LAB MANUAL FOR

MECHANICAL ENGG. LAB - II

PR-2 (4TH SEMESTER,

MECHANICAL ENGG.)

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Experiment No: 1

Aim of the experiment:—

To study about 2-S, 4-S petrol and diesel engine models.

Objective:—

After performing the above experiment, the students will be able to know,

(i) about the different I.C. engines and parts
(ii) about different operations and strokes
(iii) about working of S.I. and C.I. engines

Apparatus Required:—

(i) 2-stroke Petrol engine model
(ii) 2-stroke Diesel engine model
(iii) 4-stroke Petrol engine model
(iv) 4-stroke Diesel engine model

Theory:—

The I.C. (Internal Combustion) engines are those engines where the combustion of fuel takes place inside the engine cylinder. It is broadly divided into two types;

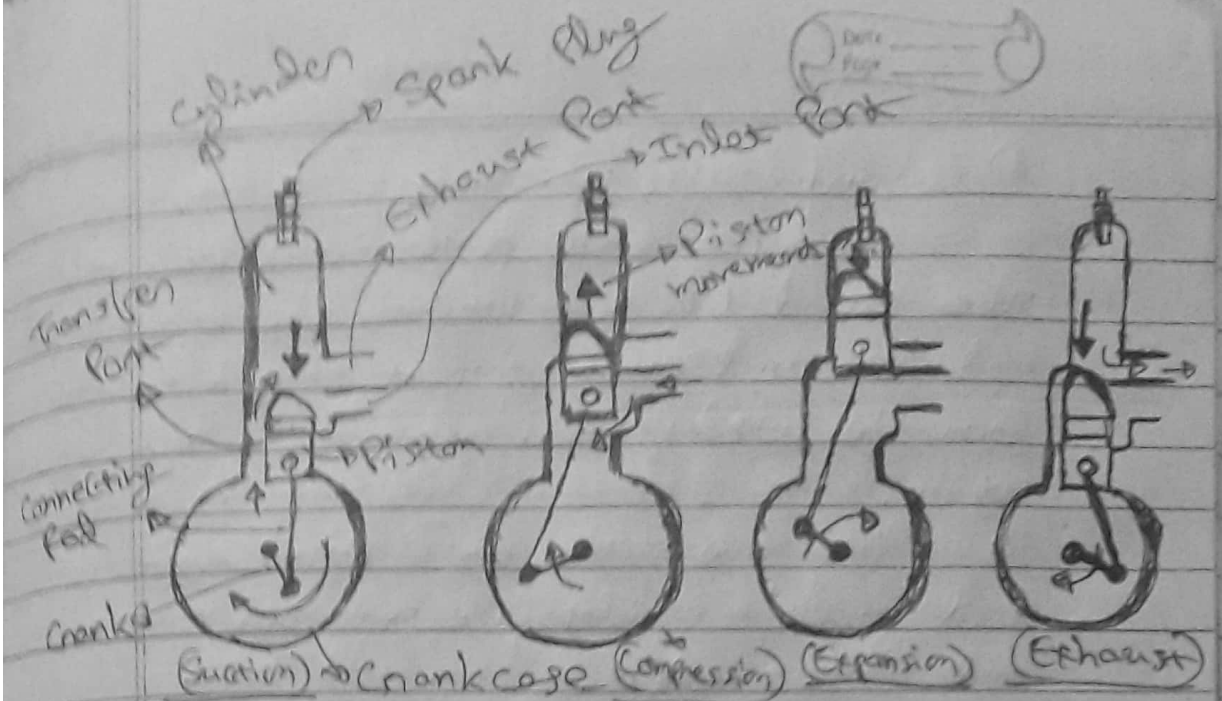
(a) Petrol Engine (S.I. or Spark Ignition)
(b) Diesel Engine (C.I. or Compression Ignition)

These are again subdivided into 4 types as per their working strokes.

(i) 2-stroke Petrol engine:—

The four operations or stages like Suction, Compression, Expansion and Exhaust are completed during the two number of strokes of the piston.

(a) Suction Stage —



In this stage the piston moves from TDC (Top Dead Centre) to BDC (Bottom Dead Centre) in the case of vertical engine. So both transfer port and exhaust port are uncovered. As there is higher pressure in the crankcase, hence air-fuel mixture is sucked into the cylinder from the crankcase through the transfer port.

(b) Compression stage —

Here the piston moves from BDC towards TDC. It first covers the transfer port and then the exhaust port. As the inlet port is open, so the air-fuel mixture enters into the crankcase. During the upward motion of the piston, the charge is compressed in the cylinder.

(c) Expansion stage —

The spark plug ignites the charge just before the end of compression stage. Due to combustion of charge, both pressure and temperature increases inside the cylinder. As piston is the only moving element, hence due to high pressure the piston moves downward from TDC to BDC. The hot gases expand and power is produced in this stage.

(d) Exhaust Stage —

Here, the piston moves from the TDC toward BDC. It uncovers the exhaust port and hot used gases goes out through the port from the cylinder. Then again the suction stage begins.

The two stroke (2-T) petrol engine is used in light vehicles like motorcycle, scooter and three wheelers.

(ii) 2-Stroke Diesel Engine :-

It is similar to 2-S (two stroke) petrol engine. Here in place of spark plug the fuel injector valve is provided. It also produces one working stroke for one revolution of crank shaft.

(a) Suction stage —

Here the piston moves from TDC to the BDC. Both the transfer port and exhaust port are uncovered. So, the air from the crankcase enters into the cylinder through the transfer port.

(b) Compression stage —

The piston moves from BDC towards TDC and covers both transfer port and exhaust port. The air in the cylinder gets compressed. Also fresh air enters into the crankcase as the inlet port is open.

(c) Expansion stage —

The fuel injection nozzle supplies diesel fuel into the cylinder just before the completion of compression stroke. As the temperature of compressed air is very high, so the diesel ignites and combustion begins.

Due to the products of combustion, the pressure becomes very high and the piston moves downward from TDC to BDC. Hence expansion of hot gases begins and power is produced during this period.

(d) Exhaust stage —

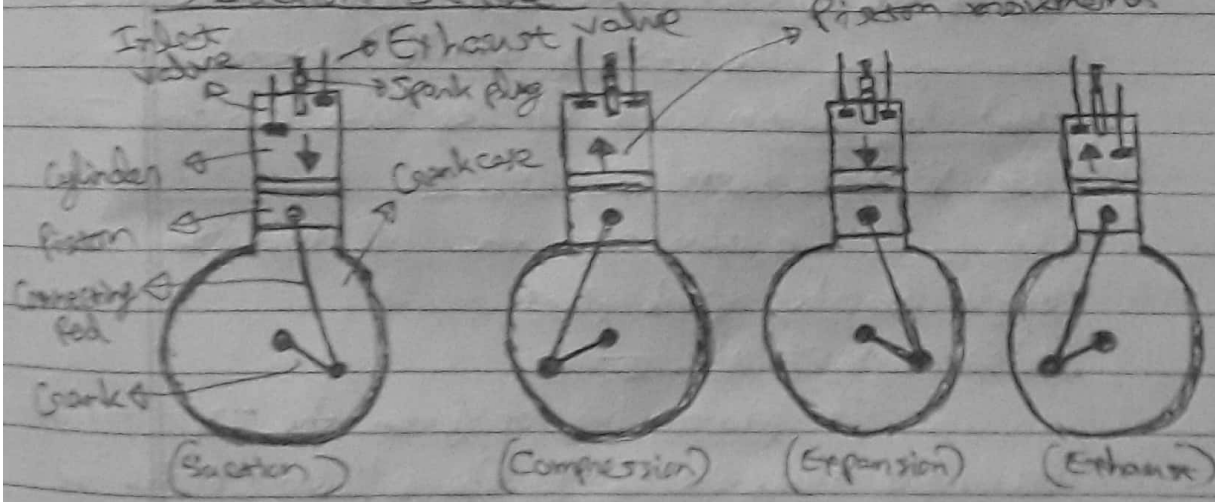
The piston moves towards BDC and opens the exhaust port. The hot burnt gases goes to outside through the exhaust port. Then the suction stage again begins.

