7. When the specimen fails, the loose pointer on the gauge will indicate the maximum load reached. At this point the pump motor should be stopped.

OBSERVATIONS AND CALCULATIONS

Test	Dimensions of specimen	Cross sectional area (cm^2)	Load at failure (kg)	Compressive strength
Along the grain Across the grain				

RESULTS

1. The compressive strength, of wood specimen along the grain
2. The compressive strength of wood specimen across the grain

PRECAUTIONS

1. The specimen should be correctly prepared. It should be ensured that the end faces are at right angles to each other.
2. Specimen should be centrally placed on the bottom plate of the machine.
3. Load should be applied gradually and at constant rate by manipulating the control
4. Valve.
5. The specimen guard should be positioned to protect the operator from flying fragments if any.

DISCUSSION

Discuss the type of failure for each case.

QUESTION

1. What is the compressive strength?
2. What are types of failure obtained when test is performed (1) along the grain (2) across the grain?
3. What is the machine capacity for compression test?
4. Define shear stress.
5. What is the factor of safety?

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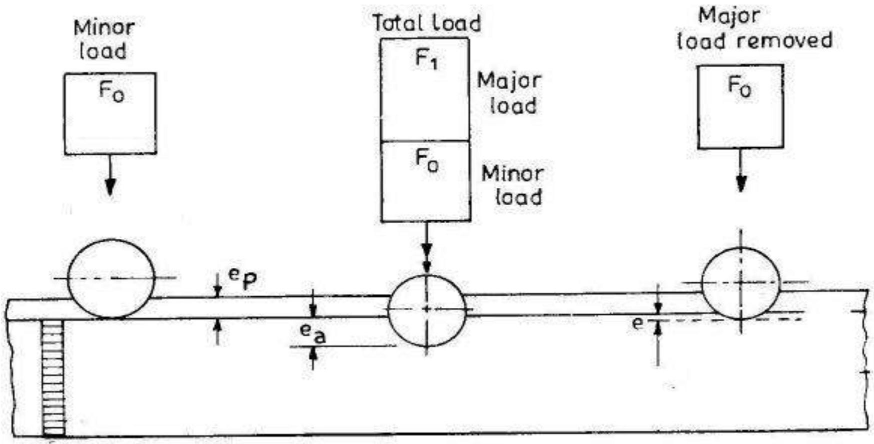
Experiment No. 4

Aim:- To determine the Rockwell Hardness of given material using Hardness Testing Machine.

THEORY

This test utilizes the depth of indentation under standard loading conditions as a measure of hardness. A minor load of 3 kg.is first applied to the penetrator to eliminate any effect due to surface imperfections. The major load is then added and the permanent depth of penetration under minor load after the removal of major load is taken as a measure of hardness.



e_p = Depth of impression made by minor-load.

$e_a + e_p$ = Depth of impression made by total load

$e_a - e$ = Recovery of metal upon taking major load off.

e = Depth of impression made by the major load which gives the measure of hardness of the material.

The dial is divided into 100 divisions; each division represents a penetration of 0.002 mm. The scale of the dial is reversed so that deep impressions give a low reading and shallow impressions a high reading, so that high numbers indicate hard materials.

1. Main screw
2. Dash pot.
3. Plunger
4. Weights.

5. Value screw
6. Dial gauge.
7. Indentor
8. Holder.
9. Lever
10. Hand wheel.
11. Load hanger.
12. Upper nut.
13. Zero setting screw
14. Adjustable lock nut.
15. 5 mm screw
16. M.S. cap.
17. Clamping cone.
18. Check nut.
19. Set position of dial gauge.
20. Test table.

For correct choice of scale, penetrator and load; the following table may be referred:

Scale Symbol	**Penetrator**	**Total load**	**Dial figures**	**Materials for which scale is used.**
A	Diamond Cone	.60 Kg	Black	Thin hardened steel strip. Other extremely hard materials when small impressions are required
B	Steel Ball 1/16"	100 Kg	Red	All mild and medium carbon steels, sheets steel and soft steel bars.
C	Diamond Cone	150 Kg	Black	Hardened steels, hardened and tempered steels, material harder than B 100.
D	Diamond Cone	100 Kg	Black	Case hardened steel when a lighter load than 150 kg is advisable.
E	1/8" Ball	100kg	Red	Cast iron, aluminium and magnesium alloys.
E	1/8" Ball	100kg	Red	Cast iron, aluminium and magnesium alloys.
F	1/1 6" Ball	60kg	Red	Annealed brass & copper and for thin sheets.
G	1/16" Ball	160kg	Red	For materials in range B 1 00 where greater senstivity is required e.g. beryllium Copper phosphor bronze
H	1/8" Ball	60kg	Red	Soft aluminum non-metallic plastics.

PROCEDURE

1. Select proper scale, load and penetrator. Insert the penetrator in the holder and attach the required proportional weights to the suspension rod.
2. Clean the specimen and position it on the clean worktable of the machine.

3. Turn the hand wheel to elevate the specimen into contact with the penetrator. Continue carefully rotating the hand wheel until the small indicating hand on the dial indicates "Set" and the main indicating hand is approx. vertical, then, if necessary rotate the dial itself until the "set" (i.e. CO and B 30) position coincides with it. In setting up the specimen in this manner, the minor load of 3 kg is automatically applied.
4. The major load is applied by pushing hand lever away from the operator.
5. As the penetrator is impressed into the specimen, the indicating hands will revolve, and when this movement ceases the impression is complete. The period of contact between penetrator and specimen after the major load has been applied is important and may vary from 10 to 20 seconds, i.e. until the pointer ceases fast movement and continues to creep slightly.
6. As soon as the impression is complete the major load must be removed by pulling the hand lever towards the operator.
7. Read the hardness number on the appropriate scale after the pointer comes to rest. It is necessary to specify the scale along with the hardness number.

OBSERVATION:

S.No	Material of test specimen	Thickness of specimen (mm)	Penetrator	Net load	Scale symbol	Rockwell Hardness number	Mean Value
1	Mild Steel					1 2 3	
2	C.I					1 2 3	
3	Brass					1 2 3	
4	Copper					1 2 3	
5	Aluminum					1 2 3	

RESULTS

1. Average Rockwell hardness number of mild steel test specimen is found to be-

2.
3.
4.
5.

PRECAUTION

1. Theindentor and anvil should be clean and well seated.
2. The surface to be tested should be clean, dry and smooth.
3. The surface should be flat and perpendicular to the indentor.
4. Tests on cylindrical surface will give low readings, the error depending on the curvature, load, indentor and hardness of the material.
5. The thickness of the specimen should be such that a mark or bulge is not produced on the reverse side of the piece. It is recommended that the thickness be at least ten times the depth of the indentation.
6. The distance between the center of the two adjacent indentations or of the center of any indentation from the edge of the test pieces should be at least three times the diameter of the impression.
7. The dashpot should be correctly adjusted to operate in 3 to 5 seconds to avoid shock loading.

QUESTIONS :

1. Define hardness of a material.
2. What is the necessity of hardness testing?
3. What measurement is made in Rockwell test?
4. Why is it necessary to have different scale for hardness number?
5. Why do we apply minor load in Rockwell testing?
6. What is the advantage of Rockwell hardness test?

Experiment No. 4 (B)

Aim:-To determine Brinell hardness number of given test specimens by using Hardness Testing Machine

THEORY

BRINELL HARDNESS TEST

The Brinell hardness is the ratio of the test load 'P' under which the steel ball having a diameter 'D' is passed into the specimen to the surface area 'F' of the made impression having a diameter.

$$BHN = \frac{P}{\frac{\pi}{2}D(D-\sqrt{D^2-d^2})} \quad kg/mm^2$$

The ball diameters and the load stages to be used are given below as per DIN 50351

Ball dia	Load Stage in Kg.					
D (mm)	30 D^2	10D^2	5 D^2	2.5 D^2	1.25 D^2	0.5 D^2
10	3000	1000	500	250	125	50
5	750	250	125	62.5	31.25	12.5
2.5	187.5	62.5	31.25	15.625	7.8125	3.125

The load stages given beyond the thick lines of the above table are not included in this hardness-testing machine HPO 250).

According to Weingraber, following load stages should be used in the Brinell hardness test.

.

Material	Hardness range	Load Stage
Soft Iron, steel		
Steel casting	67-500 HB	30 D^2
Malleable iron		
Cast iron		
Light alloys	22-315 HB	10 D^2
Casting and forging alloys dia casting alloys		
Copper, Brass, Bronze, Nickel		
Pure Aluminum,	11-158 HB	
Magnesium		5 D^2
Zinc		
Cast brass	6-78 HB	
Bearing metals		2.5 D^2
Lead	3-39 HB	
Cast brass		1.25 D^2
Bearing metals		
Lead		
Tin		0.5 D^2
Soft solder	1-15 HB	
Soft metal at Elevated temps		

The test area of the specimen should be cleaned from dirt, oil, scale and the like. Care should be taken that the diameter "d" of the impression ranges within 0.2….. 0.7 of the ball diameter D. On the spot to be tested the thickness of the specimen should be a ten fourth of the depth of impression to be expected.

CONSTRUCTIONAL DETAILS AND WORKING

PROCEDURE

1.Select proper scale, load and penetrator. Insert the penetrator in the holder and attach the required proportional weights to the suspension rod.
2.Clean the specimen and position it on the clean worktable of the machine.
3. Turn the hand wheel to elevate the specimen into contact with the penetrator. Continue carefully rotating the hand wheel until the small indicating hand on the dial indicates "Set" and the main indicating hand is approx. vertical, then, if necessary rotate the dial itself until the "set" (i.e. CO and B 30) position coincides with it. In setting up the specimen in this manner, the minor load of 3 kg is automatically applied.
4.The major load is applied by pushing hand lever away from the operator.
5.As the penetrator is impressed into the specimen, the indicating hands will revolve, and when this movement ceases the impression is complete. The period of contact between penetrator and specimen after the major load has been applied is important and may vary from 10 to 20 seconds, i.e. until the pointer ceases fast movement and continues to creep slightly.
6.As soon as the impression is complete the major load must be removed by pulling the hand lever towards the operator.
7.Take out the specimen and measure the diameter of indentation by brinell microscope.

RECORDING AND EVALUATION

BRINELL HARDNESS TEST

Material	Dimensions of specimen	Load stage	Ball dia. (mm.)	Load (Kg.)	Time of application of load	Dia. of impression	BHN	Mean value of BHN

Result: - The hardness no. of given specimen

QUESTIONS :

1. Define Hardness.
2. What is the measure of hardness in Brinell hardness test?
3. Write the Brinell hardness formula and give its unit?
4. Write the relationship between Brinell hardness and Rockwell hardness no.
5. What is the significance of ratio F/D^2 ?

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Experiment No. 5

Aim:-To determine impact strength for given specimens using (i) IZOD TEST (ii) CHARPY TEST on Universal impact Testing Machine (Pendulum type).

THEORY

(A) DESCRIPTION OF THE MACHINE

The machine is pendulum type used for the determination of Impact strength of notched and unnotched metal bars of various lengths and sections in accordance with IZOD (Cantilever) test method and CHARPY (simply supported beam) test method.

The hammer of a carefully chosen weight, when dropped from a predetermined height strikes the test, piece laid between supports in the base of the machine as shown in figure.

The striking hammer breaks the test piece. A part of the Kinetic energy of the hammer is thus absorbed in breaking the test specimen and the remaining energy causes the hammer to rise on the other side of the machine. From the height of this residual swing, the energy used in breaking the specimen is determined and in this machine, it is directly indicated in kg x m. The height of drop of the hammer can be varied within very wide limits with the help of a semicircular toothed rack. The height of drop should be chosen so that the specimen is fractured in one single blow. The striking edge of the hammer is kept at the center of percussion, so that there is practically no vibration of the pendulum when the hammer strikes the test piece and consequently little or more of the energy of the blow is lost in the pendulum.

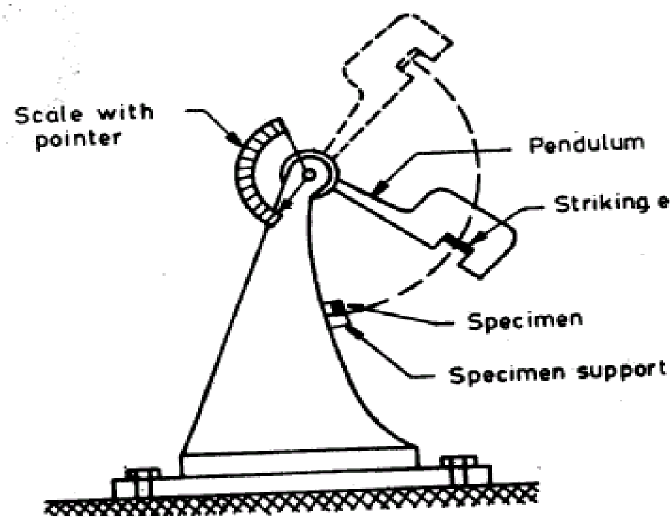
(B) DESCRIPTION OF STANDARD TEST PIECE

(a) IZOD-TEST

The test piece for Izod test is placed as a cantilever in the Izod vice in vertical position. . A 45-degree, 2 mm deep notch is machined at a distance of 21.5 mm from the free end of the test piece. Standard size of specimen is 10* 10*65 mm.

(b) CHARPY TEST

The test piece for Charpy test is placed against two anvil blocks in horizontal position, located at the base of the machine. The standard test piece is a square piece 10x10 mm. square with a 45 degree V notch 2 mm. deep, machined in the center of the 55 mm long test piece.



C) TEST PROCEDURE:

(a) IZOD-TEST

Place the Izod Vice-in the machine base the bolts placed in the bed T-slots passing through the vice holes.
Fit the Izod hammer to the Pendulum. Also check that the Izod scale is on [the side of the pointer. Set the measuring device as described before, after roughly estimating the energy required to smash the test piece and choosing the height of drop of Pendulum accordingly. Adjust the position of vice such that the center line of the test piece lies in the center of slot in the weight of the Pendulum. Tighten the Vice to the base. Now engage the hook of the Pendulum in the arrester. Place the test piece in the dies of the Vice with the V-notch facing towards the falling hammer. Place the Izod setting gauge over the Vice and gently push the taper edge of the gauge into the V-notch of the test piece, the flat face sliding over the vice. This way the center of the notch is correctly brought in level with the top of holding dies. Taking necessary precautions, release the Pendulum by pulling the release handle. Read the scale which. indicates the energy absorbed in fracturing the test piece, calculate the energy absorbed per square mm by dividing the scale reading by the minimum area of cross section i.e., the area at notch in mm2.

(b) CHARPY TEST

Replace the Izod vice by Charpy Anvil Blocks and the Izod hammer by the Charpy Hammer. Also fix the scale so that the pointer is on the side of scale for Charpy Test. Choose the height of drop of the Hammer after roughly estimating the energy required to smash the test piece and set the scale as already described. Place the test piece against the anvil blocks and adjust their position such that the V-notch in the test piece lies in the plane of swing of the edge of the striker. Clamp the anvil blocks taking care that the ends of test piece lie in the cavities of anvil blocks covering the cavities fully. Place the pendulum on the arrester and test piece in position such that the V-notch is on the side of anvil blocks, opposite to the striking side of the hammer. Pull the release handle and note the energy absorbed in fracturing the test piece. Now calculate the energy absorbed per square mm. cross sectional area of the test piece at V-notch.

OBSERVATIONS TO BE TAKEN BY THE STUDENTS

IZOD TEST

S.No	Initial reading	Final reading	Mean energy	Minimum cross-sectional area at notch.	Impact strength or Energy absorbed per square mm
1					
2					
3					

CHARPY TEST

S.No	Initial reading	Final reading	Mean energy	Minimum cross-sectional area at notch.	Impact strength or Energy absorbed per square mm
1					
2					
3					

RESULT

1. Impact strength of given specimen performing Izod Test is =
2. Impact strength of given specimen performing Charpy Test is =

PRECAUTIONS

1. The machine should be installed on a perfectly level concrete pedestal .
2. The height of fall of hammer should be correctly selected and checked.
3. The size of the test piece should be such that a single blow is sufficient to break it.
4. Before performing the test, the scale must be set as explained in the procedure.
5. The vertical slide rods of the scale attachment must be well lubricated to minimize friction losses.
6. While changing the hammer for Chary or Izod tests, the clamping bolts must be fully tightened.
7. The test piece must be set correctly before operating the machine.
8. Before releasing the pendulum, see that there is nobody there in the path of swing of the pendulum.

Viva Questions:

1. What property is determined by notched - bar impact test?
2. Define the property toughness of a material.
3. Explain: (a) Notch sensitivity. (b) Modulus of resilience.
4. What is the necessity of a notch in Charpy and Izod impact test?
5. How the specimen is supported in Charpy and Izod impact test?
6. What is the difference between Izod a Charpy test?

Experiment No. 6

Aim:-To find stiffness of Open Coil Helical Spring.

APPARATUS REQUIRED

Spring Testing machine, Micrometer, Screw Gauge, Scale, Calipers.

THEORY

Springs may be regarded as devices for storing up energy in the form of resilience. They are used either as storage for energy or else, are used to absorb excess energy depending upon the function of a particular spring under consideration. The best form of spring is that which absorbs greatest amount of energy for a given stress.

The spring may be divided chiefly into two categories:

(I) TORSION SPRING

Which is subjected to torque and resilience is mainly due to torsion. Closely coiled Helical springs subjected to axial pull falls under this category.

(II) BENDING SPRING

Which is subjected to bending only and resilience is mainly due to bending. The leaf springs fall under this category.
An open coiled helical spring can be stressed in both manners.

DESCRIPTION OF MACHINE

The Spring Testing Machine consists of (i) straining mechanism, (ii) a separate load weighing system. With suitable arrangement of gripping device, the specimen tested is interposed between a fixed head and movable head. The specimen is strained by controlling the motion of the movable head. The oil is pumped from the supply tank through a control valve into the cylinder. The piston in the top of cylinder is hereby forced upward causing the movement of movable head. The measurement of the load on the specimen is accomplished by means of pressure gauge placed in between fixed head and movable head. The deflection or the deformation can be measured with the help of scale or dial gauge.

PROCEDURE

1.Measure the dimensions of the springs such as the section of the wire, diameter of the spring, number of turns etc.
2**.**Fix the spring in between the fixed head and movable head of the machine. Start the machine.
3.Load the spring in suitable steps by controlling Control Valve of machine and measure the deflection. Take readings both while loading and unloading.

OBSERVATIONS

a) Close-coiled helical spring
Mean radius of coil, R =
Diameter of spring wire, d =
No of turns n =

Load						
Deflection						

b) Open-coiled helical spring
Mean radius of coil, R =
Diameter of spring wire, d =
No of turns, n =
Angle of spring α =

Load						
Deflection						

CALCULATIONS

For closed coiled helical spring of circular section, subjected to axial load, deflection is given by:

$$\delta = \frac{64WR^3 n}{Gd^4}$$

Where, G = modulus of rigidity.

For open coiled Helical Spring of circular section, subjected to axial load, deflection is given by:

$$\delta = \frac{64\,WR^3\;n\sec\alpha}{d^4}\left(\frac{Cos^2\alpha}{G} + \frac{2Sin^2\alpha}{E}\right)$$

Take $\frac{E}{G} = 2.5$

RESULTS

1. For closed coil helical spring material G= …………..

2. For open coiled helical spring material G = …………..

DISCUSSION

1. After calculating the values of E and G compare them with generally accepted values.
2. Discuss why the experiments will not normally give the expected results.

QUESTIOS :

1. Differentiate between Open & Close Coiled Helical Spring.
2. What is helix angle?
3. Define Proof resilience, Modulus of Resilience, Spring Stiffness
4. Define Modulus of Rigidity.
5. What is Capacity of the Spring Testing Machine used?
6. What is the least count of load scale of Spring Testing Machine?

Experiment No. 7

Aim:-To perform torsion test on Mild steel specimen.

APPARATUS REQUIRED

Torsion Testing machine, vernier, scale, permanent marker/ sketch pen.

THEORY

The problem of transmitting a torque or twisting couple from one plane to a parallel plane is often encountered in designing of machines and MOSe structures. A simple device for accomplishing this factor is a circular shaft such as one that connects an electric motor with a pump or compressor or any other mechanism.

When a circular shaft transmits a torque, each section of the shaft is subjected to shearing stress whose magnitude increases uniformly from zero at the center to maximum at the circumference. Each section of the shaft rotates or twists with respect to other section by angle, which is called angle of twist.

For the shaft of length L having circular cross-section of radius r, if T torque applied at the ends following equation is used.

$$T/J = G\theta/L = \tau/r$$

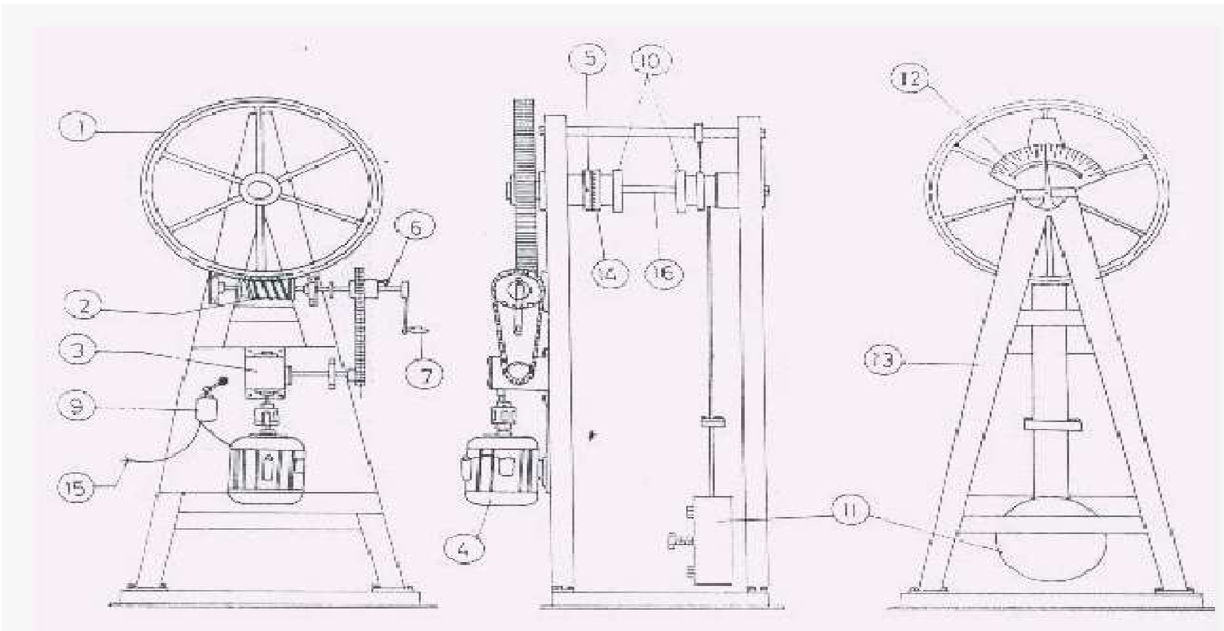
Where T is the shearing stress at a y point on the cross-section at radius r, j is polar moment of inertia ($\pi d^4/32$)

TORSION TESTING MACHINE

A torsion test is performed on a Torsion Testing machine. Generally a solid specimen of circular cross-section whose ends are machined according to machine grips and has a specified gauge length, is subjected to gradually increasing torque until the fracture takes place. Torsion testing machine consists of two independent chucks where motor and speed is resistance through a suitable resistance gear. The twist is communicated through the test sample to the other jaws on which a weighed pendulum is

attached. The resistance to deflection of pendulum causes a torque to be applied to the test piece and the angle of defection of pendulum is the measure of torque.
The loading unit has a sturdy frame (13). The instrument employs a gear system and load to test torque on rod between the square grip (10) by means of the pendulum weight (11).
The wheel (5) has shown the torque circle of the sample on the graduated wheel (14). A detachable handle (7) is mounted for initial positioning of the pendulum weight on dial (12).

A switch is fixed with frame (13). The gear wheel is moved by gear (2) being driven by a motor (4). The gear is connected through a reduction gear (3) through a chain (8) and the reduction gear is coupled to a motor. The adjustment of the counter is achieved by gear wheel (1), which can be moved backwards or forwards and locked in the desired position by clutch (6). A forward switch (9) is fixed to the frame for movement of the gear wheel and the graduation wheel to its initial position for fresh test.



TORSHON TESTING MACHINg

SNO	DESCRIPTION	SNO	DESCRIPTION
1	GEAR WHEEL	9	SWITCH
2	GEAR	10	GRIPS
3	REDUCTION GEAR	11	PENDULUM WEIGHT
4	MOTOT	12	DIAL

PROCEDURE

1. Measure the diameter of the test piece.

2. Measure the gauge length of test piece. Adjust the initial torque and angle of twist reading to zero position.
3. Insert the test piece in the grip of the machine.
4. Apply the torque initially by hand up to 100 angle of twist and note the corresponding torque. And angle of twist (Initially the reading may be taken at 2-degree interval.)
5. After the machine is operated electrically, the reading of torque may be noted at an interval of 5 to 10 degree.

6. Continue until the specimen breaks.
7.

Note: - Initially mark a line parallel to the length of test piece to visualize the helix formation.

OBSERVATION

Diameter of Ganges length of specimen d = …………….
Gauge length of specimen L = ………….
Initial Angle of twist = 0(Zero)
Initial Torque applied = 0 (Zero)

OBSERVATION TABLE

.

SNO	Angle of twist (θ) in degrees	Torque Kg-cm (T)

$T/J = G\theta/L = \tau/r$

$\tau = Tr/J$ & $\gamma = \tau/G r \theta/L$

S.NO.	τ Shearstress (Nlmm^2)	Γ (shearstrain)

GRAPH

Plot graph between
$T - \theta$
$\tau - \Upsilon$

RESULT

Front graph (T-θ)
T_{el} =
$T_{ultimate}$ =
$T_{fracture}$ =

Standard value of G = --------------------
%Error = ---------------

PRECAUTIONS

1. The specimen should be firmly fixed in jaws.
2. The specimen shouldn't be in inclined position after fixing.
3. Do not stand in the direction of swing of pendulum while doing experiment.
4.

QUESTIONS :

1. Define the following – a. Shear Stress b. Shear Strain c. Modulus of Rigidity
2. Write the relation between three Elastic constants.
3. How can we calculate modulus of rigidity using Shear stress vs. Shear strain diagram?
4. What is the use of weighted pendulum in the machine?
5. What is maximum Torque capacity of the Machine?

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Experiment No. 8

Aim:-Determination of Bucking loads of long columns with different end condition

APPARATUS REQUIRED

(1)Scale (2) Weights (3) Columns Apparatus

THEORY

Critical or Buckling load

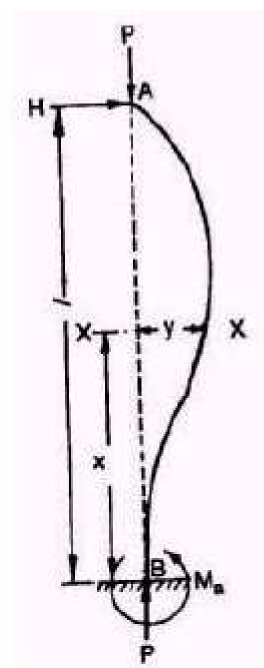
The min. axial load at which he column tends to have lateral displacement or buckle is called critical load or buckling load.
Euler's formula for critical load:

$$P_e = \frac{\pi^2 EI}{l_e^{\ 2}}$$

Where le is equivalent length of column.

