Lab Manual

for

MECHANICAL ENGG. LAB –II

4^{th} Semester, Mechanical Engg.

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EXPERIMENT-1

Aim of the Experiment-

Study of 2-S, 4-S Petrol & Diesel Engine models.

Apparatus Required-

1- Model of 2-S Petrol engine.
2- Model of 4-S Petrol engine.
3- Model of 2-S Diesel engine.
4- Model of 4-S Diesel engine.

Theory 2-S Petrol Engine.

- In this cycle Suction, compression, Expansion & Exhaust take place during 2-S of the Piston. It means that there is no working stroke after every revolution of the crank shaft.
- A two stroke engine has Ports instead of valves. The four stage of two stroke Petrol engine are described bellow.

Suction stage

- In this stage, the Piston while going down towards uncovers, Both the transfer Port and the Exhaust Port.
- The fresh fuel air mixture flows in to the engine cylinder from crank case.

compression stage-

- In this stage the Piston while moving up, first covers the transfer ports.
- After that the fuel is compressed as the Piston moves upward BDC to TDC

- In this Stage, the inlet port opens and fresh fuel air mixture enters in to the crank case.

Expansion Stage -

- Shortly before the piston reaches the TDC (During compression Stroke) the Charge is ignited with the help of a Spark plug.
- It Suddenly increases the pressure and temperature of the product of combustion But volume practically remains constant.
- Due to rise in the Pressure, the Piston is pushed down wards with a great force.
- The hot burnt gases expand due to high Speed of the piston. During this Expansion Some of the heat energy produced is transformed in to mechanical work.

Exhaust Stroke -

- In this stage the Exhaust port is opened as the piston moves down wards.
- The product of combustion, from the engine cylinder is exhausted through the Exhaust Port in to the atmosphere.
- This complete cycle and the engine cylinder ready to such the charge again.

4-Stroke Petrol Engine-

- It requires 4-S of the piston to complete one cycle of operation in the engine cylinder are describ the four-stroke of petrol engine are describ below:

Suction Stroke-

- In this stroke the inlet valve opens and the charge is sucked in to the cylinder as the piston moves downward from TDC.
- It continues till the piston reaches its BDC.

Compression Stroke-

- In this stroke, both the inlet and exhaust valves are closed and the charge is compressed as the piston moves upwards from BDC to TDC.
- As a result of compression, the pressure and temperature of the charge increases considerably.
- This completes one revolution of crank-shaft.

Expansion Stroke -

- Shortly before the piston reaches TDC (During compression stroke) the charge is ignited with the help of a spark plug.
- It suddenly increases the pressure and temperature of the products of combustion but the volume, practically remains constant.

- Due to the rise in pressure, the piston is pushed down with a great force. The hot burnt gases expand due to high speed of the piston.
- During this expansion, some of the heat energy produced is transformed in to mechanical work.

Exhaust Stroke -

- In this stroke, the exhaust valve is open as piston moves from BDC to TDC.
- This movement of the piston pushes out the products of combustion, from the engine cylinder and exhausted through the exhaust valve in to the atmosphere.

2-Stroke Diesel Engine -

- A two stroke cycle diesel engine also has one working stroke after revolution of the crank shaft. All the stage are described.

Suction Stage -

- In this stage, the piston while going down towards BDC uncovers the transport and the exhaust port.
- The fresh air flows in to the engine cylinder from the crank case.

Compression Stage -

- In this stage piston while moving up first covers the transfer port and then exhaust port.
- After that the air compressed as the piston moves upward.

- In this stage, the inlet port opens and the fresh air enters into the crank case.

Expansion stage-

- Shortly before piston reaches the TDC (During compression stroke), the fuel oil is injected in the form of very fine spray in to the engine cylinder through the nozzle known as fuel injection valve.
- At this movement, temp of compressed air is sufficiently high to ignite the fuel. It suddenly increases the pressure and temp of the products of combustion.
- Due to increase the pressure, the piston is pushed with a great force the hot burnt gases expand due to high speed of the piston.
- During the expansion, some of the heat energy produced is transformed in to mechanical work.