The two stroke diesel engine is generally used in marine propulsion.

(iii) 4-stroke Petrol engine :—

In this case the four strokes are completed during the four stages. It produces one working stroke during two revolutions of crankshaft.

(a) Suction Stroke —



The piston moves from the TDC towards the BDC and produces vacuum inside the cylinder. So, due to pressure difference the inlet valve opens and air-fuel mixture enters into the cylinder. At this time the exhaust valve remains closed.

(b) Compression Stroke —

The piston moves from BDC towards TDC. Both inlet and exhaust valves remain

closed. The air-fuel mixture becomes compressed in the cylinder and both pressure alongwith temperature increases.

(c) Expansion Stroke —

Just before the end of compression stroke, the spark plug produces spark to ignite the charge. The combustion of charge occurs and very high pressure is developed. This high pressure pushes the piston downwards and power is developed. The piston moves from TDC to the BDC and both inlet and exhaust ports remain closed.

(d) Exhaust Stroke —

The piston moves from BDC to the TDC. The exhaust valve opens while the inlet valve remains closed. The piston pushes the hot burnt gases outside through the exhaust valve. Again the suction stroke starts.

The 4-S (4-stroke) petrol engine is used in medium light vehicles like car and Jeep.

(iv) Four Stroke Diesel engine :—

In this case, the fuel injector replaces the spark plug.

(a) Suction stroke —

The piston moves from the TDC towards BDC. The air enters into the cylinder through the inlet valve and exhaust valve remains closed.

(b) Compression stroke —

Both inlet and exhaust valves remain closed and the piston moves from BDC towards the TDC. The pressure of the air increases due to compression.

(c) Expansion stroke —

Both inlet and exhaust valves

remain closed. Just before the completion of compression stroke, the diesel is sprayed into the cylinder. Due to high pressure and temperature the mixture ignites and combustion starts. Due to it, both pressure and temperature increase. Due to high pressure, the piston moves from TDC towards the BDC and power is developed.

(d) Exhaust Stroke —

The piston moves from BDC towards TDC. The exhaust valve opens and hot burnt gases move outside through the exhaust valve. The inlet valve remains open. Then again suction stroke begins.

Conclusion; —

We have studied successfully about the 2-stroke and 4-stroke petrol and diesel engines.

Precautions; —

(i) Always wear the safety shoes
(ii) Listen and obey the instructions given by the instructors
(iii) Operate and handle the models carefully.

Viva-voce Questions; —

(1) Explain about the different strokes.
(2) What do you mean by different operation?
(3) Define about ports and where these are used?
(4) What do you understand by valves?
(5) Compare the number of working strokes between 2-stroke and 4-stroke engines.
(6) Give one example for all the four types of engines.

Experiment No: 2

Aim of the Experiment :-

To determine the brake thermal efficiency of single cylinder petrol engine.

Objective :-

After completion of the experiment, the students will be able to know,

(i) about different parts of petrol engine
(ii) working of single cylinder petrol engine
(iii) the terms like BHP and Brake thermal efficiency
(iv) the procedure and calculation of efficiency

Apparatus Required :-

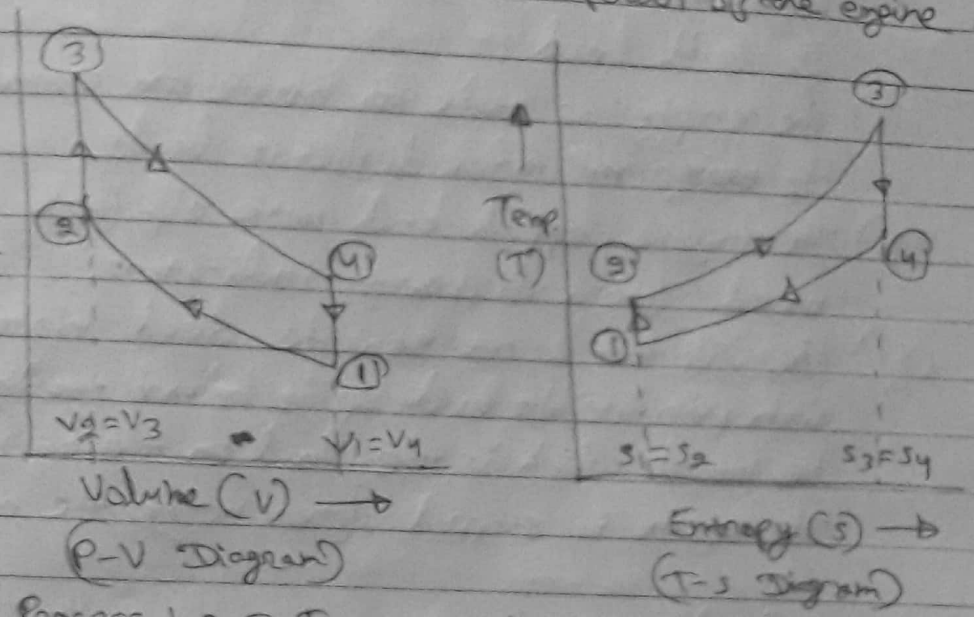
Single cylinder petrol engine with following specifications;

Honda make,
Compression ratio = 6:01,
BHP = 10,
Speed = 1500 rpm,
Bore = 73 mm,
Stroke length = 89 mm,
Orifice diameter = 20 mm,
Cooling = Water cooled,
Loading = Rope brake dynamometer,
Starting = Self start

Theory :-

The single cylinder petrol engine has one cylinder and works on the Otto cycle. The carburetor supplied air and petrol mixture during the suction stroke. The charge is compressed in the compression stroke. The spark plug provides

spark to ignite the mixture. After combustion, the hot products are produced which pushes the piston and power is generated. On the exhaust stroke, the burnt out gases move to the atmosphere through the exhaust valve. It is fitted with rope brake dynamometer which measures the brake power of the engine.



(P-V Diagram) (T-s Diagram)

Process 1-2 = Isoentropic Compression
Process 2-3 = Constant Volume Heat Addition
Process 3-4 = Isoentropic Expansion
Process 4-1 = Constant Volume Heat Rejection

Procedure:-

(i) First of all fuel is to be filled in the tank.
(ii) By using dipstick the lubricating oil level is to be checked.
(iii) The fuel line between fuel tank and engine is to be checked by opening the fuel opening knob such that no air is trapped in the line.
(iv) The decompression lever is operated in order to de-compress the engine.
(v) The engine is initially cranked slowly by the

handle and then the cranking speed is increased.

(vi) The decompression lever is pulled down at higher crank speed and engine is started.

(vii) The engine is allowed to run at a constant speed of 1500 rpm.

(viii) The engine is loaded sequentially by placing required loads (dead weights) for getting $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, full load.

(ix) The engine is made to rotate at constant speed of particular N rpm under different loads.

(x) The engine speed and rate of fuel are noted from different indicators.

(xi) The difference between the dead weight along with pan weight and spring balance reading is to be noted which is the load on the engine (W).

The engine is stopped after noting the readings.

Calculation:-

The Brake Power, $BP = \frac{\pi N (W-S)(D+d)}{60 \times 1000}$ KW

where; W = Dead weight in N,

S = Spring balance reading in N,

D = Diameter of brake drum in m,

d = Diameter of rope in m,

N = Engine speed in rpm

The Brake thermal efficiency = $\frac{BP \times 3600}{\text{Energy supplied to engine}}$

Energy supplied to engine = $m_f \times C_V$

where, m_f = mass of fuel consumed in kg/hr

C_V = Calorific value of Petrol in KJ/kg = 44300 KJ/kg

$m_f = \frac{v}{t} \times S_{petrol}$

where, v = volume of petrol consumed

t = time taken for petrol consumption

ρ_{petrol} = Density of Petrol = 748.9 kg/m^3

Conclusion :-

The value of the thermal efficiency of single cylinder petrol engine is successfully found out.

