A Laboratory manual For

MECHANICAL ENGG. LAB-II (PR-2)

S.C.T.E & V.T, Odisha

Semester – 4th

DEPARTMENT OF MECHANICAL ENGINEERING

GOVERNMENT POLYTECHNIC, SAMBALPUR

EXPERIMENT-01

***AIM:* - To study Two-stroke & Four-stroke Petrol and Diesel Engines.**

***APPARTUS USED:* -** Model of Two-stroke & Four-stroke petrol Engines.

THEORY-

CYCLE- When series of events are repeated in order, it completes one cycle. Cycle is generally classified as Four stroke cycle and Two stroke cycle.

Four stroke cycle- In Four stroke cycle, four operations are required to complete one cycle. These four operations are suction, compression, power and exhaust.

Two stroke cycles- In a two stroke cycle, the series of events of the working cycle is completed in two strokes of the piston and one revolution of the crankshaft. The four operations i.e. suction, compression, power and exhaust are completed during two strokes of the piston.

ENGINE- A power producing machine is called an engine.

HEAT ENGINE- An engine which converts heat energy into mechanical energy is called a heat engine.

Types of heat engine –

a) ***External Combustion engine-***The engine in which the combustion of fuel takes place outside the cylinder is called an external combustion engine.

b) ***Internal Combustion engine-*** *The* engine in which the combustion of fuel takes place inside the cylinder is called an internal combustion engine.

FOUR STROKE PETROL ENGINE-

In four stroke petrol engine or spark ignition engine all the events of the cycle i.e. suction, compression, expansion and exhaust take place in two revolutions of the crank shaft I.e. 720° of the crank rotation. Thus each stroke is of 180° crank shaft rotation. Therefore the cycle of operation for an ideal four stroke engine consists of the following four strokes:

a) ***Suction Stroke-*** The piston moves from Top Dead Centre (TDC) to Bottom Dead Centre (BDC). The inlet valve opens and a fresh charge of fuel and airmixture enters the cylinder. The exhaust valve remains closed. When the piston reaches Bottom Dead Centre (BDC), the inlet valve also closed.

b) ***Compression Stroke-*** The piston moves from Bottom Dead Centre (BDC) to Top Dead Centre (TDC) position. Both the valves remain closed. The charge drawn during suction stroke is compressed in this stroke.

c) ***Expansion or Power or Working Stroke-*** Just before the piston completes its compression stroke, the charge is ignited by the spark plug and the rapid explosion takes place. The expansion of hot gases pushes the piston down to

BDC position. Both the valve remains closed and the useful work is obtainedfrom the engine.

d) ***Exhaust Stroke-*** The piston moves from BDC to TDC, the exhaust valve opens and the inlet valve remains closed. The piston pushes the exhaust gases out through the exhaust valve to the atmosphere till it reaches the TDC position and the cycle is completed.

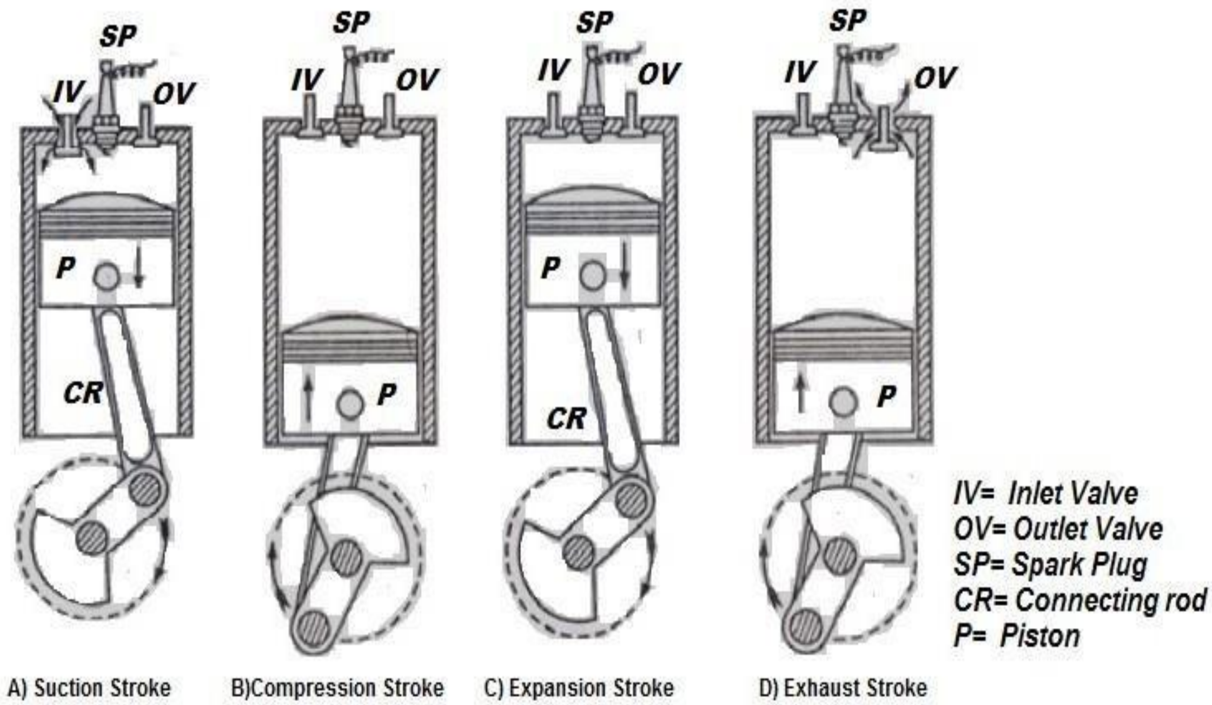


Figure- Four Stroke Petrol Engine

<u>TWO STROKE PETROL (S.I.) ENGINE-</u>

In two stroke cycle petrol engine, there are two strokes of the piston and one revolution of the crankshaft to complete one cycle. In two stroke engines ports are used instead of valve i.e. suction port, transfer port and exhaust port. These ports are covered and uncovered by the up and down movement of the piston. The top of the piston is deflected to avoid mixing of fresh charge with exhaust gases. The exhaust gases are expelled out from the engine cylinder by the fresh charge of fuel entering the cylinder. The mixture of air and petrol is ignited by an spark producedat the spark plug. The two stroke of the engine are-

First Stroke- Assuming the piston to be at the BDC position. The inlet port is converted by the piston whereas the transfer port and exhaust port are uncovered. The piston moves from BDC to TDC. The air petrol mixture enters the cylinder. On the upward movement of the piston, first of all the transfer port is converted and then immediately, the exhaust port is covered. Simultaneously the suction port also gets uncovered, the upward movement of the piston helps to compress the air fuel mixture at the top and creates partial vacuum at the bottom in the crankcase which gets filled with air fuel mixture by the atmospheric pressure. At the end of the stroke, the piston reaches the TDC position completing the compression stroke as shown in Fig. (a) and (b).