Exhaust stroke-

- In this stage, exhaust port opened & the piston moves downwards.
- Product of combustion from the engine cylinder is exhausted through the exhaust port in to the atmosphere.
- This completes the cycle, and the engine cylinder is ready to suck the air again.

4-stroke Disel engine-

- It is also know compression ignition engine. Because the ignisation takes place due to the heat produce in the engine cylinder at the end of compression stroke. Four stroke of diesel engine are described-

Suction stroke-

- IN this stroke, the inlet valve opens and the pure air sucked in to the cylinder as the piston moves down word from TDC.
- It continues till the piston reaches in the BDC.

compression stroke-

- In this stroke, both the valves are closed and the air compressed as the piston moves upwards from BDC to TDC.
- As Result of compression, pressure and tempt of the air increases considerably.
- This completes the revolutions of the crank shaft

Expansion stroke-

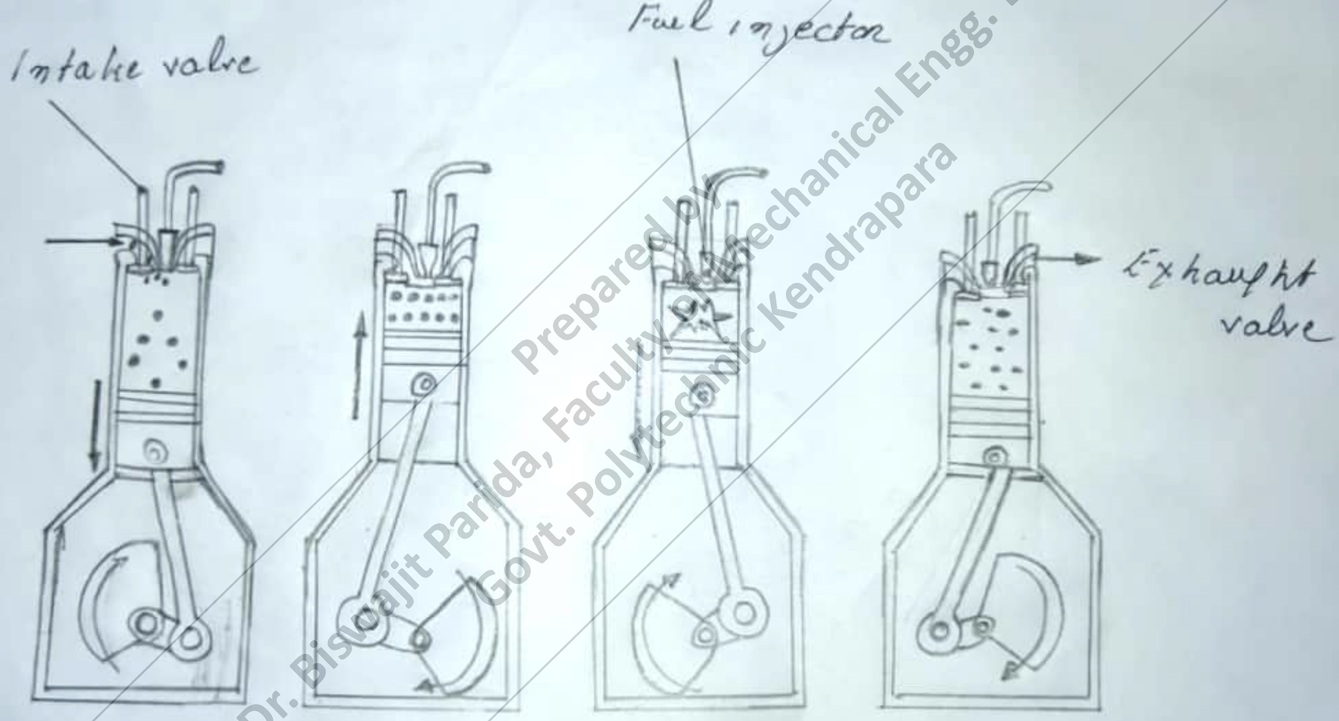
- Shortly before the piston reaches the TDC, the fuel is injected in the form of very fine spray in to the engine cylinder through the nozzle known as fuel injector or fuel injection valve.
- At this movement, temp of the compressed air is sufficiently high to ~~engine~~ ignite the fuel. It suddenly increases pressure & temp of product of combustion.
- Due to increse pressure, the piston is pushed down with a great force. The hot burnt gases expand due to high speed of the piston.
- During the expansion, some of the heat energy is transformed in to mechanical work.