Precautions :-

(i) Always wear safety shoes inside the laboratory.
(ii) Listen and follow the instructions properly.
(iii) Before starting, check all the connections to be right.
(iv) Always be with utmost care while handling the set up.

Viva-Voce Questions :-

1. Define about single cylinder petrol engine.
2. What do you mean by stroke of engine?
3. Define the term Brake Power.
4. What is Brake thermal efficiency?
5. Draw both the P-V and T-S diagrams of the petrol engine.
6. Define about mass of fuel consumed.
7. What do you mean by Calorific value?

Experiment No: 3

Date
Page

Aim of the Experiment :-

To determine the brake thermal efficiency of single cylinder diesel engine.

Objective :-

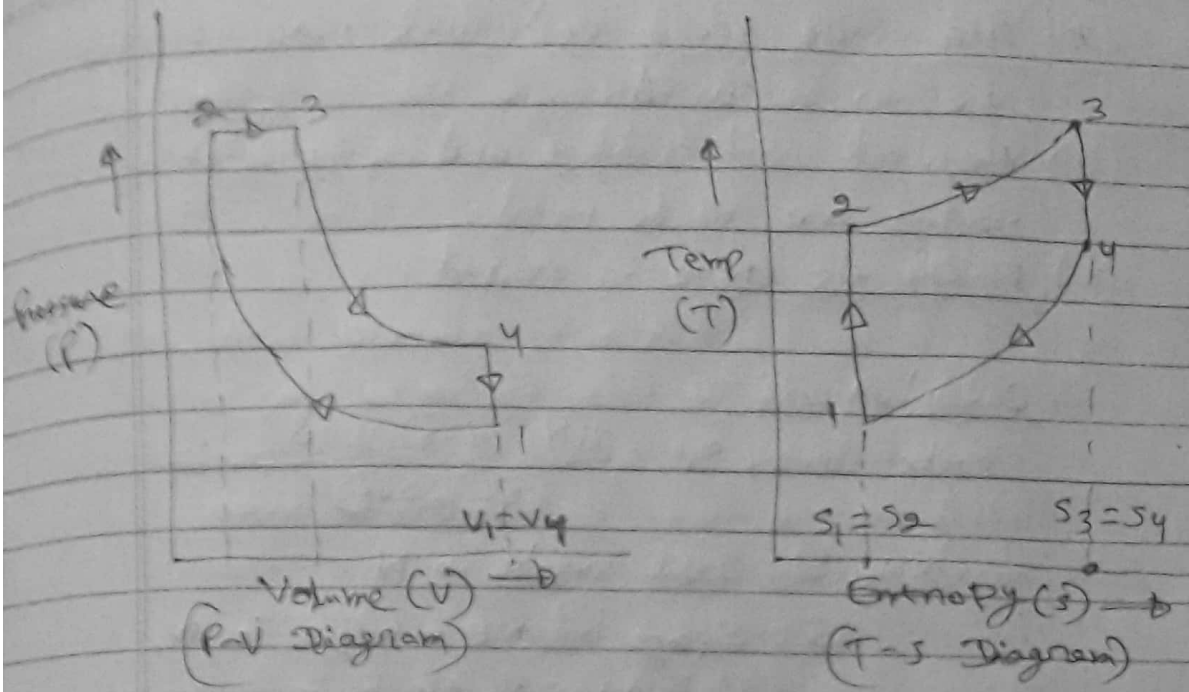
After completion of the experiment, the students will be able to know;
(i) about different parts of diesel engine
(ii) working of single cylinder diesel engine
(iii) about BHP and Brake Thermal Efficiency
(iv) the procedure and calculation of efficiency

Apparatus Required :-

Single Cylinder diesel engine is having following specifications,
Compression Ratio = 16 : 1,
BHP = 5,
Bore = 80 mm,
Stroke length = 110 mm,
Ignition type = Compression Ignition
Loading method = Rope Brake

Theory :-

The diesel engine draws the air through the inlet valve during suction stroke. During the compression stroke, the air is compressed to high pressure. Just before completion of compression stroke, the diesel is sprayed into the cylinder by the fuel injector. Due to high temperature of air, the diesel ignites and combustion starts. The hot gases produced move the piston and power is generated. In the exhaust stroke the burnt gases moves to the atmosphere through exhaust valve



Process 1-2 = Isoentropic Compression
Process 2-3 = Constant Pressure heat addition
Process 3-4 = Isoentropic Expansion
Process 4-1 = Constant Volume heat rejection

Procedure :-

(i) The diesel is to be filled in the fuel tank.
(ii) The lubricating oil height is to be checked.
(iii) After opening the fuel lock, the fuel line is to be checked such that no air is trapped.
(iv) The engine is decompressed by the lever.
(v) The engine is cranked slowly and then maximum cranking speed is obtained.
(vi) The decompression lever is pushed down to start the engine and engine speed is stabilised at 1500 rpm.
(vii) By using different dead weights the engine is loaded in different steps of $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ and full load. Then the engine speed is made stabilised at different loads.

(viii) The engine speed and fuel rate consumed are to be noted.

(ix) The dead weight reading and spring balance reading are to be noted.

(x) Finally the engine is stopped.

Calculation :-

Brake Power, $BP = \frac{\pi N (W-S)(D+d)}{(60)(1000)}$ KW

where, W = Dead weight in N

S = Spring balance reading in N,

D = Diameter of the brake drum in m,

d = Diameter of the rope in m,

N = Engine speed in rpm.

Brake Thermal Efficiency = $\frac{BP \times 3600}{\text{Energy supplied to the engine}}$

Energy supplied to the engine = $m_f \times C_v$

where, m_f = mass of diesel consumed in kg/hr

C_v = Calorific value of Diesel = 39900 KJ/kg.

$m_f = \frac{v}{t} \times \rho_{diesel}$

where, v = volume of diesel consumed

t = time taken for diesel consumption

ρ_{diesel} = Density of diesel = 832 kg/m^3

Conclusion :-

The value of brake thermal efficiency for single cylinder four stroke diesel engine is successfully found out.

Precautions :-

(i) Always wear safety shoes.

(ii) Listen and follow the instructions properly.

(iii) Before starting, check that all the connections are correct.

(iv) Always be with utmost care when handling the set-up.

Viva-voce Questions:-

(1) Define about the working of diesel engine.
(2) Write down about the stroke.
(3) What do you mean by brake thermal efficiency?
(4) Draw both P-V and T-s diagram of diesel engine.
(5) What is the function of fuel injector?
(6) What do you mean by spring balance reading?
(7) Why Rope brake dynamometer is used?
(8) What do you mean by density?.

Experiment No: 4

Aim of the Experiment :-

To determine the BHP, IHP and BSFC of multicylinder engine by Morse Test

Objective :-

After completion of the experiment, the students will be able to know,
(i) about working of multicylinder engine,
(ii) about the terms BHP, IHP and BSFC,
(iii) about the Morse Test.

Apparatus Required :-

The multicylinder engine is having following specifications,
Speed = 1500 rpm,
No. of Cylinders = 03,
BHP = 5
Compression Ratio = 7:1,
Bore = 68 mm,
Stroke length = 75 mm,
Ignition type = Spark Ignition,
Cooling type = Water cooled

Theory :-

The Morse test is generally used to find out the Indicated Power of the multi-cylinder high speed S.I. engine. It doesnot use the indicator diagram. Initially the Brake power of engine is calculated at a particular speed and load. Then one cylinder is cut-off and the Brake power for the remaining running cylinders is measured. The difference between total Brake Power and this Brake power will

give the Indicated Power of the cut-off cylinder.

