MANUFACTURING SCIENCE LAB MANUAL

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CONTENTS

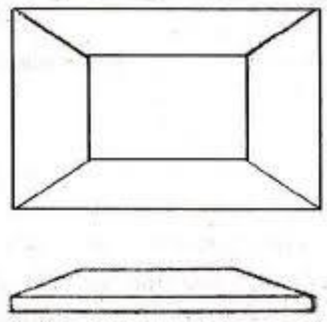
1. METAL CASTING

PREPARATION OF MOULD

Aim: To prepare a mould for a given single piece pattern

Material Required:
Moulding sand, Facing sand, Baking sand, Parting sand, core, pattern, cope box, Drug box, Bottom board.

Tools Required:
Sprue, Riser, Chaplets, Gate cutter, Trowel, Vent rod, sleek, Bellow.



One piece pattern.

Fig 5.34

Terminology of Casting:

Flask: A moulding flask is one which holds the sand mould intact. Depending upon the position of the flask, in the mould structure it is referred to by various names as drag cope and check. It is made up of wood for temporary applications or more generally of metal for long term use.

Drag: lower moulding flask.

Cope: Upper moulding flask.

Check: Intermediate moulding flask used in three moulding

Pattern: Pattern is a replica of the final object to be made with some modifications. The mould casting is made with the help of the pattern.

Parting Line: This is the dividing line between the two moulding flasks that makes up the sand mould. In split pattern it is also the diving line between the two halves of the pattern.

Bottom Board: This is a board normally made of wood which is used at the start of the mould making. The pattern is first kept on the bottom board sand is poured on it and then the ramming is done in the drag.

Facing Sand: It is a specially prepared sand which is placed around the pattern which has superior properties with regards to refractoriness permeability etc. this will ensure better surface on the castings.

Coal Dust: The small amount of carbonaceous materials sprinkled on the inner surface of the moulding cavity to give better finish to castings.

Moulding Sand: It is a mixture of sicila, clay and moisture in appropriate proportions to get the desired results and it surrounds the pattern facing sand while making the mould. The moulding sand is the mixture.

Backing Sand: It is chat constitutes most of the refractory material found in the mould. This is made up of used and burnt sand.

Core: It is used for making hellow cavities in castings.

Sprue: The passage through which the molten metal from the pouring basin reaches the mould cavity. In many cases it control the flow of metal into the mould.

Runner: The passageways in parting plane through which molten metal flow is regulated before they reach the mould cavity through the In – Gate.

Ingate: The actual entry point through which molten metal enter mould cavity.

Riser: It is a reservoir of molten metal provided in the casting so that hot metal can flow into the casting when there is a reduction in volume of metal due to solidification.

Chill: Chill are metallic objects which are placed in the mould to increase the cooling rate of molten metal.

Moulding Procedure:

1. First a bottom board is placed either on the moulding platform or the floor making surface ever.
2. The drag-moulding flask is kept upside down on the bottom board along with the drag part of the platform at the center of the flask on the board.
3. Dry facing sand is spri

Precautions:

1. There should be enough clearance between the pattern and the walls of the flask.
2. The ramming of the sand should be done properly so as not to compact it too hard, which makes the escape of gases difficult.

Result: Mould for single piece pattern is prepared.

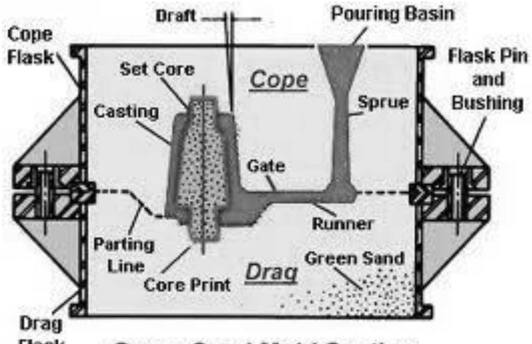
2. PREPARATION OF MOULD CAVITY USING SPLIT PATTERN

Aim: To prepare a green mould for casting using only two boxes.

Tools And Pattern: Wooden pattern made in two halves, dowelled together, the division passing through the center of the grooves; cope and drag moulding tools parting sand, brick dust etc.

Stage Sketches:

The mould can be prepared by using three boxes without any difficulty. However the same can be prepared using two boxes using an ingenious method known as false-core method.



Green Sand Mold Section

Procedure:

1. One half of the pattern is molded in the bottom box, the parting being cut an incline as shown. The other half pattern is then placed in position and sand poured and rammed to form the second parting with a slope down wards from the upper flange of the pulley
2. The top box is next placed on the bottom box and properly located. Sand is poured and rammed without damaging the false core.
3. The top box is gently removed; the upper half pattern is gently taken out from the top box.
4. The top box is replaced on the drag and the entire mould is turned upside down. The bottom box, which now is at the top, is gently lifted and the remaining half of the pattern is withdrawn.
5. The bottom box is replaced and the mould id inverted. The spruces are removed, pouring basin is cut and the mould is finished after piercing holes (vents).

Observations:

1. After ramming using moulds hardness tester check the mould hardness on all the four sides of the pattern.
2. Locate the rumen and riser 90^0 exactly.

Precautions:

1. Ramming should be uniform to impart uniform strength to the mould.
2. Apply parting sand at the partitions for esy separation of boxes.
3. Locate the two halves of pattern properly to avoid mismatch.

Result: Sand mould is prepared for the given pattern.

3. MELTING PRACTICE

Aim: To observe the melting of metals to prepare the casting.

Material Required And Apparatus: Oil furnace, Ladle to sir, Metal.

Specifications:
Capacity – 10 kgs.
Crucible – Graphite of Dia 1 ‘ x height 1.5’’
Burner – O Number
Blower – 1 HP 2880 rpm.
Oil tank – 100 lts.
Oil Consumption – 2-4 Hrs.
Insulation – Fire bricks
Outer Casting – Mild steel duly painted.

Melting Procedure For Alluminium Alloys:-
The charge materials, chemicals should be free from moisture, oil, and corrosion powder and should be preheated before charging. The calculation of charge should be done considering the melting loss of each element in the melting furnace for final desired analysis.

1. The furnace crucible should be clean and red hot for charging.
2. Aluminium alloys get readily oxidized and form dross, using proper covering top with flux and chemicals help to reduce this. Different proprietary chemicals are available for different alloys.
3. Melting should be done under steady conditions without agitation. Stirring is done to reduce gas pickup.
4. Once melting is complete, degassing using solid chemicals like hexachloro-ethane which evolves chlorine by purging with nitrogen or argon gas is done to remove the dissolved hydrogen. Hydrogen is evolved from moisture.

$$3H_2O+2Al\rightarrow Al_2O_3+6H$$

Hydrogen absorbed by liquid metal causes serious porosity in casting during solidification.
Degassing should be done in the temperature range 730^0 C to 750^0 C
5. Liquid metal after degassing is treated with sodium containing chemicals to improve mechanical properties.
6. Liquid metal once ready should not be super heated. Agitated or kept long in the furnace which will cause dressing and gas pickup. Dross should be skimmed properly before pouring.
7. Alloys containing magnesium should be melting carefully as it is highly reacting. Special fluxes and chemicals like sulphur are used to inhibit the reactivity and prevent spontaneous ignition, melting loss and dross.

Casting Defects Due To Improper Melting:

1. Improper chemical analysis: Incorrect charge, calculations, including wrong estimates of melting losses, metal recovery, excessive losses due to improper fluxing and slogging operations, improper covering of non-Ferrous melt causes this defect.

2. Gassy metal/hydrogen pickup/pinhole porosity: unclean melting causes formation and absorption of hydrogen into liquid metal. As casting solidifies, the absorbed hydrogen losses solubility and forms cavities inside casting.

3. Oxygen absorption

Excessive oxygen furnace operations in atmosphere following oxidation during melting cause this defect. It also causes loss of costly metal added in the charge.

4. Slag inclusions

Improper fluxing and slag removal slag particles to be mixed in the metal being poured. Careless pouring, lip pouring for alloys with fluid slag causes slag particles to enter casting.

5. Cold shut, misrun, unfilled castings

Low pouring temp, delay in pouring, due to many folds being poured, loss of heat from lable, due to improper covering failure of ladle opening in the bottom pouring cause premature solidification of metal causing defects.

6. Sand fusion, metal penetration, rough surface

Excessive pouring temp of liquid causes damage to the casting surface by attacking mould surface.

7. Sand erosion sand inclusions

Uncontrolled high pouring rate from ladle into mould leads to erosion of mould/core

Precautions:

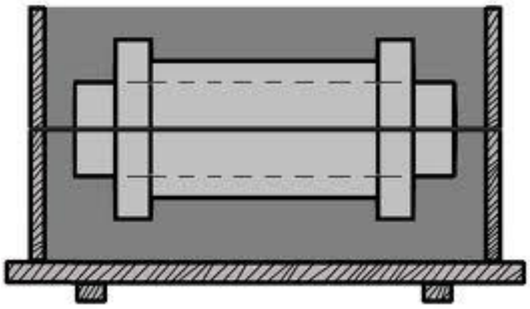
1. The furnace crucible should be clean and red hot for charging
2. Charge material should be free from oil, moisture etc.,
3. Melting must be done under steady condition to reduce gas pickup.

Result:

Melting practice is observed.

4. PATTERN MAKING

Aim: To prepare a split wooden pattern detailed below with allowance.
Tools Equipment & Material: Steel rule, out side caliper, Mortise Chisel, inside chisel, peering chisel, Firmer Chisel, Wood rasp half round file, outside gauge, outside chisel, Try square, Handsaw, Mallet, Sandpapers, Teak Wood given size



Procedure: Match the two rectangular wood pieces of stock and fix them together by wood screws at either end in the excess portion of wood. This must give a firm clamping of the wood pieces to turn into single piece.
In body portion of the pattern mark a center link using marking gauge and extend it to the dressed end.
Using the race with counter sunk make indentations at the center of each and to form locations for the head stock and tail stock center.
The wood stock is turned on the wood turning lathe using appropriate gauge and finally finished the dimensions.
Sanding paper No. ½ or No.0 does smooth finishing
The sand paper should be moved laterally on the rotating work.

Precautions:
1. The tools are kept sharp to cut freely without burning and also without much pressure to cause chipping.
2. Maintain proper turning angles.
3. Be alert to avoid accidents.

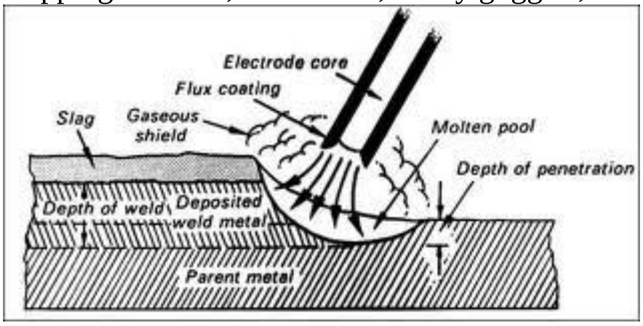
Result: The Required Split pattern is prepared

5. ARC WELDING (DIRECT CURRENT)

Aim: To conduct arc welding and study the effect of polarity on weld strength and heat effected zone.

Equipment and Material Required: D.C Welding machine, Bench vice, Tensile testing machine, M.S. Plates of 100x50x5(2), Metallurgical microscope.

Tools Required: Hack saw, Chipping hammer, wire brush, safety goggles, Hand gloves, Face shield, Files.



Welding Terminology:
1) Backing: It is the material support provided at the root side of the weld to aid in the control of the penetration.
2) Base Metal: The metal to be joined or cut.
3) Bead or Weld bead: It is the metal added during a single pass of welding. The bead appears as strikers.
4) Crater: In arc welding, a crater is the depression in the weld metal pool at the where the arc strikers.
5) Deposition Rate: Rate at which weld metal is deposited per unit time and expressed in kg/hr.
6) Fillet Weld: The metal fused into the corner of a joint made of two pieces placed at approximately 90 degrees to each other.
7) Penetration: Depth up to which the weld metal combines with the base metal as measured from the top surface.
8) Puddle: Portion that is melted by the heat of welding.
9) Root: The point at which the 2 pieces to joined are nearest.
10) Tach weld: A small weld used to temporarily hold the two pieces together during actual welding.
11) Weld face: Exposed surface of the weld.
12) Weld pass: A single movement of the welding torch or electrode along the length of the joint, which results in beats, is weld pass.

Description:
Principle of Arc welding: An arc is generated below 2 conductor cathode and anode. When they are touched to establish flow of current. An arc is sustained electric discharge through ionized gas column called plasma b/w 2 electrodes. Electrons liberated from cathode move towards anode at high speed large amount of heat is generated. To produce are potential diff b/w 2 electrodes should be sufficient.

Straight and Reverse Polarity: The positive terminal of DC supply is connected to work piece and the negative terminal to electrode and known as DCSP.
The positive terminal of DC supply is connected to electrode and negative to work piece and is known as DCSP.

Heat Affected Zone (HAZ): A HAZ of a weld is the part of welded joint, which has been heated to temperature up to solidify temperature resulting in varioud degree of microstructure as

Tensile Test: This test is carried out to determine the ultimate tensile strength under static loading of the base metal weld metal on welded joint.

Procedure:

1. Given 2 M.S. plates are filled at an angle of 45^0 at 2 surfaces to be joined (V groove is formed)
2. Electrode is fixed to electrode holder.
3. Connections to be given such that electrode- negative and work piece positive.
4. Welding is to be done carefully for the half-length of the plates.
5. The work piece is to be cut into two halves by power hacksaw.
6. The beads are polished, etched with two percent natal solution and studied under the microscope whose magnification factors 10X for the heat effected zone.
7. By gripping the beads b/w the jaws pf Tensile testing machine and load is applied until the work piece breaks and the readings is to be noted.
8. The same procedure is repeated for the remaining half which is welded by reverse polarity and th results are to be compared

Precautions:

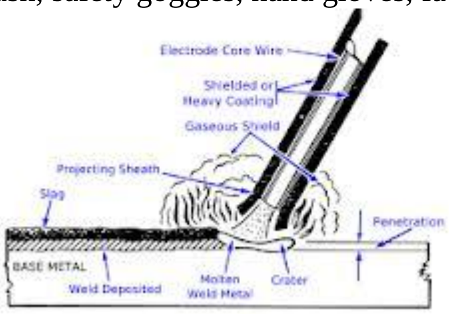
1. Edge preparation should be done very carefully.
2. Before welding ensure that the surfaces are extremely clean.
3. While welding always use face shields or goggles.