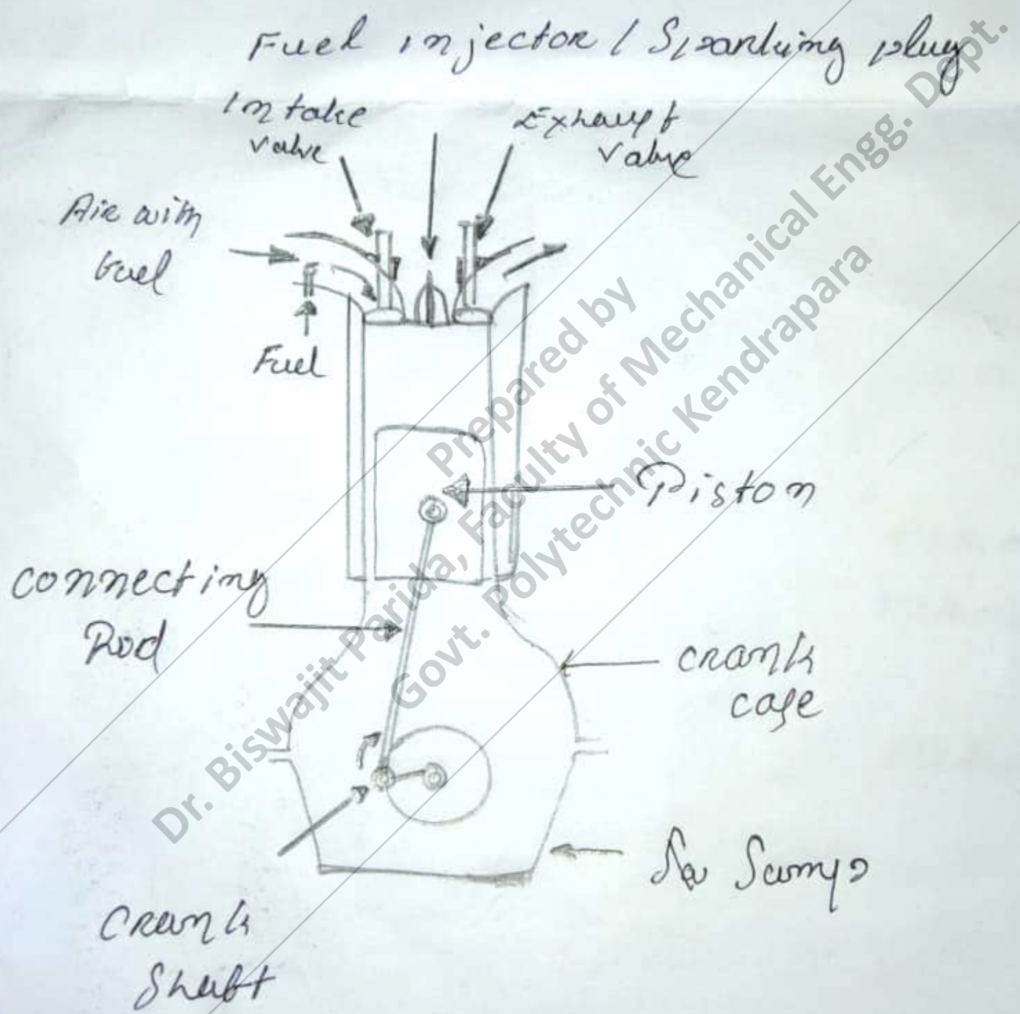
Exhaust stroke -

- In this stroke the exhaust valve is open as the piston moves from BDC to TDC.
- This movement of the piston pushes out the product of combustion from the engine cylinder through the exhaust valve into the atmosphere.
- This completes the cycle and the engine cylinder is ready to suck the fresh air again.