Procedure :-

(i) The engine is filled with proper amount of fuel and lubricant level alongwith coolant are also checked.
(ii) The engine is to be started by the ignition key and speed is maintained around 1000 rpm.
(iii) The engine speed is increased by turning the accelerator upto 1500 rpm.
(iv) The hydraulic dynamometer inlet valve is gradually opened in order to load the engine.
(v) The engine is made to run for some time period.
(vi) By using a knob, the power to one cylinder of the engine is cut-off. The engine speed is reduced as two cylinders will produce less power.
(vii) The load on the engine is reduced, such that the speed of the engine is increased and made constant at 1500 rpm.
(viii) The spring balance readings are noted.
(ix) The steps of (vi), (vii) and (viii) are repeated by cutting each cylinder separately.
(x) The BHP of cylinders are calculated when each cylinder is disconnected.
(xi) The BHP is also to be calculated when all the 3 cylinders are working.
(xii) Then by using proper equations, the IHP values are also calculated.
(xiii) Finally the BSFC is also calculated.

Calculation :-

$$BHP = \frac{(W-s)\pi(D+d)N}{4500} \text{ HP}$$

where, W = Dynamometer load in kg.

N = rpm of the engine

Let, B = BHP of the three cylinders

B_1 = BHP of cylinders when 1st is cut-off

B_2 = BHP of cylinders when 2nd is cut-off

B_3 = BHP of cylinders when 3rd cylinder is cut-off

IHP of 1st cylinder = $I_1 = B - B_1$

IHP of 2nd cylinder = $I_2 = B - B_2$

IHP of 3rd cylinder = $I_3 = B - B_3$

BHP = Brake Horse Power

IHP = Indicated Horse Power

Total IHP of the engine, $I = I_1 + I_2 + I_3$

BSFC = Brake specific fuel consumption

The BSFC is the ratio between m_f and BHP

$$BSFC = \frac{m_f}{BHP} \text{ kg/BHP/hr}$$

where, m_f = mass of fuel consumed/hr

Tabulation :-

Sl. No.	Conditions	N (rpm)	W (kg)	BHP	IHP	BSFC
1.	B	1500				
2.	B_1	1500				
3.	B_2	1500				
4.	B_3	1500				

Conclusion :-

The values of BHP, IHP, BSFC of multicylinder engine is suressfully found out.

Precaution:-

(i) Always wear the safety shoes.
(ii) Listen and follow the instructions carefully.
(iii) Check all connections before starting the engine.
(iv) While handling the set-up, maintain proper care.

Viva-Voce Questions:-

(1) What do you mean by BHP?
(2) Define about IHP.
(3) Define about BSFC.
(4) Define about multicylinder engine.
(5) Why the Morse Test is conducted?

Experiment No: 5

Aim of the Experiment;-

To determine the mechanical efficiency of an air compressor.

Objective;-

After completion of the experiment, the students will be able to know;

(i) about the parts of the compressor,
(ii) about the working of the compressor,
(iii) about the calculation of mechanical efficiency.

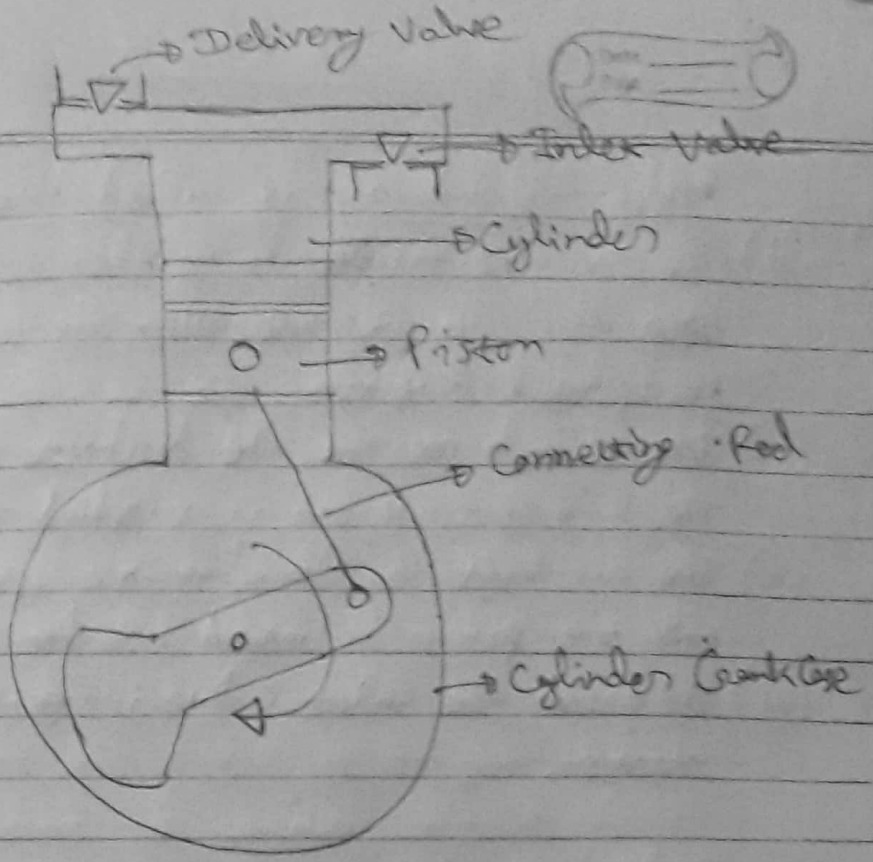
Apparatus Required;-

The following apparatus are needed;

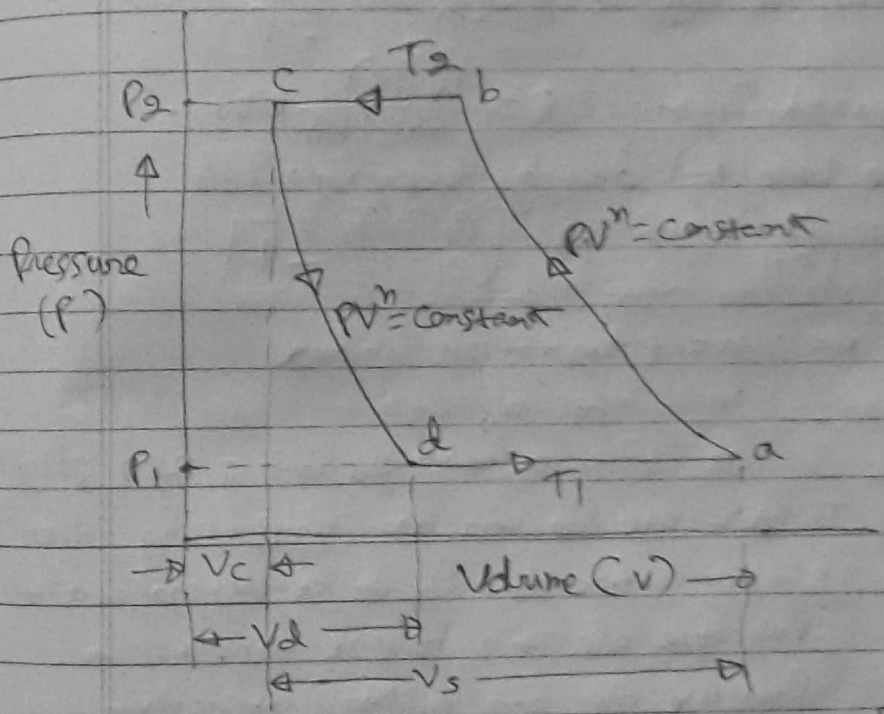
Air Compressor Test rig,
Tachometer,
Stopwatch.