S.NO	Load P (kg)	Equivalent length of column le
1	Both ends hinged	le = l
2	Both ends	le = l/2
3	One end fixed and other free	le=2l
4	One end fixed and other hinged	le = ½

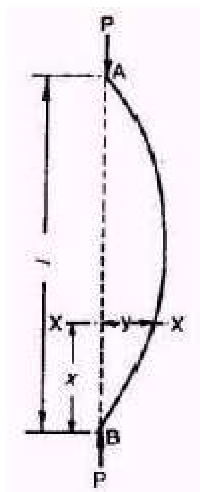
Case -1: - One end fixed and other end hinged.



$$Y = \frac{-R_A}{P.K} \times \frac{\sin Ka}{\cos Kl} + \frac{Ra.x}{P}$$

$$K = \sqrt{\frac{P}{EI}}$$

Case 2: - Both ends hinged

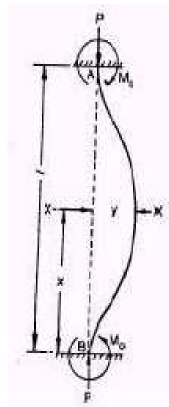


Y = B sin K .x

(Where B is a constant)

$$K = \sqrt{\frac{p}{EI}}$$

Case 3 :- Both ends fixed



$$Y = \frac{M_A}{P}(1 - \cos Kx)$$

Where MA = fixing moment.

PROCEDURE

1. Make the lever horizontal with the help of loads at either end.
2. Fix the beam with proper support so that there is no load on beam and beam is perfectly vertical.
3. Apply the load on beam by applying load on lever on one side.
4. Now by the screw mechanism is help again make the lever horizontal.
5. Check the beam for critical load.
6. Note down the deflection at various parts of the beam.
7. Repeat the above step for different loads.

OBSERVATION TABLE

S. No	Load P(kg)	Length of column (le)	Distance from one end x	Deflection of respective points measured experimentally Y_e	Deflection of same point theoretically Y_{th}	% error
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

RESULT

The percentage error is given in above table

PRECAUTIONS

1. Put the weight gently on pan.
2. Measure the distance carefully.

QUESTIONS

1. Distinguish between a beam and a column.
2. Define (a) slenderness ratio (b) Critical load.
3. What is equivalent length of a column?
4. Describe the four end conditions for column. Write the value of equivalent length of a column in each of four cases.
5. What are the limitations of Euler's formula.

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Experiment No. 9

Aim:-To perform fatigue test on a given mild steel specimen.

APPARATUS REQUIRED

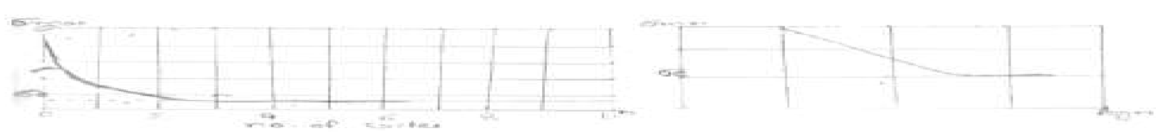
Fatigue testing machine, scale and verniercalliper.

THEORY

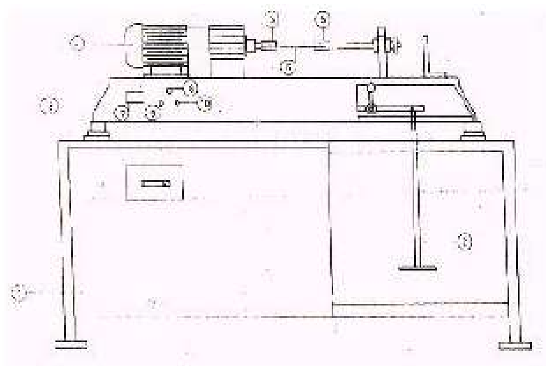
Machine parts are frequently subjected to varying stress and it is important to know the MECHANICS OF SOLIDs under such condition. The material fails under repeated loading and unloading, or under reversal of stress, at stresses smaller than the ultimate strength of the material under static loads. The magnitude of stress required to product failure decreases as the number of cycles of stresses increases. This phenomenon of the decreased resistance of a material to repeated stresses is called fatigue, and the testing of the material by the application of such stresses is called a fatigue test.

The fatigue test consists in choosing a stress level and running the specimen at that level until it fails. The number of cycles after which the specimen fails is known as life of the specimen at that stress level and recorded against it.

By taking several specimens and testing them at various loads, p - n curve such as shown in fig. can be obtained.



Here σ (stress) is represented as the function of the number of cycle n required to produce fracture (fig a).At the beginning σ decreases rapidly as n increases, but after a particular value there is no longer any change σ& the curve approaches the horizontal line. The corresponding stress is called the endurance limit of material. It is now usual practice to plot σ against log n in this manner the magnitude of the endurance limit is disclosed by a definite discontinuity in the curve.



(fig.b)

PROCEDURE

1.Measure the diameter of gauge length of specimen

2.Fix one end of the specimen between the gripping vice on the motor end and secure it tightly with spanner

3.Fix the other end of the specimen in gripping vice on the other end and secure it tight with spanner.

4.Set the Electronic counter to read 00000.

5.Switch ON the machine by pressing the push Button. With this the specimen starts rotating.

6.Gradually add weights on the suspended lever.

7.When the sample breaks, the machine automatically stops.

8.Note the number of revolution registered by the counter and the corresponding weights placed on the lever.

OBSERVATIONS

Weights placed (W) =…………….. Kg.
Diameter of specimen d =…………….. cm.
NO. of revolution n =……………. ,

OBSERVATION TABLE:

SNO	Stress Kg/cm^2	No of revolution N rpm

RESULT

The endurance limit of the material of given specimen is:

PRECAUTIONS

1.Check whether beam is firmly fixed in grips or not.
2.Add weights gradually & gently in the lever.

QUESTIONS

1. What is the necessity of fatigue testing of metals?
2. Define (a) fatigue (b) endurance limit
3. Differentiate between fluctuating and reverse loading?
4. Explain Load Vs No. of revolution diagram obtained.
5. How does the fatigue crack initiate?
6. What are the factors that affect Fatigue?
7. PREPARED BY CHECKED BY APPROVED BY

Experiment No. 10

Aim:- Verification of MAXWELL Reciprocal theorem.

APPARATUS/INSTRUMENT REQUIRED

Dial gauge, loads, meter scale, spanners.

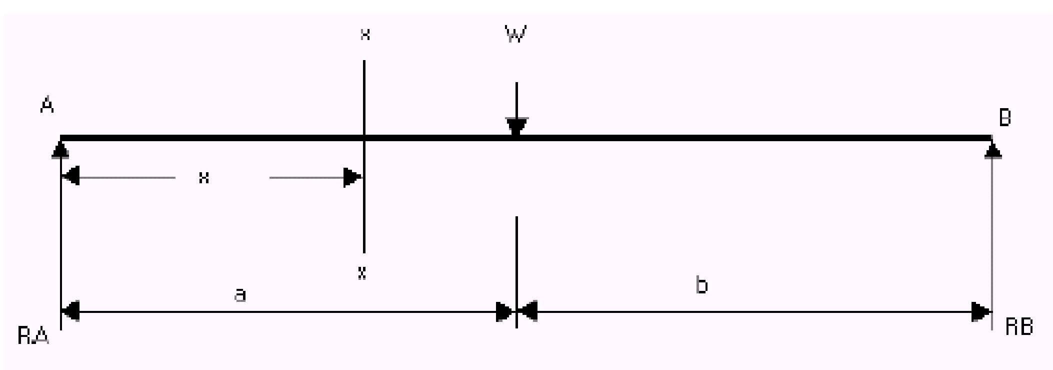
THEORY

Deflection of a simply supported beam under a concentrated toad is given by

$$\delta_{TH} == \frac{W}{EI}\left\{\frac{-bx^3}{6(a+b)} + \frac{(x-a)^3}{6} + \frac{ab\,(a+2b)\,x}{6\,(a+b)}\right]$$

Where

W = Concentrated load (Kg)
E = Modulus of elasticity (N/m2)
I = Moment of Inertia (m4)
y = Distance of point where the deflection has to determined from one end (m)
a = Distance of load from one end (m)
b = Distance of toad from other end (m)



Note: Modulus of Elasticity (E) is find out by the previous experiment.

PROCEDURE

1.Fix the beam in simply supported condition.

2.Set the dial gauge at the mid span showing zero deflection with hanger.

3.Apply the concentrated load mid point.

4.Note down the dial gauge reading. This will give the required deflection.

5.Measure the deflection at several points for the same load.

6.Change the load and repeat steps 3,4,5.

OBSERVATIONS

1.Length of the beam (l) =--------- m.

2.Distance of load from one end (a) = -------- m

3.Distance of load from other end (b) = ------- m.

4.Moment of Inertia (I) = bh3/12 = m4

Where

b = width of the beam
h = height of the beam

1. Modulus of Elasticity (E) =-----------Kg/m2

Sl. No	Load(W) (Kg)	Distance (x) (m)	Experimental Deflection δ_{exp} (m)	Theoretical Deflection δ_{Th}(m)	% Error $= \frac{\delta_{TH} - \delta_{exp}}{\delta_{TH}} \times 100\%$
1 2 3	W1=	0.25 0.45 0.65			
4 5 6	W2=	0.25 0.45 0.65			
7 8 9	W3=	0.25 0.45 0.65			

RESULT

$\delta_1 =$
$\delta_2 =$
$\delta_3 =$
$\delta_4 =$
$\delta_5 =$
$\delta_6 =$
$\delta_7 =$
$\delta_8 =$
$\delta_9 =$

PRECAUTIONS

1.Knock the apparatus gently before taking the dial gauge reading.

2.Deflection should not exceed 10mm.

3.Roller support must be properly lubricated and it should be free to rotate.

4.Don't move the dial gauge when the needle is in contact with beam

QUESTIONS

1.What is a beam?

2.What are different types of beam?

3.What is statically indeterminate beam? Give examples.

4.How is the deflection of beam related with the bending moment?

5.How the deflection and slope of beam related with the area of B.M. diagram?

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MACHINING PROCESS LAB

Course Code: MEP - 256

Vision and Mission of the Chandigarh University

Vision

"To be globally recognized as a Centre of Excellence for Research, Innovation, Entrepreneurship and disseminating knowledge by providing inspirational learning to produce professional leaders for serving the society"

Mission

M1: Providing world class infrastructure, renowned academicians and ideal environment for Research, Innovation, Consultancy and Entrepreneurship relevant to the society.

M2: Offering programs & courses in consonance with National policies for nation building and meeting global challenges.

M3: Designing Curriculum to match International standards, needs of Industry, civil society and for inculcation of traits of Creative Thinking and Critical Analysis as well as Human and Ethical values.

M4: Ensuring students delight by meeting their aspirations through blended learning, corporate mentoring, professional grooming, flexible curriculum and healthy atmosphere based on co-curricular and extra-curricular activities.

M5: Creating a scientific, transparent and objective examination/evaluation system to ensure an ideal certification.

M6: Establishing strategic relationships with leading National and International corporates and universities for academic as well as research collaborations.

M7: Contributing for creation of healthy, vibrant and sustainable society by involving in Institutional Social Responsibility (ISR) activities like rural development, welfare of senior citizens, women empowerment, community service, health and hygiene awareness and environmental protection

Vision and Mission of the Department of Mechanical Engineering

Vision

To be recognized as a center of excellence for research and innovation in Mechanical Engineering through contemporary as well as futuristic tools and technologies for serving the society at regional, national and global level

Mission

MD1: Providing quality education to the students in core and allied fields by implementing advanced pedagogies

MD2: Encouraging students towards research and development through advanced tools and technologies for providing solution to societal problems

MD3: Evolve and empower the students through core technical skills for becoming entrepreneurs and innovators

MD4: Inculcating employability and leadership skill for ensuring industry ready professional through hands on experiential learning and industrial collaboration

MD5: Developing professional and ethical standards in the mind of the young engineers by continuous learning and professional activities

1.2. State the Program Educational Objectives (PEOs)(5)

PROGRAM EDUCATION OBJECTIVES (PEOs):

PEO1: Graduates will have professional knowledge in the field of Mechanical Engineering and various other interdisciplinary domains.

PEO2: Graduates will have successful career in government services, research organizations, corporate sector, academic institutes and industries at national and international repute.

PEO3: Graduate will have compatibility of modern engineering tools and technologies for deliberating solution of various engineering problems.

PEO4: Graduate will develop skill to address the concern of society, environment and communicate effectively to lead the interdisciplinary diverse team.

PEO5: Graduates will be effectively fit for higher education, innovations, research &development, entrepreneurship and professional development.

PROGRAM OUTCOMES (POs):
Program: Bachelor of Engineering (Mechanical Engineering)
Duration: 4 years

PO1. Engineering Knowledge: Apply knowledge of mathematics, science and engineering fundamentals and Production and Industrial Engineering specialization to the solution of complex Production and Industrial Engineering problems.

PO2. Problem Analysis: Identify, formulate, research literature and analyze complex Production and Industrial Engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex Engineering problems and design system components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.

PO4. Conduct investigations of complex Engineering problems: Use research-based knowledge and research methods including analysis, interpretation of data and synthesis of information to provide valid conclusions.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. The Engineer and Society: Apply contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.

PO10. Communication: Communicate effectively on complex Engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.

PO11. Project Management and Finance: Demonstrate knowledge and understanding of Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life Long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs):

PSO1: Apply the knowledge of Production, Manufacturing and Industrial Engineering for analysis, optimization and development of mechanical system

PSO2: Apply the concepts of Design and Thermal Engineering to model, analyze and develop the mechanical components and systems

Course Objectives

- To expose hands-on training to the students on various machines like lathe, Shaper, Slotter, Milling, grinding machines.
- Focuses on equipment, work systems, machinery, and automation systems for today's manufacturing environment

Course Outcomes
After completion of course the student will be able to:

CO1	Apply the fundamentals of machining processes to perform various machining operations on Lathe, Shaper, milling, drilling and grinding machines.
CO2	Plan and organize the series of machining operation for completion of assigned job as per standard codes and procedure.
CO3	Conduct the experiment individual/team ethically, considering social, health, safety, legal and environmental aspects.
CO4	Inspect the problems occurred during various metal cutting operations and their remedial action.
CO5	Conclude the experimental results and express the same effectively in oral and written manners through report and practical presentation.

LIST OF EXPERIMENTS

1. To make a job on lathe machine which includes facing, turning, taper-turning, knurling & drilling.
2. Exercise of internal turning and threading operation on Lathe machine.
3. Study of constructional features and working on Radial drilling machine by performing various operation on it like drilling, reaming, counter boring, counter sinking and tapping operations
4. Exercise on drilling, reaming, counter boring, counter sinking and tapping on radial drilling Machine.
5. To make V threads& square threads on lathe machine.
6. To make a job on Capstan lathe machine which includes facing, turning, taper-turning & drilling.
7. Grinding of single point cutting tool & study various cutting tool materials
8. To make a slot cutting & making V block on shaper machine.
9. To make spur gear on milling machine.
10. To make a job on grinding using surface grinder.

EXPERIMENT NO.: 1

Aim: To make a job on centre Lathe, including the operations of Facing, Turning, Step Turning, Grooving, Taper Turning and V Threading.

Material: Mild Steel bar Ø 25 mm.

Instruments and Tools used: Steel Rule, Vernier Calliper, Turning Tool, Threading Tool and Thread Pitch Gauge etc.

Machinery Used: Hydraulic Power Hacksaw and centre Lathe.

Facing: Facing is the process of removing metal from the end of a work piece to produce a flat surface. It is usually the first operation and is done to prepare reference for the subsequent linear measurements. Work piece is held in the Chuck and the Facing Tool is fed at 90° to the job axis using Cross Slide.

Turning: It is an operation of removing of metal from the outer diameter of a rotating cylindrical work piece. Turning is used to reduce the diameter of the work piece. It is done by holding the work piece either in the chuck or Between Centres and feeding the Turning Tool along the axis of the work.

Step Turning: It is an operation of producing various steps of different diameters on the work piece as shown in fig. This operation is carried out in the similar way as plain turning.

Grooving: The term grooving usually applies to a process of forming a narrow cut of a certain depth, on a cylinder, cone, or a face of the part using a grooving tool held in the Tool Post.

Taper Turning: Taper turning means, to produce a conical surface by gradual reduction in diameter of a cylindrical work piece.

Taper Turning by Swivelling the Compound Rest: The compound rest is set at the desired half taper angle, rotation of the compound slide screw will cause the tool to be fed at that angle and generate a corresponding taper. This method is limited to turning a short and steep taper up to 45°. If the diameter

Of the small and large end and Length of taper are known, the half taper angle can be calculated from the equation {$\tan \alpha = (D-d) / 2L$}.

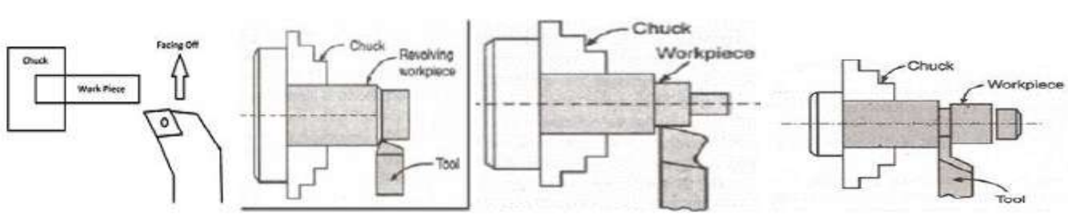
Threading: Screw threads can be cut on Centre Lathe with accuracy and versatility. Threads on lathe are cut by giving a feed to the threading tool by connecting Carriage with the Lead Screw.

V Thread: `V' threads get their name from the shape of letter 'V'. These threads are designed to induce friction to keep the fasteners from loosening. Therefore, V threads are avoided for power transfer.

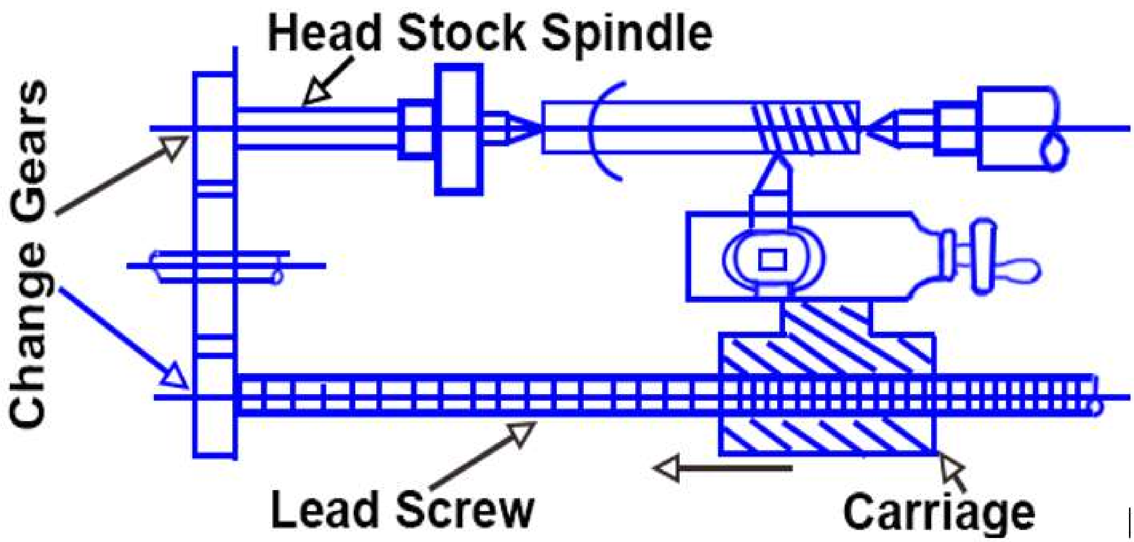
Procedure:

1. Cut a work piece of length 120 mm from Mild Steel bar Ø 25 mm.
2. Hold the work piece in the Chuck keeping about 20 mm protruding out.
3. Do facing of the protruding end.
4. Remove from the chuck, do facing of the other end and maintain length 110 mm.
5. Hold in the chuck again to turn Ø 23 mm up to 7 5mm.
6. Remove from the chuck again and hold from the machined end keeping around 80 mm length protruding.
7. Turn and then step turn Ø 18 mm to 50 mm from the free end.
8. Do Grooving using the Grooving Tool.
9. Do Taper Turning by setting the Compound Slide at required half taper angle.
10. Hold threading tool and set the quick change gear box for the required pitch of thread.
11. Start threading and repeat the operation carefully up to the full depth of thread.
12. De-burr sharp edges.
13. Use Thread Pitch Gauge or a given Nut to check depth of the thread.

Repeat above operation if the full thread is not reached.



Facing | Plain Turning | Step Turning | Grooving



Screw thread cutting on Centre Lathe

Precautions: -

1. Once machine it running, do not take the job measurements.
2. Always wear uniform in the workshop. Never wear loose clothes.
3. In case of fire, cut electric supply immediately
4. Where proper safety shoes.
5. Keep away your body parts from moving parts.
6. Always keep your mind on the job.

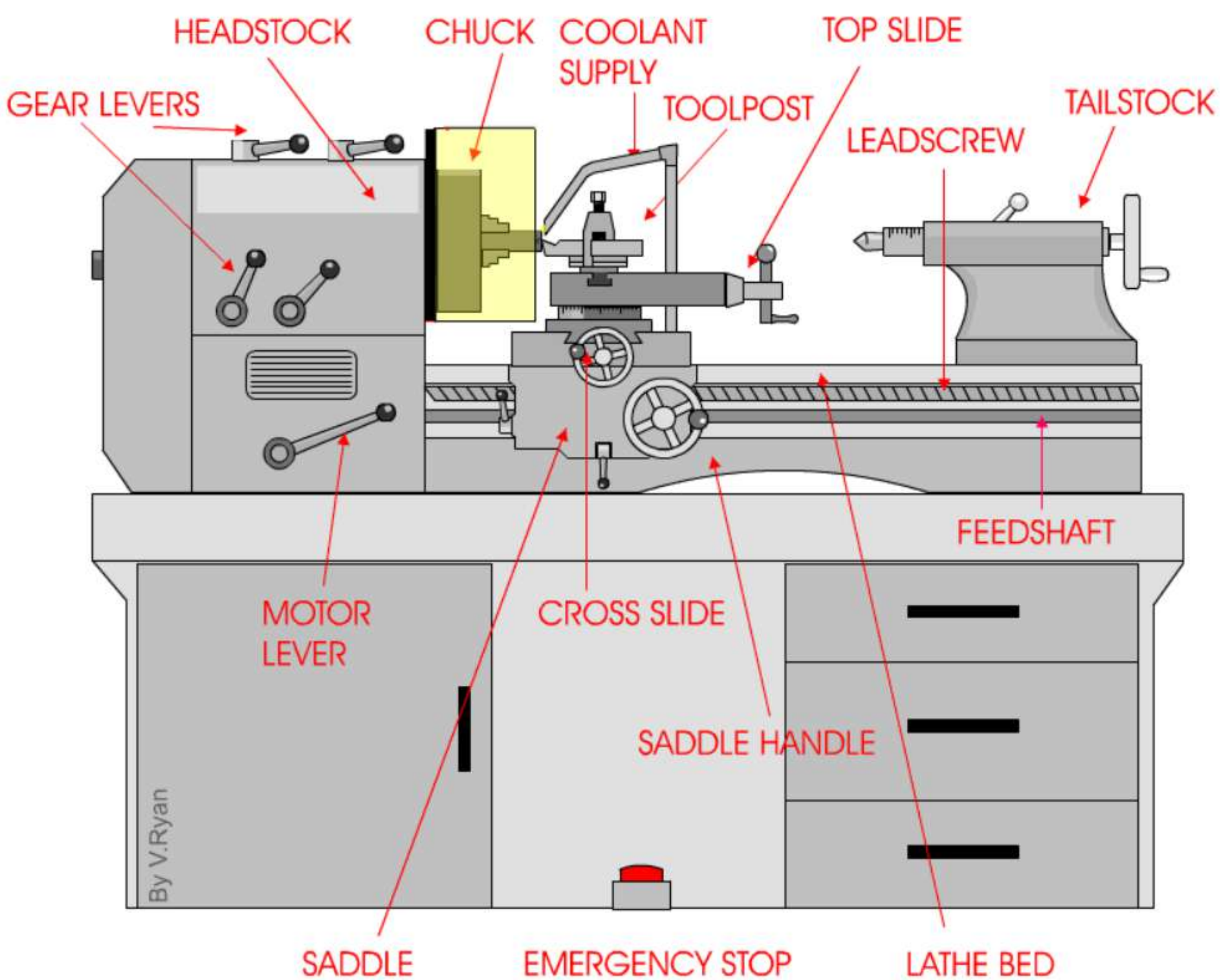
Experiment No. : 2

Aim: Exercise of internal turning and threading operation on Lathe machine.

•Material: Hollow Mild Steel Pipe Ø 25 mm.

•Instruments and Tools used: Steel Rule, Vernier Calliper, Turning Tool, and threading tool etc.

•Machinery Used: Hydraulic Power Hacksaw and Centre Lathe.



Procedure:

1. Cut Mild Steel Pipe of External diameter Ø 25 mm and internal diameter Ø 18 to length 105mm.
2. Hold the work piece in 3 Jaw Chuck so that half the length protrudes out of the Chuck.

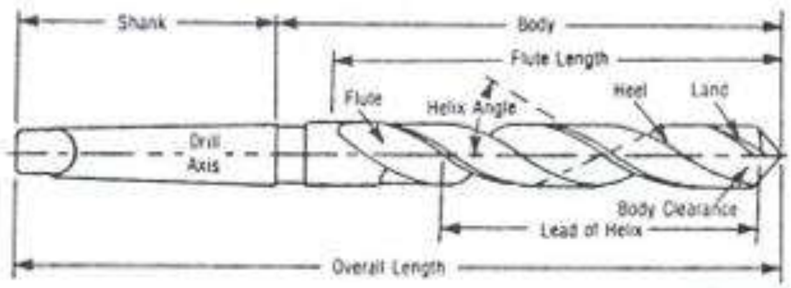
3. Hold the Turning Tool in the Tool Post and set them to the centre of the work.
4. De burr sharp edges and finish the job surface using Emery Cloth.
5. Internal turning does with turning tool up to diameter Ø 20mm to 55mm length.
6. Now make a setup for internal threading.
7. Hold the threading tool inside the tool post.
8. Set Quick Change Gear Box for the required thread pitch.
9. Hold Threading Tool and set it to the centre of the work.
10. Do Threading very cautiously as Square Thread can cause noise and Chattering.
11. Finish threads using File and Emery Cloth.
12. De burr all over.

Precautions: -

1. Once machine it running, do not take the job measurements.
2. Always wear uniform in the workshop. Never wear loose clothes.
3. In case of fire, cut electric supply immediately
4. Where proper safety shoes.
5. Keep away your body parts from moving parts.
6. Always keep your mind on the job.