Result: The effect of polarity on weld strength and heat effected zone in arc welding was studied.

6. EFFECT OF AC CURRENT ON WELD STRENGTH AND HEAT AFFECTED ZONE

Aim: To study the effect of AC current on weld strength and heat affected zone in Arc welding.

Equipment And Material Required:
A.C. welding machine, Bench Vice, Universal testing machine, metallurgical microscope, M.S. plates of 250x50x5mm.
Tools Required:
Hacksaw, chipping hammer, wire brush, safety goggles, hand gloves, face shield, files.



Description: The work piece is kept on a metallic table to which the ground lead of
The secondary windings of he transformer are connected. The other lead of the secondary is connected to an electrode holder into which electrode is gripped. When electrode is brought in contact with work piece, welding takes place. The maximum rated OC voltage which is the voltage between the output terminals when is being done is normally fixed at about 80volts.
The minimum welding load voltage can be calculated as

$$V_m = 20+0.041.$$

The percentage time in 10min period is duty cycle that a welding machine can be used at its rated output over loading. Normally 60% duty cycle is suggested.

Procedure:
1. Two M.S. plates given are filed at an angle 45^0 at the surface to be joined.
2. Beads on the plates are laid on given plates by using various currents by selecting at least 5 correct current values.
3. After welding at various currents, the beads are cross-sectioned and polished, etched with 2% natal solution.
4. The strength of the welded joints is found by suing tensile testing machine.
5. The observation are recorded and plotted for analysis.

Precautions:
1. Edge preparation should be done very carefully.
2. Before welding ensure that the surface are extremely clean.
3. While welding, always use face shields and goggles.
4. Note the current values carefully.

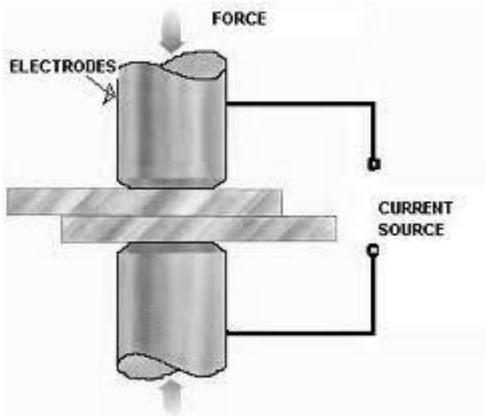
Result: Effect of current on strength of arc weld is studied.

7. SPOT WELDING

Aim: To study the effect of the current on weld strength-using spot welding process

Equipment: Spot welding machine

Material Required: two metal pieces of size 4”x2”



Description of The Equipment: A typical resistance spot welding machine essentially consists of two electrodes, out of which one is fixed. The other electrode is fixed to a rocker arm (to provide mechanical advantage) for transmitting mechanical force from a pneumatic cylinder. This is simplest type of arrangement. The other possibility is that of a pneumatic or hydraulic cylinder being directly connected to the electrode without any rocker arm.

For welding large assemblies such as car bodies, portable spot welding machines are used. Here the electrode holder and the pneumatic pressurizing system is present in the form of a portable assembly which is taken to the place, where the spot is to be made. The electric current, compressed air and the cooling water needed for the electrodes is supplied through cable and hoses from the main welding machine to the portabe unit.

In spot welding, a satisfactory weld is obtained when a proper current density (A/Sq mm) is maintained. The current density depends on the contact area between the electrode and the work piece. With the continuous use, if the tip becomes upset and the contact area increases, the current density will be lowered and consequently the weld is obtained over a large area. This would not but able to melt the metal and hence there would be no proper fusion.

A resistance-welding schedule is the sequence of events that normally take place in each of the welds. The events are the squeeze time is the time required for the electrodes to align and clamp the two work pieces together under them and provides the necessary electrical contact.

The weld time is the time of the current flow through the work pieces till they are heated to the melting temperature.

The hold time is the time when the pressure is to be maintained on the molten metal without the electric current. During this time, the pieces are to be forge welded.

The off time is time during which, the pressure on the electrode is taken off so that the plates can be positioned for the next spot. The off time is not normally specified for simple spot welding, but only when a series of spots are to be made in a predetermined pitch.

Procedure:

1. Switch on the machine and set the current in the machine to 2 Ampere
2. Set the timer to two seconds
3. Over lap the two metal pieces to the requires size and place them between the two electrodes.
4. Apply pressure by foot on the lever such that two electrodes come into contact if the over lapped metals.

5. After 2 seconds remove the pressure on the lever slowly.
6. Now the joint is ready for use.
7. Repeat the same procedure at various amperes
8. Test the strength of the joints using universal testing machine.

Precautions:
1. Ensure that the electrodes should not be touched.
2. Don’t touch the welded potion by hand immediately after the welding is done.

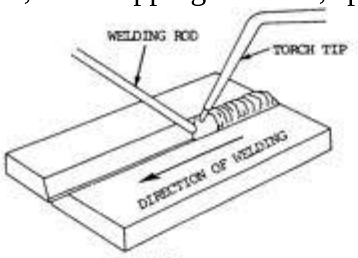
Result: Effect of current on strength of spot weld is studied.

8. BUTT WELDING USING GAS WELDING

Aim: To make butt-welding using gas welding equipment.

Equipment And Material Required:
Oxy – acetylene welding outfit, MS Sheets 150x50x1mm (2No)

Tools Required: Wire brush, hand gloves, and chipping hammer, spark lighter.



NOTE
TORCH AND ROD ANGLES ARE 45 DEG AS VIEWED BY THE OPERATOR AND PERPENDICULAR (90 DEG) TO THE WORK SURFACE AS VIEWED FROM THE END OF THE WORKPIECE.

Figure 11-4. Forehand welding.

Procedure:
1. Acetylene valve on the torch is opened slightly and lightened with the help of a spark lighter.
2. Now acetylene valve is opened to get required the flow of acetylene.
3. Oxygen valve is opened till the intermediate flame feather reduces into inner cone to get a neutral flame.
4. The torch tip is to be positioned above the plates so that white cone is at a distance of 1.5mm to 3mm from the plates.
5. Torch is to be held at an angle of 30^0 to 45^0 to the horizontal plane.
6. Now filler rod is to be held at a distance of 10mm from the flame and 1.5 mm to 3 mm from the surface of the weld pool.
7. As the backward welding allows better penetration, back ward welding is to be used.
8. After the completion of welding, slag is to be removed by means of chipping hammer, wire brush.

Precautions:
1. Ensure that torch movement is uniform.
2. See that the joints are extremely clean.

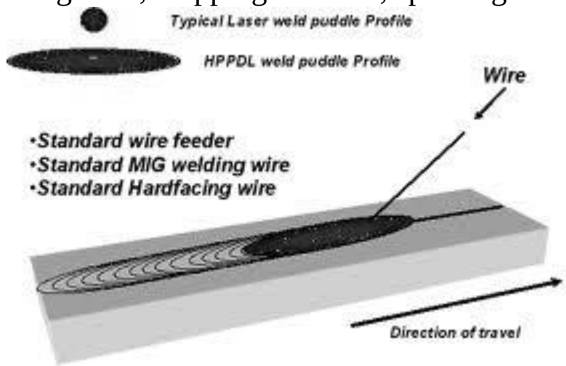
Result: A butt joint is prepared using gas welding process.

9. BRAZING

Aim: To join two sheets by brazing process.

Equipment And Material Required:
Oxy-acetylene torch, flux, filler rod, GI sheets 150x150x1mm

Tools Required: Wire brush, hand gloves, chipping hammer, spark lighter.



Description:

Brazing is coalescence of a joint with the help of a filler metal whose melting temperature is 450^{0}C and is below solidify temperature of the base metal. The filler metal is drawn into the joint by means of capillary action.

Procedure:

1. The surface to be joined is cleaned properly.
2. Sheets are joined and laid by giving proper clearance.
3. Flux is applied to the joint.
4. Joint is to be heated by using welding torch to heat the filler metal to its melting temperature when the filler material is placed at the joint.
5. The filler material is flown into the service by capillary action and joint is made.

Precautions:

1. As the filler metal fills the joint by capillary action, give only needed clearance.
2. See that the joints are extremely clean.

Result: Two sheets are joined using brazing process.

10.HYDRAULIC PRESS

Aim: To make mosquito coil stand/washer/lid using Hydraulic press.
Equipment: Hydraulic Press, Compound Die, Progressive Die, Deep-Drawing Die.
Raw Material: Mild Steel

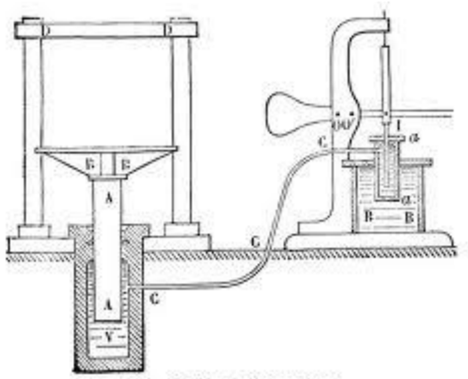


Fig. 2. Presse hydraulique.

Description of the equipment: Presses are classified in various ways. They may be classified according to

i. Source of power
ii. Method of actuation of the rams (slides)
iii. Number of slides
iv. Types of frames
v. The type of work for which the press has been designed.

Source of power: Two kinds of sources of power supply to the ram: Mechanical and hydraulic.
Mechanical presses, the energy of flywheel is utilized which is transmitted to the work piece by gears, cranks, eccentrics or levers.
The flywheel rotates freely on the crankshaft and is driven from an electric motor through gears or v- belts. The motors runs continuously and stores energy in the flywheel. When the operator presses a foot treadle or actuates a button, the clutch gets engages and the flywheel is connected to the crankshaft. (Driveshaft). Starts rotating and the stored up energy in the flywheel is transmitted to the ram on its downward stroke. The clutch to engage and disengaged the flywheel to the drive shaft can be; a Jaw clutch and the air operated clutch or an electro magnetic clutch. In manually operated mechanical presses, the clutch is disengaged to each cycle. But in automatic presses in which the metal strip is fed to the die automatically, there is no need of single stroke clutch. Disengaging mechanism and the ram moves up and down continuously. These presses can be classified as plain and geared press, the flywheel is carried on a auxiliary shaft which is connected to the main shaft. Through one or more gear reduction, depending upon size and energy needed. In this arrangement, the flywheel stores considerably more energy than the plain as its speed is higher than the main drive shaft.

In Hydraulic press, the ram is actuated by oil pressure on a piston in a cylinder.

Mechanical presses have following advantages over the hydraulic presses.
1. Run faster
2. Lower maintenance cost
3. Lower capital cost.

Advantages of hydraulic presses are

1. More versatile and easier to operate
2. Tonnage adjustable to zero to maximum
3. Constant pressure can be maintained through out the stroke
4. Force and speed can be adjusted through out the stroke.
5. Safe as it will stop at a pressure setting.
6. The main disadvantages of hydraulic press is that it is slower than a mechanical press.

A press is rated in tones of force; it is able to apply with out undue strain. To keep the deflections small, it is a usual practice to choose a press rated 50 to 100 percent higher than the force required for an operation.

Procedure:
1. Set the compound die or progressive die or deep drawing die in the required position.
2. Switch on the motor to start the machine.
3. Pass the MS sheet in to the progressive die/compound die. In case of deep drawing
4. Apply injection pressure using direction control valve.
5. The plunger punches the sheet into the mosquito coil stand/washer lid shape.
6. Release injection pressure.
7. Take out the finished product from the die.
8. Switch off the motor.

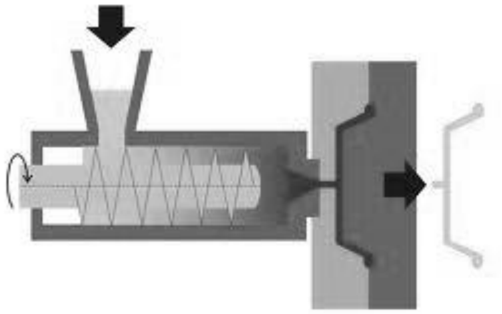
Precautions:
1. Do not apply too high injection pressure
2. Proper lubrication must be done between moving parts of die and press
3. Operate the hydraulic press carefully.

Result: Mosquito coil stand/Washer/lid is prepared using corresponding die un hydraulic press.

11.INJECTION MOULDING MACHINE

Aim: To Prepare a Plastic product using Injection Moulding machine

Equipment: Injection moulding machine.



Material Required: High grade poly ethylene

Description of The Equipment:
Hydraulic Plastic Injection Moulding machine, Model JIM-1HD has been designed for moulding variety components up to 45 Gms capacity in polystyrene. The machine is robustly built to ensure consistent high quality and volume production of precision components. Operator fatigue due to injection process is completely eliminated by use of hydraulic power for both the injection and releases operations.

Locking Unit: This locking made by Hydraulic Cylinder.

Injection Unit: Injection Unit consists of two guide rods, nuts, top and bottom plates with injection cylinder and barrel. Injection cylinder is designed to develop 3 Tons load. Barrel diameter 30mm is attached with the machine as standard.

Hydraulics: Hydraulic pump is driven by 3 HP Induction motor for a rated delivery of 14 lp, at 1440 Rpm and at 80kg/cm^2. The maximum pressure in the hydraulic system is present in our works and is not to be altered. The oil tank capacity is 60 liters. All hydraulic system manufacturers safety precautions are provided to hydraulic system by using section strainer, which will prevent the contamination entering into the system.

Oil Cooler: Oil cooler provided to keep the oil temperatures below 50^0c which will gives more life to hydraulic oil in continuous use.

Electricals: Electrical control panel with automatic blind temperature controller is fixed on the right hand side of the machine for clear viewing of the temperature and for easy to operate the switches. Designed with safety measure, which will protect the motor from over load.

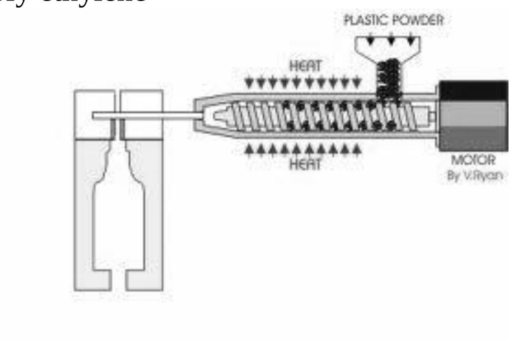
Procedure:
Injection moulding makes use of heat softening characteristics of thermo plastic materials. These materials soften when heated and re harden when cooled. No chemical change takes place when the material is heated or cool. For this reason the softening and re hardening cycle can be repeated any no. of times.
1. The granular moulding material is loaded hopper where it is metered out in a heating cylinder by a feeding device.
2. The exact amount of material is delivered to a cylinder, which is required to fill the mould completely.