Theory;-

The air compressor is a machine which compresses the air to increase the pressure. The air compressor sucks air from the atmosphere, then compresses it and finally supplied the air under high pressure to a storage vessel. The storage vessel supplies the compressed air to the place of requirement through pipelines. To run the compressor, some work is needed. So, prime mover is coupled with compressor to run it. The compressed air is used for many industrial and domestic applications like producing blast of air, paint spraying, operation of lift and pump.



Air Compressor



(P-V Diagram of Compressor)

Procedure :-

(i) The pressure in the cylinder is reduced below the atmospheric pressure by the downward movement of the piston.

(ii) The inlet valve is opened due to pressure

difference and air is sucked into the cylinder.

(iii) The pressure inside the cylinder is increased upto discharge pressure, when the piston is moved in upward direction.

(iv) Due to high pressure, the discharge valve is opened. The high pressure air is supplied to the vessel.

(v) The air left in the clearance space is expanded and the piston is moved in downward direction.

(vi) So, again the inlet valve is opened and suction starts.

Calculation :-

Mechanical efficiency, $\eta_m = \frac{B.P}{I.P}$

Indicated Power = $IP = \frac{W(N)}{60 \times 1000}$ KW,

where, W = Work done by Compressor =

$$= \left(\frac{n}{n-1}\right)(mRT_1)\left[\left(\frac{P_2}{P_1}\right)^{\left(\frac{n-1}{n}\right)} - 1\right]$$

where; n = Polytropic index

m = mass of air

R = Gas constant of air = 287 J/kg-K

T_1 = Temperature of air at compression inlet

T_2 = Temperature of air at compressor outlet

P_1 = Pressure of air before compression

P_2 = Pressure of air after compression

N = Speed in rpm.

Tabulation:-

Sl. No.	Temperature	Pressure	No. of working strokes

Conclusion:-

The value of mechanical efficiency of an air compressor is successfully found out.

Precaution:-

(i) Always wear the safety shoes.
(ii) Follow the instructions.
(iii) Check all connections before starting.
(iv) Maintain proper care, while handling the set-up.

Viva-Voce Questions:-

(1) What are the main parts of air compressor?
(2) Write about the working of air compressor.
(3) What do you mean by I.P. 2.
(4) Define about the mechanical efficiency of air compressor.

Experiment No: 6

Aim of The experiment:-

To study about different pressure measuring devices (Manometer, Bourdon tube pressure gauge).

Objective:-

After completion of the experiment, the students will be able to know;
(i) about the different parts and types of manometer,
(ii) about the working of manometer,
(iii) about the parts and working of Bourdon tube pressure gauge.

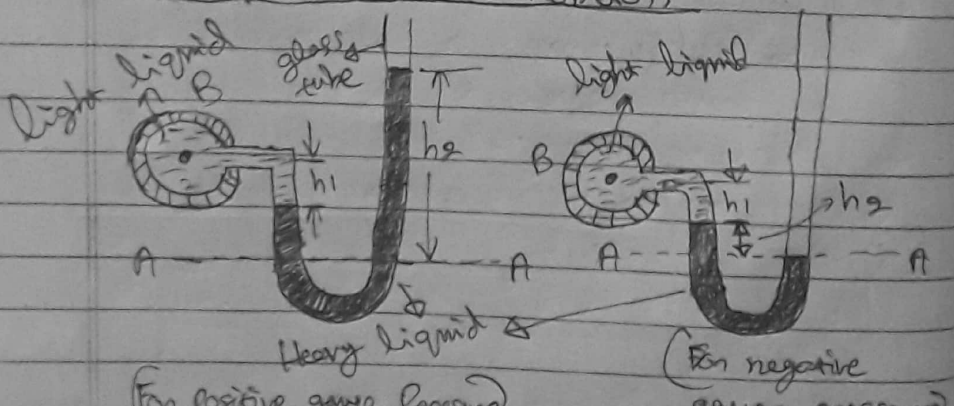
Apparatus Required:-

The followings are needed;
(i) Manometer,
(ii) Bourdon tube Pressure Gauge

Theory:-

The different types of manometers are;

(a) Simple U-tube manometer;



It is made of glass tube (bent like U shape). Its one end is connected to

the point (here point B) where pressure is to be measured and other end of tube remains open to the atmosphere. It containing heavier liquid (generally mercury) having more specific gravity than the specific gravity of the liquid whose pressure is required to be measured. The datum line is A-A.

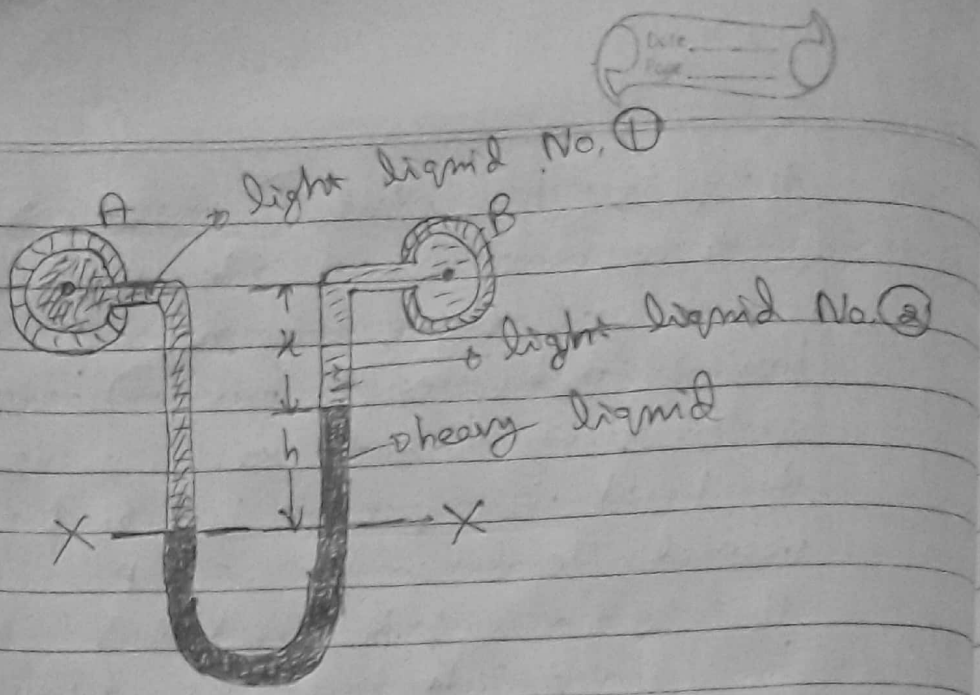
P_B = Pressure of light liquid which is to be measured
h_1 = height of light liquid above datum line
h_2 = height of heavy liquid above datum.
S_1 = Specific gravity of light liquid
S_2 = Specific gravity of heavy liquid
ρ_1 = Density of light liquid
ρ_2 = Density of heavy liquid

Pressure above the datum in the left column
= Pressure above the datum in the right column
or, $P_B + \rho_1 g h_1 = \rho_2 g h_2$
or, $\boxed{P_B = \rho_2 g h_2 - \rho_1 g h_1}$ → equation for positive gauge pressure.

For negative gauge pressure;
Pressure above the datum line A-A in the left column
= Pressure above the datum in the right column
or, $P_B + \rho_1 g h_1 + \rho_2 g h_2 = 0$
or, $\boxed{P_B = -(\rho_1 g h_1 + \rho_2 g h_2)}$ → for negative gauge pressure

(b) Differential manometer:

While simple U-tube manometer measures the pressure of the liquid at a point; the differential manometer is used to measure the difference of pressures between two points of a liquid flowing in a pipe or in two different pipes.



The two points A and B are at the same level and contains two liquids having different specific gravities. The U-tube differential manometer is connected between the two points. Datum line is the X-X line.