Conclusion -

- From the above experiment we have successfully studied about 2-stroke & 4stroke diesel & petrol engine.


Intake valve
Fuel injector
Exhaust valve


Fuel injector / Sparking plug
Intake valve
Exhaust valve
Air with fuel
Fuel
Piston
connecting Rod
crank case
Crank Shaft

Aim of the Experiment:-

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

Apparatus Required-

SL NO Equipment ~~Equipment~~ Engine Engine Specification

SL NO	Equipment	Engine	Specification
01	Single cylinder Diesel Engine Test Rig	Make BHP	5
		Speed	1500RPM
		No of cylinder	one
		Compression Ratio	16.5:1
		Bore	80mm
		Stroke	110mm
		Orifice dia	17mm
		Type of Ignition	compression ignition
		Method of loading	Rope brake
		Method of Starting	crank Start.
		Method of cooling	water

Theory - Break thermal efficiency.

Break thermal efficiency is the ratio of energy in the break power to the input fuel energy appropriate units.

Procedure -

1- Fill fuel in to the fuel tank mounted on the panel frame.

2- check the lubricating oil in the engine sump with the help of dipstick Provided.

3- Open the fuel tack Provided under the fuel tank. and ensure that no air is trapped in the fuel line connecting fuel tank & engine.

4- De compress the engine by de compression lever Provided on the top of the engine head. Lift the lever for decompression.

5- crank the engine slowly, with the help of handle Provided and ascertain Proper flow of fuel in to the pump and in turn through the nozzle in to the engine cylinder.

6- when the maximum cranking speed is attained, pull the decompression lever down, now the engine starts. Allow the engine run and stabilize. (Approximately 1500 RPM. The engine is a constant speed engine fitted with centrifugal Governer.

7- Now load the engine by placing the necessary dead weights on weighing hanger; To load the engine in steps of 1/4, 1/2, 3/4 full and 10% over load allow the engine to stabilize on every load change.

8- Records the following Parameters indicated on the panel instruments on each load step. (a) Speed of the engine from RPM indicator (b) Rate of fuel from burette.

9- Exact Load in kg (W) on the engine by adding the amount of weight added on the plan in kg (W2) minus Spring balance reading in kg (W3)

10- To stop the engine after the experiment is over push/pull the governor lever towards the engine cranking side.

CALCULATION -

In this experiment we have to calculate the break thermal efficiency of the single cylinder 4-S diesel engine.

$$B.P = \frac{\pi N (W-S)(D+d)}{60 \times 1000} \text{ in kW}$$

W = Dead weight in N

S = Spring balance.

D = Diameter of break drum in meter.

d = Diameter of rope in meter.

N = Speed of the engine.

Break thermal efficiency = $\frac{\text{Break Power}}{\text{Energy supplied to the engine}}$

$$\eta_{Bth} = \frac{B.P}{m_f \times C_V}$$

where,

C_V = calorific value of fuel (diesel)
= 11000 kcal/kg

Dencity of the diesel in 8.38 gms/cc

volume flow rate of diesel m^3/sec

$$= \frac{10}{t} \times (10^{-2})^3$$ (If volume is measured in cm^3)

Mass flow rate of diesel

$$m_f = \frac{10}{t} \times (10^{-6}) \times (0.833 \times 1000) /sec$$

$$= \frac{8.33}{t} \times 10^{-3} \ kg/sec$$

Energy supplied to the engine

$$= m_f \times C_v = \frac{8.33}{t} \times 10^{-3} \times a0,833 \ kcal/sec$$

$$= \frac{8.33 \times 10,833 \times 3.7}{t} \times 10^{-3} \ kW$$

$$= \frac{377.568}{t} \ kW$$

So $\eta_{bth} = \frac{13.12}{377.568/t}$

Conclusion:

Aim of the Experiment -

Determine the BHP, IHP, BSFC of a multi cylinder engine by morse test.