3. Set the die in position Provide spacing plates if necessary. Clamping the Die using hydraulic operate ram.
4. Set the injection pressure by rotating (clockwise) the regulator knob to suit the requirement of moulding the container.
5. Switch on the heater. Set the required timings to the timers, for top and middle heater**.** Set the temperature by adjusting automatic temperature controller to control the bottom heater. Allow sufficient time to stabilizer. When temperature reached, operate the hand lever valve to inject the material.
6. Apply injection pressure on the heated material using plunger rod.
7. The injection ram pushes the material in to the heating cylinder and in doing so pushes a small amount of heated material out of the other end of the cylinder through the nozzle and screw bushing and into the cavity of closed mould.
8. The material is cooled in a rigid state in the mould.
9. Release the injection pressure. In clamp the Die using hydraulic operated ram.
10. The mould is then opened and piece I ejected out.

Result: Required product is made using injection moulding process.

12.BLOW MOULDING

Aim: To prepare a bottle of 200ml using blow moulding machine.
Equipment: Blow moulding machine
Material Required: Low grade poly ethylene



Operating instructions:
a) Install the machine on a leveled strong flooring near the compressor (within 2 meters).
For letter rigidity foundation bolt is recommended & anti vibration rubber mounting can be used.
b) The machine must be placed in a position where all parts are accessible readily.
c) Check for loose any loose electrical connection with the help of certified electrician and with the electrical circuit enclosed.
d) Fill the lubricator with SAE 20 grade oil to the level indicated. The lubrication has been set to allow one drop of oil for every 5 strokes of air cylinder (oil) drop is factory set, no need to adjust)
e) Connect the air filter to the compressor by rubber/nylon hose (Min inside dia 10mm), pressure with standing capacity 20kg/cm^2.
f) Set the pressure switch in the compressor as per the compressor manual to switch on 7 kg/cm^2 pressure & switch off at 10kg/cm^2 (NOTE: The air pressure should not exceed 10cm^2)
g) Set the air pressure in machine by adjusting the injection & release regulator (18).
h) Set release pressure 2kg/cm^2 by adjusting release regulator.
i) Operate the hand lever valve (13) and check for smooth functioning of plunger.
j) Set the blow pressure in regulator (15) and operate the hand lever valve (14) to check flow of air throw blow nozzle.
k) Electrical connection should be given as indicated on the main plug phase, neutral and earth.
l) Proper earthing should be done.
m) Check the incoming voltage (230VAC, 50Hz) Now the machine is ready for operation.

Working Principle: The process is applied to only thermo plastics, which are used for producing hollow objects such as bottle, and flow table objects by applying air pressure to the sheet material when it is in heated and in soft pliable condition. Blow moulding can be accomplished in two manners; one is direct blow moulding and other indirect blow moulding. In the former case, a measured amount of material in the form of tube is either injected or extruded in a split cavity die. The split mould is closed around the tube, sealing off the lower end. The air under pressure is blown into the tube, which causes the tube to expand to the walls of cavity. In the latter case, a uniformly softened sheet material by heat is clamped at the edges between the die and cover, which causes the sheet to attain a hemispherical shape or the configuration of mould whatever it may be parts obtained by indirect blow moulding have excellent appearance but they are more costly as only to percent of the sheet stock is utilized and also there is a tendency for excessive thinning of sheet at the deepest point.

Procedure:
1) Set the die in position. Adjust the guide rod nuts to suit die height. Align the tapered face of the die for sealing the parison while blowing also checks for the face opening and closing of the die.
2) Ensure minimum die height is 80mm. provide spacing plates if necessary.

3) Set the injection, release and blow pressure by rotating (clockwise) the regulator knob to suit the requirement of moulding the container.
4) Feed correct quantity & quality of plastic material and switch on the power supply.
5) Switch on the heater.
6) Set the required timings controller to control the bottom heater.
7) Allow sufficient time to stabilizer.
8) When temperature reached, operate the hand lever valve.
9) Extrude the parison (Tubular form) to the required length and close the two die halves. Release the injection cylinder.
10) Operate the hand lever valve and blow the air so that the parison to form the shape of the container as designed in the die.
11) Allow the component to cool.
12) Open the die & take the product out of the die.
13) Now the machine is ready for nest cycle.

Result: Required product is made using blow moulding process.

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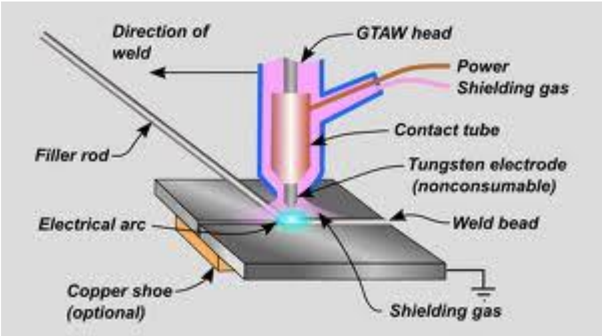
13.TIG WELDING

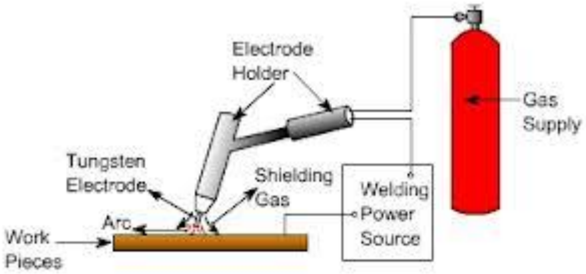
TIG WELDING

Aim: To make butt-welding using TIG welding equipment.

Equipment And Material Required:
Inert gas(helium,argon) welding outfit, MS Sheets 150x50x5mm (2No)

Tools Required: Wire brush, hand gloves, and chipping hammer, spark lighter.





Procedure:
1. Inert gas valve on the torch is opened slightly and lightened with the help of a spark lighter.
2. The torch tip is to be positioned above the plates so that white cone is at a distance of 1.5mm to 3mm
   from the plates.
3. Torch is to be held at an angle of 30^0 to 45^0 to the horizontal plane.
4. Now filler rod is to be held at a distance of 10mm from the flame and 1.5 mm to 3 mm from the surface of the weld pool.
5. As the backward welding allows better penetration, back ward welding is to be used.
6. After the completion of welding, slag is to be removed by means of chipping hammer, wire brush.

Precautions:
1. Ensure that torch movement is uniform.
2. See that the joints are extremely clean.

Result: A butt joint is prepared using gas welding process.

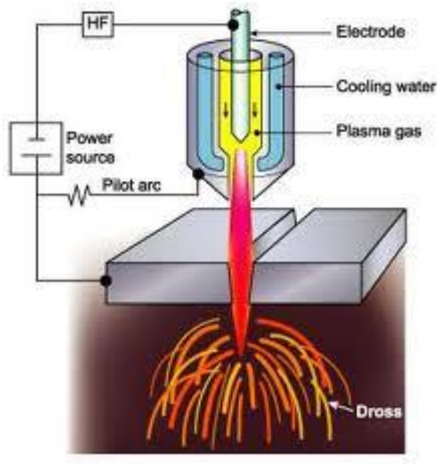
14.PLASMA CUTTING

PLASMA CUTTING

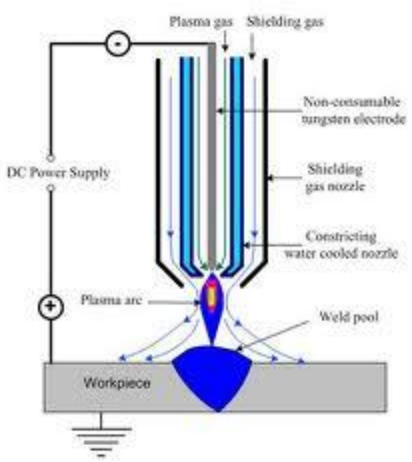
Aim: To cut a given specimen using plasama cutting equipment.

Equipment And Material Required:
plasama cutting equipment,MS Sheets 150x50x5mm

Tools Required: Wire brush, hand gloves, and chipping hammer, spark lighter.



Plasma cutting



Plasma Welding

Procedure:
1 Gas(helium or hydrogen) valve on the torch is opened slightly and lightened with the help of a spark lighter.
2. Now ionized gas are forced through the arc and nozzle (at aflow rate of 1.5 to 15 litres per min) with the result that these get ionized and become plasma
3. The torch tip is to be positioned above the plates so that white cone is at a distance of 1.5mm to 3mm from the plate.
4. Torch is to be held almost vertical to the base metal surface for cutting,
5. Torch is to be held almost vertical to the base metal surface and filler metal wire fed at angle for Welding
5. Now filler rod is to be held at a distance of 10mm from the flame and 1.5 mm to 3 mm from the surface of the weld pool.
6. As the backward welding allows better penetration, back ward welding is to be used.
7. After the completion of welding, slag is to be removed by means of chipping hammer, wire brush.

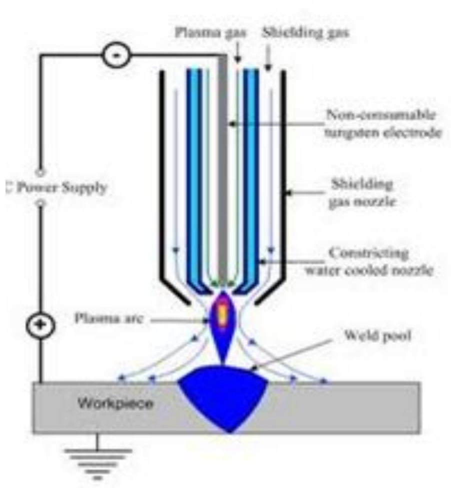
Precautions:
1. Ensure that torch movement is uniform.
2. See that the joints are extremely clean.

Result: A butt joint is prepared using plasma welding and a given piece is cut by plasma cutting

15. PLASMA ARC WELDING

Aim: To Join two given work pieces using plasma arc welding and Brazing and cut the given plate into two parts using plasma cutting.

Apparatus required:
Plasma Arc Welding System
Material Required: MS flat 50x50x10 mm –3 Nos



Plasma Welding

Theory:

Procedure:

1.The edge of the given material is prepared to the required V-shape using grinding machine

2.The machine is set to the required parameters(For Welding).

3.Place the two work pieces on the table with required position as shown in figure.

4.The work pieces are kept in the required position and tack welding is performed on the work pieces.

5.First run of welding is done to fill the gap and penetration of the weldment by holding the electrode at about 700 and filler rod at 300and move the electrode to another end uniformly.

6.Second run of welding is done with proper weaving and uniform movement so that a uniform weld bead will be obtained.

7.The scale formed is chipped with chipping hammer.

8. Filing is done to remove any spatter around the weld.

9.The machine is set to the required parameters(For Cutting)

Precautions:

1.Never look at the arc with the naked eye. Always use a shield while welding.

2.Always wear the safety hand gloves, apron and leather shoes.

3.Ensure proper insulation of the cables and check for openings.

4.Care is taken to avoid arc blow, which will cause serious defect in the weldment.

Result:The required butt joint is prepared by Plasma ArcWelding.

16.POWER PRESS

Aim: To prepare a required shape and Size of material using power press

Equipment and tools required:

- Power press machine
- Punches
- Steel Rule

Material Required:

Specimen of mild steel 250 X 12 X 2mm

Procedure:

- Take a steel of strip of given dimension and punch the holes
- Place the strip is available slot in the machine
- Punch holes on each side by pressing the lever
- After completing on one side report the same on other side

Precautions:

- Care is taken while handling the rotating parts
- Check that lubrication is done properly

Result:

The object is made by power press by using die punch to required shape

Viva Questions

1. What are the various parts in the wood turning lathe?
2. List different types of pattern?
3. What are the operations in making the pattern?
4. Define welding?
5. Give classification of welding process?
6. Define Arc welding?
7. What is effect of polarity on weld strength?
8. How much gap should maintain between weld rod and work piece?
9. What type of flux used on weld rods?
10. What is the minimum voltage for arc initiation?
11. What is the effect of current on weld strength?
12. What are different arc welding processes?
13. Differentiate between MIG and TIG welding?
14. Define spot welding?
15. What is seam welding?
16. Which type of electrode is used in spot welding?
17. What is the maximum thickness of the sheets that are spot welded?
18. What is difference between arc welding and gas welding?
19. What are the types of flames used in welding of MS plates?
20. What do you mean by backward welding and forward welding?
21. Which type of flame is used in welding of MS plates?
22. Which type of gas welding is used in welding of MS plates?
23. What is brazing?
24. What type of flame is used for brazing?
25. What is the difference between brazing and welding?
26. Difference between brazing and soldering?
27. What are the advantages of hydraulic press?
28. What is the difference between compound die and progressive die?
29. Define Deep-drawing operation?
30. Give the classification of presses?
31. Define Injection moulding process?
32. Which type of injection is used in this experiment?
33. What is raw material used in injection moulding?
34. Why oil cooler provided in this equipment?
35. Define Blow moulding process?
36. Differentiate between thermosetting and thermoplastics?
37. What is the raw material used in blow moulding?
38. Which type of compressor used in this experiment?
39. Differentiate between hydraulic and pneumatic pressure

MECHANICS OF FLUIDS
&
HYDRAULIC MACHINERY
LAB MANUAL

Department of Mechanical Engineering

MallaReddy College of Engineering and Technology

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LIST OF EXPERIMENTS

EXPERIMENT: 1

VENTURIMETER TEST RIG

Introduction

A VENTURI METER is a device that is used for measuring the rate of flow of fluid through a pipeline. The basic principle on which a Venturi Meter works is that by reducing the cross - sectional area of the flow passage, a pressure difference is created between the inlet and throat & the measurement of the pressure difference enables the determination of the discharge through the pipe.

A Venturi Meter consists of,

- An inlet section followed by a convergent cone,
- A cylindrical throat,
- A gradually divergent cone.

The inlet section of the Venturi Meter is of the same diameter as that of the pipe, which is followed by a convergent one. The convergent cone is a short pipe, which tapers from the original size of the pipe to that of the throat of the Venturi Meter. The throat of the Venturi Meter is a short parallel side tube having its cross – sectional area smaller than that of the pipe. The divergent cone of the Venturi Meter is a gradually diverging pipe with its cross – sectional area increasing from that of the throat to the original size of the pipe. At the inlet and the throat, of the Venturi Meter, pressure taps are provided through pressure rings.