P_A = Pressure of light liquid ①

P_B = Pressure of light liquid ②

h = Difference of heavy liquid in the U-tube

x = Distance of point B from heavy liquid level in the right limb

$x+h$ = Distance point A from heavy liquid level in the left limb

S_1 = Density of liquid No. ① (light)

S_2 = Density of liquid No. ② (light)

S_3 = Density of heavy liquid.

Pressure above the datum line in left limb = Pressure above the datum in the right limb

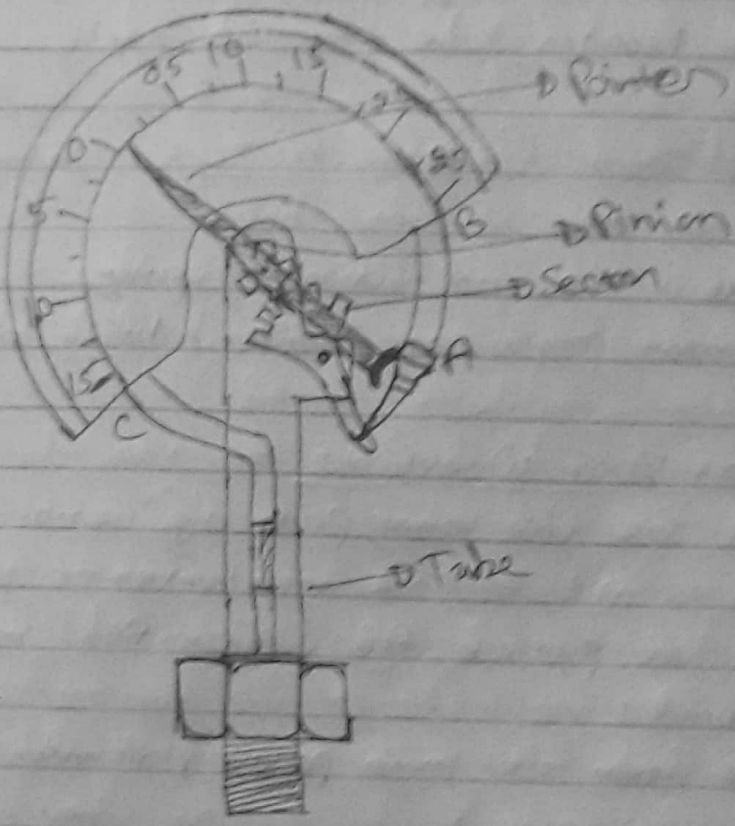
$$\text{or, } P_A + S_1 g(h+x) = P_B + S_2 g(x) + (S_3)(g)(h)$$

$$\text{or, } \boxed{P_A - P_B = S_2 g(x) - S_1 g(h+x) + S_3 (g)(h)}$$

Bourdon Tube Pressure Gauge:

It measures the pressure above and below the atmospheric pressure.

It is generally used to measure very high fluid pressure.



The Bourdon tube ABC is an elliptical tube which is bent into the arc of an circle. When the fluid under pressure flows in the tube, then it also flows through the Bourdon tube. So the tube tries to become straight. As it is kept inside a circular cover, so it tends to become circular. The end of the Bourdon tube is connected with the sector. The deformation of tube is transformed into the motion of the sector the sector is connected with pinion. So the pinion moves. The pinion is connected with the pointer. So the pointer moves on the circular scale and from the reading of the scale, the pressure value is directly noted.

Conclusion:-

We have studied successfully the pressure measuring devices like manometers and Bourdon tube pressure gauge.

Precaution:-

(i) Always wear safety shoe.
(ii) Follow the instructions properly.
(iii) Maintain proper care while handling the set-up.

Viva-Voce Questions:-

1. What are the main parts of manometer?
2. Why simple U-tube manometer is used?
3. For what purpose the differential manometer is used?
4. Write down the main parts of Bourdon tube pressure gauge.
5. How the Bourdon tube pressure gauge works?

Experiment No: 7

Aim of the Experiment:-

To verify the Bernoulli's theorem.

Objective:-

After completion of the experiment, the students will be able to know;
(i) about the mathematical formula of the theorem.
(ii) about the different types of energy heads considered in the formula
(iii) about the validity of the theorem.

Apparatus Required:-

The following are needed;
A tapered inclined pipe with piezometer tube fittings at different points,
A supply tank of water,
A measuring tank,
A stop watch,
A scale.

Theory:-

The Bernoulli's theorem states that an ideal fluid with steady flow along with streamline flow, the total energy or energy head remains constant at any point of flow. Suppose we are taking two sections 1 and 2. so, according to Bernoulli's theorem;

$$\frac{P_1}{\omega} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\omega} + \frac{V_2^2}{2g} + z_2$$

where; $\frac{P_1}{\omega}$ and $\frac{P_2}{\omega}$ = Pressure heads at points (1) and (2)

$\frac{V_1^2}{2g}$, $\frac{V_2^2}{2g}$ = Velocity heads at points (1) and (2)

Z_1 and Z_2 = Datum heads at points (1) and (2)

Procedure :—

(i) The inlet valve is opened and water is allowed to flow slowly from the supply tank.

(ii) The flow is adjusted to get a constant head in the supply tank.

(iii) By using stop watch the quantity of water collected in a particular time period inside the measuring tank is noted.

(iv) Measure and calculate the area of cross-section at the two points (a_1, a_2).

(v) By using continuity equation, the V_1 and V_2 are calculated ($Q = a_1V_1 = a_2V_2$).

(vi) The pressure heads at the two points are measured from the piezometer tubes.

(vii) The datum heads (Z_1, Z_2) are also noted.

Observations and Tabulations :—

Sl. No.	Datum head		Pressure Head		Quantity of water (m^3)	time (t)	Discharge (Q) = Quantity / time	Velocity $V = \frac{Q}{a}$		Velocity head	
	Z_1	Z_2	$\frac{P_1}{w}$	$\frac{P_2}{w}$				V_1	V_2	$\frac{V_1^2}{2g}$	$\frac{V_2^2}{2g}$
1.											
2.											
3.											

Area of section 1 = a_1 =

Area of section 2 = a_2 =

Calculation :—

Total energy head (at 1) = $\frac{P_1}{w} + Z_1 + \frac{V_1^2}{2g}$

Total energy head (or E) = $\frac{p_2}{w} + z_2 + \frac{V_2^2}{2g}$.
Calculate the above for the three number of readings taken.

Conclusion:-

We have verified that;

$$\frac{p_1}{w} + z_1 + \frac{V_1^2}{2g} = \frac{p_2}{w} + z_2 + \frac{V_2^2}{2g}$$

for all the three readings taken. So, the Bernoulli's theorem is verified.

Precaution;-

(i) Wear the safety shoes.
(ii) Follow the instructions properly.
(iii) There should not be any air bubbles in the pipe.
(iv) There should not be any leakage anywhere.
(v) It must be ensured that the flow condition is steady flow.

Viva-Voce Questions;-

(i) Define about the datum head
(ii) Define about the velocity head.
(iii) Define about the pressure head.
(iv) Write down the continuity equation.
(v) Write down the mathematical expression for the Bernoulli's equation.

Experiment No: 8

Aim of the experiment:-

To determine the C_d for the venturimeter.

Objective;-

After completion of the experiment, the student will be able to know;

(i) the parts of venturimeter,
(ii) the working of venturimeter,
(iii) the Coefficient discharge (C_d) of it.

Apparatus Required;-

(i) Venturimeter
(ii) U-tube manometer
(iii) Stop watch

Theory;-

A venturimeter is a device used to measure the rate of discharge in a pipe and fitted at different sections of the pipe.