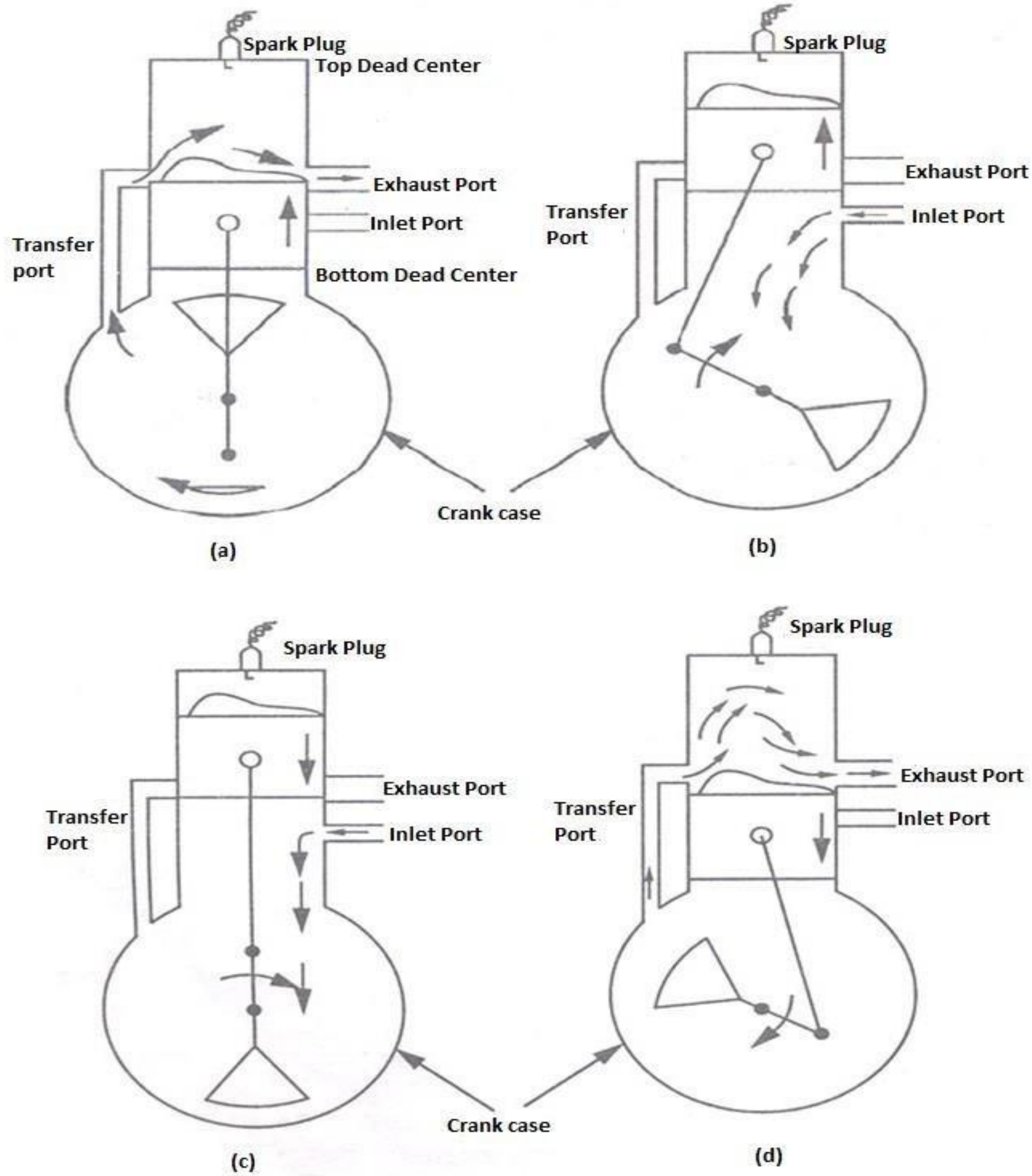


Fig-TWO STROKE CYCLE PETROL (S.I.) ENGINE-

Second Stroke- Just before the completion of the compression stroke, the compressed charge is ignited in the combustion chamber, by means of an electric spark produced by the spark plug. Combustion of air fuel mixture pushes the pistonin the downward direction, on the power stroke producing useful work. The movement of the power action is over, the exhaust port is uncovered. The exhaust gases escape to the atmosphere. Further movement of the piston covers the inlet port and the fresh charge is compressed in the crankcase. Simultaneously the transfer port is also uncovered. The compressed mixture of air fuel enters the combustion chamber. The deflected shape of the piston avoids inter-mixing of the fresh charge and exhaust gases i.e. the fresh charge rises to the top of the cylinder and pushes out most of the exhaust gases. Thus the three actions, power, exhaust and induction are completed from TDC to BDC position completing one cycle i.e. two stroke of the piston and one revolution of the crankshaft as shown in Fig. (c)and (d).

The engine which converts the heat energy into mechanical energy is known as heat engine.

Working principle of four stroke Diesel engine.

There are four strokes as:

1. Suction Stroke

2. Compression stroke

3. Expansion stroke

4. Exhaust stroke

1. Suction stroke: This stroke starts with the piston at top dead centre position. The inlet value is opened and the exhaust value is closed. The downward movement of the piston creates vacuum in the cylinder due to which air is drawn into the cylinder. The movement of the piston is obtained either by the starter motor or by the momentum of the fly wheel.

2. Compression stroke: This stroke starts with the piston at B.D.C. position. Both the inlet and exhaust values are closed.

The air sucked during the suction stroke is compressed as the piston moves in the upward direction. A few degree before the completion of compression stroke, a very fine spray of diesel is injected into the compressed air. The fuel ignites spontaneously.

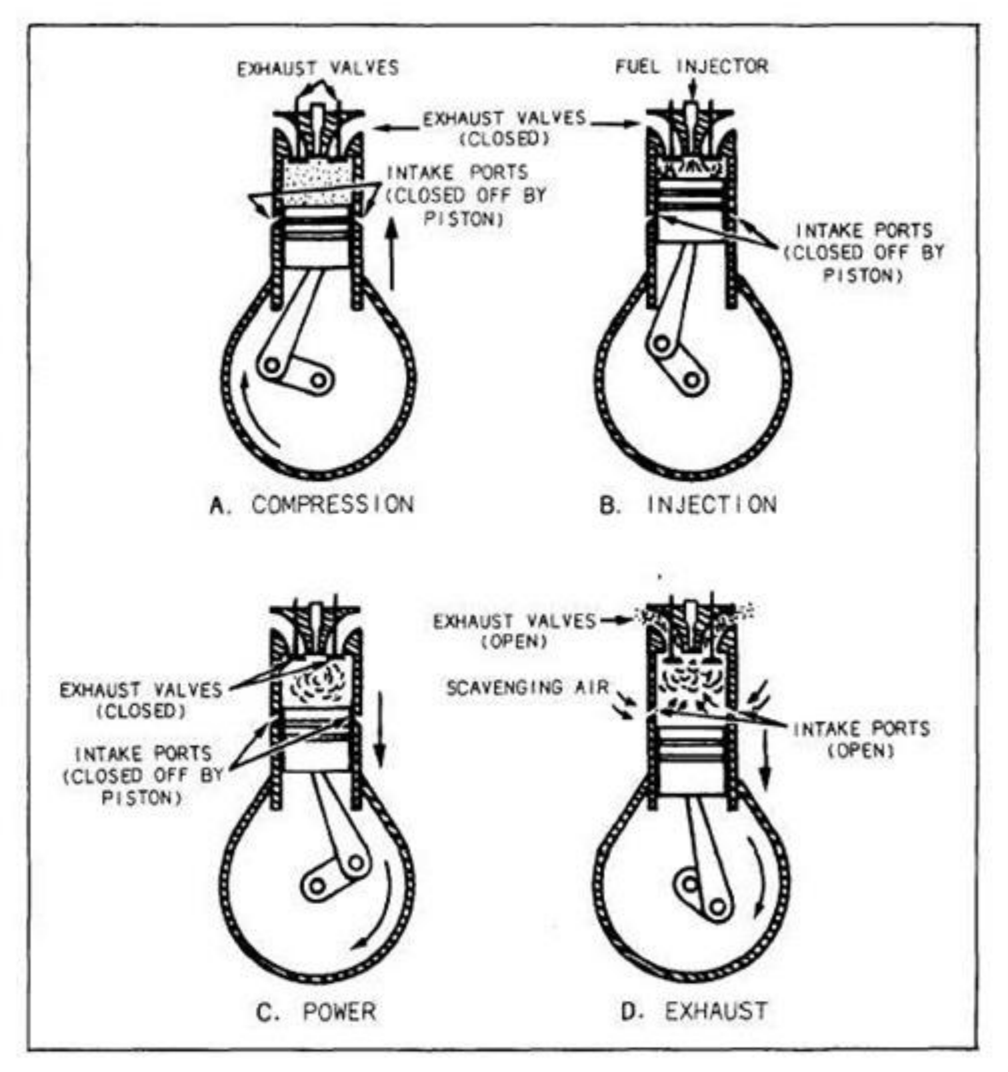


Figure of CI (diesel) Engine Cycle

3. Expansion stroke: Both the inlet and exhaust valves remain closed. The heat energy released by the combustion of the fuel, results in the rise in pressure of the gases. This high pressure rise drives the piston in the downward direction, thereby producing some useful work. This stroke is called as power stroke.