General Description:

The apparatus consists of (1) Venturimeter (2) Piping system (3) supply pump set (4) Measuring tank (5) Differential manometer (6) Sump

Constructional Specification:

- **Flow Meters:** Consists of Venturimeter of size 25 mm provided for experiments. The meter has the adequate cocks also with them
- **Piping System:** Consists of a set of G.I. piping of size 25 mm with sufficient upstream and down stream lengths provided with separate control valves and mounted on a suitable stand. Separate upstream and down stream pressure feed pipes are provided for the measurement of pressure heads with control valves situated on a common Pipe for easy operation.
- **Supply Pump Set:** Is rigidly fixed on sump. The mono block pump with motor, operating on single phase 220/240 volts 50 Hz AC supply.
- **Measuring Tank:** Measuring tank with gauge glass and scale arrangement for quick and easy measurement.
- **Differential Manometer:** Differential manometer with 1 mm scale graduations to measure the differential head produced by the flow meter.
- **Sump:** Sump to store sufficient water for independent circulation through the unit for experimentation and arranged within the floor space of the main unit.

Before commissioning:

1. Check whether all the joints are leak proof and water tight.
2. Fill the manometer to about half the height with mercury
3. Close all the cocks, pressure feed pipes and manometer to prevent damage and over loading of the manometer.
4. Check the gauge glass and meter scale assembly of the measuring tank and see that it is fixed water height and vertically.
5. Check proper electrical connections to the switch, which is internally connected to the motor.

Experiments:

1. The apparatus is primarily designed for conducting experiments on the coefficient of discharge of flow meters. Each flow meter can be connected to the manometer through the pressure feed opening and the corresponding cocks.

2. While taking readings, close all the cocks in the pressure feed pipes except the two (Down-stream and upstream) cocks which directly connect the manometer to the required flow meter, for which the differential head is to be measured. (Make sure while taking reading that the manometer is properly primed. Priming is the operation of filling the manometer upper part and the connecting pipes with water and venting the air from the pipes).

3. First open the inlet gate valve of the apparatus. Adjust the control valve kept at the exit end of the apparatus to a desired flow rate and maintain the flow steadily.

4. The actual discharge is measured with the help of the measuring tank. The differential head produced by the flow meter can be found from the manometer for any flow rate.

CALIBRATION OF VENTURIMETER

Aim: - To calibrate a given venture meter and to study the variation of coefficient of discharge of it with discharge.

Apparatus: - Venturimeter, manometer, stop watch, experimental set-up.

Procedure:-

1. Start the motor keeping the delivery valve close.
2. The water is allowed to flow through the selected pipe by selecting the appropriate ball valve.
3. By regulating the valve control the flow rate and select the corresponding pressure tapings (i.e. of orifice meter).
4. Make sure while taking readings, that the manometer is properly primed. Priming is the operation of filling the manometer's upper part and the connecting pipes with water by venting the air from the pipes. Note down the difference of head "h" from the manometer scale.
5. Note down the time required for the rise of 10cm (i.e. 0.01m) water in the collecting tank by using stop watch. Calculate actual discharge using below formula.
   Discharge: - The time taken to collect some 'R' cm of water in the collecting tank in m^3/sec.

$$Q_{act} = \frac{AXR}{T}$$

Where: A = area of the collecting tank in m^2 (0.3m X 0.3m)
R = rise of water level taken in meters (say 0.1m or 10cm)
t = time taken for rise of water level to rise 'R' in't' seconds.

6. Using difference in mercury level "h"calculate the theoretical discharge of venturimeter by using following expression

$$Q_{the} = \frac{a_1 a_2 \sqrt{2gH}}{\sqrt{a_1^2 - a_2^2}}$$

Where

H= difference of head in meters = $(h_1 - h_2) \times (\frac{S_m}{S_w} - 1) = (h_1 - h_2) \times 12.6$ m

a_1 = area of venturi at inlet = $\frac{\pi d_1^2}{4}$

a_2 = area of venturi at throat = $\frac{\pi d_2^2}{4}$

g =Acceleration due to gravity

d_1 =Inlet diameter in meters.
d_2 =Throat diameter in meters.

7. Calculate the coefficient of discharge of orifice meter (Cd):

$$Cd = \frac{Q_{act}}{Q_{the}}$$

8. Repeat the steps 3 to 7 for different sets of readings by regulating the discharge valve.

S. No.	Venturi inlet diameter d1	Throat Diameter d2
1.	25mm	13.5 mm

S. No.	Time for (10 cm) raise of water level in sec.	Actual discharge = Qa	Differential head in mm of mercury			Theoretical discharge = Qt	Cd = Qa/Qt
			h_1	h_2	H		
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Precautions:
1. Do not run the pump dry.
2. Clean the tanks regularly, say for every 15days.
3. Do not run the equipment if the voltage is below 180V.
4. Check all the electrical connections before running.

5. Before starting and after finishing the experiment the main Control valve should be in close position.
6. Do not attempt to alter the equipment as this may cause Damage to the whole system.

Results and Conclusions:

EXPERIMENT: 2

2.ORIFICE METER TEST RIG

Introduction

An ORIFICE METER is a simple device used for measuring the discharge through pipes.

The basic principle on which an Orifice meter works is that by reducing the cross – sectional area of the flow passage, a pressure difference between the two sections before and after Orifice is developed and the measure of the pressure difference enables the determination of the discharge through the pipe. However an Orifice meter is a cheaper arrangement for discharge measurement through pipes and its installation requires a smaller length as compared with Venturi Meter. As such where the space is limited, the Orifice meter may be used for the measurement of discharge through pipes.

General Description

The apparatus consists of (1) Orifice meter (2) Piping system (3) supply pump set (4) Measuring tank (5) Differential manometer (6) Sump

Constructional Specification

1. **Flow Meters:** Consists of Orifice meter of size 25 mm provided for experiments. The meter has the adequate cocks also with them.

2. **Piping System:** Consists of a set of G.I. piping of size 25 mm with sufficient upstream and downstream lengths provided with separate control valves and mounted on a suitable stand. Separate upstream and downstream pressure feed pipes are provided for the measurement of pressure heads with control valves situated on a common plate for easy operation.

3. **Supply Pump Set:** Is rigidly fixed on sump. The mono block pump with motor. Operating on single phase 220/240 volts 50 Hz AC supply.

4. **Measuring Tank:** Measuring tank with gauge glass and scale arrangement for quick and easy measurement.

5. **Differential Manometer:** Differential manometer with 1 mm scale graduations to measure the differential head produced by the flow meter.

6. **Sump:** Sump to store sufficient water for independent circulation through the unit for experimentation and arranged within the floor space of the main unit.

Before Commissioning

1. Check whether all the joints are leak proof and water tight.
2. Fill the manometer to about half the height with mercury
3. Close all the cocks, pressure feed pipes and manometer to prevent damage and over loading of the manometer.
4. Check the gauge glass and meter scale assembly of the measuring tank and see that it is fixed water tight and vertically.
5. Check proper electrical connections to the switch, which is internally connected to the motor.

Experiments

1. The apparatus is primarily designed for conducting experiments on the coefficient of discharge of flow meters. Each flow meter can be connected to the manometer through the pressure feed opening and the corresponding cocks.

2. While taking readings, close all the cocks in the pressure feed pipes except the two (Down-stream and upstream) cocks which directly connect the manometer to the required flow meter, for which the differential head is to be measured. (Make sure while taking reading that the manometer is properly primed. Priming is the operation of filling the manometer upper part and the connecting pipes with water and venting the air from the pipes).

3. First open the inlet gate valve of the apparatus. Adjust the control valve kept at the exit end of the apparatus to a desired flow rate and maintain the flow steadily.

4. The actual discharge is measured with the help of the measuring tank. The differential head produced by the flow meter can be found from the manometer for any flow rate.

CALIBRATION OF ORIFICE METER

Aim: - To calibrate a given Orifice meter and to study the variation of coefficient of discharge of it with discharge.

Apparatus: -Orifice meter, manometer, stop watch, experimental set-up.

Procedure:-

1. Start the motor keeping the delivery valve close.
2. The water is allowed to flow through the selected pipe by selecting the appropriate ball valve.
3. By regulating the valve control the flow rate and select the corresponding pressure tapings (i.e. of orifice meter).
4. Make sure while taking readings, that the manometer is properly primed. Priming is the operation of filling the manometer's upper part and the connecting pipes with water by venting the air from the pipes. Note down the difference of head "h" from the manometer scale.
5. Note down the time required for the rise of 10cm (i.e. 0.01m) water in the collecting tank by using stop watch. Calculate actual discharge using below formula.

Discharge: - The time taken to collect some 'R' cm of water in the collecting tank in m^3/sec.

$$Q_{act} = \frac{AXR}{T}$$

Where: A = area of the collecting tank in m^2 (0.3m X 0.3m)
R = rise of water level taken in meters (say 0.1m or 10cm)
t = time taken for rise of water level to rise 'R' in 't' seconds.

6. Using difference in mercury level "h" calculate the theoretical discharge of venturimeter

$$Q_{the} = \frac{a_1 a_2 \sqrt{2gH}}{\sqrt{a_1^2 - a_2^2}}$$

Where H= difference of head in meters = $(h_1 - h_2) x (\frac{S_m}{S_w} - 1) = (h_1 - h_2)$ x 12.6m

a_1 = area of venturi at inlet = $\frac{\pi d_1^2}{4}$

a_2 = area of venturi at throat = $\frac{\pi d_2^2}{4}$

g =Acceleration due to gravity ,
d_1 =Inlet diameter in meters.
d_2 =Throat diameter in meters.

7. Calculate the coefficient of discharge of orifice meter (Cd): $Cd = \frac{Q_{act}}{Q_{the}}$

8. Repeat the steps 3 to 7 for different sets of readings by regulating the discharge valve.

S. No.	Orifice inlet diameter d_1	Orifice diameter d_2
1.	25mm	13.0mm

S. No.	Time for (10 cm) raise of water level in sec.	Actual discharge = Qa	Differential head in mm of mercury			Theoretical discharge = Qt	Cd = Qa/Qt
			h_1	h_2	H		
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Calculation:-

Precautions:-

1. Do not run the pump dry.
2. Clean the tanks regularly, say for every 15days.
3. Do not run the equipment if the voltage is below 180V.
4. Check all the electrical connections before running.
5. Before starting and after finishing the experiment the main
6. Control valve should be in close position.
7. Do not attempt to alter the equipment as this may cause

Results and Conclusions:-

EXPERIMENT: 3

CENTRIFUGAL PUMP TEST RIG

Introduction

1. In general, a pump may be defined as mechanical device when connected in a pipe line, can convert the mechanical energy into hydraulic energy, Thus resulting in the flow of liquid from lower potential to higher potential.

2. Pumps are of major concern to most Engineers and Technicians. The types of pumps vary in principle and design. The selection of the pump for any particular application is to be done by understanding their characteristics. The most commonly used pumps for domestic, agricultural and industrial are Centrifugal, Reciprocating, Axial flow (stage pumps), air jet,

3. diaphragm and Turbine pumps. Most of these pumps fall mainly into a class namely Rotodynamic, Reciprocating (positive displacement) and fluid operated pumps.

4. In a Centrifugal pump, pressure head is developed by centrifugal action. The pump consists of an impeller, which rotates in a casing. Fluid enters through the eye of the pump and discharges radially outwards to the delivery pipe. Centrifugal Pumps also come based on the type of vanes: Backward curved blades, Radial Type and Forward Curved Type. Centrifugal pumps are commercially available as Single stage and Multi-stage pumps.

5. In this pump, the liquid is made to rotate in a closed chamber (volute casing), thus creating the centrifugal action, which gradually builds the pressure gradient towards outlet thus resulting in the continuous flow.

6. These pumps compared to Reciprocating pumps are simple in construction, more suitable for handling viscous, turbid (muddy), liquids can be directly coupled to high speed electric motors (without any speed reduction), easy to maintain. But, their hydraulic heads at low flow rates is limited and hence not suitable for very high heads compared to reciprocating pump of same capacity. But, still in most cases, this is the only type of pump, which is being widely used for agricultural applications because of its practical suitability. The present test rig allows the students to understand and draw the operating characteristics at various heads, flow rates and speeds.

General Description

The Test Rig mainly consists of (1) centrifugal pump set (2) Panel Board, (3) Pressure and vacuum gauges to measure the head (4) Measuring Tank to measure the discharge (5) Energy meter to measure the input to the motor and .(6) Sump.

Constructional Specification

1. **Centrifugal Pump Set:** The pump set is of special design, horizontal spindle, and vertical split case. The pump is of such a size, type & design that 1) The total head 2) Discharge and 3) Power requirements at normal speed is well suited for the experimental purposes in technical institutions.

2. **A.C. Motor:** The electric motor suitable for operation on 50 cycles A.C. Supply is provided.

3. **Gauges:** Suitable range of pressure and vacuum gauges to measure the total head on the pump with reasonable accuracy.

4. **Measuring Tank:** Is provided to measure the discharge of the pump with overflow arrangement. The tank is complete with gauge glass and scale arrangement.

5. **Piping System:** Suitable piping system with pipes, bends and valves are provided. A Simple strainer valve is provided on the suction side to prevent any foreign matter entering into the pump. The gate valve is provided in the delivery side to control the head on the pump. While starting the motor always keep the valve in close position.

6. **Panel Board:** The Panel Board houses all the necessary electrical items, like switch, starter for the above pump set and an energy meter to read the power input and it is fitted with the unit on a strong iron base with sufficient height.

7. **Input Power Measurement:** A Kilowatt-hour meter is provided to measure the power input to the motor. The energy meter constant (The Number of Revolutions per minute of the energy meter Disc) is stamped on the meter from this the input power can be easily calculated.

8. **Sump:** Is provided to store sufficient water for independent circulation through the unit for experimentation and arranged within the floor space of the main unit.

Before Commissioning

1. Check whether all the joints are leak proof and watertight.
2. Check the gauge glass and meter scale assembly of the measuring tank and see that it is fixed

water tight and vertically.

3. Check whether all the electric connection is correct.
4. See that the gauges are mounted on the correct position and their cocks closed.

Starting

Before starting the required electrical connection should be done correctly.