Apparatus Required -

Equipment		Specification
	BHP	10
	Speed	1500 RPM
Four cylinder Petrol engine Test rig.	No of cylinders	4
	compression ratio	8.5:1
	Bore	73 mm
	Stroke	89 mm
	Orific dia	20 mm
	Type of Ignition	Spark Ignition
	Type of cooling	water cooling.
	Type of Loading	Rope break loading

Theory - The morse test is used to find out the indicated power of a multi-cylinder reciprocating Engine.

- The engine is run at particular speed and the torque is measured by cutting out the firing of each cylinder in ~~turn~~ turn and noting the fall in break

Power each time while maintaining the engine speed by reducing load.

- The observed difference in brake power between all cylinder firing and with one cylinder cut out is the indicated power of the cut out cylinder.

Let
W - Dynamometer load in kg
N - RPM of the engine.
A - BHP of 4 cylinder.

$$BHP = \frac{(W-S)\,\pi\,(D+d)\,N}{4500} \text{ in hourse power}$$

B = BHP of 3 cylinder when 1st is cut off

C = BHP of 3 cylinder when 2nd is cut off
D = BHP of 3 cylinder when 3rd is cut off.
E = BHP of 3 cylinder when 4th is cut off.

Then IHP calculation

IHP of 1st cylinder = A - B
IHP of 2nd cylinder = A - C
IHP of 3rd cylinder = A - D
IHP of 4th cylinder = A - E

Total IHP calculation
Total IHP of the engine =

IHP = (1st + 2nd + 3rd + 4th)

BSFC calculation

It is the ratio between the mass of fuel consumed per hour to the BHP.

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

m_f = Fuel consumed in kg/hr

calculation -

Sl No	condition	N in RPM	W in kg
1	A	1500	
2	B	1500	
3	C	1500	
4	D	1500	
5	E	1500	

CONCLUSION -

Experiment - 5

Aim of the experiment -

To determine the mechanical efficiency of air compressor.

Apparatus Required -

1- Air compressor test ring
2- Tacho meter.
3- Stop watch.

Theory -

- An air compressor is the machine which compress the air and to rise it pressure.
- The air compressor sucks air from atmosphere, compresses it and then delivers the same under a high pressure to a storage vessel.
- From the storage vessel it may be converged vessel, it may be the pipe line to a place where the supply of compressed air is required. Since the compression of air required some work to be done on it. There fore a compressor must be driven some ~~prime~~ Prime mover.

CONSTRUCTION -

IT consist of

1- cylinder.

2- piston.

3- Inlet valve

4- Out let valve

5- Pressure Gauge.

6- Pressure vessel.

Procedure -

- When the Piston moves downward the Pressure inside the cylinder falls below the atmospheric Pressure.
- Due to this Pressure difference the IV. gets opened and the air is sucked into the cylinder. At inlet Pressure until the Piston completes the out ward stroke.
- Now when the piston moves upward the Pressure inside the cylinder goes on increasing till it reaches the discharge Pressure. At this stage discharge valve gets opened and air is delivered to the container.
- At the end of delivery stroke a small quantity of air at high Pressure is left in the clearance space. As the piston start its suction stroke. the air contained in the clearance space expands till Pressure.

- At this stage the inlet valve gets opened as a result of which fresh air is sucked in to the cylinder and the cycle is repeated.

CALCULATION -

Mechanical efficiency of compressor

$$\eta_{mech} = \frac{I.P}{B.P}$$

$$I.P = \frac{W \times N}{60 \times 1000} \text{ kW}$$

W = work by the compressor =

$$\frac{n}{n-1} \times m R T_1 \times \left\{ \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1 \right\}$$

$$\text{Brake power} = \frac{3600 \times 10 \times 0.8}{t \times n} \text{ kW}$$

where W = work done

N = Number of revolution in RPM

P_1 = Pressure of air at the inlet of the compressor

P_2 = Pressure of the air at the out let of the the compressor.

T_1 = Absolute temp of air the inlet of the compressor.

T_2 = Absolute temp of air the outlet of the compressor.