4. Exhaust stroke: This stroke starts with the piston at the B.D.C. position. The inlet value remains closed whereas the exhaust value is opened. The upward movement of the piston pushes the burnt gases out of the cylinder through the exhaust valve. At the end of exhaust stroke, the exhaust valve is also closed.

The four-strokes complete one cycle which may repeat again to produce power.

WORKING PRINCIPLE OF 2 STROKE DIESEL ENGINE

1. 1st Stroke – As the piston starts rising from its B.D.C. position, it closes the transfer and the exhaust port. The air which is already there in the cylinder is compressed. At the same time with the upward movement of the piston, vacuum is created in the crank case. As soon as the inlet port is uncovered the fresh air is sucked in the crank case. The charging is continued until the crank case and the space in the cylinder beneath the piston in filled with the air.

2. 2nd Stroke – Slightly before the completion of the compression stroke a very fine spray of diesel is injected into the compressed air (which is at a very high temperature). The fuel ignites spontaneously.

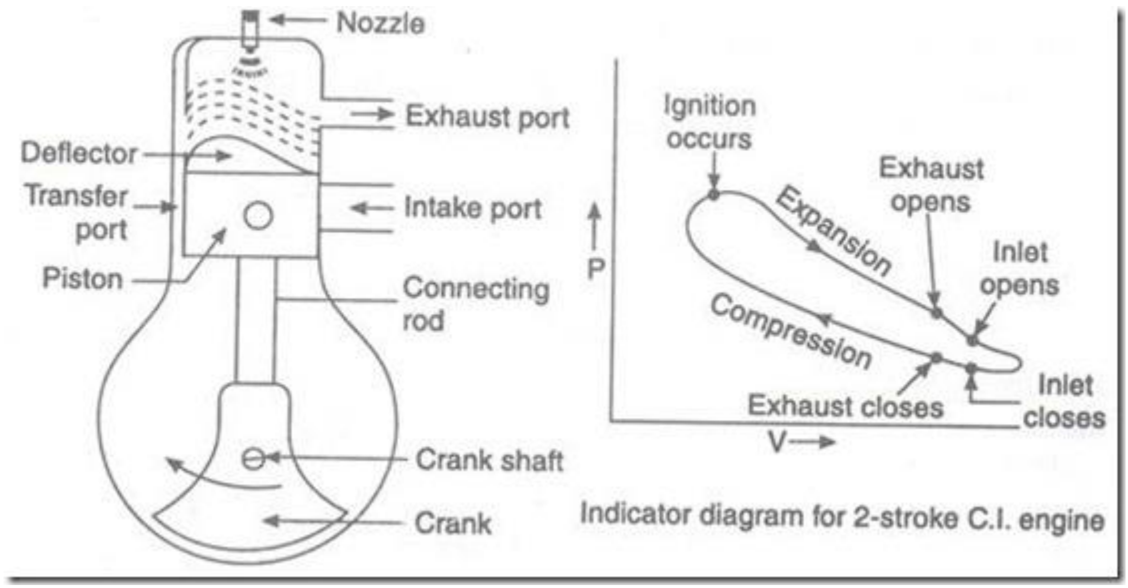


Figure of Two stroke CI Engine

Pressure is exerted on the crown of the piston due to the combustion of the air and the piston is pushed in the downward direction producing some useful power. The downward movement of the piston will first close the inlet port and then it will compress the air already sucked in the crank case.

Just at the end of power stroke, the piston uncovers the exhaust port and the transfer port simultaneously. The expanded gases start escaping through the exhaust port and at the same time the fresh air which is alredy compressed in the crank case, rushes into the cylinder through the transfer port and thus the cycle is repeated again.

EXPERIMENT NO: 02

AIM OF THE EXPERIMENT:

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

OBJECTIVE:- After performing this experiment students will be able to

i) Know about single cylinder petrol engine.

ii) What is BHP, IHP & BSFC?

iii) Know how to calculate the performance of single cylinder petrol engine.

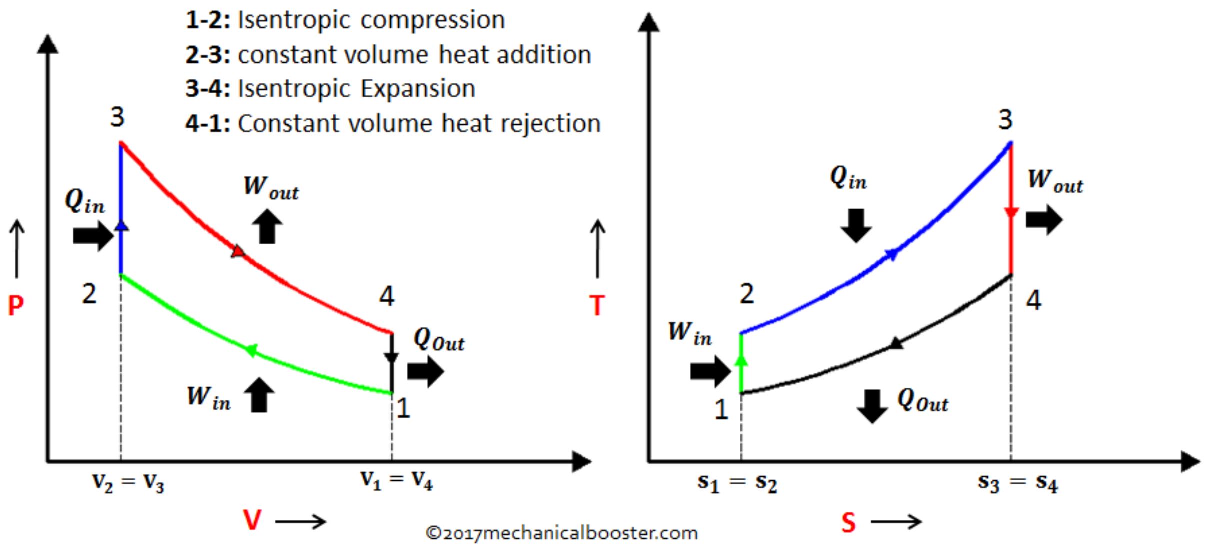
APPARATUS REQUIRED:

SL NO	EQUIPMENT	SPECIFICATION	
1	SINGLE CYLINDER PETROL ENGINE	Make	Honda
		Bhp	10
		Speed	1500
		no of cylinder	1
		compression ratio	6 : 11
		Bore	73mm
		Stroke	89mm
		orifice dia	20mm
		ignition type	spark ignition
		types of cooling	water cooled
		types of loading	rope brake loading
		types of starting	self starting

THEORY:

Petrol engine works on Otto cycle and it uses petrol as the working fluid. Here spark plug is used to ignite the fuel. Otto cycle consist of four different stages i.e suction, compression, expansion and exhaust. Here air and fuel mixture is separately prepared in the carburetor which is sucked in the suction stroke is compressed in the compression stroke .then from spark plug spark is produced and the combustion takes place. After combustion, in the exhaust stroke, the burnt out gases escapes from the engine cylinder. The single cylinder petrol engine is connected with a rope brake dynamometer to measure the load applied to the engine.