Experiments

1. The apparatus is designed to study the performance of a single stage Centrifugal Pump. The readings to be taken on the single stage centrifugal pump are (1) Total Head (2) Discharge (3) Power input and (4) Efficiency. Provision has been made to measure all these and hence the complete characteristics of the single stage Centrifugal pump in question can be studied.

2. First prime the pump and start the motor. While starting closing and delivery valve and the gauge cocks. Then slowly open the delivery valve and adjust to the required total head. The total head is measured with the help of the pressure gauge. Total head is the sum of the pressure head, Velocity head and the datum head.

3. Discharge is the amount of liquid the pump delivers over a definite period of time. It is usually expressed in liter per minute. The actual discharge is measured with the help of the measuring tank.
4. In this case the power input into the pump cannot be measured directly. Hence the power input into the AC motor is measured with the help of the energy meter connected in the line.

5. Efficiency is the relation between the power input into the pump and the power output from the pump. The power output from the pump is directly proportional to the total head and discharge. As the power input into the pump cannot be measured the power input into the motor only is taken into account and the overall efficiency of the pump is calculated.

6. If the total head (H) is measured in meters and the discharge (0) in liter per minute. The kilowatt input to the motor is measured with the help of the meter constant stamped on the energy meter. The efficiency is calculated by dividing the output by input.

7. For a particular desired speed of the pump, the entire above variable can be studied individually, thus the complete characteristics can be studied.

PERFORMANCE TEST ON CENTRIFUGAL PUMP

Aim: - To conduct a test at various heads of given centrifugal pump find its efficiency.

Apparatus: - centrifugal pump, stop watch, scale, collecting tank.

Procedure:-

1. Start the motor keeping the delivery valve close.
2. Note down the pressure gauge and vacuum gauge reading by adjusting the delivery valve to require head say 0 meters. Now calculate the total head (H).

Pressure Head = Kg/cm² x 10 = meters.

$$\text{Vacuum Head} = \frac{mm\ of\ Hg\ X\ 13.6}{1000}\ meters$$

Datum head =Distance between pressure and vacuum gauge in meter

Total Head (H)= Pressure Head + Vacuum head + Datum Head

3. Note down the time required for the rice of 10cm (i.e 0.1) Water in the collecting tank by using stop watch. Calculate discharge using below formulae **.**

Discharge: The time taken collect some 'x'cm of water in the collecting tank in m^3/sec

$$Q_{act} = \frac{AXR}{T}$$

Where:

A = area of the collecting tank in m² (0.35m X 0.35m)

h = rise of water level taken in meters (say 0.1m or 10cm)

t = time taken for rise of water level to height 'h' in seconds.

4. Note down the time taken for 'x' revolutions of energy meter disk and calculate the Input power

$$\text{Input Power} = \frac{n\ X\ 3600\ X\ 0.81}{C\ X\ T}$$

0.80 =Motor efficiency.

X = No. of revolutions of energy meter disc

T = Time for Energy meter revolutions disc. In seconds C = Energy meter constant

5. Now calculate the output power

$$\text{Output power} = \frac{W\ X\ Q\ X\ H}{1000}\ kw$$

Where:

W = Sp. Wt. of water (9810 N/m³)

Q = Discharge

H = Total Head

6. Repeat the steps from 2 to 5 for various heads by regulating the delivery valve. A Typical tabular form is given below for convenience during experiments

S. No.	Pressure gauge reading	Vaccum gauge reading	Time taken for 5rev of energy Meter disc	Time taken for collecting 10cm rise of water In collecting tank	Total head (P + V) meters	Discharge Q	Input Power Kw	Out put Power Kw	Efficiency
1									
2									
3									
4									
5									

Calculation:-

Total Head, H

$$H = (P + \frac{P_v}{760}) \text{ X } 10 \text{ m of water}$$

Where,

P = Delivery Pressure

Pv = Vacuum Pressure

Input Power, IP (Electrical)

$$IP = \frac{K \ X \ 3600 \ X \ n_m}{EMC \ X \ T} \quad \text{hp}$$

η_m = 0.70 (70% assumed)

K = no of revolutions of energy meter

EMC = Energy Meter Constant

T = Time taken for ‘K’ revolutions of Energy meter

Output Power, OP (Hydraulic)

$$\mathbf{OP} = \frac{W \ X \ Q \ X \ H}{75} \quad \mathbf{HP}$$

Where,

W =1000 kg/m^3

Q = Discharge, AR/**t m³/sec**

H =Total Head

Graphs:-

1. Discharge Vs Head
2. Discharge Vs Input power
3. Discharge Vs Efficiency

Precautions:-

Don't start the pump if the voltage is less than 380 V

1. Don't forget to give Electrical neutral and earthing connections to the main plug
2. At least once in 3 months grease/oil the rotating parts
3. Initially put the clean water free from foreign material, and change the water once in 3 months.
4. At least every week, operate the unit for five minutes to prevent clogging of moving parts

RESULTS AND CONCLUSIONS

EXPERIMENT: 4

RECIPROCATING PUMP TEST RIG

Introduction

1. In general, a pump may be defined as mechanical device when connected in a pipe line, can convert the mechanical energy into hydraulic energy, thus resulting in the flow of liquid from lower potential to higher potential.

2. Pumps are of major concern to most engineers and technicians. The types of pumps vary in principle and design. The selection of the pump for any particular application is to be done by understanding their characteristics. The most commonly used pumps for domestic, agricultural and industrial are Centrifugal, reciprocating, axial flow (stage pumps), air jet, diaphragm and turbine pumps. Most of these pumps fall mainly into a class namely rotodynamic, reciprocating (positive displacement) and fluid operated pumps.

3. Reciprocating pump is based purely on mechanical concepts, since the liquid is displaced by a piston (plunger) moving in a cylinder. They discharge a definite quantity of liquid irrespective of the head on the pump i.e., positive displacement. However, in a single acting pump, water is sucked into the cylinder in the suction stroke and delivered out of the cylinder in the delivery stroke that is the discharge only on alternate strokes, where as in double acting pump there is suction and delivery in each stroke, that is the discharge is continuous.

General Description

The Reciprocating Pump Test Rig mainly consists of

1. A Reciprocating Pump
2. A Single phase 2.0 HP 1440 RPM AC Motor
3. Piping system & Collecting tank
4. Input power Measuring arrangement and
5. SS Sump tank

Constructional Specification

1. **Reciprocating Pump:** The Reciprocating pump is of single acting type. The suction & delivery size are 1" x 3/2" respectively.
   α. Bore: 38 mm, Stroke: 48 mm.

2. **Motor:** The Motor supplied is of 2 HP 1440 RPM. It can be operated on AC 50 cycles 220 / 230 V, through mains. A smaller HP motor can be used for normal working conditions, a higher power motor is selected to test the pump at higher speed, high pressure combinations, without over loading it.

3. **Piping System:** Suitable piping system with pipes, bends valves etc. Arrangement with cocks is , also provided for connecting pressure and vacuum gauges to the delivery and suction pipes.

4. A simple strainer valve is provided on the suction side to prevent any foreign matter from entering into the pump. The gate valve is provided on the delivery side to control the Head of the pump. Note that the **delivery valve should never be closed when the pump is working**. While starting the motor always keep the valve in **open** position. Otherwise the pump parts will be damaged. **Collecting Tank:** A Collecting tank is provided to measure the discharge water through pizeo meter arrangement.

5. **Input Power Measurement:** A Kilowatt-hour meter is provided to measure the power input to the motor. The energy meter constant (The Number of Revolutions per minute of the energy meter Disc) is stamped on the meter. From this the input power can be easily calculated.

6. **Sump:** A Sump is provided compactly within the (Floor space of the main unit to store adequate water for circulation through the unit for experimentation)

Before Commissioning

1. Check whether all the joints are leak proof and watertight.
2. Check the gauge glass and meter scale assembly of the measuring tank and see that it is fixed water tight and vertically.
3. Check whether all the electric connection are correct.
4. See that the gauges are mounted on the correct position and their cocks closed.
5. Delivery valve should be in fully **open** condition.

Starting

Pour the lubricating oil **SAE 40** in the crankcase of the reciprocating pump to the required level once in a year. This will require about 250 cc of oil prime the pump before starting see that the V belt are in proper tension. Start the Motor keeping the delivery valve in fully **open** position. Open the gauge cocks, and see the pressure developed by the pump. Delivery control valve may be closed up to about 30 meters of the water head on the delivery side. Under any circumstances the valve should not be closed beyond 40 meters head on the delivery side. If the pressure exceeds this valve (40 Kg/sq.cm) the cylinder head gasket joints, piston, pressure gauge etc. would be damaged. To stop the pump set, first close the gauge cocks. Do not close the delivery valve on the other hand it may open fully. Then switch off the motor.

Experiments

Start the pump and run it at a constant speed and the hand head may be tried, say from 10 meters to 30 meters. The discharge will be more or less thank same depending upon the leakage past the piston, which is dependent this on the total on the pump 6 to 8 readings can be taken within this head range. The above procedure can be repeated and the pump tested the different heads.

Maintenance

1. As these units are built very sturdily, they do not require any routine or regular maintenance; however we recommend the following to be checked then and there to increase the life of the elements.

2. Lubricate all the working parts where provision for lubrication is made Grease cups are provided for lubricating ball bearings. Remove the grease drain plugs where fitted, and inject fresh grease through grease cups until waste grease along with a portion of fresh grease is ejected out through the grease drain hole.

3. Then run the machine for a few minutes to eject the excess grease in the bearing housings. Then fix the grease drain plug. Over greasing results in excessive heat due to a pumping action of the bearings, and it is as harmful as under greasing. Suitable grease should contain no mineral acid, free alkali or foreign matter. Suitability is of the at most importance and the grease should show no tendency to run, thin out or separate into its constituents on standing or in of such substances as graphite, talcum etc., even in an extremely finely divided state will give rise to lapping of the bearing parts. For normal condition of operation soda soap grease of softer consistency for working temperature up to 75 ° C having a melting point of about 150° / 175°C shall be used.

4. Never run the pump without water in it, as this would cause damage to stuffing box, bush bearings etc. Never try to throttle the suction side of the pump to control discharge, as it would seriously affect the performance of the pump.

PERFORMANCE TEST ON RECIPROCATING PUMP

Aim: - To conduct a test at various heads of given reciprocating pump find its efficiency.

Apparatus: - Reciprocating pump, stop watch, scale, collecting tank.

Procedure:-

1. Start the motor keeping the delivery valve fully open.
2. Note down the pressure gauge and vacuum gauge reading by adjusting the delivery valve to require head say 0 meters. Now calculate the total head (H).

   Pressure Head = Kg/cm^2 x 10 = meters.

   $$\text{Vacuum Head} = \frac{mm\ of\ Hg\ X\ 13.6}{1000}\ meters$$

   Datum head = Distance between pressure and vacuum gauge in meters

   Total head (H) = Pressure Head + Vacuum Head + Datum Head
3. Note down the time required for the rise of 10cm (i.e. 0.1m) water in the collecting tank by using stop watch. Calculate discharge using below formula.

Discharge:- The time taken to collect some 'x' cm of water in the collecting tank in

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

A = area of the collecting tank in m^2 (0.3m X 0.3m)

R = rise of water level taken in meters (say 0.1m or 10cm)

t = time taken for rise of water level to height 'h' in seconds.

4. Note down the time taken for 'x' revolutions of energy meter disk and calculate the Input power

   $$\text{Input power} = \frac{X \times 3600 \times 0.70 \times 0.80}{C \times T}\ Kw$$

   Where,

   0.70= Combined motor losses.

   0.80 = Belt (or) transmission losses.

   X = No. of revolutions of energy meter disc (say 5 Rev.)

   T = Time for Energy meter revolutions disc. In seconds C

   = Energy meter constant
5. Now calculate the output power

   $$\text{Output power} = \frac{W \times Q \times H}{1000}\ Kw$$

   Where:

   W = Sp. Wt. of water ($9810N/m^3$)

   Q = Discharge

   H = Total Head

6. Repeat the steps from 2 to 5 for various heads by regulating the delivery valve.

   Note: -- Maximum head should not exceed 2.5m (i.e. **2.5kg/sq. cm**)
7. Check the lubricating oil **SAE 40** in the crankcase of the reciprocating pump to the required level i.e 400ml.

   A Typical tabular form is given below for convenience during experiments.

Tabular Form

S. No.	Pressure gauge reading	Vacuum gauge reading	Time taken for No. of rev of energy Meter disc (T)	Time taken for collecting 10cm rise of water In collecting tank (t)	Total head (P + V) meters	Discharge Q	Input Power Kw	Output Power Kw	Efficiency
1									
2									
3									
4									
5									
6									
7									

Shut Down;

Before switching off the pump, open the discharge valve; close the pressure & vacuum gauge cocks fully.

Calculation:-

1. Total Head, H

$$H = \left(P + \frac{P_v}{760}\right) * 10 \; m \; of \; Water$$

Where,

P = Delivery Pressure, kg/cm²
Pv = Vacuum Pressure, mm of Hg.

2. Discharge, Q

$$Q = \frac{A \times R}{t \times 100} \; m^3/s$$

Where,

A = Area of collecting tank = 0.09 m².
R = Rise in water level of the collecting tank, cm. t = time for 'R' cm rise of water, sec
100 = Conversion from cm to m.

3. Input Power, IP (Electrical)

Where,

$$IP = \frac{K \times 3600 \times \eta_T}{EMC \times T} \; kW$$

η_m = transmission = 0.80
K = no of revolutions of energy meter
EMC = energy meter constant
T = Time taken for 'K' revolutions Energy meter

4. Output Power, OP (Hydraulic)

$$OP = \frac{W\ Q\ H}{1000}\ kw$$

W= Sp .Wt. of water (9810 N/m^3)
Q =Discharge, m^3/sec
H = Total Head

5. Efficiency Of The Pump, η%

$$\eta\% = \frac{OP \times 100}{IP}$$

6. Repeat the steps from 2 to 5 for various heads by regulating the delivery valve.
   Note: -- Maximum head should not exceed 2.5m (i.e. **2.5kg/sq. cm**)
7. Check the lubricating oil **SAE 40** in the crankcase of the reciprocating pump to the required level i.e 400ml.
   A Typical tabular form is given below for convenience during experiments.

Shut Down;

Before switching off the pump, open the discharge valve; close the pressure & vacuum gauge cocks fully.