Tabulation -

Sl NO	Tempt	Pressure	No of working Stroke ($n_w = N$)

CONCLUSION -

EXPERIMENT - 6

Aim of the Experiment-

Study of Pressure measuring device, Manometer & Bourdon tube Pressure gauge.

Apparatus Required-

1- Manometer

2- Bourdon tube Pressure gauge.

Theory

Manometer

- A manometer is slightly improved form of a Piezometer tube for measuring high as well as negetive Pressure.
- A Simple manometer in its Simplest form, consists of a tube bent in U-Shape one end of which is connected to the vessel containing the liquid whose intensity of pressure is to be measured and other end is open to the atmosphere.
- The liquid used in the bent tube is generally ~~mercury~~ mercury (Hg) which is 13.6 times heavier than water.
- The Pressure of liquid containing in the vessel will force the manometric

liquid in the left hand vertical limb of the U-tube downward and will force the manometric liquid to rise up in the right hand vertical limb of the U-tube through equal distance. This will happen when the pressure in the vessel is greater than atmospheric pressure.

- If pressure of liquid in the vessel is less than atmospheric pressure. The deflection of ~~atmospheric~~ pressure, the manometric liquid will be observed in the left hand limb of the U-tube.

- Since below the surface A-B, the liquid is homogenous and science the liquid is at rest, the pressure along the plane A-B in the left hand limb of the U-tube is equal to the pressure in the right hand limb of the U-tube along the plane A-B.

- Then by measuring the difference in mercury level above line A-B and equating the pressure at A and pressure at B we can measure pressure of liquid flowing in the pipe.

Study of Bourdon tube Pressure gauge -

- Bourden tube pressure gauge consist of a circular spring tube A called bourdon tube.
- The bourdon tube is made up of special quality bronze and oval in cross section.
- One end of the bourden tube is closed and connected to a link L and the other end is secured in a vertical tube B.
- The link L connects the close end of the bourdon tube to a toothed sector C which is hinged at O.
- The toothed section C gears with a pinion D which is mounted on a central spindle carrying a pointer P.
- The pointer moves on a dial graduated in pressure unit.
- The pressure gauge is connected to the vessel containing fluid under pressure.
- Due to fluid pressure in the bourdon tube, it has tendency to achieve a circular shape. But before the tube can do so, it must first straighten it self.

- This tendency of straightening moves the free bourdon tube out ward.
- As a result, the toothed sector moves about the hinge O and causes the pinion D to rotate which, in turn moves the pointer F to move on a dial graduated in bar
- The movement of the free end of the bourdon tube is proportional to the difference between the external atmospheric pressure & internal fluid pressure.
- Hence the pressure gauge records the gauge pressure which is the difference between fluid pressure and out side atmospheric pressure.

CONCLUSION -

Hence we successfully studied about manometer and bourdon tube pressure gauge

EXPERIMENT - 7

Aim of the Experiment -

Verification of Bernoulli's theorem.

Apparatus Required -

- Bernoulli's apparatus testring
- Stop watch — Digital
- Steel rule — 30 cm
- Discharge tank — 40 cm X 30 cm X 100 cm.

Theory -

Bernoullis theorem states that 'for a steady' continious incompressible and non-viscous fluid flow, the total energy or total head remains constant at all the sections along the fluid flow provided there is no lose or addition of energy.

i.e $P/\rho g + V^2/2g + Z$ = Total head H = Constant

where, $P/\rho g$ = Pressure head in m

$V^2/2g$ = velocity or kinetic head in m (where velocity of water = Q/A,

z = Potential head (Height above some assumed datum level i.e $z = 0$)

Bernoullis equation is based on euler's equation of motion. It is applicable to flow of fluid through pipe and channel. It required to be modified if the flow is compressible & unsteady.

Steady State condition

↓

- Pressure head $(P/\rho g)$
- Kinetic head $(v^2/2g)$
- Potential head (z)

↓

Total head

↓

CONSTANT → The pressure head at every gauge point depends upon the velocity at that crosssection. If the cross section area of the conduit is more the velocity will be less and pressure head is most more.