DIAGRAM:-



P-V and T-S Diagram of Otto Cycle

PROCEDURE:

1. Fill fuel into 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 lock provided under the fuel tank and ensure that no air is trapped in the fuel line connecting fuel tank and engine.
4. De-compress the engine by decompression 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 into the pump and in turn through the nozzle into the engine cylinder.
6. When maximum cranking speed is attained, pull the decompression lever down, now. The engine starts. Allow the engine to run and stabilize. (Approximately 1500 RPM. The engine is a constant speed engine fitted with centrifugal governor)
7. Now lead the engine by placing the necessary dead weights on the 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. Record 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 pan in kg (W1) plus weight of pan 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.

CALCUATION :

N = rpm of engine
V = Volume of the fuel consumed in $cm^{3.}$
W = Load on the engine in Kg.
K = Number of cylinder
t = Time taken for 10cc of fuel consumed in sec.
CV = Calorific value of fuel = 44650 KJ/Kg
In this experiment we have to calculate the brake thermal efficiency of the Single cylinder 4 Stroke Diesel engine.

$$\textbf{B.P} = \frac{\pi N\,(W-S)(D+d)}{60x1000} \textbf{ in KW}$$

Where,

W = Dead Weight in N
S = Spring Balance reading in N
D = Diameter of Brake drum in metre
d = Diameter of rope in metre
N = Speed of the engine

$$\textbf{Brake thermal efficiency} = \frac{\textit{Brake Power}}{\textit{Energy supplied to the engine}}$$

$$\eta_{Bth} = \frac{B.P}{mf\ X\ Cv} \text{ x 100 \%}$$

Where,

Cv = Calorific value of fuel (Diesel) = 11000 Kcal/kg
Density of the diesel in 8.38 gms/cc

Volume flow rate of diesel in m^3/sec

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

Mass flow rate of diesel

$m_f = \frac{10}{t}\ x\ (10^{-6})$x (0.833x1000) /sec

$= \frac{8.33}{t}$ x 10^{-3} Kg/sec

Energy supplied to the engine = m_f X $C_v = \frac{8.33}{t}$ x 10^{-3} x a0,833 Kcal/sec

$= \frac{8.33\ x\ 10{,}833\ x\ 3.2}{t}$ x 10^{-3} Kw

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

So $\eta_{bth} = \frac{B.P}{377.568/t}$

CONCLUSION :

We have successfully determined the thermal efficiency of single cylinder petrol engine.

PRECAUTION:-

i) Handle the set up carefully.
ii) Before Starting the setup check all connections are tight .
iii) Wear safety shoes.
iv) Follow the instructions properly.

VIVA VOICE:-

i) What do you mean by petrol engine?
ii) Explain the working of petrol engine.
Iii) Draw P-V & T-S diagram of petrol engine.
IV) Define stroke.
v) State different strokes of petrol engine.
vi) Define BP.
vii) Define brake thermal efficiency.

EXPERIMENT: 03

AIM OF THE EXPERIMENT:

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

OBJECTIVE: - After performing this experiment students will be able to

i) Know about single cylinder diesel engine.
ii) Find the brake thermal efficiency of the single cylinder diesel engine
iii)

APPARATUS REQUIRED:

<table>
<tr><th>SL NO</th><th>EQUIPMENT</th><th colspan="2">ENGINE SPECIFICATION</th></tr>
<tr><td rowspan="12">01</td><td rowspan="12">Single Cylinder Diesel Engine Test Rig</td><td>Make</td><td></td></tr>
<tr><td>BHP</td><td>5</td></tr>
<tr><td>Speed</td><td>1500 RPM</td></tr>
<tr><td>No. of Cylinder</td><td>One</td></tr>
<tr><td>Compression Ratio</td><td>16.5:1</td></tr>
<tr><td>Bore</td><td>80mm</td></tr>
<tr><td>Stroke</td><td>110mm</td></tr>
<tr><td>Orifice Dia</td><td>17mm</td></tr>
<tr><td>Type of Ignition</td><td>Compression Ignition</td></tr>
<tr><td>Method of Loading</td><td>Rope Brake</td></tr>
<tr><td>Method of Starting</td><td>Crank Start</td></tr>
<tr><td>Method of Cooling</td><td>Water</td></tr>
</table>

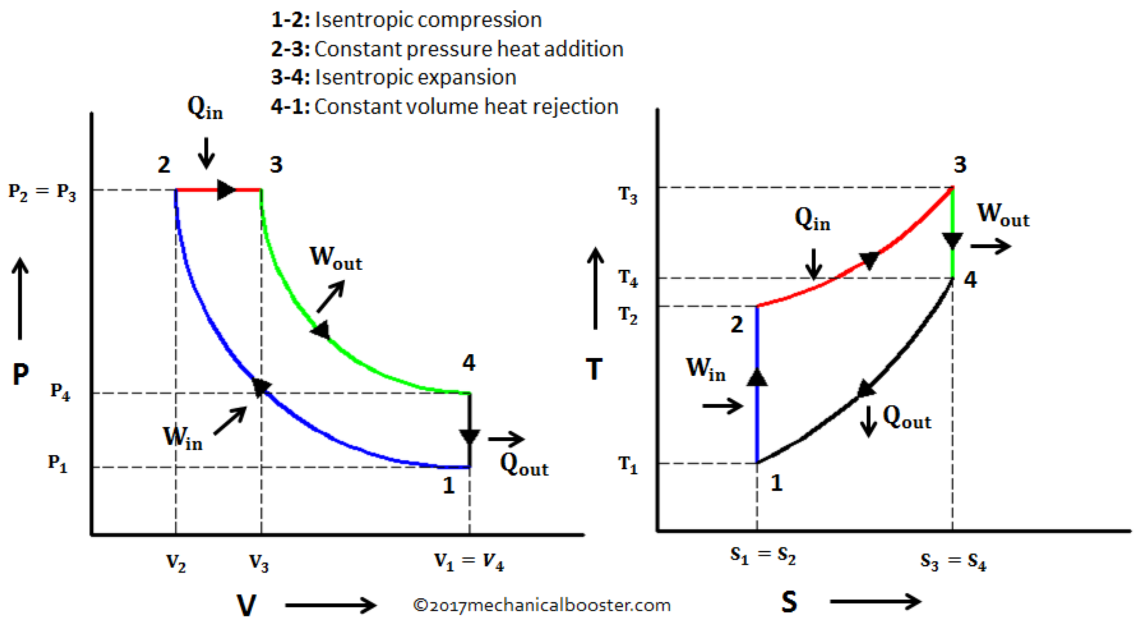
THEORY :

Diesel engine use diesel as the working fluid. Here high compression ratio of the fuel ignites the fuel. Diesel cycle consist of four different stages i.e suction, compression ,expansion and exhaust. Here only air which is sucked in the suction stroke is compressed in the compression stroke .then fuel from the fuel injector enters in to the engine cylinder at the end of compression and combustion of fuel takes place. After combustion, in the exhaust stroke, the burnt out gases escapes from the engine cylinder.

Brake Thermal Efficiency:

Brake thermal efficiency is the ratio of energy in the brake power (BP) to the input fuel energy in appropriate units.