Graphs:-

1. Discharge Vs Head
2. OP Vs Head
3. Efficiency Vs Head

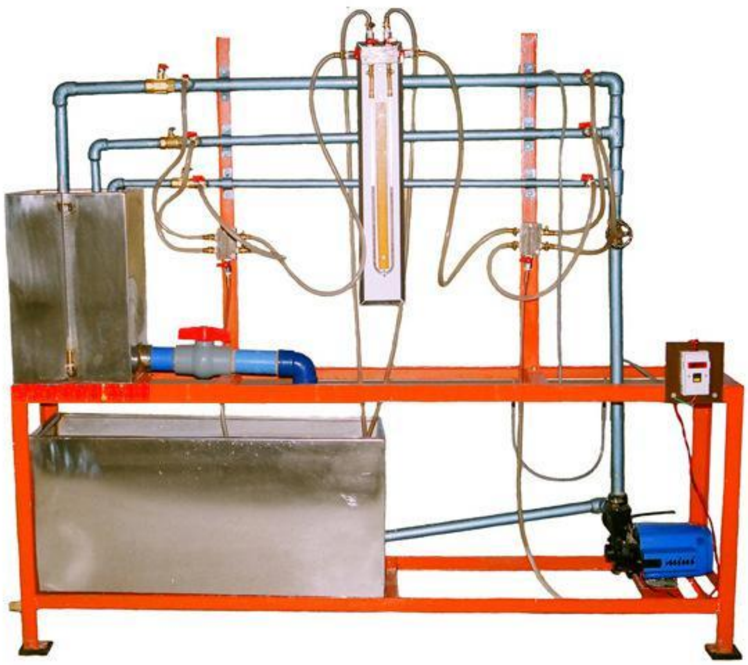
Precautions:-

1. Don't start the pump if the voltage is less than 180 V.
2. Don't forget to give Electrical neutral and earthing connections to the main plug.
3. At least once in 3 months grease/oil the rotating parts.
4. At least every week, operate the unit for five minutes to
5. prevent clogging of moving parts

Results And Conclusions

EXPERIMENT: 5

PIPE FRICTION APPARATUS



Introduction

A pipe may be of various diameters and may have bends, valves, etc. When a liquid is flowing through such pipes, the velocity of the liquid layer adjacent to the pipe wall is zero. The velocity of the liquid goes on increasing from the wall and hence shear stresses are produced in the liquid due to viscosity. This viscous action causes loss of energy, which is usually known as Frictional loss.

Here, we are going to consider two important losses that occur during flow,

- Major Losses.
- Minor Losses.

1. Major losses occur due to friction. This friction may be due to viscosity or roughness in the pipe.

2. Minor losses can be due to various reasons such as Inlet and Outlet of the pipe, bends, gates, sudden expansions and contractions. The apparatus is designed to study the friction losses that appear in long pipes and the obstructions that are encountered in the way of flow by various types of fittings.

General Description

The unit consists mainly of 1) Piping System 2) Measuring Tank 3) Differential Manometer 4) Supply pump set 5) Sump.

Constructional Specification

- **Piping System:** Piping System of size 12.7 mm, 20 mm and 20 mm (S.S.) dia. With tapings at 1 meter distance and a flow control valve.
- **Measuring Tank:** Measuring tank is provided to measure the discharge of water from the unit.
- **Differential Manometer:** Differential manometer with 1 mm scale graduations to measure the loss of head in the pipe line.
- **Supply Pump Set:** Supply pump set is rigidly fixed on the sump. The pump set is mono block pump with 0.5 HP motor operating on single phase 220 volts 50 Hz AC supply.
- **Sump:** Sump is provided to store sufficient waters for independent circulation through the unit for experimentation and arranged within the floor space of the main unit.

Before Commissioning

- Check whether all the joints are leak proof and watertight.
- Close all the cocks on the pressure feed pipes and Manometer to prevent damage and overloading of the manometer.
- Check the gauge glass and meter scale assembly of the measuring tank and see that it is fixed water tight and vertical.
- Check proper electrical connections to the switch, which is internally connected to the motor.

Experiments

1. The apparatus is primarily designed for conducting experiments on the frictional losses in pipes of different sizes. Three different sizes of pipes are provided for wide range of experiments. Each individual pipe can be connected to the Manometer through the pressure feed pipes having individual quick operating cocks.
2. While taking reading close all the cocks in the pressure feed pipe except the two (upstream and downstream) cocks, which directly connect the manometer to the required pipe for which the loss in head has to be determined. (Make sure while taking readings, that the manometer is properly primed. Priming is the operating of filling the Manometer upper part and the connecting pipes with water venting the air from the pipes).
3. First open the inlet gate valve of the apparatus. Adjust the control valve kept at the exit end of the apparatus to a desired flow rate and maintain the flow steadily.
4. The actual discharge is measured with the help of the measuring tank. For each size of the pipe the area of cross section of flow can be calculated from the known diameter of the pipes. From these two valves and the average velocity of stream through the pipe can be calculated.
5. The actual loss of head is determined from the Manometer readings. The frictional loss of head in pipes is given by the Darcy's formula. The friction coefficient indicates 'f '.

FRICTION FACTOR FOR A GIVEN PIPE LINE

Aim: - To calculate the friction factor for a given pipe line.

Apparatus: - experimental set-up, stop watch.

Procedure:-

1. Start the motor keeping the delivery valve close.
2. The water is allowed to flow through the selected pipe by selecting the appropriate ball valve.
3. By regulating the valve control the flow rate and select the corresponding pressure tapings.
4. Make sure while taking readings, that the manometer is properly primed. Priming is the operating of filling the Manometer upper part and the connecting pipes with water venting the air from the pipes. Note down the loss of head "hf" from the manometer scale.
5. Note down the time required for the rise of 10cm (i.e. 0.1m) water in the collecting tank by using stop watch. Calculate discharge using below formula.

Discharge: - The time taken to collect some 'x' cm of water in the collecting tank in m^3/sec.

$$Q = \frac{A \times R}{t}$$

A = area of the collecting tank in m^2 (0.3m X 0.3m)
R = rise of water level taken in meters (say 0.1m or 10cm)
t = time taken for rise of water level to rise 'r' in 't' seconds.

6. Calculate the velocity of the jet by following formula

$$V = \frac{\text{Discharge}}{\text{Area of the pipe}} = Q/A \text{ m/sec}$$

A = cross sectional area of the pipe= $\Pi d^2/4$
d = pipe diameter

7. Calculate the coefficient of friction for the given pipe by

.

$$h_f = \frac{4fLv^2}{2gd}$$

Where,

h_f - Loss of head of water = (h1-h2)(Sn /So – 1) = (h1-h2) 12.6/1000 m
f - Co-efficient of friction for the pipe
L - Discharge between sections for which loss of head is measured (1 meter) v - Average velocity of flow in m/sec
g - Acceleration due to gravity 9.81m/sec
d - Pipe diameter in meters

8. Repeat the steps 2 to 7 for different sets of readings by regulating the discharge valve.

Tabular Form:

S. No.	Ø of pipe	Area (a)	Manometer reading	Time for rise of 10 cm water	Discharge (Q)	Velocity (v)	Co-efficient of friction f

Calculation:-

1 Total Head, H

$$H = (h1 \pm h2) \times 12.6 \text{ m of water}$$

Where,

12.6 = conversion factor from mercury to water head

2 Discharge, Q

$$Q = \frac{A x R}{t x 100} m^3/s$$

Where,

A = Area of collecting tank = 0.125 m².

R = Rise in water level of the collecting tank, cm. t = time for 'R' cm rise of water, sec

100 = Conversion from cm to m.

3 Velocity, V

$$V = \frac{Q}{A'} \text{ m/s}$$

Where, A' = area of the pipe/fitting in use

Where

$$A' = \frac{\pi x D^2}{4} m^2$$

4 Friction Factor,(Major Losses) F:

$$F = \frac{2ghf X d}{4 LV^2}$$

h_{f} = Head Loass of the friction d= dia of the pipe

, H = total head, m of water ,
V = velocitm
g = acceleration due to gravity, 9.81m/s²
L = Distance b/w tapping = 1.5m

Head Loss Due To Fittings, (Minor Losses) K: $K = \frac{2gH}{V^2}$

Where, H = total head, m of water
V = velocity, m/sec
g = acceleration due to gravity, 9.81m/s²

Precautions:

1) Do not run the pump dry.
2) Clean the tanks regularly, say for every 15days.
3) Do not run the equipment if the voltage is below 180V.
4) Check all the electrical connections before running.
5) Before starting and after finishing the experiment the main control valve should be in close position.
6) Do not attempt to alter the equipment as this may cause damage to the whole system.

Results and Conclusions:

EXPERIMENT: 6

IMPACT OF JET OF WATER ON VANE

Introduction

When a jet of water is directed to hit a vane of any particular shape, the force is exerted on it by the fluid in the opposite direction. The amount of force exerted depends on the diameter of the jet, shape of the vane and flow rate of water. The force also depends on whether the vane is moving or stationary. The current experiment deals with the force exerted on stationary vanes.

The following are the theoretical formulae for calculating the force for different shapes of vanes based on the flow rate.

- – spherical Plate: $F_t = 2\ \rho\ A\ V^2\ /g$
- Flat Plate: $F_t = \rho A\ V^2 / g$
- Inclind plate $F_t = \rho\ AV^2 \text{ Sin } \theta' /g$

Where,

‘g’ = 9.81 m/s

‘A’ = Area of jet in m

‘ρ’ = Density of water = 1000 Kg/m

‘V’ = Velocity of jet in m/s

‘ϑ’ = Angle the deflected jet makes with the axis of the striking jet = 60°

‘F_t’ = Theoretical force acting parallel to the direction of the jet.

General Description

The apparatus consists of mainly (1) Nozzle housing, (2) Nozzle, (3) Vane, (4) Transparent Tank (5) Measuring Tank and (6) Sump.

Nozzle housing

It is of M.S rigidly fixed to the bottom of the tank having transparent tube and suitable to accommodate nozzle.

- **Nozzle:** It is of Gun Metal machined and polished nozzle of 8 mm is supplied.

- **Vane:** It is of Gun Metal machined all over and interchangeable.
  - Flat vane with normal input.
  - Hemi Spherical vane with normal input.

- **Transparent Tank:** To observe the flow and jet deflection the tank is fitted with transparent tube.

- **Measuring Tank:** It is of suitable size and provided with gauge glass, scale arrangement for quick and easy measurements. A Ball valve is provided to empty the tank.

- **Sump:** It is of suitable size with a supply pump set of 1 HP operating on single phase 220-240V 50Hz AC Supply, and a drain plug to drain the water when the unit is not in use.

Installation

Fix the transparent tube on the measuring tank with the help of four bolts and nuts provided. Make sure that the discharge spout is exactly center of the vane and connect the necessary piping to the apparatus.

Before Commissioning

- Check whether the nozzle housing, discharge pipe flange etc are fitted with gaskets to prevent water leakage.

- Check the gauge glass and meter scale assembly of the Measuring tank and see that it is fixed water tight and vertical.

Experiments

The jet of water impinging on vane exerts force on it. The force exerted on it is derived by applying impulse momentum equation to control volume of water. The force exerted by a jet of fluid on symmetric vane is given by

$$F_{th} = \rho a V^2$$

The apparatus is primarily designed for measuring the force on vane due to the impact of jet of water. Aluminum Vane is supplied to study the effect of the deflection of the impinging jet on the vane. The actual discharge is measured by using the measuring tank, by noting the time for a definite rise of water level when the water is collected in the tank. One gunmetal Nozzle of diameter 8 mm is provided. The *Co*-efficient of contraction of the nozzle can be taken as 0.67. The actual impinging jet velocity (V) in meters per second be calculated from the above flow rate and the area of the nozzle

(a) in square mm.. The theoretical force (F1 in Kg) on the vane in the direction of the jet is equal to the change of momentum per second.

A Typical tabular form for use during experiments is attached herewith.

For flat vane $F_{th} = \rho a V^2$

For hemispherical vane $F_{th} = 2\rho a V^2$

Fact = (observed reading in gm+ 250 gm) x 9.81 Newton

IMPACT OF JET OF WATER ON VANE

Aim: To find the coefficient of impact of jet on flat circular and hemispherical vanes.

Apparatus: - experimental set-up, stop watch.

Procedure:-

1. Start the motor keeping the delivery valve close.
2. The water is allowed to flow through the pipe by regulating the flow control valve up to some extent of actual force say 100gm. Convert the 100gm into Newton's and note down as actual force.
3. Note down the time required for the rise of 10cm (i.e. 0.1m) water in the collecting tank by using stop watch. Calculate discharge using below formula.

Discharge:- The time taken to collect some 'x' cm of water in the collecting tank in m^3/sec.

$$Q = \frac{A \times R}{T}$$

Where:

A = area of the collecting tank in m^2 (0.3m X 0.3m)

R = rise of water level taken in meters (say 0.1m or 10cm)

t = time taken for rise of water level to rise 'r' in't'seconds.

4. Calculate the velocity of the jet by following formula

$$V = \frac{\text{Discharge}}{\text{Co.eff. Of contraction X Area of the jet}} = Q/Cc \times A \text{ m/sec}$$

a = cross sectional area of the jet = $\Pi d^2/4$

Cc =coefficient of contraction=0.67

d =diameter of the nozzle =8mm= 0.008m

5. Calculate the theoretical force by the momentum equation $F_{th} = \rho a V^2$

ρ = Density of water =1000 kg/m^3

Ø = angle made by the velocity of the jet with outlet tangent of the vane which is zero in our case.

For flat vane $F_{th} = \rho a V^2/g$.

For hemispherical vane $F_{th} = 2\rho a V^2/g$.

For inclined vane $F_{th} = \rho a V^2 \sin\theta/g$.

F_{act} = (observed reading in gm+ 250 gm) x 9.81 **N**ewton

6. Repeat the steps from 2 to 5 for various heads by regulating the delivery valve.
7. A Typical tabular form for use during experiments is attached herewith.