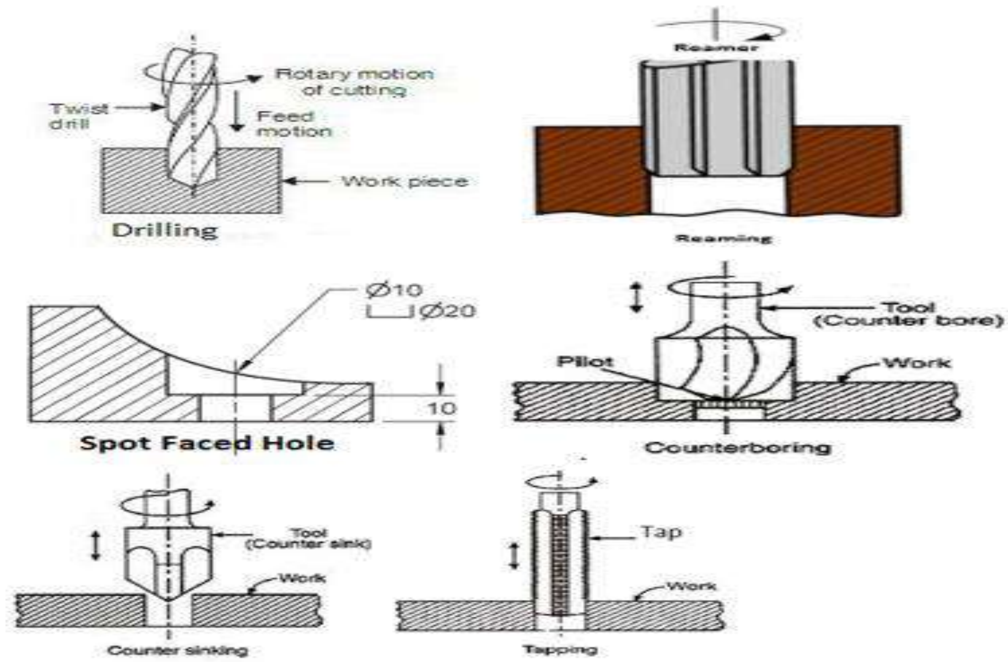
Experiment No.: 3

Aim: Study of constructional features and working of a Radial Drill Machine by performing operations like Drilling, Reaming, Counter Boring, Counter Sinking, Spot Facing and Machine Tapping etc.
Material: Mild Steel Square bar of 25x25x150 mm.
Instruments and Tools used: Steel Rule, Vernier Caliper, Tapered Shank Twist Drill Ø11.30 mm , Counter Boring Tool Ø22/Ø11 mm, Hole Mill Ø11.8 mm, Reamer Ø12mm and Counter Sunk Ø25mm x60^{o}, Try Square and Machine Vice etc.
Machinery Used: Hydraulic Power Hacksaw and Radial Drilling Machine.
Twist Drill: It is the most common type of Drill used in the Drilling Operations for making new holes. The Twist Drills are generally made of High Speed Steel (HSS).



Carbide Tipped Twist Drills: These Drills are also being used in Industry for mass production operations. CTTD's use throw away insert and do not require re- sharpening like HSS Drills.
Core Drill: It is also called a Multi Fluted Drill. It carries a minimum of three flutes on its body and has no Drill Point which is required for initiating a new hole.

Drilling Operations:
Drilling: Drilling is the process of machining, a circular hole in the work piece using a multi point rotary cutting tool called a Drill. We can produce either a new hole or enlarge the pre made hole in the process of Casting or Forging.
Reaming: It is the process of finishing a drilled hole to its accurate size and geometry. It is done by using a Multi Fluted Cutting Tool called a Reamer.
Spot facing: It is the process of machining a circular spot around a drilled hole in uneven surface so that the head of a bolt could seat on even surface.
Counter Boring: It is a process of making flat-bottomed cylindrical enlargement of the mouth of a hole, usually of little mm depth, for receiving a cylindrical screw head.



Counter sinking: It is the process of Cone shaped enlargement at the end of a hole to accommodate the screw heads. Counter sinking tools of cone angles of 60º, and120º are commonly used.

Machine Tapping: It is the operation of making internal threads on the Drilling Machine using a special Tap called a Machine Tap. Machine Tapping is used when the large no of threaded holes are to be made.

Radial Drilling Machine

A Radial Drilling Machine is a geared Drill Head that is mounted on an Arm Assembly that can be moved around to the extent of its Arm reach. The drill head of the Radial Drilling Machine can be moved, adjusted in height, and rotated. The Radial Drilling Machine is considered the most versatile type of Drill Machines. There is no need to reposition work pieces because the Arm can extend as far as its length could allow. Moreover, it is easier to manoeuvre large work pieces with the Radial Drilling Machine.

Some major parts of the Radial Drilling Machine are discussed below:

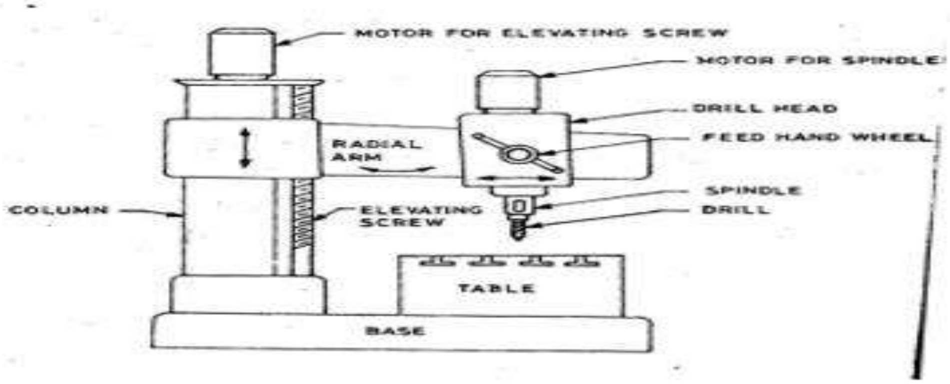
Column - Holds the Radial Arm which can be moved around according to its length.

Elevating Screw - Adjusts the vertical height of the Radial Arm along the Column.

Table – It is the platform on which work pieces are clamped and worked upon.

Spindle - The part of the Drill Machine which rotates in bearing and holds and feeds the drill in to the work.

Radial Drilling Machine



Radial Drilling Machine

Drill Head – It is mounted on the Radial Arm and carries a driving motor and a mechanism for revolving and feeding the drill into the work piece. The drill head can be moved horizontally on the guide ways provided in the Radial Arm, and can be clamped at any desired position.

Radial Arm - holds and supports the drill head assembly and can be moved around on the extent of its length.

Base: it is the part which supports the entire machine. When bolted to the floor provides vibration free operation for machining accuracy. The top of the base is like a work table and has T slots for directly holding the work which is too large for the Table.

Procedure:

1. Mark the position of the holes for the various operations to be done on the job.
2. Clamp the Machine Vice on the Table.
3. Use parallel pieces to support the work and clamp in the Machine Vice.
4. Do Centre Drilling on all the locations for guiding the Drill Point while drilling.
5. Drill holes Ø11.3 on all the locations except for Tapping.
6. Hole Mill the 2nd hole to Ø11.8 mm.
7. Ream the 2nd hole to Ø12.0 mm. Note that Reamer is never rotated anti clockwise even when taking out of the Hole.
8. Drill holeØ10.25 mm the 3rd hole and Do Machine Tapping. Note Set lowest spindle RPM.
9. Do Counter Boring in the 4th hole.
10. Do counter sinking in the in the 5th hole.
11. Remove and de burr the job all over.

Precautions:-

1. Once machine it running, do not take the job measurements.
2. Always wear uniform in the workshop. Never wear loose clothes.
3. In case of fire, cut electric supply immediately
4. Where proper safety shoes.
5. Keep away your body parts from moving parts.
6. Always keep your mind on the job.
7. The Arm must always stay over the table area only.

CHANDIGARH UNIVERSITY

DEPARTMENT OF MECHANICAL ENGINEERING

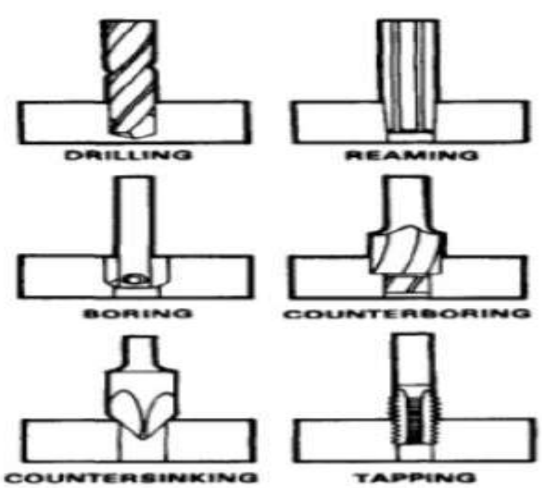
MACHINING PROCESS LAB	Subject Code: MEP-256

Experiment No.: 4

AIM: Exercise on drilling, reaming, counter boring, counter sinking and tapping on radial drilling

Machine Material: Mild Steel Square bar of 25x25x150 mm.
Instruments and Tools used: Steel Rule, Vernier Calliper, Tapered Shank Twist Drill Ø11.30 mm , Counter Boring Tool Ø22/Ø11 mm, Hole Mill Ø11.8mm,Reamer Ø12mm and Counter Sunk Ø25mmx60º,Try Square and Machine Vice etc.
Machinery Used: Hydraulic Power Hacksaw and Radial Drilling Machine.
Operations performed on radial drilling machines
Drilling: Drilling is the process of machining, a circular hole in the work piece using a multi-point rotary cutting tool called a Drill. We can produce either a new hole or enlarge the pre made hole in the process of Casting or Forging.
Reaming: It is the process of finishing a drilled hole to its accurate size and geometry. It is done by using a Multi Fluted Cutting Tool called a Reamer.
Spot facing: It is the process of machining a circular spot around a drilled hole in uneven surface so that the head of a bolt could seat on even surface.
Counter Boring: It is a process of making flat-bottomed cylindrical enlargement of the mouth of a hole, usually of little mm depth, for receiving a cylindrical screw head.
Counter sinking: It is the process of Cone shaped enlargement at the end of a hole to accommodate the screw heads. Counter sinking tools of cone angles of 60º, and120º are commonly used.
Machine Tapping: It is the operation of making internal threads on the Drilling Machine using a special Tap called a Machine Tap. Machine Tapping is used when the large no of threaded holes are to be made.

- Drilling
- Reaming
- Boring
- Counter Boring
- Counter Sinking
- Tapping
- Spot Facing



Procedure:

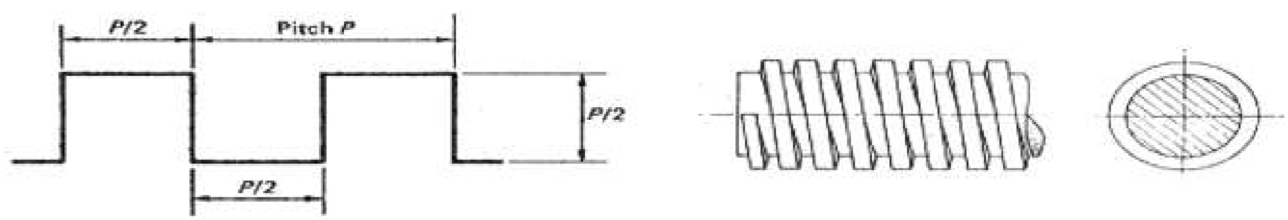
1. Mark the position of the holes for the various operations to be done on the job.
2. Clamp the Machine Vice on the Table.
3. Use parallel pieces to support the work and clamp in the Machine Vice.
4. Do Centre Drilling on all the locations for guiding the Drill Point while drilling.
5. Drill holes Ø11.3 on all the locations except for Tapping.
6. Hole Mill the 2^{nd} hole to Ø11.8 mm.
7. Ream the 2^{nd} hole to Ø12.0 mm. Note that Reamer is never rotated anti clockwise even when taking out of the Hole.
8. Drill hole Ø10.25 mm the 3^{rd} hole and Do Machine Tapping. Note Set lowest spindle RPM.
9. Do Counter Boring in the 4^{th} hole.
10. Do counter sinking in the in the 5^{th} hole.
11. Remove and de burr the job all over.

Precautions:-

1. Once machine it running, do not take the job measurements.
2. Always wear uniform in the workshop. Never wear loose clothes.
3. In case of fire, cut electric supply immediately
4. Where proper safety shoes.
5. Keep away your body parts from moving parts.
6. Always keep your mind on the job.
7. The Arm must always stay over the table area only.

Experiment No. : 5

Aim: To make V threads and Square threads on a job using Lathe.
Material: Mild Steel bar Ø 25 mm.
Instruments and Tools used: Steel Rule, Vernier Calliper, Turning Tool, and threading tool etc.
Machinery Used: Hydraulic Power Hacksaw and Centre Lathe.
Square threads: Square threads are named after their square geometry. They are the most efficient having the least friction and are often used for screws that carry high power. But they are also the most difficult and expensive to machine.
Square thread parameters:



PITCH OF SQUARE THREAD

Procedure:

1. Cut Mild Steel bar Ø 25 mm to length 105 mm.
2. Hold the work piece in 3 Jaw Chuck so that half the length protrudes out of the Chuck.
3. Hold the Turning Tool and Grooving Tool in the Tool Post and set them to the centre of the work.
4. Do Facing and turn Ø 23 mm on the available length.
5. De burr sharp edges and finish the job surface using Emery Cloth.
6. Remove job from the Chuck and hold from the machined end.
7. Do Facing and turn Ø 23 mm on the remaining length.
8. Turn Ø 20 mm to 55 mm length.
9. Do Grooving as per the sketch.
10. Set Quick Change Gear Box for the required thread pitch.
11. Hold Threading Tool and set it to the centre of the work.
12. Do threading very cautiously as Square Thread can cause noise and chattering..
13. Do not feed threading tool by more than 0.25 mm.

14. Finish threads using File and Emery Cloth.
15. De burr all over.

Precautions: -

1. Once machine it running, do not take the job measurements.
2. Always wear uniform in the workshop. Never wear loose clothes.
3. In case of fire, cut electric supply immediately
4. Where proper safety shoes.
5. Keep away your body parts from moving parts.
6. Always keep your mind on the job.

PREPARED BY CHECKED BY APPROVED BY

Experiment No. : 6

AIM: To make a job on Turret and Capstan Lathe, including the operations of Facing, Turning, Centre Drilling, Drilling and Counter Boring.

Material: Mild Steel bar Ø 25 mm.

Instruments and Tools used: Steel Rule, Vernier Calliper, Turning Tool, centre Drill, TSTD Ø8.0 mm and Counter Boring Tool Ø 12 mm etc.

Machinery Used: Hydraulic Power Hacksaw and Turret Lathe and Capstan Lathe.

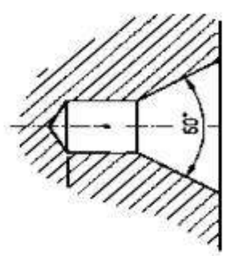
Turret and Capstan Lathe: These lathes are used for repetitive work, involved in the production of the large no. of the similar components. They have a rotatable Hexagonal Turret resembling a Capstan to hold tools for successive machining operations. Turret and Capstan Lathes are similar in construction and they are grouped together as semi-automatic Machine Tools. Still some differences are there between these two lathes which are explained below.

Difference between Capstan and Turret lathe:

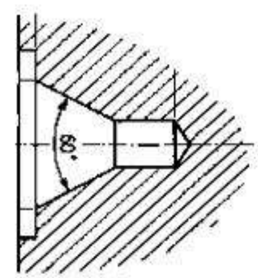
S No.	Capstan Lathe	Turret Lathe
1	It is for light duty operations.	It is for heavy duty operations.
2	The Capstan Head is mounted on the Ram and the Ram is mounted on the Saddle.	The Turret Head is directly mounted on the Saddle and the Saddle slides over the Bed ways.
3	The Saddle will not be moved during machining.	The Saddle is moved along with the Turret head during machining.
4	The lengthwise movement of Capstan is less.	The lengthwise movement of Turret is more.
5	Short work pieces only can be machined.	Long work pieces can be machined.
6	It is easy to move the Capstan Head as it slides over the Ram.	It is difficult to move the Turret Head along with Saddle.
7	As the construction of Capstan Lathe is not rigid, heavy cuts cannot be given.	As the construction of Turret Lathe is rigid, heavy cuts can be given.
8	It is used for machining work pieces up to Ø 60 mm.	It is used for machining work pieces up to Ø 200 mm.
9	Collet is used to hold the work piece.	Jaw Chuck is used to hold the work piece.

Centre drilling: The main purpose of centre Drilling is to drill a hole that will act as a centre of rotation for the subsequent operations. Centre drilling is done using a drill of special shape, called a centre Drill.

A type Centre Drill



A type Centre Drilling



B type Centre Drilling

Procedure:

1. Cut Mild Steel bar Ø 25 mm to length 105 mm.
2. Fix all the tools required in the Turret Head.
3. Hold the work piece in the 3 jaw Chuck so that about 60 mm length protrudes out of the Chuck.
4. Do Facing and turn Ø 20 mm to length 50 mm using Front Tool Post (FTP).
5. Bring Turret closer to the job and do Centre Drilling.
6. Index Turret and do drilling operation.
7. Again, index the Turret and do Counter Boring.
8. Clean the job with emery cloth or a file and de-burr sharp corners.
9. Check dimensions with Vernier Calliper and remove the job from the Chuck.
10. Hold the job in Collet of the Capstan Lathe.
11. Do facing and turn Ø 23 mm in the remaining length.
12. De - burr sharp edges.
13. Remove job from the machine and do final inspection.

Precautions: -

1. Once machine it running, do not take the job measurements.
2. Always wear uniform in the workshop. Never wear loose clothes.
3. In case of fire, cut electric supply immediately
4. Where proper safety shoes.
5. Keep away your body parts from moving parts.
6. Always keep your mind on the job.

EXPERIMENT NO.7

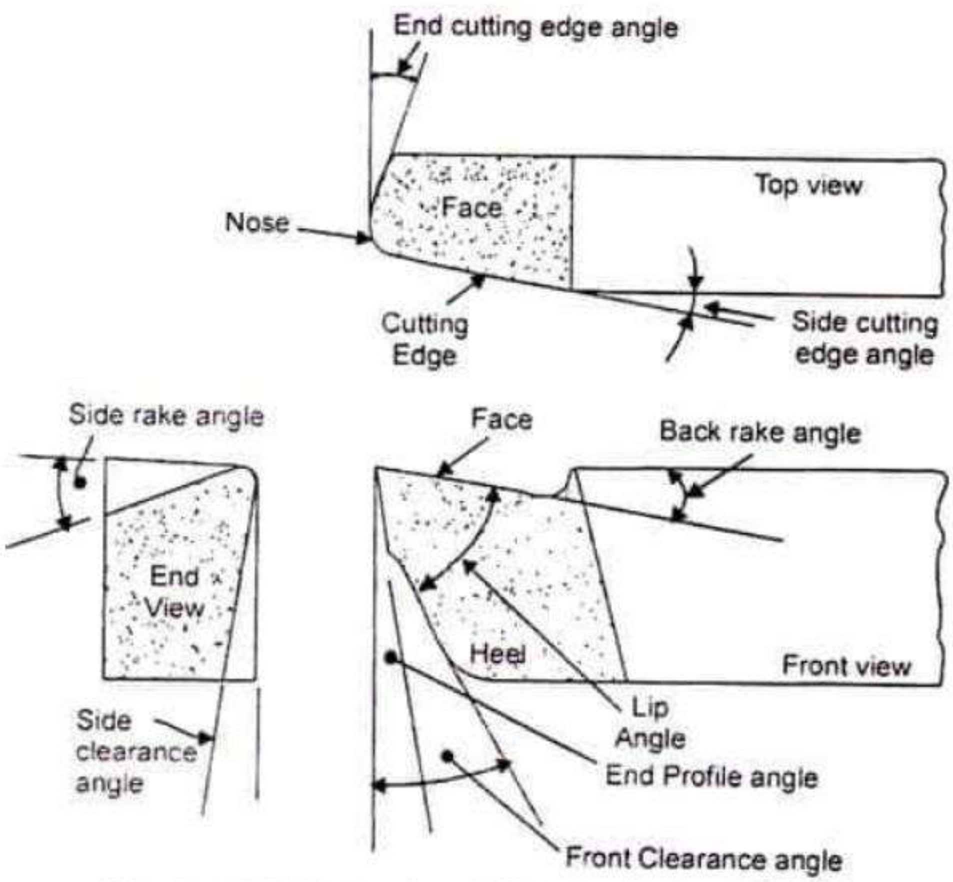
Aim: To make or Grind a Single Point Cutting Tool.

Material: MS Blank10x10x100 mm.

Instruments and Tools used: Bevel Protractor, Surface plate etc.

Machinery Used: Tool and Cutter Grinder.

Single Point Cutting Tool Nomenclature:



1: Side Cutting Edge Angle:

The angle between side cutting edge and the side of the tool shank is called side cutting edge angle. It is often referred to as the lead angle.

2: End Cutting Edge Angle:

The angle between the end cutting edge and a line perpendicular to the shank of the tool shank is called end cutting edge angle.

3: Side Relief Angle:

The angle between the portion of the side flank immediately below the side cutting edge and a line perpendicular to the base of the tool.

4: End Relief Angle:

The angle between the end flank and the line perpendicular to the base of the tool is called end relief angle.

5: Back Rake Angle:

The angle between the face of the tool and line perpendicular to the base of the tool measures on perpendicular plane through the side cutting edge. It is the angle which measures the slope of the face of the tool from the nose, towards the rack. If the slope is downward the nose it is negative back rake.

6: Side Rake Angle:

The angle between the face of the tool and a line parallel to the base of the tool measured on plane perpendicular to the base and the side edge. It is the angle that measure the slope of the tool face from the cutting edge, if the slope is towards the cutting edge it is negative side rake angle and if the slope is away from the cutting edge, it is positive side rake angle. If there is no slope the side rake angle is zero.

Tool Signature:

Back Rake Angle-Side Rake Angle-End Relief Angle-Side Relief Angle-End Cutting Edge Angle-Side Cutting edge Angle-Nose Radius.

α_b- α_s- θ_e- θs- Ce- Cs- R

Precautions:-

1. Once machine it running, do not take the job measurements.
2. Always wear uniform in the workshop. Never wear loose clothes.
3. In case of fire, cut electric supply immediately
4. Where proper safety shoes.
5. Keep away your body parts from grinding wheel.
6. Always keep your mind on the job.
7. Bring work in contact with the grinding wheel very cautiously.

	CHANDIGARH UNIVERSITY
	DEPARTMENT OF MECHANICAL ENGINEERING
MACHINING PROCESS LAB	**Subject Code: MEP-256**

EXPERIMENT NO.8

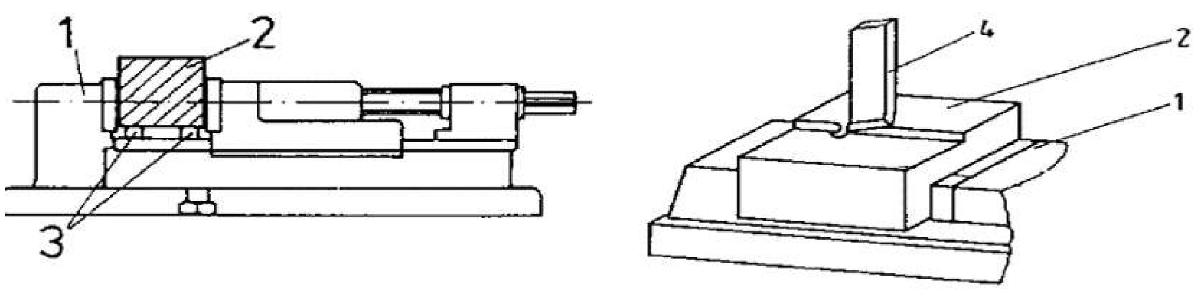
Aim: To make a job with flat surfaces (Rectangular Block) on Shaper.

Material: Mild Steel Square bar of 60x60 mm.

Instruments and Tools used: Steel Rule, Vernier Caliper, Vernier Height Gauge, Surface Plate ,Try Square and Machine Vice etc.

Machinery Used: Hydraulic Power Hacksaw and Shaper.

Shaper/Shaping Machine: The Shaping Machine is used to machine flat surfaces especially where a large amount of metal has to be removed. The Shaping Machine is a simple and yet extremely effective Machine Tool. It is used to machine metals, such as Steel, Cast Iron and Aluminium, to produce flat surfaces. However, it can also be used to manufacture Gears, Rack and Pinion and other complex shapes. Milling Machines are much more expensive; however they can do all the operations done on Shaper very efficiently and accurately. A Work piece clamped in Machine Vice and being machined is shown on Shaper in the figures below.



1. Machine vice 2. Work Piece 3. Parallel Pieces 4. Shaper Tool

Procedure:

1. Hold the work piece in the Machine Vice.
2. Machine the surface of the work piece taking a cut of 0.5 mm.
3. Keeping machined face on the surface plate and do marking for the thickness.

4. Place the machined surface over the parallel pieces and clamp the work piece.
5. Machine to the marking and check for the parallelism of the two machined surfaces.
6. Clamp from the machined faces and machine the remaining sides.
7. Remove from the Vice and check dimensions.

Precautions:-

1. Move the Ram manually once before start the machine.
2. Stay clear of the machine when it is running.
3. Do not stay in front of the Ram.
4. Work piece must be held tightly.
5. Once machine it running, do not take the job measurements.
6. Always wear uniform in the workshop. Never wear loose clothes.

Experiment No.9

Aim: To make spur gear on milling machine.

Material: Mild Steel Square bar of 60x60 mm.

Instruments and Tools used: Steel Rule, Vernier Calliper, Vernier Height Gauge, Surface Plate ,Try Square and Machine Vice etc.

Machinery Used: Hydraulic Power Hacksaw and Shaper.

Milling is the process of machining using rotary cutters to remove material by advancing a cutter into a work piece. This may be done varying direction on one or several axes, cutter head speed, and pressure.[3] Milling covers a wide variety of different operations and machines, on scales from small individual parts to large, heavy-duty gang milling operations. It is one of the most commonly used processes for machining custom parts to precise tolerances. The Shaping Machine is used to machine flat surfaces especially where a large amount of metal has to be removed. The Shaping Machine is a simple and yet extremely effective Machine Tool. It is used to machine metals, such as Steel, Cast Iron and Aluminium, to produce flat surfaces. However, it can also be used to manufacture Gears, Rack and Pinion and other complex shapes. Milling Machines are much more expensive; however they can do all the operations done on Shaper very efficiently and accurately. A Work piece clamped in Machine Vice and being machined is shown on Shaper in the figures below.

Procedure:

1. Hold the work piece in the Machine Vice.
2. Machine the surface of the work piece taking a cut of 0.5 mm.
3. Keeping machined face on the surface plate and do marking for the thickness.
4. Place the machined surface over the parallel pieces and clamp the work piece.
5. Machine to the marking and check for the parallelism of the two machined surfaces.
6. Clamp from the machined faces and machine the remaining sides.
7. Remove from the Vice and check dimensions.

Precautions:-

1. Move the Ram manually once before start the machine.
2. Stay clear of the machine when it is running.
3. Don't stay in front of the Ram.
4. Workpiece must be held tightly.
5. Once machine it running, do not take the job measurements.
6. Always wear uniform in the workshop. Never wear loose clothes.

CHANDIGARH UNIVERSITY

DEPARTMENT OF MECHANICAL ENGINEERING

MACHINING PROCESS LAB	Subject Code: MEP-256

Experiment No.10

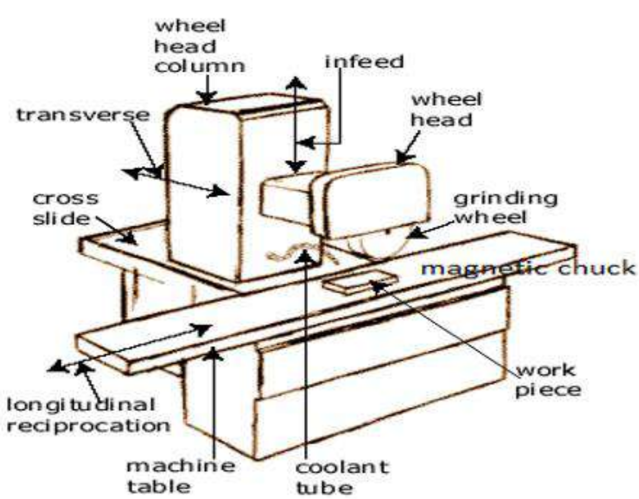
Aim: To Grind a job with flat surfaces (Rectangular Block) on Surface Grinder.

Material: Mild Steel Block of Dimensions 50.5x50.5x40.5mm (LxBxH) from Practical Exercise No.4

Instruments and Tools used: Vernier Caliper, Vernier Height Gauge, Surface Plate, Try Square and Precision Vice and Out Side Micrometre etc.