DIAGRAM:



P-V and T-S Diagram of Diesel Cycle

PROCEDURE:

1. Fill fuel into 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 lock provided under the fuel tank and ensure that no air is trapped in the fuel line connecting fuel tank and engine.
4. De-compress the engine by decompression 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 into the pump and in turn through the nozzle into the engine cylinder.
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7. Now lead the engine by placing the necessary dead weights on the 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. Record 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 pan in kg (W1) plus weight of pan 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 brake thermal efficiency of the Single cylinder 4 Stroke Diesel engine.

$$\textbf{B.P} = \frac{\pi N\,(W-S)(D+d)}{60x1000} \textbf{ in KW}$$

Where,
W = Dead Weight in N, S = Spring Balance reading in N, D = Diameter of Brake drum in meter,
d = Diameter of rope in meter N = Speed of the engine

$$\textbf{Brake thermal efficiency} = \frac{Brake\ Power}{Energy\ supplied\ to\ the\ engine}$$

$$\eta_{Bth} = \frac{B.P}{mf\ X\ Cv}$$

Where,

Cv = Calorific value of fuel (Diesel) = 11000 Kcal/kg
Density of the diesel in 8.38 gms/cc

Volume flow rate of diesel in m^3/sec = $\frac{10}{t}\ x\ (10^{-2})^3$ (If volume is measured in cm^3)
Mass flow rate of diesel

$m_f = \frac{10}{t}\ x\ (10^{-6})$x (0.833x1000) /sec

$= \frac{8.33}{t}$ x 10^{-3} Kg/sec

Energy supplied to the engine = m_f X $C_v = \frac{8.33}{t}$ x 10^{-3} x a0, 833 Kcal/sec

$= \frac{8.33\ x\ 10{,}833\ x\ 3.2}{t}$ x 10^{-3} Kw

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

So $\eta_{bth} = \frac{B.P}{377.568/t}$

CONCLUSION :

The brake thermal efficiency of single cylinder diesel engine is found to be_____________.

PRECAUTION:-

i) Handle the set up carefully.
ii) Before Starting the setup check all connections are tight .
iii) Wear safety shoes.
iv) Follow the instructions properly.

VIVA VOICE:-

i) What do you mean by Diesel engine?
ii) Explain the working o Diesel engine.
Iii) Draw P-V & T-S diagram of Diesel engine.
IV) Define stroke.
v) State different strokes of Diesel engine.
vi) Define BP.
vii) Define brake thermal efficiency.

EXPERIMENT NO: 04

AIM OF THE EXPERIMENT:

Determine the BHP, IHP and BSFC of multi cylinder petrol engine by Morse test.

OBJECTIVE:- After performing this experiment students will be able to

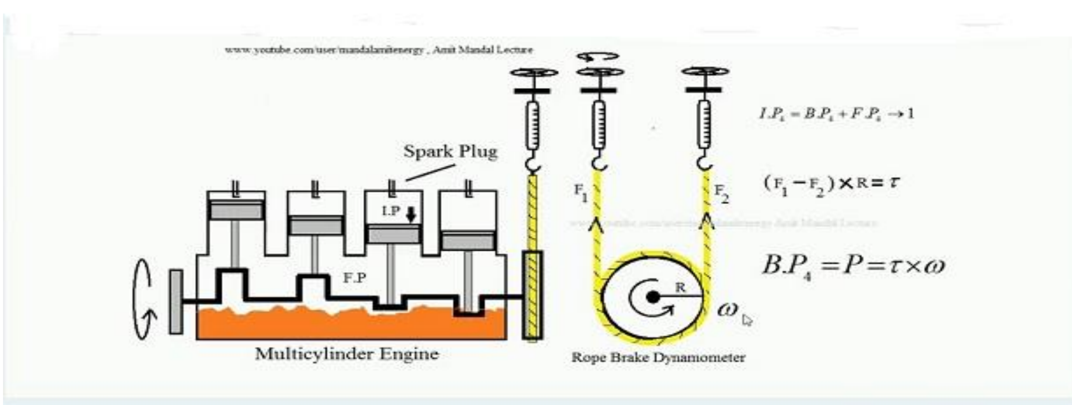
i) Why morse test is required.
ii) What is BHP, IHP & BSFC?

APPARATUS REQUIRED:

Sl No	Equipment	Specification	
01	Four cylinders Petrol Engine Test Rig.	BHP	5-7
		Speed	1500 RPM
		No of cylinder	3
		Compression Ratio	7.8: 1
		Bore	68 mm
		Stroke	75 mm
		Orifice Dia	24 mm
		Type of ignition	Spark Ignition
		Type of cooling	Water Cooling
		Type of loading	Rope Brake Loading
		Type of starting	Self Starting

THEORY:

- The Morse test is used to find out the **indicated** power of a multi cylinder reciprocating engine.
- The engine is run at a particular speed and the torque is measured by cutting out the firing of each cylinder in turn and noting the fail in brake power each time while maintaining the set 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.



PROCEDURE:-

1. Before starting the engine fill the fuel tank, check the engine cooling system and electrical connections.
2. Start the engine with the help of ignition key .wait until the digital RPM indicator indicates idle speed of approx 800 to 1000 RPM. Ensure the oil pressure gauge reading up to 2-3 kg/cm^2.
3. Increase the speed by turning the accelerator knob clockwise until the Rpm indicators reads 1500RPM.
4. Now open the dynamometer inlet gate valve gradually to load the engine through hydraulic dynamometer. The load is indicated on a dial type spring balance in terms of kg.
5. Allow the engine to run for few minutes.
6. Now cut off power to one cylinder by pulling the knife switch provided on the engine panel. Here the engine is running on two cylinders so speed of the engine decreases. So by reducing / adjusting the load, the engine comes back to its previous rated speed (1500 RPM).
7. After that record the spring balances reading.
8. Repeat steps 6 & 7 by cutting off each cylinder separately.
9. Calculate the BHP when all the 3 cylinders are working.
10. Similarly calculate the BHP of 3 cylinders when each of the cylinders is disconnected.
11. Calculate IHP of the engine.

CALCULATION :

Let W = Dynamometer load in Kg N = RPM of the engine A = BHP of 4 cylinder
IHP= Indicated horse power BHP=Brake horse power

$$\text{BHP} = \frac{(w-s)\pi\,(D+d)N}{4500} \text{ in Horse Power}$$

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

Then **IHP Calculation**:
IHP of 1st cylinder = A-B
IHP of 2nd cylinder = A-C
IHP of 3rd cylinder = A-D

Total IHP Calculation
Total IHP of the engine = IHP (1st + 2nd + 3rd)

BSFC Calculation:

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

$$\textbf{S.F.C} = \frac{mf}{BHP}\ \textbf{Kg/ BHP. Hr}$$

m_f = Fuel consumed in Kg/hr

TABULATION:-

SL NO	CONDITION	N IN RPM	W IN KG	BHP	IHP	BSFC
1	A	1500				
2	B	1500				
3	C	1500				
4	D	1500				

CONCLUSION :

We have successfully calculated BHP, IHP and BSFC of multi cylinder petrol engine by Morse test.

PRECAUTION:-

i) Handle the set up carefully.
ii) Before Starting the setup check all connections are tight .
iii) Wear safety shoes.
iv) Follow the instructions properly.

VIVA VOICE:-

i) Define BHP?
ii) Define IHP?
iii) Define BSFC?
iv) What is the purpose of conducting morse test?

EXPERIMENT NO : 05

AIM OF THE EXPERIMENT:-To determine the mechanical efficiency of a single stage air compressor.

OBJECTIVE:- After performing this experiment students will be able to

i) Know about air compressor?

ii) Know Different components and working of air compressor?