The theoritical discharge, $Q_{th} = \frac{A_1 A_2}{\sqrt{(A_1^2 - A_2^2)}} \sqrt{2gh}$

A_1 = Area at inlet,

A_2 = Area at outlet,

h = head difference between two points

The actual discharge, $Q_{act.}$ is less than the theoritical discharge, as head loss occurs due to friction.

$C_d = \frac{Q_{act.}}{Q_{th}}$ where, C_d = Coefficient of discharge for venturimeter

Again, $h = 13.6y$

where, y = manometer reading

Procedure:-

(i) The two limbs of the differential manometer is connected with throat and mouth of venturimeter.

(ii) The stop cock is made 'on' and water supply is adjusted to get proper manometer reading.

(iii) The discharge is measured in a particular time period by collecting water in the measuring tank.

(iv) The difference in mercury level in the two limbs of manometer are noted.

(v) The experiment is repeated for different values of 'Q'

Observations and Tabulations:-

Area of the inlet (mouth), $A_1 = \frac{\pi}{4} D_1^2$; D_1 = mouth diameter,

Area of the throat, $A_2 = \frac{\pi}{4} D_2^2$; D_2 = throat diameter.

Sl. No	Manometer reading (y)	h = 13.6 y	Measuring tank			Time (t)	Discharge actual $Q_{act.}$	$C_d = \frac{Q_{act.}}{Q_{th.}}$
			Initial reading (a)	Final Reading (b)	Quantity = (b-a)			

Calculation:-

Find out the mean value of C_d.

Conclusion:-

The C_d of the venturimeter is determined sucessfully.

Precautions:-

(i) Wear safety shoes.

(ii) No air must be present in the line

(iii) All readings to be taken carefully.

Viva-Voce Questions:-

(i) What do you mean by venturimeter?

(ii) Define about theoritical discharge.

(iii) Define about C_d of venturimeter.

Experiment No: 9

Aim of the Experiment :-

To determine C_c, C_v, C_d for orifice.

Objectives :-

After completion of the experiment, the students will be able to know;

(i) them terms like C_c, C_d, C_v

(ii) working of orifice

(iii) relation between C_c, C_d, C_v.

Apparatus Required :-

(i) Supply tank with orifice, scale and sliding apparatus.

(ii) Stop watch

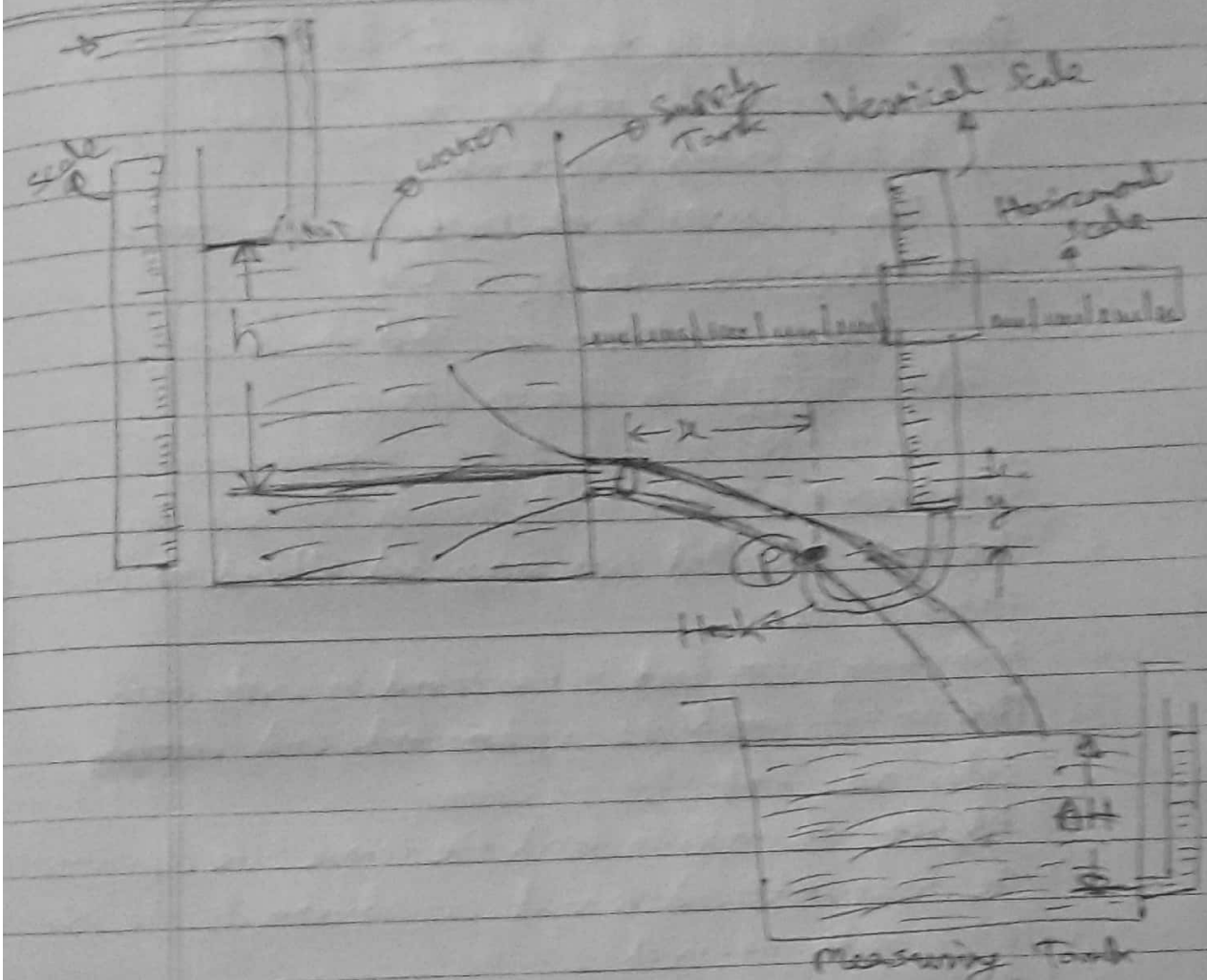
(iii) Measuring tank

Theory :-

When the waterjet leaves an orifice, then it becomes contracted. The maximum contraction takes place at a section slightly on the downstream side of the orifice. Here the jet is approximately horizontal. This section is called as vena-contracta.

The coefficient of contraction (C_c) is the ratio of area of jet at vena-contracta to the orifice area.

The coefficient of velocity (C_v) is the ratio of the actual velocity at vena-contracta to the theoritical velocity.



x = Horizontal ordinate of point P in the jet
y = Vertical ordinate of same point
h = height of liquid in meter
So, $C_v = \frac{x}{\sqrt{4yh}}$

The coefficient of discharge is the ratio between the actual discharge with the theoritical discharge
The actual discharge can be calculated by the formula, $Q_{act.} = \frac{\text{Quantity of water collected } (Q)}{\text{time } (t)}$

The theoritical discharge,
$Q_{th.} = (a)\sqrt{2gh}$
where, a = area of the orifice = $\frac{\pi}{4} d^2$,
d = diameter of the orifice.

Quantity of water, $Q = \frac{L \times B \times \Delta h}{t}$

L = Length of tank,

B = Breadth of tank

Δh = water level rise in the tank

$C_d = C_c \times C_v$ or, $C_c = \frac{C_v}{C_d}$

$C_d = \frac{Q_{act.}}{Q_{th.}}$

Procedure :-

(i) The tank is filled with water and allowed to flow through orifice.

(ii) A constant water head is maintained in supply tank.

(iii) The initial readings of horizontal and vertical scales are noted.

(iv) Adjust the hook to touch the centre line of water.

(v) The horizontal and vertical co-ordinates of the point (P) is to be measured.

(vi) The time period and height of water in the measuring tank are noted.

(vii) It is repeated for different constant heads.