Machinery Used: Surface Grinder.

Grinding: It is an abrasive machining process that uses a grinding wheel as the cutting tool. Surface Grinder uses a rotating abrasive wheel to remove material for creating flat surfaces. Al_2O_3 is the most common abrasive used for grinding.



Surface Grinder

Procedure:

1. Dress the Grinding wheel using a Diamond Dresser.

2. Hold the work piece on the Magnetic Chuck.

3. Adjust the Table Stoppers as per the length of the Work Piece.
4. Bring Work under the rotating Grinding Wheel and lower the Grinding Wheel to touch the Work Piece gently.
5. Grind surface of the work piece to completely clean the surface. Use coolant if required.
6. De clamp from the Chuck and measure the thickness of the Work.
7. Grind to the required thickness from the opposite side by clamping on the Chuck from the side ground in operation no.6.
8. Clamp the Precision Vice on the Magnetic Chuck and hold the Work from the ground surfaces.
9. Rest the work on parallel pieces and clamp.
10. Grind to clean the complete surface.
11. Grind rest of the thickness from the other side.
12. De clamp from the Vice.

Precautions:-

1. Once machine it running, do not take the job measurements.
2. Always wear uniform in the workshop. Never wear loose clothes.
3. In case of fire, cut electric supply immediately
4. Where proper safety shoes.
5. Keep away your body parts from grinding wheel.
6. Always keep your mind on the job.
7. Bring work in contact with the grinding wheel very cautiously.

Manufacturing Techniques Lab

Course Code: MEP - 206

Vision and Mission of the Chandigarh University

Vision

"To be globally recognized as a Centre of Excellence for Research, Innovation, Entrepreneurship and disseminating knowledge by providing inspirational learning to produce professional leaders for serving the society"

Mission

M1: Providing world class infrastructure, renowned academicians and ideal environment for Research, Innovation, Consultancy and Entrepreneurship relevant to the society.

M2: Offering programs & courses in consonance with National policies for nation building and meeting global challenges.

M3: Designing Curriculum to match International standards, needs of Industry, civil society and for inculcation of traits of Creative Thinking and Critical Analysis as well as Human and Ethical values.

M4: Ensuring students delight by meeting their aspirations through blended learning, corporate mentoring, professional grooming, flexible curriculum and healthy atmosphere based on co-curricular and extra-curricular activities.

M5: Creating a scientific, transparent and objective examination/evaluation system to ensure an ideal certification.

M6: Establishing strategic relationships with leading National and International corporates and universities for academic as well as research collaborations.

M7: Contributing for creation of healthy, vibrant and sustainable society by involving in Institutional Social Responsibility (ISR) activities like rural development, welfare of senior citizens, women empowerment, community service, health and hygiene awareness and environmental protection

Vision and Mission of the Department of Mechanical Engineering

Vision

To be recognized as a center of excellence for research and innovation in Mechanical Engineering through contemporary as well as futuristic tools and technologies for serving the society at regional, national and global level

Mission

MD1: Providing quality education to the students in core and allied fields by implementing advanced pedagogies

MD2: Encouraging students towards research and development through advanced tools and technologies for providing solution to societal problems

MD3: Evolve and empower the students through core technical skills for becoming entrepreneurs and innovators

MD4: Inculcating employability and leadership skill for ensuring industry ready professional through hands on experiential learning and industrial collaboration

MD5: Developing professional and ethical standards in the mind of the young engineers by continuous learning and professional activities

1.2. State the Program Educational Objectives (PEOs) (5)

PROGRAM EDUCATION OBJECTIVES (PEOs):

PEO1: Graduates will have professional knowledge in the field of Mechanical Engineering and various other interdisciplinary domains.

PEO2: Graduates will have successful career in government services, research organizations, corporate sector, academic institutes and industries at national and international repute.

PEO3: Graduate will have compatibility of modern engineering tools and technologies for deliberating solution of various engineering problems.

PEO4: Graduate will develop skill to address the concern of society, environment and communicate effectively to lead the interdisciplinary diverse team.

PEO5: Graduates will be effectively fit for higher education, innovations, research &development, entrepreneurship and professional development.

PROGRAM OUTCOMES (POs):
Program: Bachelor of Engineering (Mechanical Engineering)
Duration: 4 years

PO1. Engineering Knowledge: Apply knowledge of mathematics, science and engineering fundamentals and Production and Industrial Engineering specialization to the solution of complex Production and Industrial Engineering problems.
PO2. Problem Analysis: Identify, formulate, research literature and analyze complex Production and Industrial Engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
PO3. Design/ Development of Solutions: Design solutions for complex Engineering problems and design system components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.
PO4. Conduct investigations of complex Engineering problems: Use research-based knowledge and research methods including analysis, interpretation of data and synthesis of information to provide valid conclusions.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6. The Engineer and Society: Apply contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams and in multi disciplinary settings.
PO10. Communication: Communicate effectively on complex Engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.
PO11. Project Management and Finance: Demonstrate knowledge and understanding of Engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12. Life Long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs):

PSO1: Apply the knowledge of Production, Manufacturing and Industrial Engineering for analysis, optimization and development of mechanical system

PSO2: Apply the concepts of Design and Thermal Engineering to model, analyze and develop the mechanical components and systems

	# CHANDIGARH UNIVERSITY	
	## DEPARTMENT OF MECHANICAL ENGINEERING	
Manufacturing Techniques Lab		**Course Code: MEP-206**

Course Objectives

Course Outcomes

After completion of course the student will be able to:

CO1	
CO2	
CO3	
CO4	
CO5	

LIST OF EXPERIMENTS

1. Sand testing experiments to determine Moisture content & Shatter index
2. To determine Green strength & clay content of Sand.
3. Sand testing Experiments to Determine Core & Mold Hardness
4. To determine the permeability of sand and grain fineness number
5. Preparation of lap joint, butt joint & T joints with the help of MIG welding.
6. Practice of TIG welding technique for the preparation of butt, lap and T joint
7. Preparation of lap joint, butt joint & T joints with the help of Resistance spot welding.
8. To Analyze the microstructure of different heat treated steel specimen and their effect on mechanical properties.
9. To examine the effect of Quenching, Normalizing and Tempering on steel components.
10. Determination of harden ability of steel specimen by Jominy END quench test.

Experiment 1

AIM: Sand testing experiments to determine Moisture content & Shatter index.

APPARATUS: For measuring moisture of molding sand sample

Sand, weight measuring instrument, metal sheet, lifter, steel balls, calcium carbide and rapid moisture meter.

THEORY:-

Rapid moisture meter is based on the principle that the amount of acetylene gas produced during a reaction between moisture in the sand and powder of calcium carbide is proportional to the moisture content. The amount of gas produced con be noted by measuring its pressure in a close vessel. Thus moisture content is directly proportional to the pressure of the gas. The pressure gauge of the rapid moisture meter is thus directly calibrated in the percentage moisture.

PROCEDURE:

1. A measured amount of sand (50 Gins) is taken.
2. Sand is put in the rapid moisture meter along with the steel balls. The function of the steel balls is to mix the sand and the calcium carbide powder.
3. A measured amount of calcium carbide is the put in the container carefully so that sand and the powder do not get mixed.
4. The cap of the container is tightened.
5. The moisture meter is shaken vigorously and the reaction starts.
6. The reading is taken from the gauge which is gives the value of percentage moisture.

Chemical reaction:

The following reaction takes place in the container

CaC2+.H20—+C2H2+Ca $(OH)_2$

Observation and result:

Sample No.	Percentage moisture

To determine shatter index of a molding sand sample.

APPARATUS: Sand rammer, Shatter index tester.

THEORY:-

This tester is designed to drop a rammed specimen of moulding sand from a particular height on to a steel plate and collect the sand remaining on particular standard mesh sieve. The shatter index is defined as the proportion by weight of standard specimens which is retained by a particular sieve when the specimens has been shattered by felling from a particular height on solid plate.

Prepare a test specimen in standard specimen tube on 'Metrex' Sand Rammer and record the weight of sand in it. Insert the tube containing the rammed specimen in the top socket below the plunger and inject it by gently pulling down the handle. Weight the sand retained through the sieve, then percentage of this proportion will give the shatter Index complete with sieve, Pan, steel plate.

SHATTER INDEX TESTER

SAND RAMMER

A sand rammer is a piece of equipment used in foundry sand testing to make test specimen of molding sand by compacting bulk material by free fixed height drop of fixed weight for 3 times. It is also used to determine compatibility of sands by using special specimen tube and a linear scale.

Mechanism

Sand rammer consists of calibrated sliding weight actuated by cam, a shallow cup to accommodate specimen tube below ram head, a specimen stripper to strip compacted specimen out of specimen tube, a specimen tube to prepare the standard specimen of 50 mm diameter by 50 mm height or 2 inch diameter by 2 inch height for an AFS standard specimen.

Specimen Preparation

The cam is actuated by a user by rotating the handle, causing a cam to lift the weight and let it fall freely on the frame attached to the ram head. This produces a standard compacting action to a pre-measured amount of sand.

Sand rammer

Variety of standard specimen for Green Sand and Silicate based (CO_2) sand are prepared using a sand rammer along with accessories

Specimen	Type of sand
Compression (Cylindrical)	Green Sand and Silicate based sand
Tensile Specimen	Silicate based sand
Transverse Specimen	Silicate based sand

The object for producing the standard cylindrical specimen is the have the specimen become 2 inches high (plus or minus 1/32 inch) with three rams of the machine. After the specimen has been prepared inside the specimen tube, the specimen can be used for various standard sand

tests such as the permeability test, the green sand compression test, the shear test, or other standard foundry tests.

The sand rammer machine can be used to measure compactability of prepared sand by filling the specimen tube with prepared sand so that it is level with the top of the tube. The tube is then placed under the ram head in the shallow cup and rammed three times. Compactability in percentage is then calculated from the resultant height of the sand inside the specimen tube.
A rammer is mounted on a base block on a solid foundation, which provides vibration damping to ensure consistent ramming

Used for sand types

- Green sand
- Oil sand
- CO_2 sand
- Raw sand i.e. base sand i.e. un-bonded sand.

PROCEDURE:

1. For this a standard specimen is prepared by sand rammer.
2. The sand specimen is drop through a specified height on to a steel anvil.
3. The complete broken mass of the sand is then put on a 12 mm mesh sieve.
4. Part of it (finer mass) will pass through the sieve.
5. Then the shatter index of the sand sample can be calculated.

Shatter index (%age) = weight of broken moulding sand specimen left on sieve/total weight of moulding sand

Precautions:

- Always Keep Rammer plunger in lifted condition with the help of lifting cam when not in use.
- Do not turn ramming cam handle and allow the weight to fall unless a sample is being rammed.
- Clean the equipment after use.

Protect the Parts from rusting; apply rust preventing oil when not in use.

- Clean and lubricate all moving parts of the rammer.

Clean the specimen tube before preparation of the specimen.

Experiment 2

AIM: To determine Green strength & clay content of Sand.

APPARATUS: Sand rammer, universal testing machine (U.T.M).

SPECIMEN: Green sand test specimens =50x50 & 50x100.

Theory: The U.T.M machine is used to determine various strengths, such as compression, shear, tensile, transverse & deformation of moulding sand.

Strength test:

Measurements of strength of moulding sands can be carried out on the universal sand strength testing machine. The strength can be measured in compression, shear and tension.

The sands that could be tested are green sand, dry sand or core sand. The compression and shear test involve the standard cylindrical specimen that was used for the permeability test.

Horizontal strength testing machine

(a) **Green compression strength:**

Green compression strength or simply green strength generally refers to the stress required to rupture the sand specimen under compressive loading. The sand specimen is taken out of the specimen tube

and is immediately (any delay causes the drying of the sample which increases the strength) put on the strength testing machine and the force required to cause the compression failure is determined. The green strength of sands is generally in the range of 30 to 160 KPa.

PROCEDURE:

1. Insert the compression pads in the respective position as shown in diagram.
2. Prepare standard specimen of diameter 50x50mm height.
3. Place the specimen between the compression pads so that the plain surfaces of the specimen touch against the pads.
4. Rotate the wheel clockwise until the load starts applying on specimen. (this will be seen by movement of pressure gauge needle) & then uniformly at about 16 RPM, till the specimen collapses.
5. The red pointer also moves along with the needle. As soon as the sample collapses the needle returns while the red pointer remains at the maximum reading before collapse of the specimen. To read compression strength on the scale (C.S. Scale). Indicated by the idle pointer.
6. Take minimum three readings from the sample batch and take the average.

Precautions

1. Do not overload the gauge.
2. Keep the equipment clean.
3. Remove air completely from oil reservoir.

clay content of Sand

CLAY CONTENT TEST FOR MOULDING SAND

APPARATUS : Moulding sand sample.

Clay washer: Consists of stirrer, glass jar, siphon, timer unit, 53 micron sieve pan, wash bottle.

Specification of clay washer equipment

- **Width:** 260
- **Depth:** 180
- **Height:** 750
- **Weight:** 36
- **Range:** 50 gms

Clay washer

Procedure:

1. Take dried sand sample of 50gms into glass jar and fill halfway with water. Add some amount of alkaline sodium hydroxide.
2. Fill up the glass jar with distilled water up to upper mark.
3. Turn jar holder side and hold the jar as shown in diagram and take the jar holder under it. Keep the jar on jar holder. Let the solution stir for 8-10 minutes.
4. Remove the glass jar and rinse sand and fines adhering to the stirrer into the glass jar by means of wash bottle.

5. Allow the sand to settle for 8 to 10 min then fill the siphon with fresh water and insert short leg into glass jar to siphon out the muddy water up to 25mm mark.
6. Repeat this procedure till the water in the jar becomes colorless (free from clay).

7. After this sample is heated under infrared lamp to make it washed & dried sand sample.
8. Allow it to cool & weight the sample.
9. Now find out the % of clay by following formula

% clay= A-B/A x100

Where A= weight of dry sand sample.

B = weight of the washed & dried sand sample.

Precautions:

1. Clean the equipment after use.
2. Protect the Parts from rusting; apply rust preventing oil when not in use.

Experiment 3

AIM: Sand testing Experiments to Determine Core & Mold Hardness

APPARATUS : sand sample.

Consists of digital indicator and special geometry plunger to read hardness of Green Mould from 0 to 100 Nos.

SPECIFICATION OF MOULD HARDNESS EQUIPMENT

- Width: 115
- Depth: 40
- Height: 165
- Weight: 1
- Utility: To test Hardness of prepared sand mold
- Range: 0-100

HARDNESS TESTER (DIGITAL)

Procedure:

1. Apply the instrument vertically, placing the tip on mould surface of which hardness is to be measured.
2. Gently press on the surface until the surface of the bottom ring contacts the mould surface throughout the periphery.
3. The depth of penetration of the tip into the mould indicates the green hardness, which is indicated on the dial directly.

Tabular column for Core Hardness Test

Sr. No	%Sand	%Sodium Silicate	Core Hardness Number
1			
2			
3			

Tabular column for Mould Hardness Test

SL. NO	% of Water	Mould hardness Number
1		
2		

Precautions:

- Keep the instrument clean and away from dust ensure that all sticking sand is removed from the instrument before and after every test.
- Do not tamper with the setting and calibration

Experiment 4

AIM: To determine the permeability of sand and grain fineness number

APPARATUS: Permeability Meter Consists of air tank, water tank, manometer unit, permeability chart, two orifices, rubber seal and siphon.

THEORY:

Permeability is a property of foundry sand with respect to how well the sand can vent, *i.e.* how well gases pass through the sand. And in other words, permeability is the property by which we can know the ability of material to transmit fluid/gases. The permeability is commonly tested to see if it is correct for the casting conditions.

The grain size , shape and distribution of the foundry sand, the type and quantity of bonding materials, the density to which the sand is rammed, and the percentage of moisture used for tempering the sand are important factors in regulating the degree of permeability.

SAND TYPE USED: Green Sand, No-bake Sand, Oil Sand, CO2 Sand

SPECIFICATION PERMEABILITY METER

- Width: 300
- Depth: 300
- Height: 440
- Range: Large Orifice-36 to 2450 No. & SmallOrifice-1.1 to 49No

PERMEABILITY METER

Pre-Setting

1. Place the instrument on leveled platform. Clean the air and water tank from inside, adjust “O-P-D” valve at ‘O’.
2. Opening of the air tube inside water tank by thumb and pour distilled water up to the water level a mark on the outside on the water tank insert air tank into water tank carefully.
3. A cup with valve is provided at the left side of the manometer to fill the water in manometer tank.
4. This valve is operated by unscrewing the knob and water is filled in the manometer tank.
5. The water level should coincide will the zero of the manometer scale or slightly above zero mark
6. The valve is closed by screwing in the knob.
7. Final zero level is adjusted by opening “ zero adjusts screw” provided in front of manometer tank.

Selection of orifice

1. The manometer scale is calibrated for 0 to 10 & indicates pressure in gms. Per sq. cm. of water
2. It is recommend to use small orifice for permeability below 50 & large orifice for permeability above 50 .

Operation

1. Screw proper orifice with washer on the rubber sealing boss. Tighten the orifice by by fingers only.
2. Take the specimen tube with rammed specimen and place it inverted over the rubber sealing boss put the valve on ‘P’ position.
3. Read the height of the water column in the manometer tube. Find out corresponding permeability number from the chart fixed on the instrument.
4. Put the valve on ‘0’ position. Whenever the air tank is flues with water tank, keep the valve on ‘D’ position and slowly lift the air tank to the top position.
5. Lift the air tank drum slowly up keeping the valve ‘D’ position to avoid any water entering the air tube.

Precautions:

1. It is advisable to remove water from water tank by using siphoning attachment provided with the instruments
2. Instrument should be away from vibration.
3. Keep air tank clean.
4. Do not use metallic piece to clean the orifice. Always use blown air to clean orifices.
5. Ensure positive sealing of the specimen tube on rubber sealing boss.

6. Pull the air tank slowly to bring it to its original position. Keeping valve in ‘D’ position to avoid any water entering the air tube.
7. For removal of the water completely from manometer use zero adjustment valve.

GRAIN FINENESS NUMBER OF MOULDING SAMPLE

The AFS Grain Fineness Number (AFS-GFN) is one means of measuring the grain fineness of a sand system. GFN is a measure of the average size of the particles (or grains) in a sand sample. AFS-GFN gives the metal casting facility a means to verify its molding sand is staying within specification for the castings being produced and avoid conditions that could lead to potential casting problems.

Procedure:

The grain fineness of molding sand is measured using a test called sieve analysis , which is performed as follows:

1. A representative sample of the sand is dried and weighed, then passed through a series of progressively finer sieves (screens) while they are agitated and tapped for a 15-minute test cycle.
2. The sand retained on each sieve (grains that are too large to pass through) is then weighed and recorded.
3. The weight retained on each sieve is divided by the total sample weight to arrive at the percent retained on each screen.
4. The percentage of sand retained is then multiplied by a factor, or multiplier, for each particular screen (Table 1). The factors reflect the fact that the sand retained on a particular sieve (e.g. 50 mesh) is not all 50 mesh in size, but rather smaller than 40 mesh (i.e. it passed through a 40 mesh screen) and larger than 50 mesh (it won't pass through 50 mesh screen). The result should be rounded to one decimal place.
5. The individual screen values then are added together to get the AFS-GFN of the sand, representing an average grain fineness (Table 1).

This number is the weighted mathematical average of the particle sizefor that sand sample. Many metal casting facilities have developed computer spread sheets to perform these calculations, limiting the potential for human error.

By itself, GFN does not identify if the sand will be a good molding material or produce the qualities needed in a particular metal casting sand system. Because GFN represents an average fineness, sands with very different grain size distribution may have similar GFN numbers. So, the distribution of sand grains on the screens is another critical factor in effective sand molding. The distribution refers to the quantity of sand retained on each individual sieve, rather than the average of all sand retained on all sieves.

Metal casting facilities typically want to avoid an excessive amount of either coarse (6-30 mesh) or fine (270-PAN) materials and should favor a bell-curve type distribution. Table 2 shows a comparison of two sands that have the same AFS-GFN but different distributions. Sand A is a 5-sieve sand because 10% or more of the sample was retained on each of five adjacent sieves (40, 50, 70, 100 and 140). Sand B is a 3-sieve sand because 10% or more was retained on each of only three adjacent sieves (50, 70 and 100). Many metalcasting facilities would prefer the 5-sieve sand because the wider distribution generally helps to minimize expansion defects. The standard for AFS-GFN and sand distribution is usually determined by the individual metalcasting facility for its particular sand system and depends on factors like casting quality requirements, molding process used and alloys poured.

Table 1. Mathematical Factors for Calculation of AFS-GFN (sample size of 78.4 g)

ASTM E-11 Sieve Size	Weight Retained on Sieve (g)	Retained	Multiplier	Product *
6 Mesh	0	0	0.03	0
12 Mesh	0	0	0.05	0
20Mesh	0	0	0.1	0
30Mesh	0.7	0.9	0.2	0.18
40Mesh	3.9	4.9	0.3	1.47
50Mesh	19.4	24.7	0.4	9.88
70Mesh	37.3	47.6	0.5	23.8
100 Mesh	16.3	20.8	0.7	14.56
140 Mesh	0.8	1	1	1
200 Mesh	0	0	1.4	0
270 Mesh	0	0	2	0
Pan	0	0	3	0
TOTAL	78.4	100	----	50.89**

* Product is percent retained times multiplier

** AFS GFN=50.9 (sum of all products rounded to one decimal)

Table 2. Distribution of Two Sand Samples

Sieve	Sand A Percent Retained	Sand B Percent Retained
20	0	0
30	1	0
40	24	1
50	22	24
70	16	41
100	17	24
140	14	7
200	4	2
270	1	0
Pan	0	1
AFS-GFN	57.X	57.X

Experiment 5

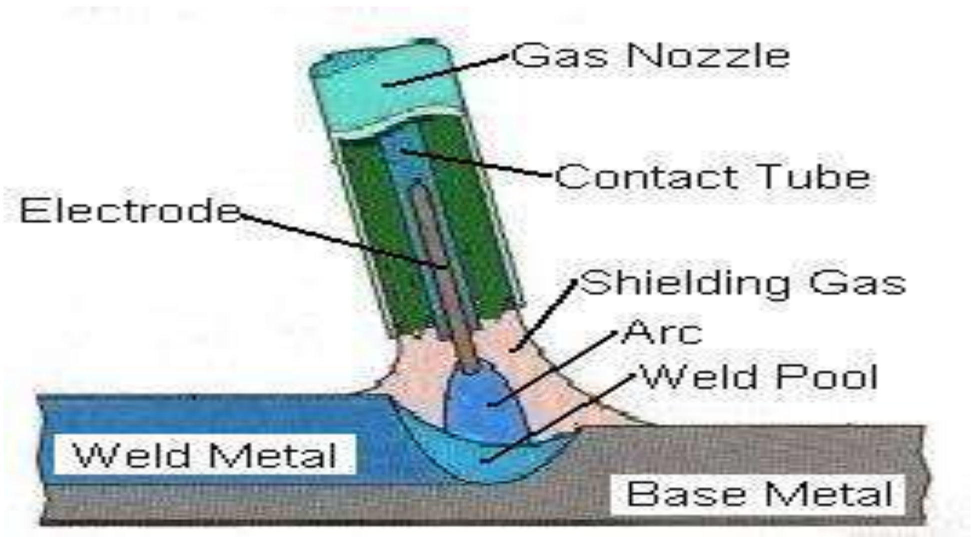
AIM: Preparation of lap joint, butt joint & T joints with the help of MIG welding.

Theory:

Definition of MIG Welding

Metal Inert Gas (MIG) welding combines two metals by using a filler wire with a current to produce the electrode. Inert gas is also used simultaneously to protect the weld from any air contaminants.

MIG welding or Gas metal arc welding (GMAW): is a welding process in which an electric arc forms between a consumable wire electrode and the work piece metal(s), which heats the work piece metal (s), causing them to melt, and join. Along with the wire electrode, a shielding gas feeds through the welding gun, which shields the process from contaminants in the air. The process can be semi-automatic or automatic. A constant voltage, direct current power source is most commonly used with GMAW, but constant current systems, as well as alternating current, can be used.



MIG WELDING

EQUIPMENTS ;

- Welding power source and cables.
- Welding torch and wire electrode coiled on a spool.
- Wire feed mechanism and controls consisting of a pair of driving rolls, electric motors etc.
- Shielding gas cylinder, pressure regulator and flow meters.
- Controls.

Advantages:

- High quality welds can be produced much faster
- Since a flux is not used, there is no chance for the entrapment of slag in the weld metal resulting in high quality welds
- The gas shield protects the arc so that there is very little loss of alloying elements. Only minor weld spatter is produced
- MIG welding is versatile and can be used with a wide variety of metals and alloys
- The MIG process can be operated several ways, including semi and fully automatic.

Disadvantages;

- The MIG welding cannot be used in the vertical or overhead welding positions because of the high heat input and the fluidity of the weld puddle
- The equipment is complex.

Experiment 6

AIM: Practice of TIG welding technique for the preparation of butt, lap and T joint.

Theory:

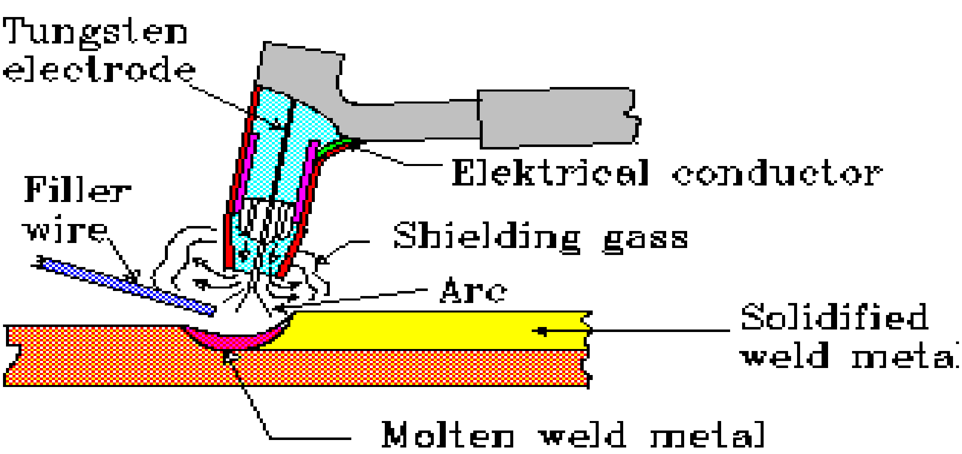
TIG WELDING

Definition of TIG Welding

Tungsten Inert Gas (TIG) welding joins reactive metals using a non-consumable Tungsten electrode. Inert gas, commonly Argon, is released at the same time as the electrodes to produce a weld without air contaminants. Tungsten is not the filler, it just creates the arc between the electrode and metal, but a filler may be used if needed.

THEORY:

In this arc welding process, welding heat is produced from an electric arc established between ht tungsten electrode and the job. A shielding gas {argon, helium, nitrogen etc.} is used to avoid atmospheric contamination of the molten weld pool. Filler metal, If required is fed separately.



TIG WELDING

This process uses a non-consumable tungsten electrode, which is mounted in a special electrode holder. This holder is also designed to furnish a flow of inert gas around the electrode and around the arc. Welding operation is done by striking an arc between the work piece and tungsten electrode in an atmosphere of inert gas. The arc is struck either by touching the electrode with a scrap metal tungsten piece or using a high frequency unit. After striking the arc, it is allowed to impinge on the job and a

molten weld pool is created. The welding torch and the filler metal are generally kept inclined at angles of 70-80 degree and 10-20 degree respectively with the flat work piece. Filler metal, if required should be added by dipping the filler rod in the weld pool. When doing so, the tungsten electrode should be taken a little away from weld pool. However the heated end of filler rod as well as the electrode should be within the inert gas shield. Both D.C. and A.C. power source can be used.