APPARATUS REQUIRED:

SL.NO.	EQUIPMENT	SPECIFICATION	QUANTITY
01	Air compressor test rig		01
02	Tachometer		01
03	Stop watch		01

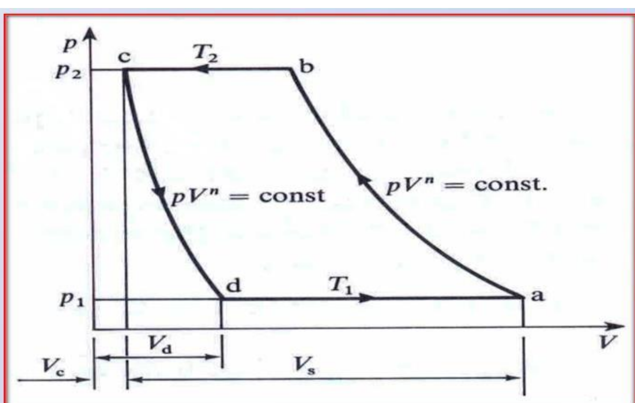
THEORY:-

An air compressor is the machine which compress the air and to raise its 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 by 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. Therefore a compressor must be driven by some prime mover.

CONSTRUCTION: it consists of the following components.

1. Cylinder
2. Piston
3. Inlet valve
4. Outlet valve
5. Pressure gauge
6. Pressure vessel

DIAGRAM:



Indicator diagram for a reciprocating compressor

WORKING PROCEDURE:-

- When the piston moves downward the pressure inside the cylinder falls below the atmospheric pressure.
- Due to this pressure difference the I.V. gets opened and the air is sucked into the cylinder .
- Now when the piston moves upward the pressure inside the cylinder goes on increasing till it reaches the discharge pressure . at this stage the 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 reaches upto the required limit.
- At this stage the inlet valve gets opened as a result of which fresh air is sucked into the cylinder and the cycle is repeated.

CALCULATION:-

Mechanical efficiency of compressor η_{mech}= B.P/I.P

I.P=$\frac{W X N}{60X1000}$kw

W = Work by the compressor = $\frac{n}{n-1}$ x m RT_1X { $(\frac{p2}{p1})\wedge\frac{n-1}{n}$-1 }

Brake Power = $\frac{3600 \ x\ 10\ x\ 0.8}{t\ x\ n}$ 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 outlett of the compression

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.	**Temperature**	**Pressure**	**No.of working strokes (n_w=N)**	

CONCLUSION :

We have successfully determined the mechanical efficiency of a single stage air compressor which is found to be_______________.

PRECAUTION:-

i) Handle the set up carefully.

i) Before Starting the setup check all connections are tight .

ii) Wear safety shoes.

iii) Follow the instructions properly.

VIVA VOICE:-

i) What is air compressor?
ii) What is the need of compressed air?
iii) Where it is used?
iv) Draw the P-V single stage air compressor.

EXPERIMENT No 6

Aim:- To study Viscosity, Velocity & Pressure measuring device.

Theory:-Viscosity measuring device:-

1. Capillary tube
2. Viscometer.

Capillary tube: - Poiseiulle showed that the volume (v) of a liquid or gas flowing per second through a horizontal capillary tube of a given radius length (L) under a constant difference of pressure (ΔP) between two ends is inversely proportional to the viscosity of fluid. The volume offluid through the f tube in t is given by

The lesser the volume of flowing fluid through the tube per unit time, the larger the viscosity.

Viscometer:- It is an instrument to measure the viscosity. It measures some quantity which is a function of viscosity. The quantity measured is usually time taken to pass certain volume of the liquid through an orifice fluid at the bottom of the viscometer. The temperature of liquid, while itis being passed through the orifice should be maintained constant. Some viscometer is used are say bolt universally, redwood, Engler viscometer which has a vertical tube. The times in second to pass 60cc of fluid liquid for the determination of viscosity is "say bolt second".

The following empirical relations are used to determine kinematics viscosity in stokes:-

A) Say bolt universal viscometer
B) **Red wood viscometer**
C) Engler viscometer

Velocity measuring device:-

Rota Meter.

Construction: - A Rota meter is a device to find the velocity of a flow in a pipe with the aid of rotating free float. It is essentially an orifice meter with fixed pressure drop and variable orifice area. Fluid is allowed to flow vertically upward through a tapered transparent tube placedvertically with a large end at the top. The float is freely suspended upside the tube. The maximum diameter of float is slightly less then the minimum bore. There are two L-bend lies on the inlet and outlet of the tube. Guide wire for float is calibrated at the centre of the tapered tube. The outlet portion for fluid generally less then the inlet portion. The tapered tube is generally having the glass covering on the part of taking the reading of the float

Working: - When there is no flow, float rests at bottom, but fluid when some velocity float has rises upward to make way for fluid motion. The float rises to such a position that the pressure loss across the amuler orifice just balances to the weight of the float mechanism which is attached to it. The float therefore attains a state of equilibrium and the distance from the stop to float is a measure of the discharge in liter/second. The float is provided with slantwise slots to enable it to occupy a stable position at the center of tube.

Pressure measuring device:-

A) **Dead weight piston gauge**

B) Mechanical gauge

A) Dead weight piston gauge:- This is the direct method for precise determination to of a piston steady pressure measurement. The instrument consists of a piston & a cylinder of known area connected to a fluid pressure on the piston equal to the pressure times the piston area. This force can be balanced by weight fitted on the top of the vertical piston. This is the most accurate device and used for precision and for calibrating other pressure gauge. The pressure of liquid is balanced by known weight. Pressure in Kgf/cm2 or KN/m2

B) Mechanical gauge:-By the help of spring or dead weight balanced the liquid column whose pressure is to be measured. In gauge are the liquid exert the force on a movable diaphragm or piston, which is the resisted by a spring of known valve. The intensity of pressure then would be equal to the force F divided by the area a of the diaphragm or piston $P = F/a$

They are suited for the measurement of high pressure when it is more then to atmospheres. The most accurate and reliable region on the scale of mechanical gauge in between 40% & 70% of the maximum may give direct pressure reading, portability and wider operating gauge. They can fairly accurate reading if properly calibrated.

1. Bourdon tube pressure gauge
2. Diaphragm pressure gauge
3. Dead weight pressure gauge

Viva Questions:-

1. Define and explain the Newton’s law of viscosity?
2. Define construction of bourdon tube pressure gauge?
3. Define construction of Rotameter?
4. What is meant by calibration?
5. Which type of fluid is used in bourdon tube pressure gauge?

EXPERIMENT NO : 07

AIM :

Verification of Bernoulli's Theorem.

SPECIFICATION

Pipelines	: 40 mm,
Collecting/ Measuring Tank	: 30 Liter
Sump Tank Size	: 50 Liter
Stabilizing Tank Size	: 25 cm x 25 cm x 75 cm
Sheet	: 3mm
Pump	: 0.5 Hp (Kirlosker make)
Control panel	: Switch & starter.

THEORY

Considering frictionless flow along a variable area duct, the law of conservation of energy states that for an in viscid, incompressible, irrational and steady flow along a steam line the total energy (or head) remains the same. This is called Bernoulli's equation. The total head of flowing fluid consists of pressure head, velocity head and elevation head. Hence

$$\frac{p_1}{w} + \frac{V_1^2}{2g} + Z_1 = \frac{p_2}{w} + \frac{V_2^2}{2g} + Z_2$$

Neglecting losses. Or $\frac{p}{w} + \frac{V^2}{2g} + Z$ = Constant

Where P, V and Z refer to the Pressure, Velocity and Position of the liquid relative to some Datum at any section.

EXPERIMENTAL SET UP

The experimental set up is consist of :

1. A variable area duct made of Perspex sheets of known size at entrance, centre and outlet.
2. Piezometer tubes fitted at regular interval.
3. An outlet valve at the discharge end of the duct.
4. Supply of water with the help of flexible pipe from Hydraulic Bench.
5. Outlet of water from the apparatus to the discharge measuring tank of Hydraulic Bench.