The value of pressure head of the first gauge point is more and subsequently decrease up to centre of gauge point. again the pressure head increases and will form a Parabolic curve.

Simple U tube Manometer:- A manometer transparent tube of 10 mm or more, bent in a U shape is called U-tube or simple manometer. U-tube manometer can measure both Positive and negative Pressure.

Procedure.

(i) Measure the area of conduit at various gauge points.

(ii) Open the supply valve and adjust the flow so that the water level in the inlet tank remains constant.

(iii) Measure the height of water level in the collecting tank by a piezometric tube with the help of steel rule.

(iv) Measure the discharge of the conduit with the help of measuring tank.

(v) Note the time duration by stop watch from beginning of initial flow to end of the flow.

(vi) Repeat the steps (i) to (v) for two more readings.

Technical Specification -

Length of the discharge tank (L)

= 40 cm = 0.4 m

Breadth of discharge tank (b)

= 30 cm = 0.3 m

Area of measuring tank (A)

$= l \times b = 0.4 \times 0.3 = 0.12 m^2$

Observation -

Depth of water collected in dis- discharge tank.

$h = \_\_ cm = \_\_ m$

volume of water collected in the tank

$q = A \times h = 0.12 m^2 \times \_\_ m^3$

Time of collection (t) = — Sec

CALCULATION TABLE -

1 Tube NO	2 Area of flow of tubes A in (m²)	3 Discharge $Q = q/t$ in (m^3/s)	4 velocity of flow V in m/s $V = Q/A$	5 velocity head $V^2/2g$ in, m	6 Pressure head $P/\rho g$ in, m	7 Datum head Z	8 Total head(H) = $P/\rho g + V^2/2g + Z$ (m)	9 Remark

EXPERIMENT- 8

Aim of the Experiment-

Determination of (Cd) of venturimeter-

Apparatus Required-

1- venturimeter test rig
2- Stop watch (Digital)
3- Steel rule (L = 30cm)

THEORY- A venturi meter is an instrument used to measure the rate of discharge at different section of the pipe line. A venturimeter consists of 3 parts.

- converging section.
- Throat section.
- Divergent section.

co-efficient of discharge $C_d = \frac{Q_{act}}{Q_{th}}$

where $Q_{act} = \frac{l \times b \times h}{t}$

l = length of discharge tank.
b = breadth of discharge tank.
h = height of discharge tank.
t = time taken in second.

$$Q_{th} = \frac{A_1 \times A_2 \times \sqrt{2gh}}{(\sqrt{A_1^2 - A_2^2})}$$

where A_1 = Inlet area of venturimeter.
A_2 = Outlet area of venturimeter.

Experimental Procedure -

- Set the manometric pressure tube to atmospheric pressure by opening the upper valve.
- Now the supply of water may be controlled by the stop valve.
- One of the valves of any pipe may be opened and closed all of other there valves/pipes.
- Note the discharge reading for the particular flow by measuring the height of the discharge tank.
- Note the time taken by stop watch for the particular ~~force flow~~ flow.
- Note the readings for pressure head from the U-tube manometer. which its corresponding reading of discharge.
- Now take three readings for this pipe and calculate Cd for that instrument formula given.
- Now close this valve and open another valve having different diameter pipe and repeat this procedure as mentioned above. There such readings also taken and calculate Cd.

- Similarly take readings for all others diameter pipe and calculate C_d in each case.

Technical Specification -

length of discharge tank,
$l = 40\,cm = 0.4\,m$, Breath of the discharge tank, $b = 30\,cm = 0.3\,m$

Height of dischange tank
$h = 100\,cm = 0.10\,m$, Inlet dia of venturi meter
$D_1 = 2\,cm = 0.02\,m$

Inlet area $(A_1) = \pi/4 \times (D_1)^2$
$\pi/4 \times (0.02)^2 = \_\_\_ m^2$

Out let dia of ventorimeter (throat dia)
$D^2 = 1\,cm = 0.01\,m$

Out let area $(A_1) = \pi/4 \times (D_2)^2$
$= \pi/4 \times (0.01)^2 = \_\_\_ m^2$