EQUIPMENT :

- Welding torch, tungsten electrode and Filler metal.\
- Welding power source, high frequency unit, D.C. suppressor unit and cable.
- Inert gas cylinder, pressure regulator and flow meter.
- Cooling water supply.
- Water and gas solenoid valves.

Advantages:

- Cleaner - Using Tungsten to provide its electrical current, TIG welding decreases the amount of sparks, smoke and fumes produced.
- Precision - TIG welding has less contamination in its weld, providing more precise and higher quality welds.

- Autogenous Welds - These welds do not require a filler material to be used. TIG welding can create a weld by melting one part to the other. Autogenous welds are most commonly used when welding thinner materials.

Disadvantages:

- Setup - TIG welding requires more setup time and is not as user-friendly.
- Price - These welds tend to be more expensive and take longer than MIG welding especially in thicker metals.
- Complexity - TIG welding is more complex and requires more skill than the MIG welding process

Experiment 7

AIM : Preparation of lap joint, butt joint & T joints with the help of Resistance spot welding.

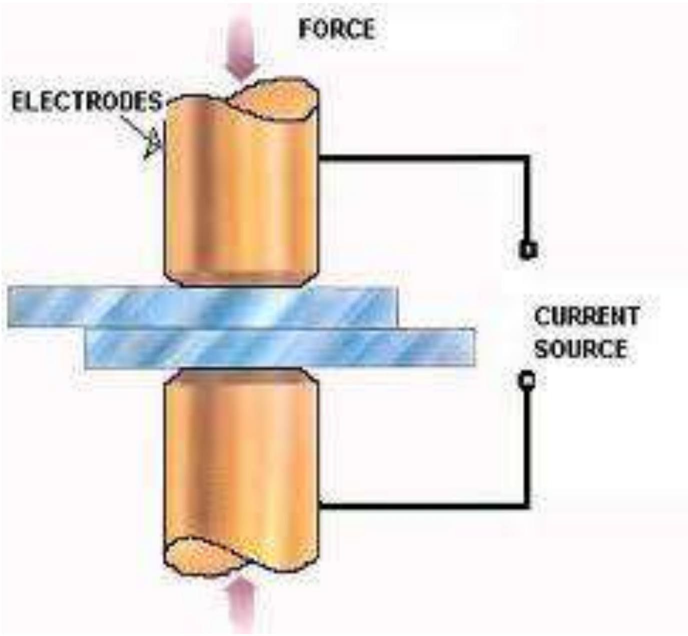
Theory:

SPOT WELDING

THEORY:

Spot welding is a process in which contacting metal surfaces are joined by the heat obtained from resistance to electric current. Work-pieces are held together under pressure exerted by electrodes. Typically the sheets are in the 0.5 to 3 mm (0.020 to 0.12 in) thickness range. The process uses two shaped copper alloy electrodes to concentrate welding current into a small "spot" and to simultaneously clamp the sheets together. Forcing a large current through the spot will melt the metal and form the weld. The attractive feature of spot welding is a lot of energy can be delivered to the spot in a very short time (approximately ten milliseconds). That permits the welding to occur without excessive heating to the remainder of the sheet.

Projection welding is a modification of spot welding. In this process, the weld is localized by means of raised sections, or projections, on one or both of the work pieces to be joined. Heat is concentrated at the projections, which permits the welding of heavier sections or the closer spacing of welds. The projections can also serve as a means of positioning the work pieces



Spot welding figure

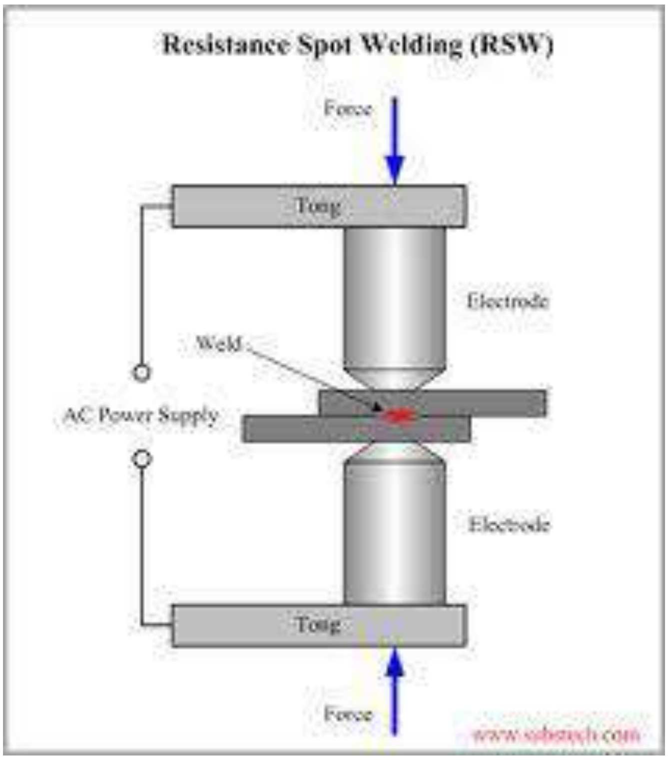


Figure: Spot Welding

Precautions taken while performing different welding processes

- Always wear safety goggles and full sleeve shirt.
- Keep a fire extinguisher nearby.
- Wear dry insulating gloves.
- Do not put hands between tips.
- Do not breathe the fumes.
- Use proper ventilation.
- Do not touch tongs and tips with bare hands.
- Touch them only after it gets cooled.
- Wear proper insulating gloves if handling hot work or parts is necessary.

Some safety tips are as follows:

- Welding process requires heating, so remove all the inflammable materials near the vicinity.
- Wear protective gear to avoid injury caused by fire or gas.
- Fire extinguisher should be in operating condition
- Proper ventilation can avoid accumulation of toxic materials
- A welding operator should always wear woolen clothes instead of cotton as it can catch fire easily.
- In extremely dangerous cases of welding, the person doing the welding process should wear flameproof jackets to avoid fire

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Experiment 8

AIM: Analyze the, microstructure of different heat treated steel specimen and their effect on mechanical properties.

APPARATUS: Sample specimens, emery papers, polishing wheel, etchant, metallurgical microscope.

THEORY: Microstructural examination can provide quantitative information about the grain size of specimens, grain shapes, amount of interfacial area per unit volume, dimensions of constituent phases, amount of distribution of the phases and effect of heat treatment on mechanical properties.

Microstructural examination in other words is also called Metallographic, which is a specialized discipline in the science of materials technology. Several necessary steps in doing metallographic of materials include:

A) Selection of sample or specimen
B) Polishing it to make it flat and mirror smooth
C) Etching to create relief on the surface to be observed

} Sample preparation

D) Observing the structures on microscope
E) Sketching or photographing the structures

} Observation and recording

PROCEDURE: A sample specimen is prepared observing following procedure:

a) **Selection of Specimen**

A specimen is so selected that it represents, as far as possible, the whole section or the entire piece. Only a small piece can be used and only a plane or flat section can be observed.

b) **Cutting the Specimen**

Having selected a particular area in whole mass, specimen is cut. Hacksaw or power hacksaw may be taken into application. The edges of specimen are beveled or chamfered slightly to prevent tearing of polishing cloth / emery paper.

c) **Obtaining flat specimen surface**

Primarily, application of a fairly coarse file or grinding is done to achieve a flat surface. Then, using emery papers of progressively finer grades, grinding of the specimen is done.

d) **Polishing to fine finish**

The cloth covered polishing wheels and fine abrasive slurry is used to produce a final mirror-finish. The wheel is first washed off the old abrasive and then some fine abrasive is applied on wet cloth.

e) **Etching**

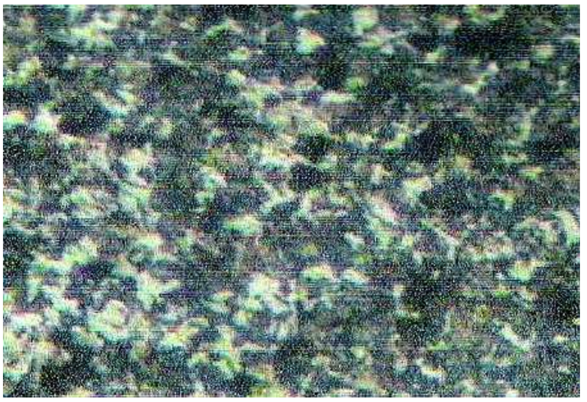
There are specific etchants suitable for various purposes and metals. To etch a specimen, it is first ensured to be clean and dry. Then a small amount of etchant is taken into a white porcelain evaporating dish. Then, etchant is dropped over the surface with help of small tuft of clean cotton. The surface should be kept completely covered with etchant liquid. Etching turns the shiny mirror appearance into a slightly cloudy mirror one.

Then, etchant is removed with flowing tap water and quickly the specimen is blown dry.

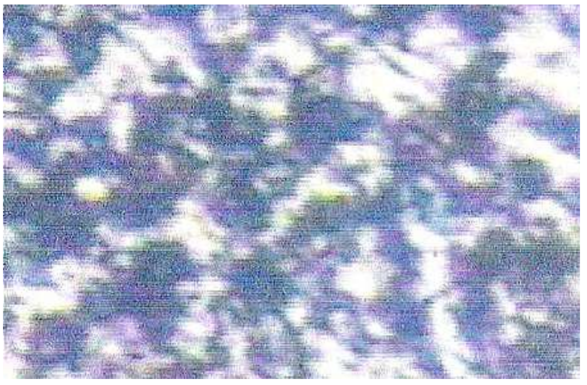
Then, using the metallurgical microscope, the microstructure of the specimen is observed.

RESULTS: Various microstructures show the following characteristics:

Quenched Medium Carbon Steel: The specimen of medium carbon steel is heated at 900°C for 1 hour and cooled in water. The microstructure shows mixture of ferrite and pearlite. Bright grains are pearlite and dark grains are ferrite. Microstructure shows more ferrite i.e dark grains.



Normalized Steel: The specimen of medium carbon steel is heated at 900°C for 1 hour and cooled in air. The microstructure shows mixture of ferrite and pearlite. . Bright grains are pearlite and dark grains are ferrite Microstructure shows more equal amount of pearlite and ferrite.



Tempered steel: The specimen of medium carbon steel is heated at 900°C for 1 hour and cooled in water and then again place in furnace and heated up to its critical temperature(230-600c). The microstructure shows mixture of ferrite and pearlite. Bright grains are pearlite and dark grains are ferrite.

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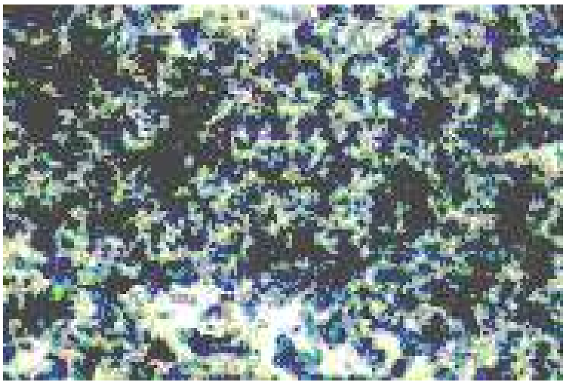

PRECAUTIONS:

A) At any instance while polishing, or afterwards, never touch the polished surface with fingers, because it deposits a film or tarnish, hiding the microstructure of specimen.

B) Every polishing scratch should be removed completely before proceeding further.

C) Specific etchant should be used corresponding to metal, so that any chemical attack or corrosion does not take place.

D) Etchant should be washed off immediately after etching and specimen should be immediately blown dry after washing off the etchant.

E) The spattering of etchant in eyes, or on clothes should be avoided.

F) Hands should be thoroughly washed after using an etchant.

G) Heat due to friction should be avoided at every stage(cutting, grinding or polishing etc.) as it can cause alteration in microstructure.

QUESTIONS FOR VIVA-VOCE

a) What do you understand by Hyper- & Hypo-eutectoid steels?
b) What is the importance of studying the microstructure of metals?
c) What is the general procedure followed to examine microstructure of a particular sample?
d) Why is etching done?
e) What precautions should be observed while using an etchant (while performing etching operation)?

Experiment 9

AIM : Examine the effect of quenching , normalizing and tempering on steel components.

Apparatus: Muffle furnace, quenching media (water, oil) and steel specimen tong.

Theory: Carbon steel (plain carbon steel) is steel which contains main alloying elements is carbon. Here we find maximum up to 1.5% carbon and other alloying elements like copper manganese, silicon most the steel produced no-a-day is plain carbon steel. It is divided in to the following types depending upon the carbon content

1. Dead or mild steel (up to 0.15% carbon)
2. Low carbon steel (0.15 %-0.45% carbon)
3. Medium carbon steel (0.45% -0.8% carbon)
4. High carbon steel (0.8%-1.5% carbon)

Steel with low carbon content has properties similar to iron. As the carbon content increases the metal becomes harder and stronger but less ductile and more difficult to weld. Higher carbon content lowers the melting point and its temperature resistance Carbon content cannot alter yield strength of material low carbon steel has carbon Content of 1.5% to 4.5% low carbon steel is the most common type of steel as its price is relatively low while its provides material properties that are acceptable for many applications. It is neither externally brittle nor ductile due to its low carbon content. It has lower tensile strength and malleable.

Heat treatment: Samples wear subjected to different heat treatment, normalizing, hardening, and tempering in accordance to ASM International standards the process of heat treatment is carried out first by heating the material and then cooling it in the brine, water and oil. The purpose of heat treatment is to soften the metal, to change the grain size, to modify the structure of the material and to relieve the stress set up in the material after hot and cold working. The various heat treatment processes commonly employed in engineering practice as follows:-

1. **Normalizing**:- the process of normalizing consist of heating the metal to a temperature of 30 to 50 c above the upper critical temperature for hyper - eutectoid steels and by the same temperature above the lower critical temperature for hyper-eutectoid steel. It is held at this temperature for a considerable time and then quenched in suitable cooling medium. Improve tensile strength, to remove strain and to remove dislocation.

2. **Hardening** :- The process of hardening consist of heating the metal to a temperature of 30 -50 c above the upper critical point for hypo - eutectoid steels and by the same temperature above the lower critical temperature for hyper -eutectoid steels. It is held this temperature for some time and then quenched. The purposes of hardening are to increase the hardness of the metal and to make suitable cutting tools.

3. **Tempering**: - This process consists of reheating the hardened steel to some temperature below the lower critical temperature, followed by any desired rate of cooling. The purpose is to relive internal stress, to reduce brittleness and to make steel tough to resist shock and fatigue

4. **Normalising**: - a) at the very beginning the specimen was heated to the temperature of 900 deg Celsius.

b) There the specimen was kept for 2 hour.

c) Then the furnace was switched off and the specimen was taken out.

d) Now the specimen is allowed to cool in the ordinary Environment.i.e. The specimen is air cooled to room temperature. The process of air cooling of specimen heated above Ac 1 is called normalizing.

5. Quenching:- This experiment was performed to harden the cast iron. The process involved putting the red hot cast iron directly in to a liquid medium.

a) The specimen was heated to the temp of around 900 deg Celsius and wear allowed to homogenize at that temp for 2 hour.

b) An oil bath was maintained at a constant temperature in which the specimen had to there the specimen was kept for 2 hour.

C) After 2 hour the specimen was taken out of the furnace and directly quenched in the oil bath.

d) After around half an hour the specimen was taken out of the bath and cleaned properly.

e) New the specimen attains the liquid bath temp within few minutes. But the rate of cooling is very fast because the liquid does t readily.

Tempering: - This is the one of the important experiment carried out with the objective of the experiment being to induce some amount of softness in the material by heating to a moderate temperature range.

a) Fist the 4 specimen was heated to 900 deg Celsius for 2 hour and then quenched specimen were heated to 900 deg Celsius for 2 hour and then quenched in the oil bath maintained at room temp.

b) Among the 4 specimen 2 were heated to 250 deg Celsius. But for different time period OF 1 hour, 1and half hour and 2 hour respectively.

c) Now 3 more specimens were heated to 450 deg Celsius and for the time period of 1 hour.1 and half and 2 hour respectively.

d) The remaining specimens were heated to 650 deg Celsius for same time interval of 1 hour. 1 and half and 2 hour respectively.

Hardness testing:-The heat treated specimens. Hardness was measured by means of Rockwell hardness tester. The procedure adopted can be listed as follows:

1. First the Indenter was inserted in the machine; the load is adjusted to 100 kg
2. The minor load of a 10 kg was first applied to seat of the specimen

3. Now the major load applied and the depth of indentation is automatically recorded on a dial gauge in terms of arbitrary hardness numbers. The dial contains 100 divisions. Each division corresponds to a penetration of 002 mm. the dial is reversed so that a high hardness, which results in small penetration, results in a high hardness number. The hardness value thus obtained was converted into C scale by using the standard converter chart

Experiment 10

AIM: Determination of harden ability of steel specimen by Jominy END quench test.

Apparatus:

Jominy test apparatus, furnace, Rockwell hardness tester and a grinder.

Theory:

Jominy end quench test is used to determine hardenability of steels. The process of increasing the hardness of steel is known as Hardening. Specific specimen with standard dimensions, used for the test is given in fig.1. The hardness of hardened bar is measured along its length.

3.1 Hardenability:

The depth up to which steel can be hardened is defined as hardenability. A steel having high hardness need not have high hardenability. Hardenability may be defined as susceptibility to hardening by quenching. A material that has high hardenability is said to be hardened more uniformly throughout the section that one that has lower hardenability. M.A Gross man devised a method to decide hardenability.

3.1.1 Critical diameter:

The size of the bar in which the zone of 50% martensite occurs at center is taken as critical diameter. This is a measure of hardenability of steel for a particular quenching medium employed.

3.1.2. Severity of Quench:

The severity of quench is indicated by heat transfer equivalent.

$$H = f/k$$

f = Heat transfer factor of Quenching medium and the turbulence of the bath. k = Thermal conductivity of bar material.

The most rapid cooling is possible with severity of quench as infinity.

3.1.3 Ideal Critical Diameter;

The hardenability of steel can be expressed as the diameter of bar that will form a structure composed of 50% martensite at the center when quenched with H = infinity. This diameter is

defined as ideal critical diameter.

Description of Apparatus:

Jominy end quench apparatus is shown in fig 2.
The apparatus consists of a cylindrical drum. At the top of the drum provision is made for fixing the test specimen. A pipe line is connected for water flow, which can be controlled by means of a stop cock.

Procedure:

1. Out of the given steel bar, the standard sample is to be prepared as per the dimensions shown in the fig.
2. The austenitising temperature and time for the given steel is to be determined depending on its chemical composition.
3. The furnace is setup on the required temperature and sample is kept in the furnace.
4. The sample is to be kept in the furnace for a predetermined time (based on chemical composition of steel) then it is taken out of the furnace and is kept fixed in the test apparatus.
5. The water flow is directed onto the bottom end of the sample. The water flow is adjusted such that it obtains shape of umbrella over bottom of sample.
6. The quenching to be continued for approximately 15minutes.
7. A flat near about 0.4 mm deep is grounded on the specimen.
8. The hardness of the sample can be determined at various points starting from the quenched end and the results are tabulated.
9. The graph is plotted with hardness values versus distance from quenched end. From the results and graph Plotted the depth of hardening of the given steel sample can be determined.

Precautions:

1. The specimen is to be handled carefully while transferring from furnace to test apparatus.
2. Proper water flow (at high pressure) over the bottom end of specimen is to be ensured.

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DEPARTMENT OF MECHANICAL ENGINEERING

Manufacturing Techniques Lab	Course Code: MEP-206

Observation Table

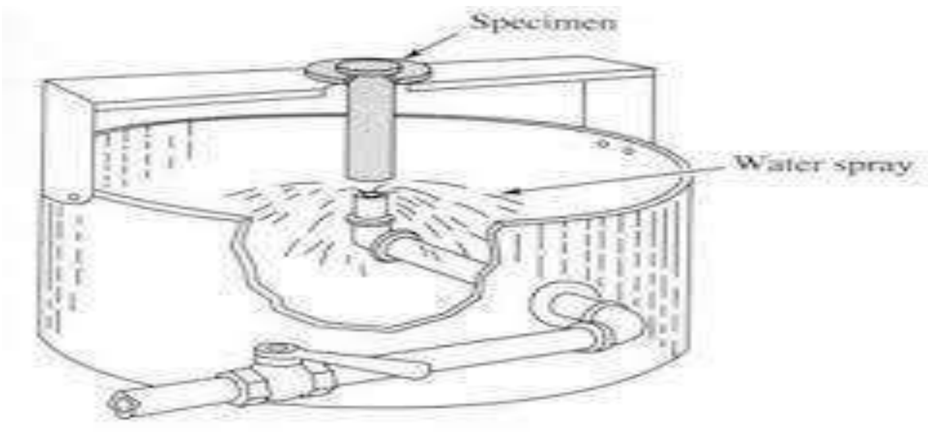
S.No.	Distance from quenched end	Hardness

RESULTS:

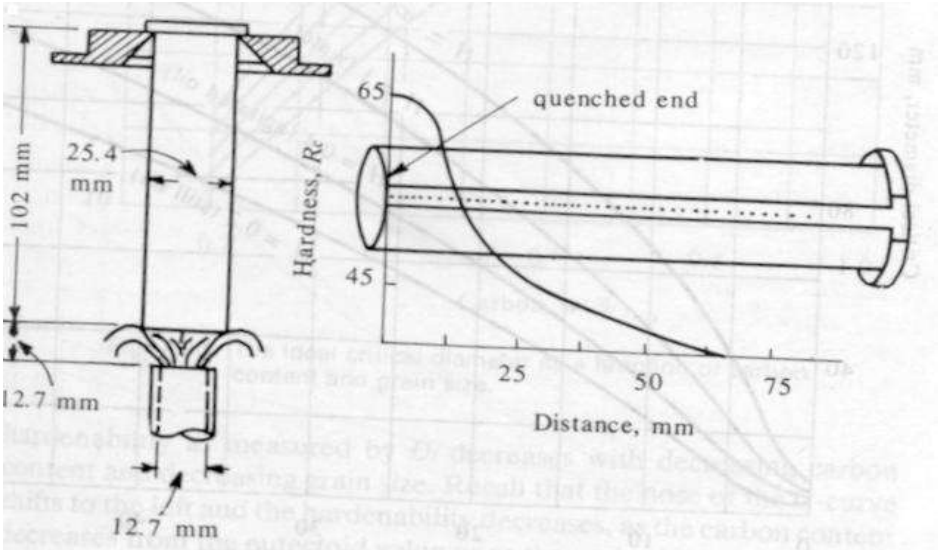
Hence determine the hardenability of steel.

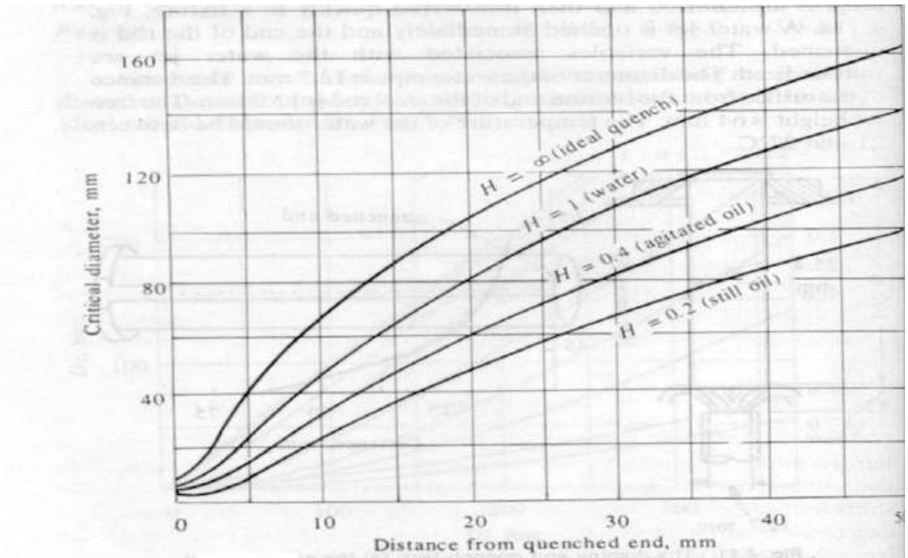
Fig 1

Fig 2



Jominy End Quench Test Setup





The relationship between the Jominy distance and the critical diameters for various quenching media and *H* values.

REVIEW QUESTIONS:

i) What is the difference between Hardness & Hardenability?

ii) What is severity of quench?

iii) What is critical diameter?

iv) What is the ideal critical diameter?

v) What is the quenching medium employed in the test?

vi) What are the important precautions to be observed in the test?

vii) Why a flat is to be ground on the test specimen?

viii) What is the equipment used to measure the hardness of specimen in the experiment?

REFRIGERATION & AIR CONDITIONING LAB

Course Code: MEY-303/ MEP - 358

Vision and Mission of the Chandigarh University

Vision

"To be globally recognized as a Centre of Excellence for Research, Innovation, Entrepreneurship and disseminating knowledge by providing inspirational learning to produce professional leaders for serving the society"

Mission

M1: Providing world class infrastructure, renowned academicians and ideal environment for Research, Innovation, Consultancy and Entrepreneurship relevant to the society.

M2: Offering programs & courses in consonance with National policies for nation building and meeting global challenges.

M3: Designing Curriculum to match International standards, needs of Industry, civil society and for inculcation of traits of Creative Thinking and Critical Analysis as well as Human and Ethical values.

M4: Ensuring students delight by meeting their aspirations through blended learning, corporate mentoring, professional grooming, flexible curriculum and healthy atmosphere based on co-curricular and extra-curricular activities.

M5: Creating a scientific, transparent and objective examination/evaluation system to ensure an ideal certification.

M6: Establishing strategic relationships with leading National and International corporates and universities for academic as well as research collaborations.

M7: Contributing for creation of healthy, vibrant and sustainable society by involving in Institutional Social Responsibility (ISR) activities like rural development, welfare of senior citizens, women empowerment, community service, health and hygiene awareness and environmental protection

Vision and Mission of the Department of Mechanical Engineering

Vision

To be recognized as a center of excellence for research and innovation in Mechanical Engineering through contemporary as well as futuristic tools and technologies for serving the society at regional, national and global level

Mission

MD1: Providing quality education to the students in core and allied fields by implementing advanced pedagogies

MD2: Encouraging students towards research and development through advanced tools and technologies for providing solution to societal problems

MD3: Evolve and empower the students through core technical skills for becoming entrepreneurs and innovators

MD4: Inculcating employability and leadership skill for ensuring industry ready professional through hands on experiential learning and industrial collaboration

MD5: Developing professional and ethical standards in the mind of the young engineers by continuous learning and professional activities

1.2. State the Program Educational Objectives (PEOs)(5)

PROGRAM EDUCATION OBJECTIVES (PEOs):

PEO1: Graduates will have professional knowledge in the field of Mechanical Engineering and various other interdisciplinary domains.

PEO2: Graduates will have successful career in government services, research organizations, corporate sector, academic institutes and industries at national and international repute.

PEO3: Graduate will have compatibility of modern engineering tools and technologies for deliberating solution of various engineering problems.

PEO4: Graduate will develop skill to address the concern of society, environment and communicate effectively to lead the interdisciplinary diverse team.

PEO5: Graduates will be effectively fit for higher education, innovations, research &development, entrepreneurship and professional development.

PROGRAM OUTCOMES (POs):
Program: Bachelor of Engineering (Mechanical Engineering)
Duration: 4 years

PO1. Engineering Knowledge: Apply knowledge of mathematics, science and engineering fundamentals and Production and Industrial Engineering specialization to the solution of complex Production and Industrial Engineering problems.

PO2. Problem Analysis: Identify, formulate, research literature and analyze complex Production and Industrial Engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

PO3. Design/ Development of Solutions: Design solutions for complex Engineering problems and design system components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.