PROCEDURE

1. Measure the distance of each Piezometer tube from the inlet section and area of cross-section.

2. Measure the area of discharge measuring tank.

3. Adjust the flow when the head in tube becomes constant. Note the height in all tubes i.e. pressure head p/w.

4. Note the Initial Reading of water measuring tank and collect water for certain time 't' in tank and note final reading of water. Calculate the discharge. By dividing the discharge with area of cross-section under each tube calculate the velocity head i.e.

$$\frac{V^2}{2g}$$

5. As the duct is horizontal so the height of each tube from ground is constant. Head Z is zero.

6. Calculate the total head

$$\frac{P}{w}+\frac{V^2}{2g}+Z \text{ which is constant}$$

Repeat the experiment for different flow.

Closing Procedure:

1. When experiment is over, switch OFF pump first.
2. Switch OFF power supply to panel.

PRECAUTIONS & MAINTTENANCE INSTRUCTIONS

1. Do not run the pump at low voltage i.e. less than 180 volts.
2. Never fully close the delivery line and by-pass line valves simultaneously.
3. Always keep apparatus free from dust
4. To prevent clogging of moving part, run pump at least once in a fortnight.
5. Frequently grease/oil the rotating parts, once in three months
6. Always use clean water
7. If apparatus will not in use for more than one month, drain the apparatus completely, and fill pump with cutting oil.

FORMULA USED :

$$\frac{p}{w}+\frac{V^2}{2g}+Z = cons\tan t$$

$$\frac{p_1}{w} + \frac{V_1^2}{2g} + Z_1 = \frac{p_2}{w} + \frac{V_2^2}{2g} + Z_2$$

OBSERVATION TABLE

Area of measuring tank (A) = 25cm x 30 cm = 750 cm^2

S. NO.	MEASUREMENT TANK READING				Discharge $Q = \frac{A(h_2 - h_1)}{t} cm^3$
	Initial level Cm h1	Final level Cm h2	h2 - h1	Time t sec	
1					
2					

Table No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Area of the pipe (a) = length*width															
Velocity $V = \frac{Q}{a}$															
Velocity Head $\frac{V^2}{2g}$															
Datum head Z = 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pressure Head $\frac{P}{W} = h$															
Total Head $\frac{p}{w} + \frac{V^2}{2g} + Z$															

EXPERIMENT NO 8

Aim:- To determine the coefficient of discharge of Venturimeter.

Apparatus Used:- Venturimeter, installed on different diameter pipes, arrangement ofvarying flow rate, U- tube manometer, collecting tube tank, vernier calliper tube etc.

Formula Used:-

$$C_d = \frac{Q\sqrt{A^2 - a^2}}{A\,a\sqrt{2\,g\,\Delta h}}$$

Where

A = Cross section area of inlet a = Cross section area of outlet

Δh = Head difference in manometerQ = Discharge

C_d = Coefficient of discharge

g = Acceleration due to gravity

Theory:-Venturimeter are depending on Bernoulli's equation. Venturimeter is a device usedfor measuring the rate of fluid flowing through a pipe. The consist of three part in short

1. Converging area part
2. Throat
3. Diverging part

Procedure:-

1. Set the manometer pressure to the atmospheric pressure by opening the upper valve.
2. Now start the supply at water controlled by the stop valve.
3. One of the valves of any one of the pipe open and close all other of three.
4. Take the discharge reading for the particular flow.
5. Take the reading for the pressure head on from the u-tube manometer for corresponding reading of discharge.
6. Now take three readings for this pipe and calculate the C_d for that instrument using formula.
7. Now close the valve and open valve of other diameter pipe and take the three reading for this.
8. Similarly take the reading for all other diameter pipe and calculate C_d for each.

Observations:-

Discharge					Manometer Reading				$Cd = \frac{Q\sqrt{A^2 - a^2}}{Aa\sqrt{2g\Delta h}}$
Initial reading	Final reading	Difference	Time (sec)	Q	h_1	h_2	h_2-h_1	h_2-h_1 $\Delta h = 13.6(h_2-h_1)$	

Result:-

Precautions:-

1.Keep the other valve closed while taking reading through one pipe. 2.The initial error in the manometer should be subtracted final reading.3.The parallax error should be avoided.

4. Maintain a constant discharge for each reading.
5. The parallax error should be avoided while taking reading the manometer.

Viva Questions:-

1. Venturimeter are used for flow measuring. How?
2. Define co efficient of discharge?
3. Define parallax error?
4. Define converging area part?
5. Define throat?
6. Define diverging part?

EXPERIMENT NO : 09

AIM OF THE EXPERIMENT

To determine the hydraulic coefficients C_c, C_v and C_d for orificemeter.

EQUIPMENT :

1. Supply tank fitted with round orifice, Mouth piece scale and sliding arrangement: water inlet pipe and Piezometer tube.
2. Measuring tank
3. Stand for mounting supply tank.

THEORY :

Orifices are devices used for discharging fluids into the atmosphere. It is the opening in the wall of a tank or in a plate which may be fitted in a pipe such that the plate is normal to the axis of the pipe. The discharging fluid from the tank/conduit through the orifice comes out in the form of a free jet. In the process, the total energy of the fluid in the tank is converted to kinetic energy as the jet issues out into the atmosphere. The jet cross section initially contracts to a minima and then expands partly due to the viscous resistance offered by the surrounding atmosphere and partly due to inertia of the fluid particles. The section which has the minimum area is known as 'vena contracts'. The contraction and expansion of the jet results in loss of energy.

The actual velocity at vena contracts is smaller than the theoretical velocity due to frictional resistances at the orifice edges. The ratio between the actual velocity and the theoretical velocity of the jet is known as coefficient of velocity C_v. Its value also depends upon the size and shape of the orifice and the head causing flow. The coefficient velocity for a vertical orifice is determined experimentally by measuring the horizontal and vertical coordinates of the issuing jet. The water flows through an orifice under a constant head H. Let V be the actual velocity (which is horizontal) of the jet. Obviously, while covering horizontal distance, the jet is acted upon by gravity with a downward acceleration 'g'. Consider a small particle of water at vena contracts. Suppose it falls through a vertical distance 'y' in a horizontal distance x, in time t sec.

Then $x = Vt$ and $y = \frac{1}{2} g t^2$

Or $$y = \frac{1}{2} \frac{g x^2}{V^2}$$

Or $$V = \sqrt{\frac{g x^2}{2y}}$$

But theoretical velocity $V = \sqrt{2gH}$

$$\therefore \qquad C_v = \sqrt{\frac{gx^2}{2y \times 2gH}} = \sqrt{\frac{x^2}{4yH}}$$

Since actual area of the jet is less than the area of the orifice, and the actual velocity is less than the theoretical velocity; therefore, actual discharge is less than the theoretical discharge. The ratio between the actual discharge and the theoretical discharge is called coefficient of discharge C_d..

$$\therefore \qquad C_d = \frac{Q_{act}}{a\sqrt{2gH}}$$

where $a\sqrt{2gH}$ is the theoretical discharge

The actual discharge passing through an orifice = Actual velocity at vena contracts

X Area of jet at vena contracts

$$= C_v\sqrt{2gH} \times C_c \times a$$

But $a\sqrt{2gH}$ = Theoretical discharge through orifice.

i.e. $$\frac{Actual \quad discharge \quad through \quad orifice}{Theorical \quad discharge \quad through \quad orifice} = \frac{C_v\sqrt{2gH}}{a\sqrt{2gH}} \times C_c \times a = C_v \times C_c$$

i.e. $C_d = C_v \times C_c$

$$C_c = \frac{C_d}{C_v}$$

PROCEDURE :

1. Adjust the inflow of water to the inlet tank till the steady state condition is achieved by in and outflow from the orifice and the head causing flow through the orifice as indicated by the Piezometer tube is constant. Measure the head ‘H’.
2. Using the hook gauge, measure x and y coordinates at different points on the centre line of the jet. Knowing ‘h’; the head causing flow and x and y co-ordinates, coefficient of velocity can be obtained from the formula.

$$C_v = \sqrt{\frac{x^2}{4yH}}$$

3. Note the initial reading of water level in the measuring tank, and simultaneously start the stop watch. After an interval of time note the reading of the water level. Difference in the two readings gives the rise in water level during the given time. Knowing, area of measuring tank, actual discharge Q_a can be obtained. Hence C_d can be calculated as

$$C_d = \frac{Q_{act}}{a\sqrt{2gH}}$$

4. Calculate $C_c = \dfrac{C_d}{C_v}$

   Repeat the above steps for different heads h and take five readings.

5. Repeat the experiment for mouth piece and convergent orifice.

Closing Procedure:

1. When experiment is over, switch OFF pump first.
2. Switch OFF power supply to panel.

PRECAUTIONS & MAINTTENANCE INSTRUCTIONS

1. Do not run the pump at low voltage i.e. less than 180 volts.
2. Never fully close the delivery line and by-pass line valves simultaneously.
3. Always keep apparatus free from dust
4. To prevent clogging of moving part, run pump at least once in a fortnight.
5. Frequently grease/oil the rotating parts, once in three months
6. Always use clean water
7. If apparatus will not in use for more than one month, drain the apparatus completely, and fill pump with cutting oil.

<u>OBSERVATION</u>

Dia of circular orifice = 10mm = 1 cm

Area of circular orifice (a) $= \dfrac{\pi D^2}{4}$ cm^2 $= \dfrac{3.14 \times 1^2}{4}$

$= 0.78$ cm^2

Dia of circular mouth piece = 10mm = 1 cm

Area of circular mouth piece (a) $= \dfrac{\pi D^2}{4}$ cm^2 $= \dfrac{3.14 \times 1^2}{4}$

$= 0.78$ cm^2

Sump Tank Capacity = 50 Liter
Collecting tank Capacity = 30 Liter
Area of collecting tank (A) = 25*30 = 750 cm^2

OBSERVATION TABLE FOR Cv, Cc and Cd FOR MOUTHPIECE

S. NO.	MEASUREMENT TANK READING				Discharge $Q_{act} = \frac{A(h_2 - h_1)}{t} cm^3/\sec$	Head H cm
	Initial level Cm h_1	Final level Cm h_2	h_2 - h_1	Time t sec		
1						
2						

S. NO.	X AXIS (in cm)			Y AXIS (in cm)			$Q_{th} = a\sqrt{2gH}$	$C_d = \frac{Q_{act}}{a\sqrt{2gH}}$	$C_v = \sqrt{\frac{x^2}{4yH}}$	$C_c = \frac{C_d}{C_v}$
	X_1	X_2	X = X_2 - X_1	Y_1	Y_2	Y = Y_2 - Y_1				
1										
2										

OBSERVATION TABLE FOR Cv, Cc and Cd FOR ORIFICE

S. NO.	MEASUREMENT TANK READING				Discharge $Q_{act} = \frac{A(h_2 - h_1)}{t} cm^3/\sec$	Head H cm
	Initial level Cm h_1	Final level Cm h_2	h_2 - h_1	Time t sec		
1						
2						
3						

S. NO.	X AXIS (in cm)			Y AXIS (in cm)			$Q_{th} = a\sqrt{2gH}$	$C_d = \frac{Q_{act}}{a\sqrt{2gH}}$	$C_v = \sqrt{\frac{x^2}{4yH}}$	$C_c = \frac{C_d}{C_v}$
	X_1	X_2	$X = X_2 - X_1$	Y_1	Y_2	$Y = Y_2 - Y_1$				
1										
2										
3										

EXPERIMENT NO : 10

AIM OF THE EXPERIMENT :- To determine the Darcy's and Chezy's constant for the given pipes, ii. To plot the following graph:

- Darcy's constant 'f' vs Reynold's number.
- Chezy's constant 'C' vs Reynold's number

EQUIPMENT: a) Pipes of 15, 20, 25 and 32 mm diameters 'D' of length 'L' 3 m with flow control valve in each pipe. Upstream and down stream pressure feed pipes as manifold are provided for the measurement of pressure head with control valves situated on a common place for easy operation.

b) measuring tank size 0.6 x 0.6 x 0.8 metre with overflow arrangement, gauge glass, scale arrangement and drain valve. c) U tube Differential Mercury Manometer of Range 0.5 m and Scale graduations: 1mm to measure the loss of head. c) Stop watch.

BASICS: When water flows through a pipe, a velocity gradient and hence shear stress is produced in the water due to viscous action causing loss of energy. This loss is known as frictional loss. Allow water to flow through the given pipe and measure the head loss due to friction as H_{Hg} cm of mercury using the manometer connected at a known distance of L cm. The actual discharge Q_a through the pipe is determined by noting the time for collecting h cm of water in the measuring tank. Actual discharge $Q_a = \frac{ah}{t_m}$ Where a - Area of cross-section of measuring tank in cm^2. H - Height difference of water in measuring tank in cm. T_{m} - The mean time to collect wate for a height difference of h cm, measured in seconds (tm = 60 to 120 s) Darcys' constant, f can be calculated from the relationship. Head loss $H_w = \frac{fLV^2}{2gD}$ Where H_w - H_{Hg} * 12.6 cm of water. L - Test length in cm. V - Velocity of water inside the pipe $V = \frac{Q_a}{\left(\frac{\pi}{4}D^2\right)}$ D - Inside diameter of pipe Chezy's constant C can be calculated from the relationship $V = C\sqrt{mi}$ Where V - Velocity of water inside the pipe line cm/s. i - Hydraulic gradient, H_w / L m - D/4 - Hydraulic mean depth (ie. Cross sectional area / wetted perimeter). Reynold's number for flow through the pipe line is calculated as, Re = (? / ?) V D Where, ? - Mass density of water (1000 kg/m^3 at 30^0 C.) V - Velocity of water inside the pipe D - Diameter of pipe ? -Absolute (dynamic) viscosity of water and is equal to7.82 * 10^{-4} kg/m.s. at 30^{0}C.

PROCEDURE: i. Connect the mercury manometer to the pressure tappings at the ends of the test length of pipe and close all the valves (pipe line & manometer). ii. Open the needle valves of the manometer & pressure tapping. Ensure that the manometer is primed. iii. Open the inlet valve fully and adjust the outlet valve of the selected pipeline in which the experiment has to be conducted, to note the maximum possible head difference (H_{Hg}) of the mercury column. Divide the value (H_{Hg}) by seven to fix the steps in the pressure difference for the seven sets of readings. iv. Adjust the outlet valve to get the required pressure difference in the manometer and note down the readings of manometer. v. Note the time in seconds to collect water for a rise of h cm in the measuring tank twice as t_1 and t_2. If the difference in readings exceeds 10%, take a third reading within the range. vi. Repeat the experiment for different manometer readings.

Calculation and graph: Prepare detailed sample calculation for one set of readings as explained in the principle. Calculate the remaining sets of readings and tabulate them. Draw the required graphs using the data tabulated with suitable scale i) Darcy's constant 'f' vs Reynold's number ii) Chezy's constant 'C' vs Reynold's number

MAINTENANCE: After completing the experiment close the inlet valve and open all the gate valves & needle valves then make them closed. Drain the water from measuring tank after completing the experiment Drain the mercury from manometer by opening the drain plug provided at bottom after two/three months and clean the glass tubes with soap water then fix the drain plug and pour the mercury.

Sl.No	Manometer reading, in mm of Hg			Head loss, mtr of water, H_w	Time for 10 cm raise of water level			Actual Discharge Q_a m^3/s	Velocity V m/s	Darcy's Coefficient of friction f	Hydraulic gradient, i	Chezy's Constant, C	Reynold's number R
	h_1	h_2	h_1-h_2		t_1	t_2	t_m						
1													
2													
3													
4													
5													
6													
7													