Tabulation :-

Sl. No.	Head (h)	Horizontal Distance (x)	Vertical Distance (y)	$C_v = \frac{x^2}{\sqrt{4yh}}$	water level rise (Δh)	Quantity of water $= L B (\Delta h) = Q$	time (t)	$C_d = \frac{Q_{act}}{Q_{th}}$	$C_c = \frac{C_d}{C_v}$

Calculation :- Mean value of C_c is to be calculated.

Conclusion:-

The values of C_c, C_d, C_v are determined successfully for the orifice.

Precautions:-

(i) Wear safety shoes.
(ii) The head must be kept constant.
(iii) The orifice must be completely opened.
(iv) All readings to be noted carefully.

Viva-Voce Questions:-

(i) What do you mean by orifice?
(ii) Define about C_c.
(iii) Define about C_d.
(iv) Define about C_v.
(v) What is vena-contracta.

Experiment No: 10

Aim of the experiment:-

To determine Darcy's coefficient for flow through pipe.

Objectives:-

After completion of the experiments, the students will be able to know;
(i) about the major head loss through pipe
(ii) about the mathematical formula for head loss
(iii) about the Darcy's coefficient

Apparatus Required:-

(i) Different diameter pipes
(ii) Inverted U-tube manometer
(iii) Measuring tank
(iv) Stop Watch

Theory:-

For pipe flow, the major head loss is due to friction. From experiments, it is found that the head loss due to friction
(i) depends on pipe roughness
(ii) is directly proportional to wetted area
(iii) changes inversely with some power of pipe diameter
(iv) changes with square of velocity
So, the head loss due to friction,

$$h_f = \frac{f l V^2}{2gD}$$

f = Darcy's coefficient
l = length of pipe
V = Velocity of flow
D = Diameter of pipe

Procedure :-

(i) The diameter of pipes, length of pipes and size of collecting tank are noted

(ii) The main inlet valve is fully opened keeping outlet valve closed.

(iii) The outlet valve of one of the pipe is partly opened.

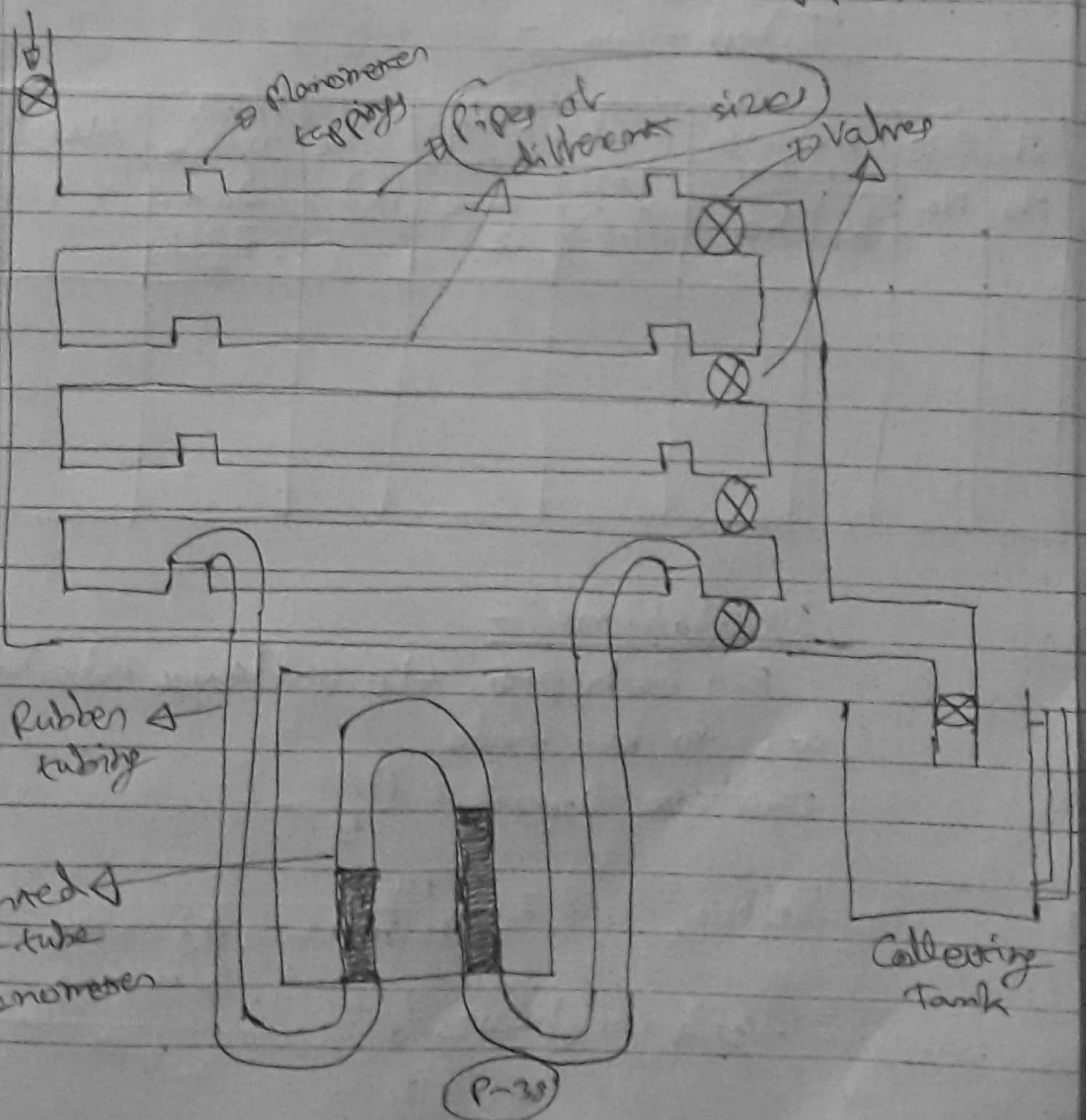
(iv) Then the flow is made steady.

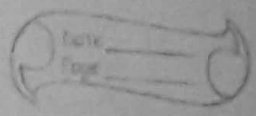
(v) The manometer reading in both manometer limbs (h_1, h_2) are noted.

(vi) The water is collected in the measuring tank, the water rise is noted along with time period.

(vii) By opening the outlet valve in different ways (full, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$) readings are taken.

(viii) The above steps are repeated for all pipes.





Observations:-

Length of the pipelines;

L_1 =

L_2 =

L_3 =

L_4 =

Area of Cross-section of pipes;

A_1 =

A_2 =

A_3 =

A_4 =

Temperature of water, θ =

Kinematic viscosity of water, ν =

Area of tank = A

Tabulations:-

Sl No	Pipe No	Manometer reading		Head loss (h_f)	Water level rise (z)	Time (t)	Actual Discharge = Qact. = $\frac{z*A}{t}$	Velocity (V)	Friction factor (f)
		h_1	h_2						

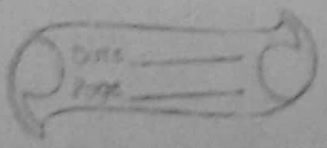
Calculations;-

For each pipe, the following calculations are to be made.

Discharge, $Q_{actual} = \frac{A \times z}{t}$

Velocity, $V = \frac{Q_{act.}}{A_1 \text{ or } A_2 \text{ or } A_3 \text{ or } A_4}$

Darcy's coefficient, $f = \frac{h_f \times D \times 2g}{L V^2}$



Conclusions:-

The Darcy's coefficient is calculated in satisfactory manner.

Precautions:-

(i) Use safety shoes.
(ii) No air bubble must be present in the manometer.
(iii) There must be no leakage in the pipe.

Viva-Voce Questions:-

(i) Define about the pipe.
(ii) Define about major loss in pipe.
(iii) What do you mean by frictional resistance in pipe flow?
(iv) Define about actual discharge.
(v) Define about Darcy's coefficient.