PO4. Conduct investigations of complex Engineering problems: Use research-based knowledge and research methods including analysis, interpretation of data and synthesis of information to provide valid conclusions.
PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6. The Engineer and Society: Apply contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.
PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams and in multi disciplinary settings.
PO10. Communication: Communicate effectively on complex Engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.
PO11. Project Management and Finance: Demonstrate knowledge and understanding of Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12. Life Long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs):

PSO1: Apply the knowledge of Production, Manufacturing and Industrial Engineering for analysis, optimization and development of mechanical system

PSO2: Apply the concepts of Design and Thermal Engineering to model, analyze and develop the mechanical components and systems

Course Objectives

- Focuses on equipment, work systems, machinery, and automation systems for today's manufacturing environment
- To provide students the opportunity to acquire hands-on experience in the use of the engineering equipment, systems, and tools in the lab
- To understand working and construction of hydraulic and pneumatic circuits

  To understand, diagnose an automated system.

Course Outcomes

After completion of course the student will be able to:

CO1	Apply the basic concepts of automation and its components
CO2	Design hydraulic & pneumatic circuit integrated with PLC
CO3	Classify the FMS, develop and execute the CNC program for machining the component on lathe and milling machines
CO4	Inspect the the various features of industrial Robot and its applications considering social, health, safety, legal and environmental aspects.
CO5	Conclude the experimental results and express the same effectively in oral and written manners through report and practical presentation.

LIST OF EXPERIMENTS

1. To study the various elements of Mechanical Refrigerator System through system through cut section, models/actual apparatus.
2. To calculate co-efficient of performance and draw P-H diagram for VC cycle To familiarize with microprocessor based PLC and its industrial applications
3. To evaluate the performance of domestic air conditioner.
4. Study the performance of Electro-Lux-Refrigrator.
5. To calculate the COP of an Ice Plant Tutor
6. To find COP of year round in condition.
7. Visit to a HVAC plant for studying the various processes for Winter and summer air conditioning.
8. To calculate COP of water cooler unit.
9. To calculate cop of water to water Heat Pump.

EXPERIMENT NO.: 1

Aim: - To study the various elements of Mechanical Refrigerator System through system through cut section, models/actual apparatus.

Study: - Main Components of Refrigeration System are:-

1) Refrigerant
2) Compressor
3) Condenser
4) Evaporator
5) Expansion Devices

Description:

The detail study of every component of refrigeration system is as follows:-

1) **REFRIGERANT**:- It is a heat carrying medium which during their cycle in the refrigeration system absorb heat from a low temperature system and discard the heat so absorbed to a higher temperature system. The properties of an ideal refrigerant are:-
   (1) Low Boiling Point
   (2) High critical temperature
   (3) Low specific heat of liquid
   (4) Low specific volume of vapour
   (5) High latent heat of refrigeration
   (6) Non corrosive to metal
   (7) Non flammable or non-explosive
   (8) Non- toxic
   (9) Low in cost
   (10) Easy to liquefy at moderate pressure and temperature.

2) **COMPRESSER:** It is a machine to compress the vapour refrigerant from the evaporator and to raise its pressure so that the corresponding saturation temp. is higher than that of cooling medium. It also circulates the refrigerant through the system.

   Classification of Compressor:-

   (a) According to method of compression
      i) Reciprocating compressor
      ii) Rotary compressor
      iii) Centrifugal compressor.
   (b) According to number of stages.
      i) Single acting compressor Multi acting compressor
      ii) Dry expansion evaporator

(c) According to number of stages
   I. Single stage compressor
   II. Multi stage compressor

(d) According to method of drive employed
   I. Direct drive compressor.
   II. Belt drive compressor.

(e) According to location of prime-mover
   i) Semi – hermetic compressor
   ii) Hermetic compressor

3) CONDENSER: It is an important device used in the high pressure side of a refrigeration system. Its function is to remove heat of hot vapour.

Classification of Condenser:

i) Air cooled condenser
ii) Water cooled condenser
iii) Evaporative condenser.

4) EVAPORATOR: It is the device which is used in low-pressure side of refrigeration system. The liquid refrigerant after passing through the expansion value enters into the evaporator, here it provides cooling effect and absorbs heat, and so it changes the liquid refrigerant into vapour refrigerant form.

Classification of Evaporator:-

a) According to the type of construction
   i) Bare Tube coil evaporator.
   ii) Finned tube type evaporator.
   iii) Plate evaporator.
   iv) Shell and tube evaporator.
   v) Shell and coil evaporator.
   vi) Tube-in-tube evaporator.
b) According to method in which liquid refrigerant is fed
   i) Flooded evaporator
   ii) Dry expansion evaporator
c) According to mode of heat transfer
   i) Natural convection evaporator
   ii) Forced convection evaporator.

d) According to operating conditions.
   i. Frosting evaporator
   ii. Non-frosting evaporator.
   iii. Defrosting evaporator.

5) EXPANSION DEVICE:- It is an important device which divides high pressure side and low pressure side of a refrigerator system. It reduces the high pressure liquid refrigerant to low pressure refrigerant before being fed to evaporator. It also controls the flow of refrigerant according to the load on evaporator

Classification of Expansion Devices:-

i) Capillary tube
ii) Hand operated expansion valve
iii) Automatic or constant pressure expansion
iv) Thermostatic expansion valve
v) Low side float valve

Prepared By-	Reviewed By-	Approved By-

Experiment No. 2

Aim: To calculate co-efficient of performance and draw P-H diagram for VC cycle.

List of Equipment Used:

Table 2.1: List of Equipments

S.N.	Equipment	Range	Quantity
1.	Power supply	Single Phase, 220 V	1
2.	Water Supply	@ 4LPM at 1bar	NA
3.	Socket with earth connection	5-15 amp	1

Introduction:

Refrigeration is the branch of science that deals with the process of reducing and maintaining the temperature of a space or material below the temperature of the surroundings. Heat must be removed from the body being refrigerated and transferred to another body whose temperature is below that of the refrigerated body.

Theory:

Refrigeration may be defined as the process of removing heat from a substance under controlled conditions. It is used for the manufacture of ice and similar products. This is widely used for cooling of storage chambers in which perishable foods, drinks, and medicines are stored. The refrigeration has also wide applications in submarine ships, aircrafts.

Vapour compression cycle:

The refrigerant starts at some initial state or condition, passes through a series of processes in a definite sequence and returns to the initial condition. This series of processes is called a cycle.

The Standard Vapour Compression Cycle (SVCC) consists of the following processes:

- 1-2 Reversible adiabatic compression from the saturated vapour to a super heated Condition (electrical) input.

- 2-3 Reversible heat rejection at constant pressure (de-superheating and condensation of the refrigeration)
- Irreversible is enthalpy expansion from saturated liquid to a low-pressure vapour.
- Reversible heat addition at constant pressure.

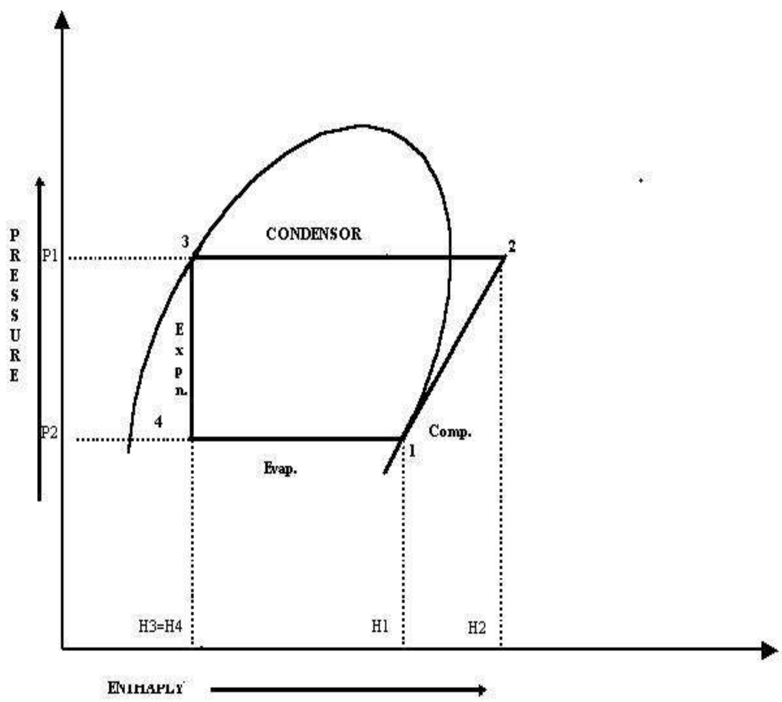


Figure 2.1: VC cycle

Standard vapour compressor cycle (svcc):

Compressor:

The main function of compressor is to raise the pressure and temperature of the refrigerant by the compression of the refrigerant vapour and then pump it into the condenser.

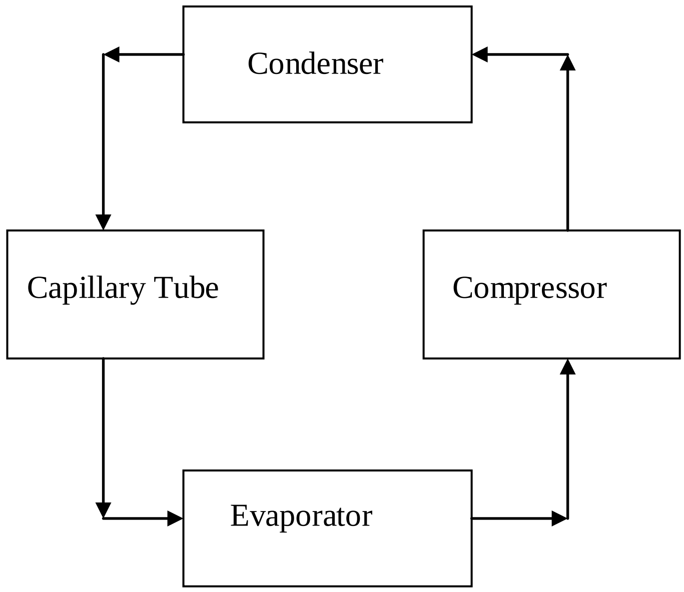


Figure 2.2: VC cycle

Condenser:

Condense the vapour refrigerant into the liquid by condenser fan and passes it into the receiver tank for recirculation.

Capillary tube:

It expands the liquid refrigerant at high pressure to the liquid refrigerant at low pressure so that a measured quantity of liquid refrigerant is passed into the evaporator.

Evaporator:

Evaporates the liquid refrigerant by absorbing the heat into vapour refrigerant and sends back into the compressor.

Drier:

A drier is used in between the condenser and expansion device. The main function of the drier is to absorb the moisture from the liquid refrigerant and filter the dust particles.

Accumulator:

An accumulator is fitted in between the Evaporator and Compressor. It prevents the liquid refrigerant from entering the compressor.

Co-efficeint of performance:

The coefficient of performance of (C.O.P.) of a refrigerating cycle is defined as the ratio between net refrigeration (output) and compressor work (input).

$$C.O.P = \frac{RE}{CW}$$

$RE = H_1 - H_4$

$CW = H_2 - H_1$

$$C.O.P. = \frac{H_1 - H_4}{H2 - H1}$$

Description:

The set up demonstrates the basic principal of a refrigeration cycle. The test rig is designed for the study of Vapour Compression Refrigeration Cycle. The set up consist of Instrumentation is done to measure the temperature & pressure wherever necessary.

Precaution & maintenance instructions:

1. Never run the apparatus if power supply is less than 180 volts and above 230 volts.
2. Do not start unit, before putting the water in the evaporator.
3. During the observation do note open the evaporator.

Experimental procedure:

Starting procedure:

1. Close all the valves V_1 to V_5.
2. For batch operation, fill known amount of water in the evaporator tank.
3. Put the temperature sensor T_6 in the evaporator tank.
4. Note down the reading of temperature T_{6i}.
5. Switch ON the mains power supply.
6. Switch ON the compressor.
7. Wait for 2-3 minutes to switch 'ON' the compressor.
8. Open the valve V_2 and V_3.
9. Switch ON the pump for 30 sec after every 10 minutes.
10. After 10 minutes, note the temperature sensors reading.
11. Note down the voltage and current.
12. Note down the volume of water in evaporator.
13. Note down the time.
14. Note down the reading of pressures.
15. Note all the reading after every 10 minute till the temperature of water in evaporator comes constant.
16. Repeat the experiment for different volume of water.
17. Repeat the experiment by switching 'ON' the heater (load condition)
    - Switch 'OFF' the supply.
    - Close valve V_1 to V_5.
18. For continuous operation, open the valve V_4 and drain the water.
19. Connect pipe evaporator water outlet to drain.
20. Connect water supply to rotameter.
21. Set a flow rate of water with help of valve V_1.
22. Put the temperature sensor T_6 at evaporator water outlet.
23. Repeat the steps 5 to 15.
24. Repeat the experiment for different flow rates of water.

Closing procedure:

1. Switch 'OFF' the main supply.
2. Close water supply to rotameter.
3. Open the valve V_4 to drain out the water.

OBSERVATION & CALCULATION:

Table 2.2: Data

Power factor Cos Φ	= 0.7
Density of water	= 1000 kg/m^3
Specific heat of water C_p	= 4.186 kJ/kg ^{o}C

Table 2.3: Observation table

T_{6i} = ------------ (^{o}C)

For batch operation

Sr. No.	t (min)	P1 (kg/cm^2)	P2 (kg/cm^2)	T1 (^{o}C)	T2 (^{o}C)	T3 (^{o}C)	T4 (^{o}C)	T6 (oC)	Vwe (Ltrs)	V (Volts)	I (Amp)

Table 2.4 Observation table

T_{6i} = ------------ (°C)

For continuous operation

Sr. No	t (min)	P1 (kg/cm²)	P2 (kg/cm²)	T1 (°C)	T2 (°C)	T3 (°C)	T4 (°C)	T5 (oC)	T6 (oC)	Vwr (LPH)	V (Volts)	I (Amp)

CALCULATIONS:

Mark points 1,2,3 using (P_1, T_1), (P_2, T_2), (P_2, T_3) respectively on P-h diagram for (R-134 A) read H_1, H_2 and H_3 (where $H_3 = H_4$).

$$(C.O.P.)_{TH} = \frac{H1 - H4}{H2 - H1}$$

$$RE_{Act} = m_b\, C_p\, (T_{6i} - T_6) \text{(kJ/sec)}$$

$$RE_{Act} = m_c\, C_p\, (T_5 - T_6) \text{ (kJ/sec)}$$

$$CWAct = \frac{V\, I\, Cos \text{ (kJ/sec)}}{1000}$$

Nom	Column Heading	Units	Type
Cos Φ	Power factor.		Given
C_p	Specific heat of water	kJ/kg°C.	Given
(C.O.P.) Rel(b)	Relative co-efficient of performance for batch operation		Calculated

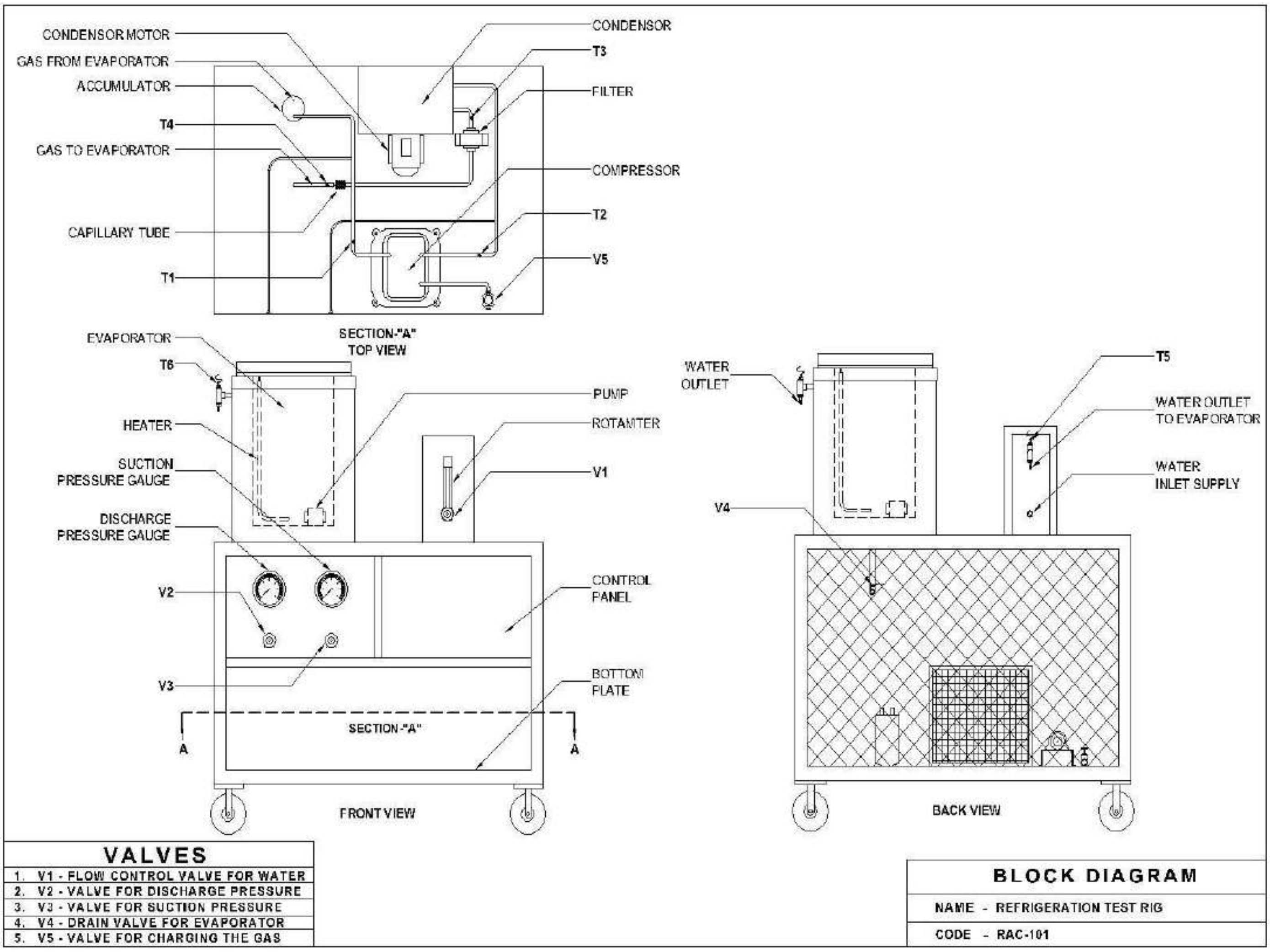
(C.O.P.) Rel(c)	Relative co-efficient of performance for continuous operation		Calculated

Table 5 NOMENCLATURE

(C.O.P.) Th	Theoretical co-efficient of performance.		Calculated
(C.O.P.) Act(b)	Actual co-efficient of performance. for batch operation		Calculated
(C.O.P.) Act(c)	Actual co-efficient of performance for continuous operation		Calculated
CW_{Act}	Actual compression work	kJ/kg	Calculated
H1	Enthalpy of refrigeration effects at compressor inlet	kJ/kg	Calculated
H2	Enthalpy of compressor work at compressor outle	kJ/kg	Calculated
H3	Enthalpy of sub cooling at the outlet of condenser	kJ/kg	Calculated
H4	Enthalpy of refrigerant inlet of evaporator	kJ/kg	Calculated
I	Ammeter reading	Amp.	Measured
m(b)	Mass of water for batch operation	kg/sec.	Calculated
m(c)	Mass of water for continuous operation	kg/sec.	Calculated
P_1	Pressure at compressor suction	kg/cm^2	Measured
P_2	Pressure at compressor discharge	kg/cm^2	Measured
$RE_{Act(b)}$	Actual Refrigeration effect for batch operation	kJ/sec	Calculated
$RE_{Act(c)}$	Actual Refrigeration effect for continuous operation	kJ/sec	Calculated
T_1	Temperature at compressor suction	In C	Measured
T2	Temperature at compressor discharge	In C	Measured
T_3	Temperature at condenser outlet	In C	Measured

T_4	Temperature at evaporator inlet	In C	Measured
T_5	Temperature of water inlet for continuous operation	C	Measured
T_6	Temperature of, water in evaporator for batch cooling / water outlet for continuous operation	C	Measured
T6i	Temperature of water before cooling in batch operation	C	Measured
t	Time	sec	Measured
V	Voltmeter reading	Volts	Measured
V_{we}	Volume of water in evaporator for batch cooling	Ltrs	Measured
V_{wr}	Flow rate of water through evaporator for continuous cooling	LPH	Measured
w	Density of water	kg/m^3	Given

Figure 2.3: BLOCK DIAGRAM



Result(s): COP of the refrigeration test rig

Review Questions

Q1 What is COP?

Q2 What is VC cycle?

Q3 Explain various components of VC cycle

Prepared By-	Reviewed By-	Approved By-

Experiment No. 3

Aim: To evaluate the performance of domestic air conditioner.

List of Equipment Used:

Table 3.1: List of Equipments

S.N.	Equipment	Range	Quantity
1.	Power supply	Single Phase, 220 V	1
2.	Socket with earth connection	5-15 amp	1

Introduction:

Air conditioning is the simultaneous control of the temperature, humidity, motion and purity of the atmosphere in a confined space. Air conditioning applies in the heating season as well as in the cooling season. TheAir conditioning has wide applications in submarine ships, aircrafts and rockets. Air conditioning is associated with the human comfort and controlling the humidity ratio.

Theory:

Air conditioning may be defined as the process of removing heat from a substance under controlled conditions. It also includes the process of reducing and maintaining the temperature of a body below the general temperature of its surroundings. This is widely used for cooling of storage chambers in which perishable foods, drinks, and medicines are stored. Figure shows the schematic of the unit with complete description.

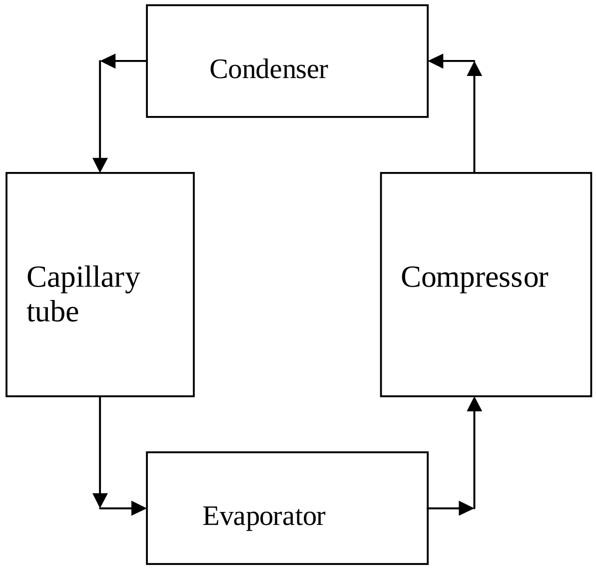


Figure 3.1: VC cycle components

Compressor:

The main function of compressor is to raise the pressure and temperature of the refrigerant by the compression of the refrigerant vapour and then pump it into the condenser.

Condenser:

Condense the high pressure vapour refrigerant into the high pressure liquid by condenser fan and passes it into the receiver tank for recirculation

Capillary tube:

Expands the liquid refrigerant at high pressure to the sub cooled liquid refrigerant at low pressure so that a measured quantity of liquid refrigerant is passed into the evaporator.

Evaporator:

Evaporates the sub cooled liquid refrigerant by absorbing the sensible heat into vapour refrigerant and sends back into the compressor.

Vapour compression cycle:

The refrigerant starts at some initial state or condition, passes through a series of processes in a definite sequence and returns to the initial condition. This series of processes is called a cycle.

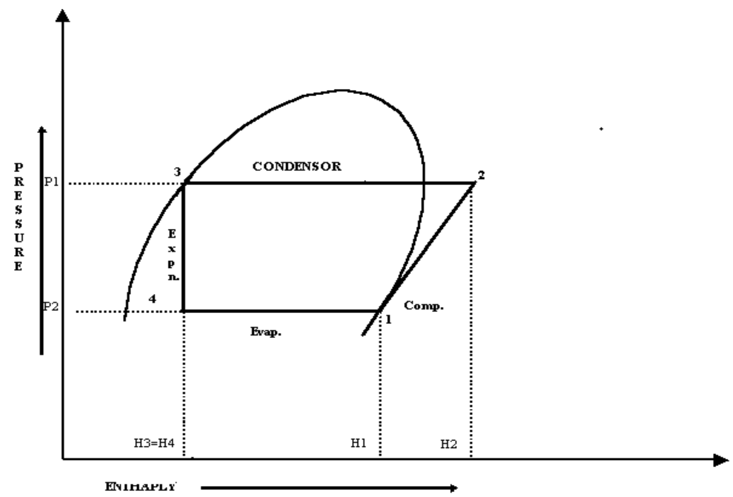


Figure 3.2: Standard vapour compression cycle (svcc):

The Standard Vapour Compressor Cycle (SVCC) consists of the following processes:

- Reversible adiabatic compression from the saturated vapour to a super heated condition.
- Reversible heat rejection at constant pressure (sub cooling liquid and condensation of the refrigerant)
- Irreversible enthalpy expansion from saturated liquid to a low pressure sub cool liquid.

- Reversible heat addition at constant pressure.

Coefficient of performance (c.o.p):

The coefficient of performance of (C.O.P.) of a refrigerating cycle is defined as the ratio between net refrigeration (output) and compressor work (input).

COP = RE/ CW

$RE=H_1 - H_4$

$CW=H_2 - H_1$

$C.O.P= (H_1 – H_4) / H_2 – H_1$

Description:

The window air-conditioning test rig unit is required to conduct experiments and demonstrate the processes of cooling of atmospheric air. The unit consists of a compressor. Both evaporator and the air cooled condenser are mounted on board with separate fans. Air is sucked from the room and is supplied to the room after cooling. The system is provided with energy meter, a digital temperature indicator. The unit will be fitted with all instrumentation facilities so that temperature and pressure can be measured at different points in the air-conditioning system.

Experimental procedure:

Startingprocedure:

1 Close valves of pressure gauges.

2 Switch ‘ON’ the main power supply.

3 Switch ‘ON’ the compressor.

4 Wait for 2-3 minutes for switch ‘ON’ the compressor.

5 Open the valves of pressure gauges.

6 After 10 minutes note down the reading of temperature sensor.

7 Note down the reading of pressure gauges.

8 Note down the voltage & ampere.

9 Repeat steps 6 to 9 after every 10 minutes till the temperature of outlet of air come constant.

Closingprocedure:

1 Switch ‘OFF’ the compressor.

2 Switch ‘OFF’ the mains.

Observation & Calculations:

8.1 OBSERVATION TABLE:

Sr. No.	P1 (kg/cm^2)	P2 (kg/cm^2)	T1 (°C)	T2 (°C)	T3 (°C)	T4 (°C)	T5 (°C)	T6 (°C)	V (Volts)	I (Amp)

Calculations:

$$H1 = (0.011\times T_1 - 1.98)P_1 + (0.652\times T_1) + 415.723$$

$H2 = (0.011 \times T_2 - 1.98)P_2 + (0.652 \times T_2) + 415.723$

$H4 = 1.228 \times T_3 + 199.93$ $(H_3 = H_4)$

$$C.O.P = \frac{H1 - H4}{H1 - H2}$$

Nomenclature:

Nom.	Column Heading	Units	Type
C.O.P.	Co-efficient of performance for compressor	*	Calculated
P_1	Pressure at compressor suction	kg/cm^2	Measured
P_2	Pressure at compressor discharge	kg/cm^2	Measured
T_1	Temperature at compressor suction	°C	Measured
T_2	Temperature at compressor discharge	°C	Measured
T3	Temperature at condenser outlet	°C	Measured
T4	Temperature at evaporator inlet	°C	Measured
T_5	Temperature of air at inlet of duct	°C	Measured
T_6	Temperature of air at outlet of duct	°C	Measured
H_1	Enthalpy of refrigeration effects at compressor inlet	kJ/ kg	Calculated
H_2	Enthalpy of compressor work at compressor outlet	kJ/ kg	Calculated
H_3	Enthalpy of sub cooling at the outlet of condenser	kJ/ kg	Calculated
H_4	Enthalpy of refrigerant inlet of evaporator	kJ/ kg	Calculated

I	Ampere meter reading	Amps	Measured
V	Voltmeter reading	Volts	Measured

Precaution & maintenance instructions:

10.1 Operate the Valves gently.

10.2 Never run the apparatus if power supply is less than 180 volts and above 230 volts.

10.3 Duct should be free from dust particles.

Result(s): COP of the vapour compression refrigeration system

Review Questions

Q1 What is COP?

Q2 What is VC cycle?

Q3 Explain various components of VC cycle

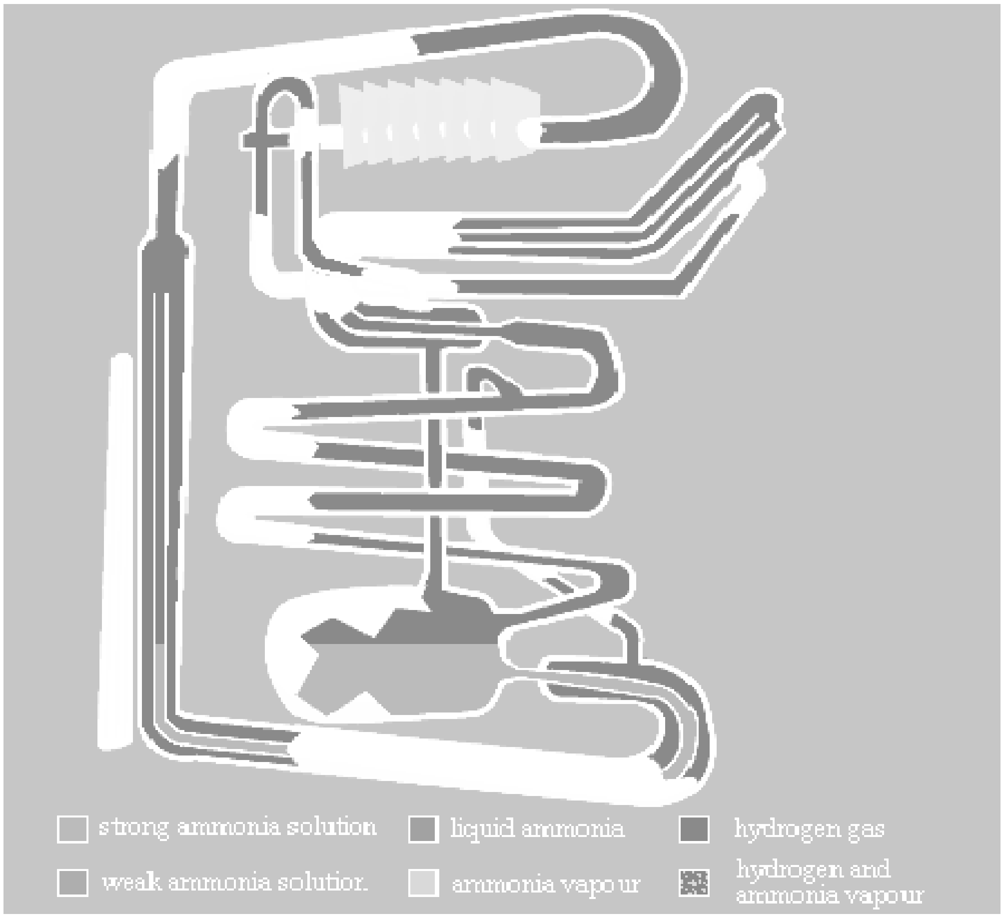
Q.4 what are pychrometric processes

Prepared By-	**Reviewed By-**	**Approved By-**

Experiment No 4

Aim: Study the performance of Electro-Lux-Refrigrator.

Theory: This type of refrigerator is generally used for domestic purposes as it is more complicated in its instructions and work. This type of refrigerator was developed first in 1925 by Munters and Boltzervon when they were at Royal Institute of Technology. This type of refrigerator is known as three fluids absorptions system.



The elimination of aqua pump from the absorption machine would produce a system with a complete absence of moving parts and working input .the main purpose to eliminate the pump is to make the machine noiseless. It use a refrigerant , a solvent and an inert gas for working of system .

This inert gas is confined to low side of the system only by this absence. It is possible to maintain the uniform pressure throughout the system and at the same time permitting the refrigerant to evaporate at low temperature. Corresponding to its partial pressure. In high pressure side of the system, there exists only the refrigerant which is subjected to total pressure of the system so that it is condensed by using the normal cooling the water or air as it is done in other system.n low system side of system, the total pressure is the sum of partial pressure of ammonia vapor and the partial pressure of hydrogen which is used as inert gas. The liquid ammonia which comes into the evaporator evaporates at the partial pressure of ammonia.

WORKING: The strong aqua ammonia solution is heated in generator by the application of external heat source and NH_3 vapor is removed from the solution the water vapor caused with the NH_3 vapor is passed in the condenser and it is condensed by using the external cooling of source. The liquid NH_3 from under gravity to evaporator and it is evaporated in the presence of hydrogen atmosphere absorbing the heat from the evaporator and it maintain low temperature in the evaporator. This mixture of hydrogen and ammonia vapor is passed into the absorber and the work solution of the aqua ammonia solution comes in contact with the hydrogen and ammonia vapor and it absorb only ammonia, making the solution rich in ammonia and hydrogen is separated as shown in fig this strong solution is further passed to the generator and it completes the cycle.

There is pump to create the pressure differential between condenser and evaporator or not as expansion value. The evaporator side is changed with H_2 so that total pressure is same as that of condenser side.The cycle operates on the principle of Dalton's law where pr.(NH_3)+pr.(H_2)=Constant ,so that the total pressure is same throughout the system. Due to the presence of H_2 in the low side of the system, pressure of NH_3 will be below that of NH_3 on the condenser side. Thus the NH_3 can evaporate at low pressure while H_2 takes no parts in the process except to supply its partial pressure to maintain the balance.H_2 is prevented entering into the condenser side by strong solutions forming a trap absorber and liquid Nh3. U-trap at the condenser outlet. The H_2 returns to the evaporator having no affinity for the absorbent. The H_2 is held in this position by the U tube.

Due to the small pressure difference in this system, solution is circulated through absorber and generator by the thermal action. The parts are so arranged that the liquid refrigerant flow to the evaporator by the gravity action only. Core is taken to keep the hydrogen isolated in the proper parts of the system. Otherwise the pressure will be unbalanced and machine will stop.

The liquid NH_3 also evaporates in the presence of air or other inert gases, but lightest the gas, the faster .The evaporation takes place, since H_2 is the light gas and readily available and is also non-corrosive and in insoluble in water, it is generally used for this type of refrigeration system

Experiment No. 5

Aim: To calculate the COP of an Ice Plant Tutor

Table 1: List of Equipments

S.N.	Equipment	Range	Quantity
1.	Power supply	Single Phase, 220 V	1
2.	Ethylene glycol	NA	20 Litre
3.	Socket with earth connection	5-15 amp	1
4.	Water Supply	NA	NA

Introduction:

Natural ice is used for preservation purposes for a very long time. But it has been replaced to a large extend by manufactured ice since the beginning of twentieth century because of the uncertainly of the natural supply and also because of the cost of transportation to the retail trade. The manufacture of ice is one of the principal needs of refrigeration and it will continue, as ice is the cheapest means for short time preservation of food. A vast amount of research has been put in developing a least-expensive means of manufacture. The quantity of ice required for different purposes is very large so that the manufacture of ice is one of the principal applications of refrigeration. Ice factories are commonly installed now in every small town of India to fulfill day-to-day requirements of the people. The appearance of the ice plays important role for the sale in the retail trade. Therefore, preliminary chemical treatment and filtration of water, agitation of water during freezing to ensure transparency, core sucking to remove impurities from the water supply and scoring of the ice cakes in sizes required for retail trade, are important features of ice manufacturing. In present day ice factories, all the operations mentioned above are automatically done to keep the speed of production and distribution.

Theory:

The vapour compression refrigeration cycle is based on a circulating fluid media viz, a refrigerant having special properties of vaporizing at temperatures lower than the ambient and condensing back to the liquid form, at slightly higher than ambient conditions by controlling the saturation temperature and pressure. When the refrigerant evaporates or boils at temperatures lower then ambient it extracts or removes heat from the load and lowers the temperature consequently providing cooling. The superheated vapour is increased to a level by the compressor to reach a saturation pressure so that heat added to vapour is dissipated/rejected into the atmosphere, using operational ambient conditions with cooling medias such as air or water. The vapour is condensed to the liquid form and recycled again to form the refrigeration cycle. The main components used in refrigeration cycle are:

1. Compressor
2. Condenser
3. Throttling device
4. Evaporator.

The working and function of these components is given below:

1 Compressor:

The compressor is known as the heart of the refrigeration system. It pumps the refrigerant vapour in refrigeration cycle as the heart pumps blood in the body. The low temperature, pressure, super heated vapour from the evaporator is conveyed through suction line and compressed by compressor to a high pressure, without any change of gaseous state and the same is discharged into condenser. During this process heat is added to the refrigerant and is known as heat compression. The compressor should have a compression ratio to raise the pressure of refrigerant to such a level that the saturation temperature of the discharged refrigerant is higher than the temperature of the available cooling medium, to enable the superheated refrigerant to condenser at normal ambient condition.

2 Condenser:

The heat added in the evaporator and compressor to the refrigerant is rejected in condenser at high temperature. This superheated refrigerant vapours enters the condenser to dissipate its heat in three stages. First on entering the refrigerant loses its super heat, it then loses its latent heat at which the refrigerant is liquefied at saturation temperature pressure. This liquid loses its sensible heat, further the refrigerant leaves the condenser as a sub-cooled liquid. The heat transfer from refrigerant to cooling medium takes place in the condenser. The sub-cooled liquid from condenser is collected in a reservoir and is then fed through the throttling device by liquid line to the evaporator. There are several methods of dissipating the rejected heat into the atmosphere by condenser.

There are water-cooled, air cooled and evaporative cooled condensers.

3 Throttling device:

Throttling device is designed to pass maximum possible liquid refrigerant to obtain a good refrigeration effect. The line should be properly designed to have minimum pressure drop. The throttling device is a pressure reducing device and a regulator for controlling the refrigerant flow. It also reduces the pressure from the discharge pressure to the evaporator pressure without any change of state of the liquid refrigerant. Various types of throttling devices are:

- Capillary tubes
- Thermostatic valves
- Hand expansion valves
- Hand valves

4 Evaporator:

The liquid refrigerant from the condenser at high pressure is fed through a throttling device to an evaporator at a low pressure. On absorbing the heat to be extracted from media to be cooled, the liquid refrigerant boils actively in the evaporator and changes state. The refrigerant gains latent heat to vaporize at saturation temperature / pressure and further absorbs sensible heat from media to be cooled and gets fully vaporized and superheated.

Coefficient of performance:

The coefficient of performance of (C.O.P.) of a refrigerating cycle is defined as the ratio between net refrigeration (output) and compressor work (input).

$$C.O.P = \frac{RE}{CW}$$

$$RE = H_1 - H_4$$

$$CW = H_2 - H_1$$

$$C.O.P = (H_1 - H_4) / (H_2 - H_1)$$

Description:

The test rig is designed for the study of thermodynamics of vapour compression refrigeration cycle by way of demonstration and experimentation. It has a facility to measure various parameters for experimentation. Ice cans are kept in Ethylene Glycol solution, which is cooled by the refrigerant evaporator. A pump is provided for the uniform temperature distribution of Ethylene Glycol solution. As conventional ice plants take 12-24 hours to complete the cycle, this ice plant is specially designed to demonstrate all the processes of ice formation and hence it is most suitable for laboratory use.

Precaution & maintenance instructions:

1 Never run the apparatus if power supply is less than 180 volts and above 230 volts.

2 Always close the door of the tank during experimentation open the door only for putting ice tray or lifting the same.

Experimental procedure:

Startingprocedure:

1. Close all the valves V_1 to V_4.
2. Ensure that ON/OFF switches given on the panel are at 'OFF' position.
3. Prepare Ethylene glycol solution by mixing 20 L Ethylene Glycol and 20 L water.
4. Open the door of evaporator tank, fill the solution in the tank and note down the temperature (T_i).
5. Switch ON the mains supply.
6. Switch ON the compressor

7. Wait for 2-3 minute till the compressor switch 'ON'.
8. Switch ON the pump.
9. Fill the water in the ice tray.
10. Put temperature sensor T_6 in the tray water.
11. Wait till Ethylene Glycol temperature reaches up to 0^oC.
12. Put the ice tray in the tank in this way that solution does not comes in contact with water directly.
13. Open the valve V_1 and V_2.
14. After 10 minutes, Note down the temperature sensors reading.
15. Note down the voltage.
16. Note down the current.
17. Note down pressure gauge reading.
18. Note down the time.
19. Repeat steps 14 to 18 till the temperature of water in the ice tray reaches upto 0^oC.
20. Remove the sensor T_6.
21. Lift the tray from the tank outside and collect the ice from the tray.

Closing procedure:

1 Switch OFF the compressor.

2 Switch OFF the pump.

3 Switch OFF the mains supply.

4 Connect the temperature sensor T6 back to the connector.

5 Open the valve V3 to drain the ethylene glycol solution.

Observation & calculation:

Table 2: Data available	
Power factor	Cos Φ= 0.8
Specific heat of Ethylene Glycol solution	Cps = 3.735 kJ/kg-oC
Density of Ethylene Glycol solution	ρs = 1070 kg/m3

8.2 Observation table:

V_b = 40 Ltrs.

T_i = _________ (°C) , = _________

Sr. No.	t (min)	P1 (kg/cm²)	P2 (kg/cm²)	T1 (°C)	T2 (°C)	T3 (°C)	T4 (°C)	T5 (°C)	T6 (°C)	V (Volts)	I (Amps)

Calculations:

Mark points (P_1, T_1), (P_2, T_2) and (P_2, T_3) on P-h Chart and note the H_1, H_2 and H_3 (H_3 = H_4) **(**R-134a)

$$COP_{theo} = \frac{H_1 - H_3}{H_2 - H_1}$$

$$= \frac{V_b \times \rho_s}{t \times 1000} \text{ (kg/sec)}$$

$$N = M \times C_{ps} \times (T_i - T_5) \text{ (kJ/sec)}$$

$$W = \frac{V \times I \times Cos\,\phi}{1000} \text{ (kJ/sec)}$$

$$COP_{act} = \frac{N}{W}$$

M

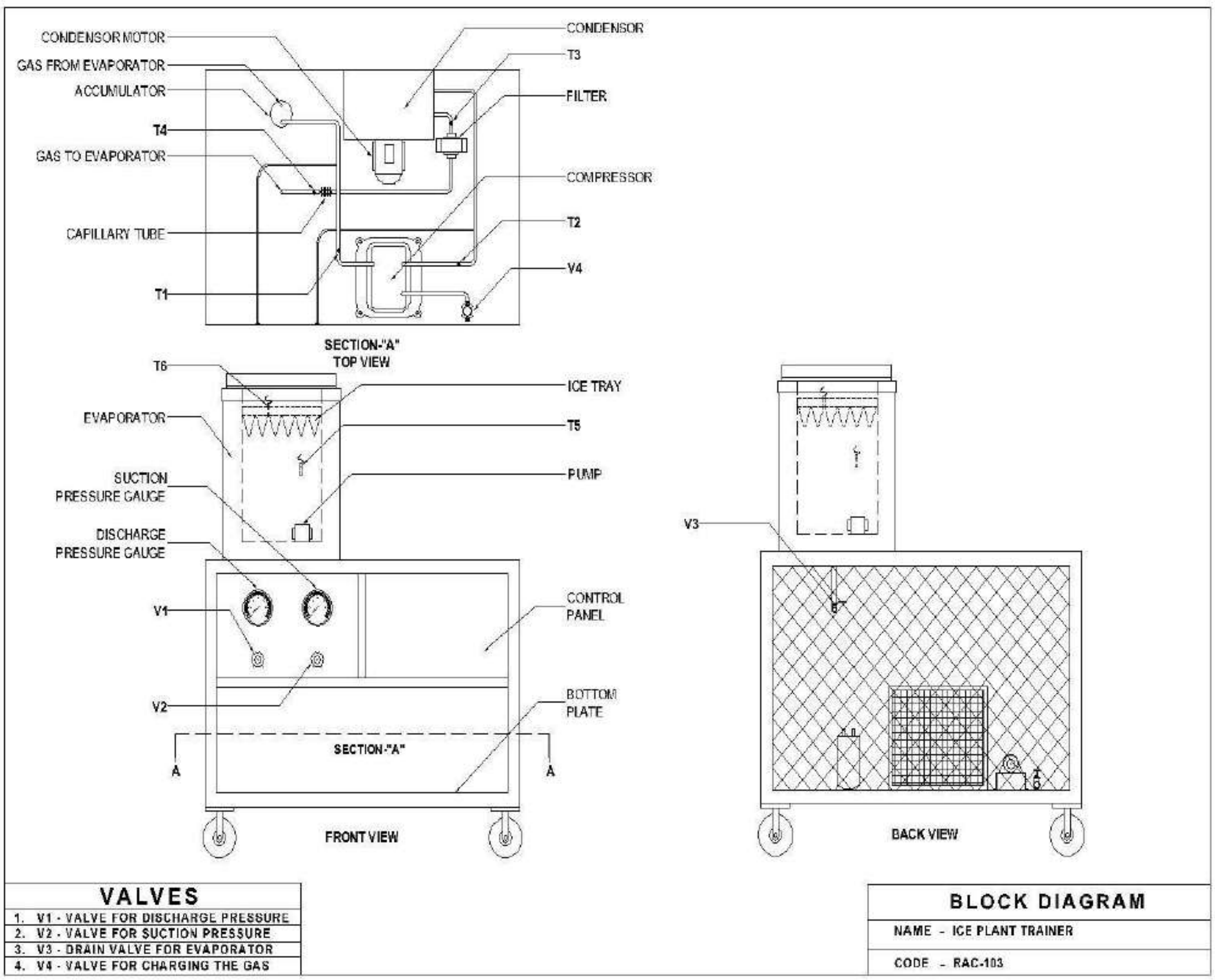
$$COP_{rel} = \frac{COP\ act}{COP_{theo}}$$

Nomenclature:

Nom	Column Heading	Units	Type
Cos ф	Power factor.		Given
Cps	Specific heat of Ethylene Glycol solution	kJ/kg-°C	Given
H1	Enthalpy of refrigeration effects at compressor inlet	kJ/kg	Measured

H2	Enthalpy of compressor work at compressor outlet	kJ/kg	Measured
H3	Enthalpy of sub cooling at the outlet of condenser	kJ/kg	Measured
H4	Enthalpy of refrigerant inlet of evaporator	kJ/kg	Measured
I	Ampere meter reading	Amp.	Measured
M	Mass of Ethylene Glycol solution	kg/sec	Calculated
N	Net refrigerating effect	kg/sec	Calculated
P1	Compressor inlet pressure	kg/cm^2	Measured
P2	Compressor outlet pressure	kg/cm^2	Measured
T_1	Compressor inlet temperature	^oC	Measured
T2	Compressor outlet temperature	^oC	Measured
T_3	Condenser outlettemperature	^oC	Measured
T4	Evaporator inlet temperature	^oC	Measured
T5	Final temperature of Ethylene Glycol solution	^oC	Measured
T6	Ice temperature	^oC	Measured
Ti	Initial temperature of Ethylene Glycol solution	^oC	Measured
t	Time	sec	Measured
V	Voltage Reading	Volts	Measured
Vb	Volume of Ethylene Glycol solution in the tank	m^3	Measured
W	Power consumed by compressor	kJ/sec	Calculated
ρs	Density of Ethylene Glycol solution	kg/m^3	Given
COP_{rel}	Relative co-efficient of Performance		Calculated
COP_{ac}	Actual co-efficient of Performance		Calculated
COP_{theo}	Theoretical co-efficient of Performance		Calculated

13. BLOCK DIAGRAM



Result(s): COP of the ice plant is found

Review Questions

Q1 What is COP?

Q2 What is VC vycle?

Q3 Explain various components of VC cycle

Prepared By	Reviewed By	Approved By

Experiment No. 6

Aim:

To find COP of year round in condition.

List of Equipment Used:

Table 1: List of Equipments

S.N.	Equipment	Range	Quantity
1.	Power supply	Single Phase, 220 V	1
2.	Socket with earth connection	5-15 amp	1

Introduction:

Air conditioning is the simultaneous control of the temperature, humidity, motion and purity of the atmosphere in a confined space. Air conditioning applies in the heating season as well as in the cooling season. The Air conditioning has wide applications in submarine ships, aircrafts and rockets. Air conditioning is associated with the human comfort and controlling the humidityratio.

Theory:

Air conditioning may be defined as the process of removing heat from a substance under controlled conditions. It also includes the process of reducing and maintaining the temperature of a body below the general temperature of its surroundings

Compressor:

The main function of compressor is to raise the pressure and temperature of the refrigerant by the compression of the refrigerant vapour and then pump it into the condenser.

Condenser:

Condense the high pressure vapour refrigerant into the high pressure liquid by condenser fan and passes it into the receiver tank for recirculation

Capillary tube:

Expands the liquid refrigerant at high pressure to the sub cooled liquid refrigerant at low pressure so that a measured quantity of liquid refrigerant is passed into the evaporator.

Evaporator:

Evaporates the sub cooled liquid refrigerant by absorbing the sensible heat into vapourrefrigerant and sends back into the compressor.

Vapour compressioncycle:

The refrigerant starts at some initial state or condition, passes through a series of

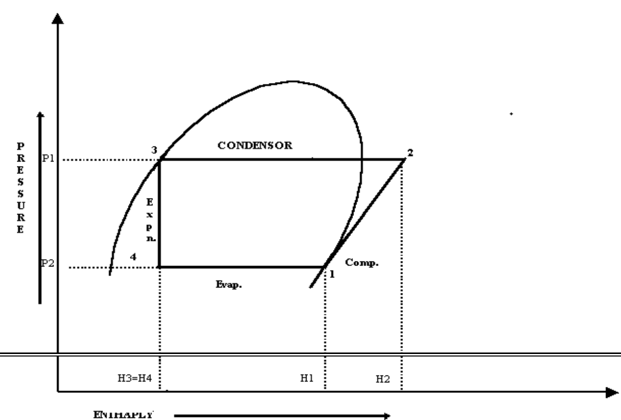


Figure 2: Standard vapour compression cycle (svcc):

processes in a definite sequence and returns to the initial condition. This series of processes is called acycle.

The Standard Vapour Compressor Cycle (SVCC) consists of the following processes

- Reversible adiabatic compression from the saturated vapour to a super heatedcondition.
- Reversible heat rejection at constant pressure (sub cooling liquid and condensation of therefrigerant)
- Irreversible enthalpy expansion from saturated liquid to a low pressure sub coolliquid.
- Reversible heat addition at constant pressure.

Coefficient of performance (c.o.p):

The coefficient of performance of (C.O.P.) of a refrigerating cycle is defined as the ratio between net refrigeration (output) and compressor work (input).

$$C.O.P = \frac{RE}{CW}$$

$$RE = H_1 - H_4$$

$CW = H_2 - H_1$

$$C.O.P = \frac{H_1 - H_4}{H_2 - H_1}$$

Description:

The air-conditioning test rig unit is required to conduct experiments and demonstrate the processes of cooling of atmospheric air. The unit consists of a compressor. Both evaporator and the air cooled condenser are mounted on board with separate fans. Air is sucked from the room and is supplied to the room after cooling. The system is provided with voltmeter and ammeter, a digital temperature indicator. The unit will be fitted with all instrumentation facilities so that temperature and pressure can be measured at different points in the air-conditioning system. Steam generator is provided from which steam comes directly to the air inlet of air conditioning. Suitable valves and fittings are fitted in the pipe line of steam. Water level indicator is provided to safe guard of heater.

Precaution & maintenanceinstructions:

1. Operate the Valves gently.
2. Never run the apparatus if power supply is less than 180 volts and above 230 volts.
3. Duct should be free from dustparticles.

Experimentalprocedure:

1.1 Close all thevalves.

1.2 Switch 'ON' the main power supply.

1.3 Switch 'ON' thecompressor.

1.4 Wait for 2-3 minutes for switch 'ON' thecompressor.

1.5 Open both the valves below pressureguages.

1.6 After 10 minutes note down the reading of temperaturesensor.

1.7 Note down the reading of pressuregauges.

1.8 Note down theVoltage.

1.9 Note down thecurrent.

1.10 Repeat steps 6 to 9 after every 10 minutes till the temperature of outlet of air come constant.

Observation &calculation:

Table 2: OBSERVATIONTABLE

Sr. No.	P1 (kg/cm2)	P2 (kg/cm2)	T1 (□C)	T2 (□C)	T3 (□C)	T4 (□C)	T5 (□C)	T6 (□C)	V (Volts)	I (Amp)

Calculations:

Mark points 1, 2, 3 using (P1, T1), (P2, T2) and (P2, T3) respectively on P-h diagram for **(**R-22) and read H1, H2 and H3 (where H3 = H4) to calculate COP.

$$C.O.P = \frac{H_1 - H_4}{H_2 - H_1}$$

For cooling andhumidification:

Starting procedure

1. Close valves below the pressuregauges.
2. Open the funnel and air vent valve of steamgenerator.
3. Fill water in the steam generator upto 3/4th of its capacity by observing the level of

   water in levelindicator.

4. Switch 'ON' the main powersupply.
5. Switch 'ON' the heater of steam generator and set the temperature of steam with the help of DTC (100-120 oC). And wait until steam temperature reaches desired value.
6. Switch 'ON' thecompressor.
7. Wait for 2-3 minutes for switch 'ON' thecompressor.
8. Open the valves below thegauges.
9. Allow steam to pass through the pipe and slowly open the wet steam vent valve to release wet steam from thepipe.
10. Close the wet steam ventvalve.
11. Rotate psychrometer and note down the ambient temperature ofair.
12. After 10 minutes note down the temperature of air by putting sling psychrometrer in front of airduct.
13. Note down the reading of pressure gauges and temperaturesensors.
14. Note down theVoltage.
15. Note down thecurrent.

Repeat steps 6 to 9 after every 10 minutes till the temperature of outlet of air come constant

Closing procedure:

1. Stop steam supply by closing the steamvalve.
2. Switch 'OFF' thecompressor.
3. Switch 'OFF' themains.
4.

Observation & calculation:

Table 3: observation table

Sr.No.	Time (t)	Ambient Temp.		Conditioning Temp.	
		Dry(T7)	Wet(T8)	Dry(T9)	Wet(T10)

Calculations:

To calculate the specific humidity X1 at temperature T7 &T8.

X(kg/kg ofdryair) [from psychrometric chart]

To calculate the specific humidity X2 at temperature T9 &T10

X_2 (kg/kg ofdryair) [from psychrometricchart]

$X = X_2 - X_1$ (kg/kg of dry air)

T = T8 – T7 (oC)

For heating:

Starting procedure:

1. Switch 'ON' the main powersupply.
2. Switch 'ON' the air heater.
3. After 10 minutes note down the temperature of ambient air by rotating sling psychrometer and also of conditioned air by putting sling psychrometer in front of air duct.

Closing procedure

1. Switch 'OFF' theheater.
2. Switch 'OFF' the mains powersupply.

Observation & calculation:

Table 4: OBSERVATION TABLE

Sr.No.	Time t	Ambient Temp.		Conditioning Temp.	
		Dry(T7)	Wet(T8)	Dry(T9)	Wet(T10)

Calculations:

To calculate the specific humidity X1 at temperature T7 &T8.