Tabular Column:

S. No./ type of vane	Fact Newton	Time taken for 10cm rise of water	Q m^3/sec	Velocity Q/Cc x A	F_{act}	F_{th} ρaV^2Newton	Vane Co-eff. F_{act}/F_{th}
1							
2							
3							
4							
5							
6							
7							

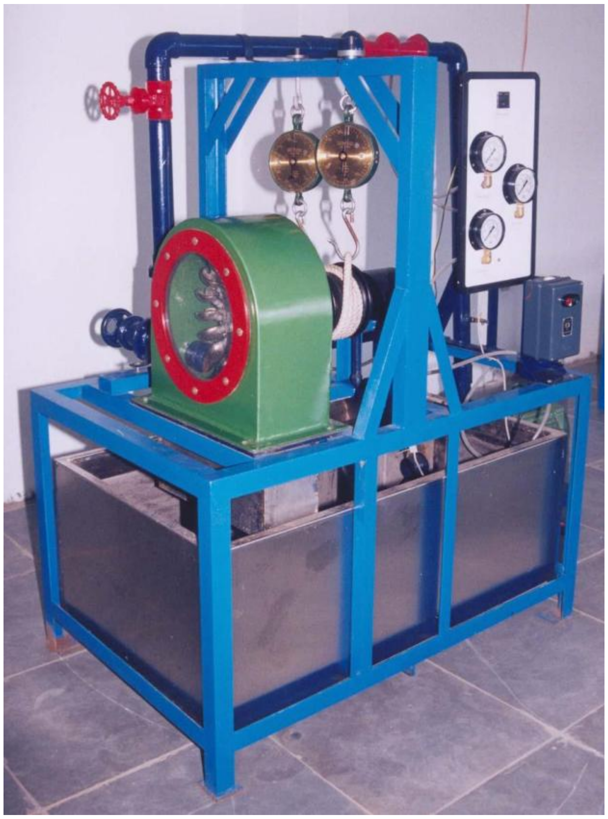
Precautions:

- Do not run the pump dry.
- Clean the tanks regularly, say for every 15 days.
- Do not run the equipment if the voltage is below 180V.
- Check all the electrical connections before running.
- Before starting and after finishing the experiment the main control valve should be in close position.
- Do not attempt to alter the equipment as this may cause damage to the whole system.

Results and Conclusions:

EXPERIMENT: 7

PELTON WHEEL TURBINE TEST RIG



Introduction

Hydraulic (or Water) Turbines are the machines that use the Energy of water (Hydro – Power) and convert it into Mechanical Energy. Thus the Turbines become the Primover to run Electrical Generators to produce electricity, Viz., Hydro Electric Power.

Turbines are classified as Impulse and Reaction Types. In Impulse Turbine, the head of the water is completely converted into a jet, which impulse the force on the Turbine. In Reaction Turbine, it is the pressure of the flowing water, which rotates the runner of the Turbine. Of many types of Turbine, the Pelton Wheel, most commonly used, falls into this category of Impulse Turbine while the Francis & Kaplan fall into the category of Reaction Turbines.

Normally, Pelton Wheel requires high Heads and Low Discharge while the Francis & Kaplan (Reaction Turbines) requires relatively low Heads and high Discharge. These corresponding Heads and Discharges are difficult to create in a laboratory size Turbine from the limitation of the pumps availability in the market. Nevertheless, at least the performance characteristics could be obtained within the limited facility available in the laboratories. Further, understating of various elements associated with any particular Turbine is possible with this kind of facility.

General Description

The unit essentially consists of casing, with a circular transparent window kept at the front for the visual inspection of the impact of the Jet on buckets. a bearing pedestal, a rotor assembly of shaft, Runner & brake drum, all mounted on a suitable sturdy iron base plate, A rope brake arrangement is provided to load the turbine. The input to the turbine can be controlled by adjusting the spear position by means of a hand wheel fitted. The water inlet pressure is measured by a pressure gauge and for the measurement of speed a digital tachometer is used.

An Optimum size sump is provided to store sufficient water from independent circulation through the unit for experimentation.

Constructional Specifications

- **Casing:** of an iron having a large circular transparent Window.
- **Runners:** of electroplated MS disc fitted with accurately finished electroplated buckets.
- **Shaft:** of Stainless steel for rust free operation and for high strength.
- **Nozzle:** designed for smooth flow and efficient operation.
- **Spear:** of stainless steel designed for efficient operation.
- **Ball Bearings:** of double row deep groove rigid type in the casing and double row self aligning type in the pedestal both of liberal size.

Technical Specifications

- Pelton Turbine
  - 1. Power output : 1 K Watt
  - 2. No. of Buckets : 17Nos.
- Supply Pumpset
  - Capacity : 5 HP
  - Type : Centrifugal
- Flow Measuring Unit
  - Size of Venturi meter : 50 mm.
  - Diameter of inlet : 50 mm
  - Diameter of throat : 25 mm.

Before Commissioning

1. Check whether all the joints are perfectly matched.
2. Check whether all the electric connection is correct.
3. See that the gauges are mounted on the correct position and their cocks are closed.

Starting Up

Pour adequate water in the sump. Make sure before starting that the pipe lines are free from foreign matter. Also note whether all the joints are water tight and perfectly matched. Prime the pump and start it with closed gate valve. Then slowly open the gate valve situated above the turbine and open the cock fitted to the pressure gauge and so that the pump develops the rated head. If the pump develops the required head, slowly open the turbine spear by rotating the hand wheel until the turbine attains the normal rated speed (1000 RPM). Run the turbine at the normal speed for about 10 minutes and carefully note the following:

- Operation of the bearings, temperature rise, noise etc.,

- Vibration of the unit.
- Steady constant speed and speed fluctuations if any.

In addition to this, on the sump side note the operation of the stuffing box. (The stuffing box should show an occasional drip of water. If the gland is over tightened, the leakage stops but the packing will heat up burn and damage the shaft.) .If the operation of the above parts is normal, load the turbine slowly and take readings. Open the water inlet valve and allow some cooling water through the brake drum when the turbine runs under load, so that the heat generated by the brake drum is carried away by the cooling water.Do not suddenly load the turbine, load the turbine gradually and at the same time open the spear to run the turbine at normal speed.

Experiments

Water turbines are tested in the hydraulic laboratory to demonstrate the principles of water turbines, to study their construction, and to give the students a clear knowledge about the different types of turbines and their characteristics. Turbines shall be first tested at constant net supply head by varying the load, speed and spear setting. However the net supply head on the turbines tested in which case the power developed by the turbine and the best efficiently speed will also be reduced. The output power from the turbine is calculated from the readings taken on the brake and the speed of the shaft. The input power supplied to the turbine is calculated from the net supply head on the turbine and discharge through the turbine. Efficiency of the turbine being the ratio between the output and input and can be determined from these two readings. The discharge is measured by the 50mm Venturi meter and with the Pressure Gauges. Supply Head is measured with the help of the pressure gauge. The speed of the turbine is measured with digital tachometer fitted to the turbine. After starting and running the turbine at normal speed for the sometime, load the turbine and take readings.

Note the following:

1. Net supply head (pressure gauge reading + height of the gauge center above the center line of the jet).
2. Discharge (Pressure Gauges readings)
3. Turbine shaft speed.
4. Alternator readings
5. For any particular setting of the spear first run the turbine at light load and then gradually load it. The net supply head on the turbine shall be maintained constant at the rated value and this can be done by adjusting the gate valve fitted just above the turbine. A typical tabular form is given below for the convenience during experiment.

IMPORTANT FORMULA

$$\text{Efficiency} = \frac{\text{Output power}}{\text{Input Power X frictional efficiency}} \text{ X } 100$$

Input Power = 9810 x Supply head in meters (H) x Discharge(Q) = $\frac{W \text{ x } Q \text{ x } H}{1000}$ kw;

Frictional efficiency =85%= 0.85

Discharge = $K\sqrt{h}$ m^3/sec

Where, h = (P1 - P2) x 10 m

$$K = \frac{a1\ a2\ \sqrt{2g}}{\sqrt{(a1^2 - a2^2)}}$$

Where, a_1= Diameter of the venturimeter inlet = 50 mm/0.05m
a_2= Diameter of the Venturimeter throat = 25 mm /0.025m

P_1 = Inlet pressure,
P_2 = Throat pressure

Output Power = $\frac{2\pi NT}{60000\ N}$ Kw.

= RPM of the turbine shaft T=
Torque of the turbine shaft T=
(W_1-W_2) x R x 9.81
W = Load applied on the turbine.
R = Radius of the brake drum with rope in meters = 0.12 meters

Shut Down

Before switching off the supply pump set, first remove the load on the brake down. Close the cooling inlet water Jet valve. Slowly close the spear to its full closed position. Then close the gate valve just above the turbine. Pressure Gauge cocks and Venturimeter cocks should be closed in order to isolate the pump set when the turbine is working under load. If the electric line trips off when the turbine is working first unload the turbine, close all the valves and cocks. Start the electric motor against, when the line gets the power and then operate the turbine by opening the valve in the order said above.

PERFORMANCE TEST ON PELTON WHEEL TURBINE

Aim: To conduct performance test on the given Pelton wheel turbine

Apparatus: Pelton wheel turbine test rig.

Specifications:

Pelton Turbine

1. Power output	:	1 K Watt
2. No. of Buckets	:	17Nos.

Supply Pumpset

3.Capacity	:	5 HP
4.Type	:	Centrifugal

Flow Measuring Unit

5.Size of Venturi meter	:	50 mm.
6.Diameter of inlet	:	50 mm
7.Diameter of throat	:	25 mm.

Procedure:

1. Connect the supply water pump-water unit to 3 ph, 440V, 30A, electrical supply, with neutral and earth connections and ensure the correct direction of the pump motor unit.
2. Keep the Gate Valve and Sphere valve closed.
3. Keep the Brake Drum loading at zero.
4. Press the green button of the supply pump starter. Now the pump picks-up the full speed and becomes operational.
5. Slowly open the Sphere Valve so that the turbine rotor picks the speed and conduct experiment on constant speed.
6. Note down the readings of speed, load and pressure gauges readings and tabulated below.

Tabular Form:

S.No.	Speed	Supply head	Pressure Gauges Reading			Discharge m^3/sec	Break weight W_1-W_2	Input Power	Output Power	Efficiency OP / IP
			P_1	P_2	$P_1 - P_2$					
1.										
2.										
3.										
4.										
5.										
6.										
7.										

Calculation:

1. Total Head of Turbine in meters of water, H

   Where, P = Pressure gauge readings in Kg/Cm^2

$$H = \left(P + \frac{P_v}{760}\right) * 10\ m\ of\ Water$$

Pv = Vacuum Pressure gauge m of water readings in mm of hg

1. Discharge, Q

$$Q = \frac{Cd * A1 * A2 * \sqrt{2gh}}{\left(\sqrt{A1^2 - A2^2}\right)}\ m^3/s$$

Where, h = $(P_1 - P_2)$ x 10

A_1 = Area of the Inlet $A_1 = \dfrac{\pi d_1^2}{4}$

Where, d_1 = Inlet diameter = 50mm

A_2 = Area of the throat $A_2 = \dfrac{\pi d_2^2}{4}$

Where, d_2 = Throat diameter = 25mm

Cd = 0.95 (Constant) for Venturimeter or

Cd = 0.62 (Constant) for Orifice enter

2. Input to the turbine, IP(Hydraulic)

$$IP = \frac{WQH}{1000}\ kW$$

Where, W = 9810 Kg/m^3

Q =Discharge in m^3/s

H =Total Head in m of water

4. Output from turbine, OP (Mechanical Work done)

Where,
$$OP = \frac{2\pi NT}{60000\ x\ \eta_T}\ kW$$

N = Turbine Speed in rpm

T = Torque in N-m

T= F X R X 9.81 N m

η_T = Transmission Efficiency = 0.8

Where, $F = F_1 \sim F_2$

R = Radius of Brake Drum=0.125m

5. Turbine Efficiency,

$$\eta_t = \frac{OP}{IP}\ X\ 100$$

6. Unit Quantities – Under Unit Head,

a) Unit Speed

$$N_u = \frac{N}{\sqrt{H}}$$

b) Unit Power,

$$P_u = \frac{P}{H^{3/2}}$$

c) Unit Discharge,

$$Q_u = \frac{Q}{\sqrt{H}}$$

d) Specific Speed,

$$N_S = \frac{N\sqrt{P}}{H^{\frac{5}{4}}}$$

Precautions:

1. Do not start Pump set if the supply voltage is less than 300V (Phase to Phase voltage)
2. Do not forget to give electrical earth and neutral connections correctly, otherwise the RPM indicator gets burnt.
3. Initially, fill in the tank with clean water free from foreign material, change the water every six months.
4. Frequently, at least once in three months, grease all visual moving parts.
5. At least every week, operate the unit for five minutes to prevent any clogging of moving parts.
6. To start and stop supply pump, always keep Gate Valve closed.
7. It is recommended to keep Sphere Rod setting at close positions before starting the turbine. This is to prevent racing of the propeller shaft without load.
8. In case of any major faults, Please write to the manufacturers and do not attempt to repair.

Results And Conclusions:

EXPERIMENT: 8

BERNOULLI'S EXPERIMENT

Introduction

Bernoulli's Theorem gives the relationship between pressure head, velocity head and the datum. Here the attempt has been made to study the relationship of the above said parameters using venturimeter.

General Description

- The apparatus consists of a specially fabricated clear **ACRYLIC Venturimeter** with necessary tappings connected to a **Multibank Piezometer** also made of clear
  - **ACRYLIC**.
- The apparatus consists of two overhead tanks interconnected with the venturimeter, which is placed in between the tanks.
- The overhead tanks are provided with the Head variation mechanism for conducting the experiments at various heads.
- Water in the sump tank is pumped using a **Monobloc Centrifugal pump** (Kirloskar make) which passes through the control valve to the overhead tank.
- The height of the water in the **collecting tank** is measured using the **acrylic Piezometer** to find the flowrate.
- The whole arrangement is mounted on an **aesthetically** designed **sturdy frame** made of MS tubes and **NOVAPAN Board** with all the provisions for holding the tanks and accessories.

Aim:

- The experiment is conducted to
- Study of Pressure Gradient at different zones. ○ Verification of Bernoulli's Equation.
- Comparative analysis under different flow rates

Apparatus:

1) Venturimeter, 2)Piezometer, 3) Overhead Tank, 4)Sump Tank, 5) Centrifugal Pump

Procedure:

1) Fill in the sump tank with clean water.
2) Keep the delivery valve closed.
3) Check and give necessary electrical connections to the system.
4) Switch on the pump & Slowly open the delivery valve.
5) Adjust the flow through the control valve of the pump.
6) Allow the system to attain the steady state. i.e., let the water pass from the second overhead tank to the collecting tank.
7) Note down the Pressure head at different points of the venture meter on the multi-tube piezometer. (Expel if any air is the by inserting the thin pin into the piezometer openings)
8) Close the ball valve of the collecting tank and measure the time for the known rise of water.
9) Change the flow rate and repeat the experiment.