Specific Gravity of mercury (S_g)
~~$= \frac{PHgo}{}$~~

$= \frac{PHg}{PH_2O} = \frac{1000}{1000} = 1$

calculation table -

(1) Sl No	(2) Initial height h_1 m	(3) Final height h_2 m	(4) Net head $= (h_1 - h_2)$	(5) $Q_{act} = \frac{l \times b \times h}{t}$ m^3/sec

(6) $Q_{th} = \frac{A_1 \times A_2 \times \sqrt{2gH}}{(\sqrt{A_1^2 - A_2^2})}$ m^3/sec	(7) $C_d = Q_{act}/Q_{th}$	(8) Remark

<u>conclusion</u> -

From the above experiment we have calculated C_d of venturimeter.

Experiment - 9

Aim of the Experiment.

Determination of C_c C_v C_d from orifice meter.

Apparatus Required -

1- Supply tank with overflow arrangement.
2- Orifice plate of diameter (different)
3- Hook Gauge.
4- Collecting tank.
5- Piezometric tube.

Formula used -

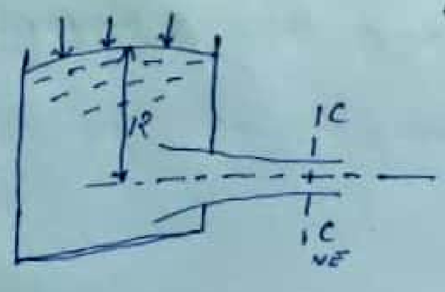
$$C_d = \frac{Q_{actual}}{Q_{theoretical}}$$

$Q_{theoretical}$ = Theoretical velocity × Theoritical area $= \sqrt{2gh} \cdot a$

$$C_d = \frac{Q}{\sqrt{2gh} \cdot a}$$

$$C_v = \frac{\text{Actual velocity of jet at vena contracta}}{\text{Theoritical velocity}}$$

$$C_c = \frac{\text{Area of jet at vena contracta}}{\text{Area of orifice.}}$$



THEORY- A mouthpiece is a short length of pipe which is two or three times its diameter in length. If these pipe is fitted externally to the orifices, the mouthpiece is called external cylindrical mouthpiece and discharge through orifice increase is a small opening of any cross section on the side of bottom of the tank. through which the fluid is following orifice coefficient of velocity is defined as the ratio of two actual.

Discharge to orifice ration of the actual velocity of the jet at vena-contracta to the coefficient of theoretical velocity of the jet coefficient of contraction of defined as ratio of the actual velocity of jet at vena-contracta.

vena contracta - The fluid out is in form of jet goes on contracting form orifice up to dispute of about 1/2 the orifice dia. After the expend this least relation.

coefficient of contraction

$$C_c = \frac{\text{area of jet at vena contracta}}{\text{Area of orifice.}}$$

$$C_d = \frac{Q_{actual}}{Q_{theoretical}}$$

Procedure ~

1- Set the mouthpiece of which the C_c C_v C_d are to be determined.

2- Note the initial height of water in the steady flow tank and the height of datum from the bottom of orifice and mouthpiece. Type remains constant for a particular mouthpiece or orifice.

3- By using the stop valve, set a particular flow in tank and tank height of water in tank.

4- Take the reading of discharge on this particular flow.

5- Using hook gauge, find the volume of x_0 y for mouthpiece

6. Take three readings using hook gauge for one particular orifice.

7. Using the formula get value C_d C_v

and C_c for a particular orifice and mouth piece.

Observation –

$x' + y'$ are reading on horizontal / vertical scale.

average a_0	$h = \mu a_0$	x'	y'	$x = x' - x_0$	$y = y' - y_0$	$C_v = x/2gh$

h = Reading on Piezometer

a0 = Reading on Piezometer at level on centre of mouth piece.

y0 = Reading on vertical scale at exit of orifice.

x0 = Reading on horizontal scale at exit of orifice.

1	2	3	4	5	6	7	8	9
Sl No	X	IP	FR	volume	Time	Q = V	Cd = Q/2gh	Average