X(kg/kg ofdryair) [from psychrometric chart]

To calculate the specific humidity X2 at temperature T9 &T10

X_2 (kg/kg ofdryair) [from psychrometricchart]

$X = X_2 - X_1$ (kg/kg of dry air)

T = T8 – T7 (oC)

Nomenclature:

Nom	Column Heading	Units	Type
C.O.P.	Co-efficient of performance		Calculated
CW	Compressor work	kJ/ kg	Calculated
H1	Enthalpy of refrigeration effects at compressor inlet	kJ/ kg	Calculated
H2	Enthalpy of compressor work at compressor outlet	kJ/ kg	Calculated

H3	Enthalpy of sub cooling at the outlet of condenser	kJ/ kg	Calculated
H4	Enthalpy of refrigerant inlet of evaporator	kJ/ kg	Calculated
I	Ampere meter reading	Amps	Measured
P1	Pressure at compressor suction	kg/cm2	Measured
P2	Pressure at compressor discharge	kg/cm2	Measured
T1	Temperature at compressor suction	° C	Measured
T2	Temperature at compressor discharge	° C	Measured
T3	Temperature at condenser outlet	° C	Measured
T4	Temperature at evaporator inlet	° C	Measured
T5	Temperature of air at inlet of duct	° C	Measured
T6	Temperature of air at outlet of duct	° C	Measured
V	Voltmeter reading	Volts	Measured
T7	Dry bulb temperature of ambient air	° C	Measured
T8	Wet bulb temperature of ambient air	° C	Measured
T9	Dry bulb temperature of conditioning air	° C	Measured
T10	Wet bulb temperature of conditioning air	° C	Measured

Result(s): COP of the vapour compression Air refrigeration system and P-h diagram.

Review Questions

Q1 What is COP?

Q2 What is VC cycle?

Q.3 What are pychrometric processes

CHANDIGARH UNIVERSITY

DEPARTMENT OF MECHANICAL ENGINEERING

REFRIGERATION & AIR CONDITIONING LAB	Subject Code: MEY – 303 / MEP-358

Prepared By-	Reviewed By-	Approved By-

Experiment No – 7

Aim – Visit to a HVAC plant for studying the various processes for Winter and summer air conditioning.

Experiment No. 8

Aim: To calculate COP of water cooler unit.

List of Equipment Used:

Table 1: List of Equipments

S.N.	Equipment	Range	Quantity
1.	Power supply	Single Phase, 220 V	1
2.	Ethylene glycol	NA	20 Litre
3.	Socket with earth connection	5-15 amp	1
4.	Water Supply	NA	NA

Introduction:

Natural ice is used for preservation purposes for a very long time. But it has been replaced to a large extend by manufactured ice since the beginning of twentieth century because of the uncertainly of the natural supply and also because of the cost of transportation to the retail trade. The manufacture of ice is one of the principal needs of refrigeration and it will continue, as ice is the cheapest means for short time preservation of food. A vast amount of research has been put in developing a least-expensive means of manufacture. The quantity of ice required for different purposes is very large so that the manufacture of ice is one of the principal applications of refrigeration. Ice factories are commonly installed now in every small town of India to fulfill day-to-day requirements of the people. The appearance of the ice plays important role for the sale in the retail trade. Therefore, preliminary chemical treatment and filtration of water, agitation of water during freezing to ensure transparency, core sucking to remove impurities from the water supply and scoring of the ice cakes in sizes required for retail trade, are important features of ice manufacturing. In present day ice factories, all the operations mentioned above are automatically done to keep the speed of production and distribution.

Theory:

The vapour compression refrigeration cycle is based on a circulating fluid media viz, a refrigerant having special properties of vaporizing at temperatures lower than the ambient and condensing back to the liquid form, at slightly higher than ambient conditions by controlling the saturation temperature and pressure. When the refrigerant evaporates or boils at temperatures lower then ambient it extracts or removes heat from the load and lowers the temperature consequently providing cooling. The superheated vapour is increased to a level by the compressor to reach a saturation pressure so that heat added to vapour is dissipated/rejected into the atmosphere, using operational ambient conditions with cooling medias such as air or water. The vapour is condensed to the liquid form and recycled again to form the refrigeration cycle. The main components used in refrigeration cycle are:

1 Compressor

2 Condenser

3 Throttling device

4 Evaporator.

The working and function of these components is given below:

1 Compressor:

The compressor is known as the heart of the refrigeration system. It pumps the refrigerant vapour in refrigeration cycle as the heart pumps blood in the body. The low temperature, pressure, super heated vapour from the evaporator is conveyed through suction line and compressed by compressor to a high pressure, without any change of gaseous state and the same is discharged into condenser. During this process heat is added to the refrigerant and is known as heat compression. The compressor should have a compression ratio to raise the pressure of refrigerant to such a level that the saturation temperature of the discharged refrigerant is higher than the temperature of the available cooling medium, to enable the superheated refrigerant to condenser at normal ambient condition.

2 Condenser:

The heat added in the evaporator and compressor to the refrigerant is rejected in condenser at high temperature. This superheated refrigerant vapours enters the condenser to dissipate its heat in three stages. First on entering the refrigerant loses its super heat, it then loses its latent heat at which the refrigerant is liquefied at saturation temperature pressure. This liquid loses its sensible heat, further the refrigerant leaves the condenser as a sub-cooled liquid. The heat transfer from refrigerant to cooling medium takes place in the condenser. The sub-cooled liquid from condenser is collected in a reservoir and is then fed through the throttling device by liquid line to the evaporator. There are several methods of dissipating the rejected heat into the atmosphere by condenser.

There are water-cooled, air cooled and evaporative cooled condensers.

3 Throttling device:

Throttling device is designed to pass maximum possible liquid refrigerant to obtain a good refrigeration effect. The line should be properly designed to have minimum pressure drop. The throttling device is a pressure reducing device and a regulator for controlling the refrigerant flow. It also reduces the pressure from the discharge pressure to the evaporator pressure without any change of state of the liquid refrigerant. Various types of throttling devices are:

- Capillary tubes
- Thermostatic valves
- Hand expansion valves
- Hand valves

4 Evaporator:

The liquid refrigerant from the condenser at high pressure is fed through a throttling device to an evaporator at a low pressure. On absorbing the heat to be extracted from media to be cooled, the liquid refrigerant boils actively in the evaporator and changes state. The refrigerant gains latent heat to vaporize at saturation temperature / pressure and further absorbs sensible heat from media to be cooled and gets fully vaporized and superheated.

Coefficient of performance:

The coefficient of performance of (C.O.P.) of a refrigerating cycle is defined as the ratio between net refrigeration (output) and compressor work (input).

$$C.O.P = \frac{RE}{CW}$$

$$RE = H_1 - H_4$$

$$CW = H_2 - H_1$$

$$C.O.P = (H_1 - H_4) / (H_2 - H_1)$$

Description:

The test rig is designed for the study of thermodynamics of vapour compression refrigeration cycle by way of demonstration and experimentation. It has a facility to measure various parameters for experimentation. Ice cans are kept in Ethylene Glycol solution, which is cooled by the refrigerant evaporator. A pump is provided for the uniform temperature distribution of Ethylene Glycol solution. As conventional ice plants take 12-24 hours to complete the cycle, this ice plant is specially designed to demonstrate all the processes of ice formation and hence it is most suitable for laboratory use.

Precaution & maintenance instructions:

1 Never run the apparatus if power supply is less than 180 volts and above 230 volts.

2 Always close the door of the tank during experimentation open the door only for putting ice tray or lifting the same.

Experimental procedure:

Startingprocedure:

1. Close all the valves V_1 to V_4.
2. Ensure that ON/OFF switches given on the panel are at 'OFF' position.

i. Prepare Ethylene glycol solution by mixing 20 L Ethylene Glycol and 20 L water.

ii. Open the door of evaporator tank, fill the solution in the tank and note down the temperature (T_i).

iii. Switch ON the mains supply.

iv. Switch ON the compressor

v. Wait for 2-3 minute till the compressor switch 'ON'.

vi. Switch ON the pump.

vii. Fill the water in the ice tray.

viii. Put temperature sensor T_6 in the tray water.

ix. Wait till Ethylene Glycol temperature reaches up to 0^oC.

x. Put the ice tray in the tank in this way that solution does not comes in contact with water directly.

xi. Open the valve V_1 and V_2.

xii. After 10 minutes, Note down the temperature sensors reading.

xiii. Note down the voltage.

xiv. Note down the current.

xv. Note down pressure gauge reading.

xvi. Note down the time.

xvii. Repeat steps 14 to 18 till the temperature of water in the ice tray reaches upto 0^oC.

xviii. Remove the sensor T_6.

xix. Lift the tray from the tank outside and collect the ice from the tray.

Closingprocedure:

1 Switch OFF the compressor.

2 Switch OFF the pump.

3 Switch OFF the mains supply.

4 Connect the temperature sensor T6 back to the connector.

5 Open the valve V3 to drain the ethylene glycol solution.

Observation & calculation:

Table 2: Data available	
Power factor	Cos Φ= 0.8
Specific heat of Ethylene Glycol solution	Cps = 3.735 kJ/kg-oC
Density of Ethylene Glycol solution	ρs = 1070 kg/m3

8.2 Observation table:

V_b = 40 Ltrs.

T_i = _________ (°C) , = _________

Sr. No.	t (min)	P1 (kg/cm^2)	P2 (kg/cm^2)	T1 (°C)	T2 (°C)	T3 (°C)	T4 (°C)	T5 (°C)	T6 (°C)	V (Volts)	I (Amps)

Calculations:

Mark points (P_1, T_1), (P_2, T_2) and (P_2, T_3) on P-h Chart and note the H_1, H_2 and H_3 (H_3 = H_4) **(**R-134a)

$$COP_{theo} = \frac{H_1 - H_3}{H_2 - H_1}$$

$$= \frac{V_b \times \rho_s}{t \times 1000} \text{ (kg/sec)}$$

$$N = M \times C_{ps} \times (T_i - T_5) \text{ (kJ/sec)}$$

$$W = \frac{V \times I \times Cos\,\phi}{1000} \text{ (kJ/sec)}$$

$$COP_{act} = \frac{N}{W}$$

M

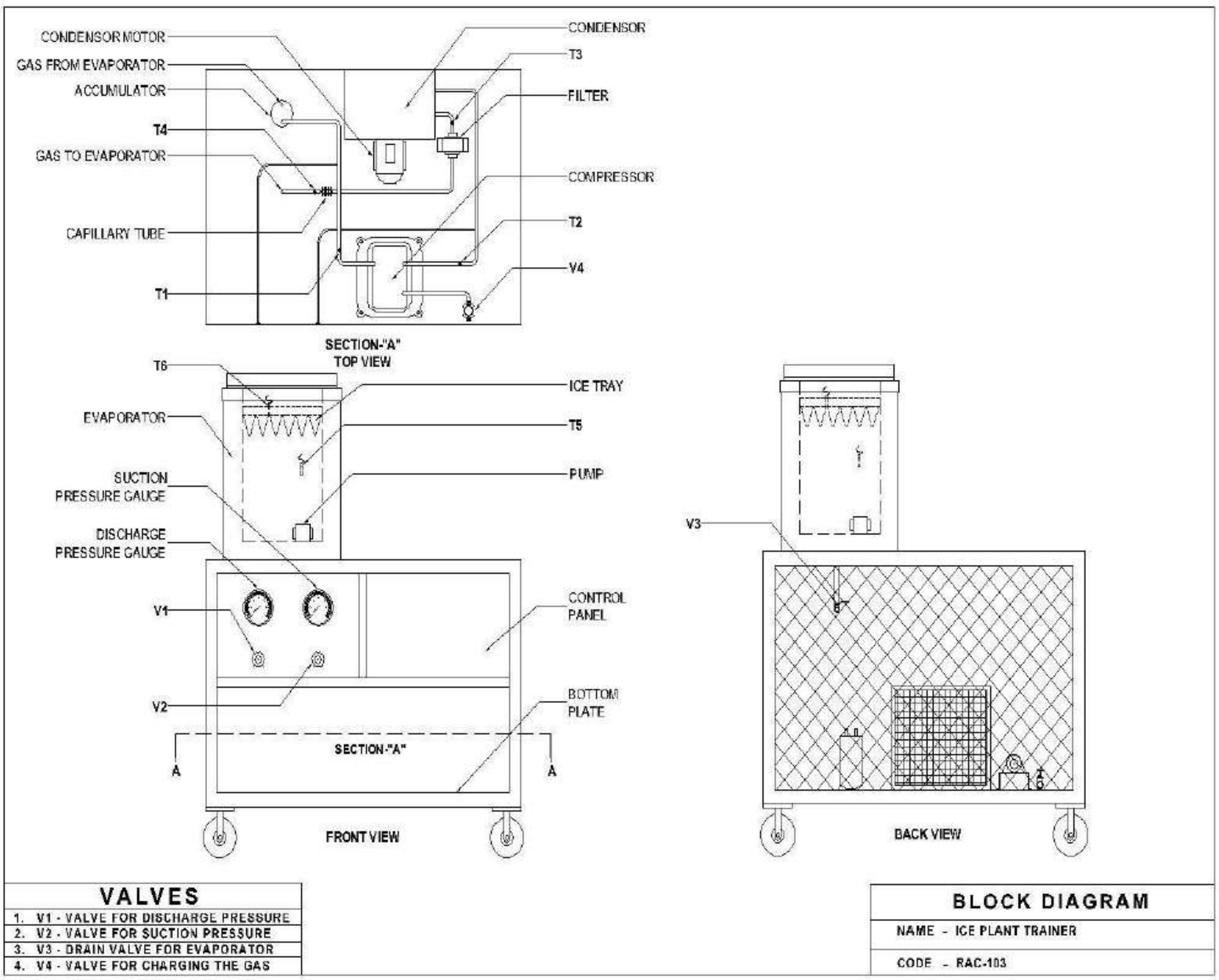
$$COP_{rel} = \frac{COP\ act}{COP_{theo}}$$

Nomenclature:

Nom	Column Heading	Units	Type
Cos ϕ	Power factor.		Given
Cps	Specific heat of Ethylene Glycol solution	kJ/kg-°C	Given
H1	Enthalpy of refrigeration effects at compressor inlet	kJ/kg	Measured
H2	Enthalpy of compressor work at compressor outlet	kJ/kg	Measured
H3	Enthalpy of sub cooling at the outlet of condenser	kJ/kg	Measured

H4	Enthalpy of refrigerant inlet of evaporator	kJ/kg	Measured
I	Ampere meter reading	Amp.	Measured
M	Mass of Ethylene Glycol solution	kg/sec	Calculated
N	Net refrigerating effect	kg/sec	Calculated
P1	Compressor inlet pressure	kg/cm^2	Measured
P2	Compressor outlet pressure	kg/cm^2	Measured
T_1	Compressor inlet temperature	^oC	Measured
T2	Compressor outlet temperature	^oC	Measured
T_3	Condenser outlettemperature	^oC	Measured
T4	Evaporator inlet temperature	^oC	Measured
T5	Final temperature of Ethylene Glycol solution	^oC	Measured
T6	Ice temperature	^oC	Measured
Ti	Initial temperature of Ethylene Glycol solution	^oC	Measured
t	Time	sec	Measured
V	Voltage Reading	Volts	Measured
Vb	Volume of Ethylene Glycol solution in the tank	m^3	Measured
W	Power consumed by compressor	kJ/sec	Calculated
ρs	Density of Ethylene Glycol solution	kg/m^3	Given
COP_{rel}	Relative co-efficient of Performance		Calculated
COP_{ac}	Actual co-efficient of Performance		Calculated
COP_{theo}	Theoretical co-efficient of Performance		Calculated

13. BLOC DIAGRA



Result(s): COP of the ice plant is found

Review Questions

Q1 What is COP?

Q2 What is VC vycle?

Q3 Explain various components of VC cycle

Prepared By	Reviewed By	Approved By

Experiment No. 9

Aim: To calculate cop of water to water Heat Pump.

List of Equipment Used:

Table 1: List of Equipments

S.N.	Equipment	Range	Quantity
1.	Power supply	Single Phase, 220 V	1
2.	Water Supply	@ 4LPM at 1bar	NA
3.	Socket with earth connection	5-15 amp	1

Introduction:

In this arrangement water is used as a source of heat and it is also used as a medium of air conditioning fluid. The heat pumps can operate on low temperature heat energy and rejecting heat at a higher temperature. The basic heat sources that are normally used are air, water and earth. When heat pumps are installed, frequently provision is made for both heating and cooling services to be supplied simultaneously to the separate zones of buildings.

Theory:

The heat pump is a machine that absorbs heat at one location and transfers it to another location at a different temperature. Heat Pump is the modern expression for a refrigeration system in which heat discharged at the condenser is of prime importance. Thus heat pump is device which collects heat from one source and delivers it to another source using refrigeration cycle. The medium being cooled serves as heat source. Heat is picked up by the refrigerant, which is pumped to another higher level by the compressor and given to the condenser for medium cooling the condenser, so that it can be used practically.There is no difference in the cycle of operations between a refrigerating machine and a heat pump. The main difference between a refrigerator and a heat pump is of the purpose or desired effect

expected. While a refrigerator is used to produce cooling effect, a heat pump is used to utilize the heat delivered at high temperature for heating purpose.

Vapour compression cycle:

The refrigerant starts at some initial state or condition, passes through a series of processes in a definite sequence and returns to the initial condition. This series of processes is called a cycle.

The Standard Vapour Compression Cycle (SVCC) consists of the following processes:

- Reversible adiabatic compression from the saturated vapour to a super heated Condition (electrical) input.
- Reversible heat rejection at constant pressure (de-superheating and condensation of the refrigeration)
- Irreversible is enthalpy expansion from saturated liquid to a lowpressure vapour.
- Reversible heat addition at constant pressure.

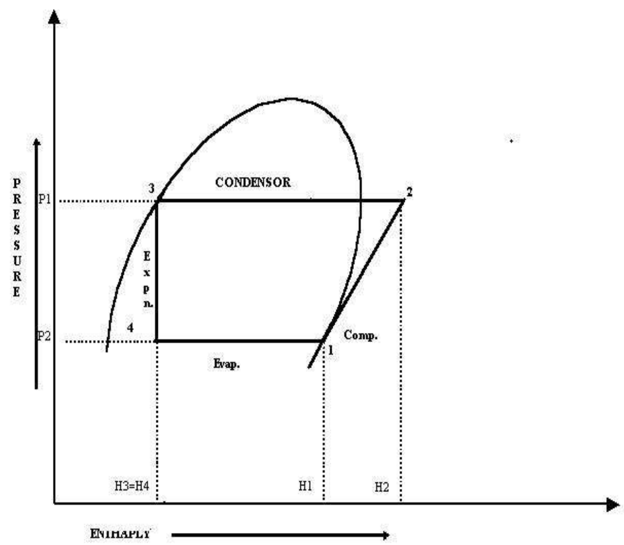


Figure 1: Standard vapour compression cycle (svcc):

Coefficient of performance:

The coefficient of performance of (C.O.P.) of a refrigerating cycle is defined as the ratio between net refrigeration (output) and compressor work (input).

$$C.O.P = \frac{RE}{CW}$$

$RE = H_1 - H_4$

$CW = H_2 - H_1$

$C.O.P = \underline{H1 - H4}$

$H2 - H1$

Description:

Unit is fitted with water cooled condenser, drier, capillary tube expansion valve, and evaporator. Suction gauge and discharge gauges are provided to measure pressure. Temperature sensors and Digital temperature indicator with thumb wheel switch are provided to measure temperatures. The voltmeter and ampere meter is provided to calculate the compressor work. Rotameter are provided to measure the flow rate of water through condenser and evaporator.

Precaution & maintenance instructions:

1. Never run the apparatus if power supply is less than 180 volts and above 230 volts.

2. Always close the door of the tank during experimentation

Experimental procedure:

1. Close all the valves V_1 to V_7.
2. Ensure that all switches are at 'OFF' position.
3. Connect pipes to condenser water outlet, evaporator water outlet to drain.
4. Connect water supply to rotameter.
5. Open the valve V_1, V_2.
6. Set a flow rate for condenser by adjusting valve V_1.
7. Set a flow rate for evaporator by adjusting valve V_2.
8. Switch on the main supply.
9. Switch on the compressor.
10. Wait for 2-3 minutes till the compressor switches 'ON'.
11. Open the valve V_3 and V_4.

12 After 10 minutes, Note down the flow rates of condenser and evaporator.
13 Note down the voltage and current.
14 Note down the temperature readings.
15 Note down the time.
16 Repeat the steps 12 to 16 till the steady state achieves.
17 Repeat the experiment for different flow rates.

Observation & calculation:

Table 2: Data	
Power factor Cos ϕ	= 0.7
Specific heat of water C_p	= 4.186 kJ/ kg-^oC
Density of water ρ_w	= 1000 kg/m^3

Table 2: Observation table

S. No.			
V (Volts)			
I (Amp.)			
t (sec)			
T_1 (^oC)			
T_2 (^oC)			
T_3 (^oC)			
T_4 (^oC)			
T_5 (^oC)			
T_6 (^oC)			

T_7 (°C)			
P_1 (kg /cm²)			
P_2 (kg /cm²)			
W_c			
W_e			

Calculations:

Mark the points (P_1, T_1), (P_2, T_2) and (P_2, T_3) and (P_2, T_4) on P-h Chart for **(**R134a) and get valves:

(P_1, T_1) = H_{ci}

(P_2, T_2) = H_{co}

(P_2, T_3) = H_{ei}

(P_2, T_4) = H_{eo}

Cycle operating as refrigeration:

$$COP_R = \frac{H}{CW}$$

Cycle operating as heat pump:

$$COP_H = \frac{H\ ci - H\ co}{H\ ci - H\ eo}$$

$$CW = \frac{VICos\phi}{1000} \text{ (kJ/sec)}$$

$$COP_H = \frac{H^c}{CW}$$

Nomenclature:

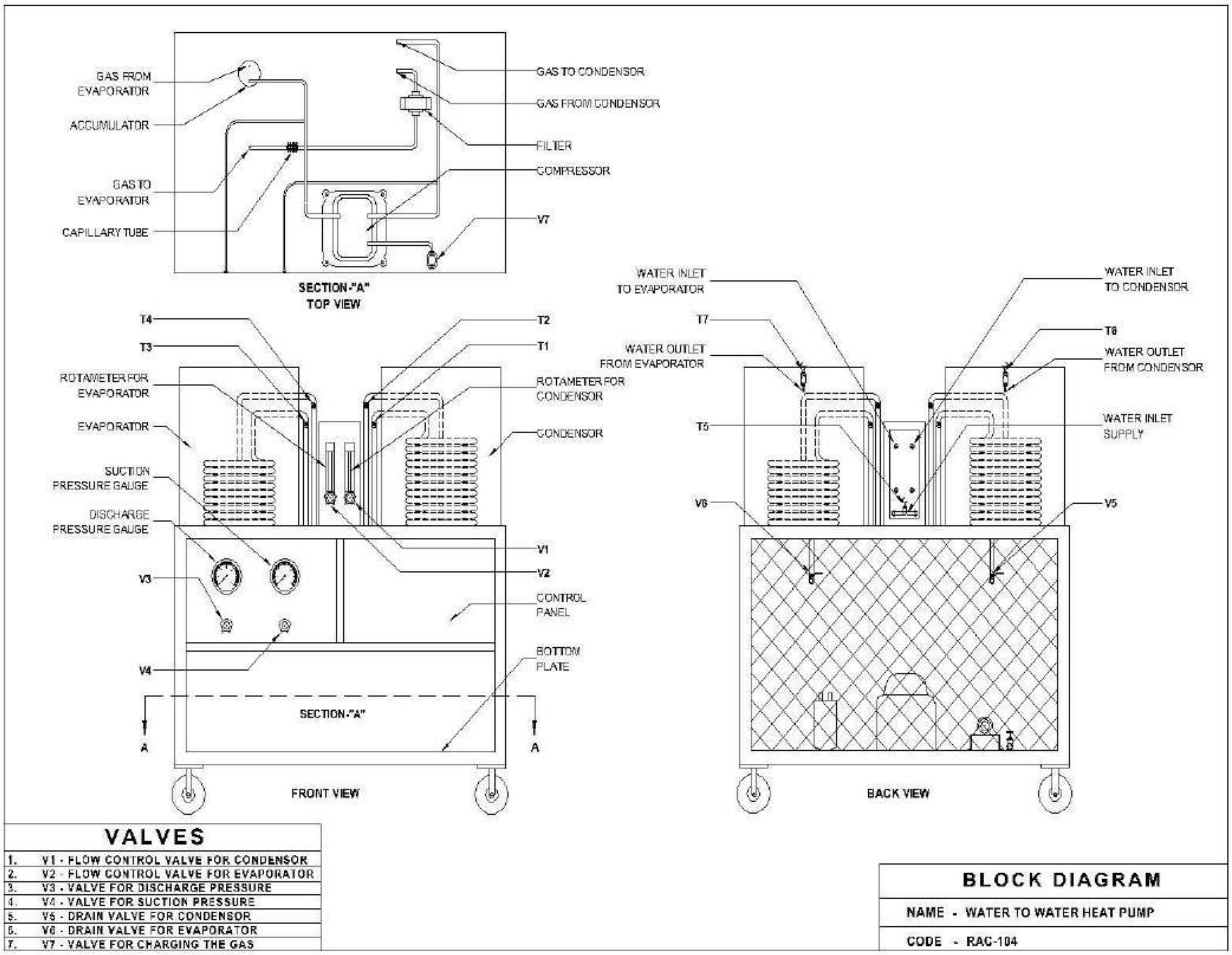
Nom	Column Heading	Units	Type
Act. COP_R	Actual COP of refrigeration		Calculated
Act. COP_H	Actual COP of heat pump		Calculated
CW	Compressor Work	kJ/sec	Calculated
Cp	Specific heat of water	kJ/ kg^{o}C	Given
Cosϕ	Power factor		Given
Hc	Heat carried away by condenser cooling water	kJ/sec	Calculated
He	Heat given by water in evaporator	kJ/sec	Calculated
I	Ampere meter reading	Amp.	Measured
me	Mass flow rate of water in evaporator	kJ/sec	Calculated
mc	Mass flow rate of condenser water	kJ/sec	Calculated
P1	Compressor inlet pressure	kg/cm^2	Measured
P_2	Compressor outlet pressure	kg/cm^2	Measured
T1	Temperature of refrigerant at condenser inlet	^{o}C	Measured

T2	Temperature of refrigerant at condenser outlet	°C	Measured
T3	Temperature of refrigerant at evaporator inlet	°C	Measured
T4	Temperature of refrigerant at evaporator outlet	°C	Measured
T5	Temperature of water inlet to condenser	°C	Measured
T6	Temperature of water outlet from condenser	°C	Measured
T7	Temperature of water outlet from evaporator	°C	Measured
Theo. COP_H	Theoretical COP of heat pump		Calculated
Theo. COP_R	Theoretical COP of refrigeration		Calculated
t	Time	sec	Measured
V	Voltage Reading	Volts	Measured
WC	Flow rate of water through condenser	LPH	Measured
WE	Flow rate of water through evaporator	LPH	Measured
ρw	Density of water	kg/m^3	Given
dTc	Temperature difference of water in condenser	°C	Measured
dTe	Temperature difference of water in evaporator	°C	Measured

	CHANDIGARH UNIVERSITY
	DEPARTMENT OF MECHANICAL ENGINEERING

REFRIGERATION & AIR CONDITIONING LAB	Subject Code: MEY – 303 / MEP-358

BLOC DIAGRAM



Result(s): Working of heat pump is understood

Review Questions

Q1 What are heat pumps?

Q2 How they are different from refrigerators

Q3 Briefly explain the vapour compression cycle

Prepared By-	Reviewed By-	Approved By-