Observation:

Sl. No	Static Head Loss, h										Time for 'R' cm rise in water 'T' sec
	1	2	3	4	5	6	7	8	9	10	
1											
2											
3											
4											
5											

Calculations:

1. Discharge, Q_{act}
2. Where $Q = \frac{A\ X\ R}{t\ X\ 100}\ m^3\ s$

A = Area of collecting tank = 0.045 m².
R = Rise in water level of the collecting tank,
cm. t = time for 'R' cm rise of water, sec
100 = Conversion from cm to m.

3. Pressure Head,

Where, Pressure head = $\frac{P}{\rho g}$ =h m of water

ρ = Density of water.
g = Gravitational constant
h = Head measured, m of water column

3. Velocity Head, $Velocity\ Head = \frac{V^2}{2g}\ m\ of\ water$

Where,
V = **Q / a**, a = Area at the particular section* of the venturimeter m².

4. Verification of BERNOULLI'S EQUATION
Bernoulli's Equation is given as: After Finding

$$\frac{P}{\rho g} + \frac{V^2}{2g} + z = 0$$

a. Pressure Head, h
b. Velocity head, $V^2/2g$
at different cross-section of the Venturimeter.

Put the same in the above equation for different points and verify whether all the values obtained are same.

Note: Consider the datum, z to be constant.

Precautions:

1. Do not run the pump dry.
2. Clean the tanks regularly, say for every 15days.
3. Do not run the equipment if the voltage is below 180V.
4. Check all the electrical connections before running.
5. Before starting and after finishing the experiment the main
6. Control valve should be in close position.
7. Do not attempt to alter the equipment as this may cause
8. Damage to the whole system.

Result and Conclusion:

EXPERIMENT: 9

FRANCIS TURBINE TEST RIG

Introduction

Hydraulic (or Water) Turbines are the machines that use the Energy of water (Hydro – Power) and convert it into Mechanical Energy. Thus the Turbines become the Primover to run Electrical Generators to produce electricity, Viz., Hydro Electric Power.

Turbines are classified as Impulse and Reaction Types. In Impulse Turbine, the head of the water is completely converted into a jet, which impulse the force on the Turbine. In Reaction Turbine, it is the pressure of the flowing water, which rotates the runner of the Turbine. Of many types of Turbine, the Pelton Wheel, most commonly used, falls into this category of Impulse Turbine while the Francis & Kaplan fall into the category of Reaction Turbines. Normally, Pelton Wheel requires high Heads and Low Discharge while the Francis & Kaplan (Reaction Turbines) requires relatively low Heads and high Discharge. These corresponding Heads and Discharges are difficult to create in a laboratory size Turbine from the limitation of the pumps availability in the market. Nevertheless, at least the performance characteristics could be obtained within the limited facility available in the laboratories. Further, understating of various elements associated with any particular Turbine is possible with this kind of facility.

General Description

- The apparatus consists of the following major parts
  a) Monobloc Centrifugal Pump of Kirloskar Make.
  b) Turbine Unit
  c) Sump Tank
  d) Venturimeter with pressure tappings.
- All are arranged in such a way that the whole unit works as a recirculating water system.
- Centrifugal pump set supplies water from Sump Tank to the Turbine through control valve.
- Water re - enters the Sump Tank after passing through the Turbine unit.
- Loading of the Turbine is achieved by a rope brake drum connected to spring balance.
- Provisions for measurement of Turbine speed (digital RPM indicator), Head on Turbine (Pressure gauge) are built in on the control panel.
- The whole arrangement is mounted on an **aesthetically designed sturdy frame** made of **MS angle** with all the provisions for holding the tanks and accessories.\

Aim:

The experiment is conducted to obtain Constant Head and Speed characteristics.

Apparatus:

1) Monobloc Centifugal Pump of Kirloskar Make 2) Turbine Unit, 3) Sump Tank, 4) Venturimeter with pressure tappings.

Procedure:

A. To obtain constant head characteristics.

- Set the Vane position.
- Keep the Delivery valve open at Maximum.
- Set the head at required value.
- Now apply the load.
- Operating the delivery valve, maintain the head to the
- Set value.
- Repeat the steps 4 and 5 till the maximum load the turbine can take.
- In the meantime, Note down the turbine speed, vacuum head and Venturimeter readings for each loadings.

A. To obtain constant speed characteristics.

1. Set the Vane position.
2. Keep the Delivery valve open at Maximum.
3. Set the speed to the required value using the same delivery Valve.
4. Now apply the load.
5. Operating the delivery valve, maintain the speed to the
6. Set value.
7. Repeat the steps 4 and 5 till the maximum load the turbine can take.
8. In the meantime, Note down the turbine speed, vacuum head and Venturimeter readings for each loadings.

B. Performance under unit head – unit quantities.

In order to predict the behavior of a turbine working under varying conditions and to facilitate comparison between the performances of the turbines of the same type but having different outputs and speeds and working under different heads, it is often convenient to express the test results in terms of certain unit quantities. From the output of the turbine corresponding to different working heads (Tabular Column - 1), it is possible to compute the output, which would be developed if the head was reduced to unity (say 1 Meter): the speed being adjustable so that the efficiency remains unaffected.

a) Unit Speed,

$$N_u = \frac{N}{\sqrt{H}}$$

b) Unit Power,

$$P_u = \frac{P}{H^{3/2}}$$

c) Unit Discharge,

$$Q_u = \frac{Q}{\sqrt{H}}$$

d) Specific Speed,

The Specific Speed of any Turbine is the speed in rpm of a turbine geometrically similar to the actual turbine but of such a size that under corresponding conditions it will develop 1 metric horse power when working under unit head (i.e. 1 meter). The Specific Speed is usually computed for the operating conditions corresponding to the maximum efficiency.

$$N_s = \frac{N\sqrt{P}}{H^{5/4}}$$

Observation:

Constant Head/Speed

Sl. No	Turbine speed N rpm	Delivery Pressure`P' Kg/cm²	Vacuum pressure 'Pv' mm of hg	Venturimeter Head		Load Applied	Time for 'n' pulses of energy meter, t sec
				P1 Kg/cm²	P2 Kg/cm²		
1							
2							
3							
4							
5							

CALCULATIONS

1. Total Head of Turbine in meters of water, H

$$H = \left(P + \frac{P_v}{760}\right) * 10$$ m of water

Where, P = Pressure gauge readings in Kg/Cm²

Pv = vacuum Pressure gauge readings in mm of hg

2. Discharge, Q

$$Q = \frac{Cd \times A1 * A2 * \sqrt{2gh}}{(\sqrt{A1^2 - A2^2})}\ m^3/s$$

Where,

h = $(P_1 \sim P_2)$ x 10

A1 = Area of the Venturimeter

$$A_1 = \frac{\pi * D_1^2}{4}\ m^2$$

Where, D1 = Flowmeter Inlet diameter = 100mm

A2 = Area of the throat of the Venturimeter

$$A_2 = \frac{\pi * D_2^2}{4}\ m^2$$

Where, D2 = Flowmeter Throat diameter = 50mm

Cd = 0.95 for Venturimeter

Cd = 0.62 for Orificemeter

3. Input to the turbine, IP(Hydraulic)

$$IP = \frac{WQH}{1000}\ kW$$

Where, W = 9810 Kg/m³, Q =Discharge in m³/s, H =Total Head in m of water

4. Output from turbine, OP (Mechanial Workdone)

$$OP = \frac{V\ X\ I}{\eta_t\ X\ \eta_a}\quad kw$$

Where, V =Voltmeter reading in volts, I =Ammeter reading in amps, ηT = Transmission Efficiency (Belt Transmission) = 0.75., ηA = Alternator Efficiency = 0.73.

Precautions:

1. Do not start Pump set if the supply voltage is less than 300V (Phase to Phase voltage)
2. Do not forget to give electrical earth and neutral connections correctly; otherwise the RPM indicator gets burnt.
3. Initially, fill in the tank with clean water free from foreign material, change the water every six months.
4. Frequently, at least once in three months, grease all visual moving parts.
5. At least every week, operate the unit for five minutes to prevent any clogging of moving parts.
6. To start and stop supply pump, always keep Gate Valve closed.
7. It is recommended to keep Sphere Rod setting at close positions before starting the turbine. This is to prevent racing of the propeller shaft without load.
8. In case of any major faults, Please write to the manufacturers and do not attempt to repair.

Result and Conclusion:

EXPERIMENT: 9

KAPLAN TURBINE TEST RIG

Introduction

Hydraulic (or Water) Turbines are the machines that use the Energy of water (Hydro – Power) and convert it into Mechanical Energy. Thus the Turbines become the Primover to run Electrical Generators to produce electricity, Viz., Hydro Electric Power.

Turbines are classified as Impulse and Reaction Types. In Impulse Turbine, the head of the water is completely converted into a jet, which impulse the force on the Turbine. In Reaction Turbine, it is the pressure of the flowing water, which rotates the runner of the Turbine. Of many types of Turbine, the Pelton Wheel, most commonly used, falls into this category of Impulse Turbine while the Francis & Kaplan fall into the category of Reaction Turbines. Normally, Pelton Wheel requires high Heads and Low Discharge while the Francis & Kaplan (Reaction Turbines) requires relatively low Heads and high Discharge. These corresponding Heads and Discharges are difficult to create in a laboratory size Turbine from the limitation of the pumps availability in the market. Nevertheless, at least the performance characteristics could be obtained within the limited facility available in the laboratories. Further, understating of various elements associated with any particular Turbine is possible with this kind of facility.

General Description

- The apparatus consists of the following major parts
  - e) Monobloc Centrifugal Pump of Kirloskar Make.
  - f) Turbine Unit
  - g) Sump Tank
  - h) Venturimeter with pressure tappings.
- All are arranged in such a way that the whole unit works as a recirculating water system.
- Centrifugal pump set supplies water from Sump Tank to the Turbine through control valve.
- Water re - enters the Sump Tank after passing through the Turbine unit.
- Loading of the Turbine is achieved by a rope brake drum connected to spring balance.
- Provisions for measurement of Turbine speed (digital RPM indicator), Head on Turbine (Pressure gauge) are built in on the control panel.
- The whole arrangement is mounted on an **aesthetically designed sturdy frame** made of **MS angle** with all the provisions for holding the tanks and accessories.\

Aim:
The experiment is conducted to obtain Constant Head and Speed characteristics.

Apparatus:
1) Monobloc Centifugal Pump of Kirloskar Make 2) Turbine Unit, 3) Sump Tank, 4) Venturimeter with pressure tappings.

Procedure:

B. To obtain constant head characteristics.

- Set the Vane position.
- Keep the Delivery valve open at Maximum
- Set the head at required value.

- Now apply the load.
- Operating the delivery valve, maintain the head to the
- Set value.
- Repeat the steps 4 and 5 till the maximum load the turbine can take.
- In the meantime, Note down the turbine speed, vacuum head and Venturimeter readings for each loadings.

C. To obtain constant speed characteristics.

1. Set the Vane position.
2. Keep the Delivery valve open at Maximum.
3. Set the speed to the required value using the same delivery Valve.
4. Now apply the load.
5. Operating the delivery valve, maintain the speed to the
6. Set value.
7. Repeat the steps 4 and 5 till the maximum load the turbine can take.
8. In the meantime, Note down the turbine speed, vacuum head and Venturimeter readings for each loadings.

D. Performance under unit head – unit quantities.

In order to predict the behavior of a turbine working under varying conditions and to facilitate comparison between the performances of the turbines of the same type but having different outputs and speeds and working under different heads, it is often convenient to express the test results in terms of certain unit quantities. From the output of the turbine corresponding to different working heads (Tabular Column - 1), it is possible to compute the output, which would be developed if the head was reduced to unity (say 1 Meter): the speed being adjustable so that the efficiency remains unaffected.

a) Unit Speed,

$$N_u = \frac{N}{\sqrt{H}}$$

b) Unit Power,

$$P_u = \frac{P}{H^{3/2}}$$

c) Unit Discharge,

$$Q_u = \frac{Q}{\sqrt{H}}$$

d) Specific Speed,

The Specific Speed of any Turbine is the speed in rpm of a turbine geometrically similar to the actual turbine but of such a size that under corresponding conditions it will develop 1 metric horse power when working under unit head (i.e. 1 meter). The Specific Speed is usually computed for the operating conditions corresponding to the maximum efficiency.

$$N_s = \frac{N\sqrt{P}}{H^{5/4}}$$

Observation:

Constant Head/Speed

Sl. No	Turbine speed N rpm	Delivery Pressure`P' Kg/cm²	Vacuum pressure 'Pv' mm of hg	Venturimeter Head		Load Applied	Time for 'n' pulses of energy meter, t sec
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5							

CALCULATIONS

1. Total Head of Turbine in meters of water, H

$$H = \left(P + \frac{P_v}{760}\right) * 10 \quad \text{m of water}$$

Where, P = Pressure gauge readings in Kg/Cm²

Pv = vacuum Pressure gauge readings in mm of hg

2. Discharge, Q

$$Q = \frac{Cd \times A1 * A2 * \sqrt{2gh}}{\left(\sqrt{A1^2 - A2^2}\right)} \ m^3/s$$

Where,

h = ($P_1 \sim P_2$) x 10

A1 = Area of the Venturimeter

$$A_1 = \frac{\pi * D_1^2}{4} \ m^2$$

Where, D1 = Flowmeter Inlet diameter = 100mm

A2 = Area of the throat of the Venturimeter

$$A_2 = \frac{\pi * D_2^2}{4} \ m^2$$

Where, D2 = Flowmeter Throat diameter = 50mm

Cd = 0.95 for Venturimeter

Cd = 0.62 for Orificemeter

3. Input to the turbine, IP(Hydraulic)

$$IP = \frac{WQH}{1000} \ kW$$

Where, W = 9810 Kg/m³, Q =Discharge in m³/s, H =Total Head in m of water

4. Output from turbine, OP (Mechanial Workdone)

$$OP = \frac{V\ X\ I}{\eta_t\ X\ \eta_a}\quad kw$$

Where, V =Voltmeter reading in volts, I =Ammeter reading in amps, ηT = Transmission Efficiency (Belt Transmission) = 0.75., ηA = Alternator Efficiency = 0.73.

Precautions:

1. Do not start Pump set if the supply voltage is less than 300V (Phase to Phase voltage)
2. Do not forget to give electrical earth and neutral connections correctly; otherwise the RPM indicator gets burnt.
3. Initially, fill in the tank with clean water free from foreign material, change the water every six months.
4. Frequently, at least once in three months, grease all visual moving parts.
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8. In case of any major faults, Please write to the manufacturers and do not attempt to repair.

Result and Conclusion: