A Laboratory manual

For

MECHANICAL ENGINEERING LAB – II (PR- 2)

In accordance to syllabus

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

Semester – IV

DEPARTMENT OF MECHANICAL ENGINEERING

GOVERNMENT POLYTECHNIC, MAYURBHANJ

ODISHA – 757049

Affiliated to S.C.T.E & V.T, Odisha and A.I.C.T.E, New Delhi

SYLLABUS

MECHANICAL ENGINEERING LABORATORY (PRACTICAL-2)

Name of the Course: Diploma in **Mech/Auto/Aero & Other Mechanical Allied Branches**			
Course code:		Semester	3rd
Total Period:	60	Examination	3 hrs
Lab. periods:	4 P/week	Sessional	25
Maximum marks:	75	End Semester Examination:	50

COURSE OBJECTIVES

Students will develop ability towards

- Conducting experimentations to determine properties of a solid material subject to uniaxial loading and impact
- Conducting experimentations towards determining characteristics of a fuel
- Study of equipment employing using fuels.

1. Strength of Materials and thermal Laboratory

1.1 Determine end reactions in a simply supported beam using parallel force apparatus.

1.2 Determination of Young's modulus using Searle's apparatus

1.3 Determination of torsional rigidity of the shaft using torsion testing machine

1.4 Determination of salient points (Young's modulus, yield point, fracture point) from stress- strain curve using Universal Testing Machine

1.5 Determination of hardness number by Rockwell/Vickers hardness testing machine

1.6 Determination of toughness using Impact testing machine (Charpy/Izod)

1.7 Determination of Flash point and fire point

1.8 Joule's experiment

Experiment No 1: Study of 2-S, 4-S petrol & diesel engine models.

Practical Significance:

IC Engine forms an integral part of every one's life right from transportation to agriculture and many other areas where electricity has not reached. As a diploma engineer in mechanical engineering it is important to know the parts and operation of these machines to have a basic knowledge of the same.

Relevant theory:

IC Engines are classified as 2 stroke or 4 stroke depending upon the no of revolution taken by the crank to complete one cycle of operation. It is also classified in terms of fuels used s.a. petrol or diesel fired engines.

1. **2 stroke engine:** If all the 4 strokes of engine are completed within one revolution of the crank.
2. **4 stroke engine:** If all the 4 strokes of engine are completed within two revolution of the crank.
3. **Petrol engine (Spark Ignition):** Uses Petrol as a form of fuel.
4. **Diesel engine (Compression Ignition):** Uses Diesel as a form of fuel.

Important parts of an engine:

1. **Engine Block:** It is the main part of an engine as all other parts are bolted to it.
2. **Cylinder head:** It is attached to the top of the engine block to stop the gases from escaping and helping in the compression process. Valves, spark plugs, fuel injectors are attached to it.
3. **Piston:** A cylindrical part which is the reciprocating part of an engine and helps in receiving and pushing gases into or out of the combustion chamber.
4. **Piston ring:** Rings are present on the cavity of the piston in order to stop gases and lubricants to mix.
5. **Connecting Rod:** It connects the Piston to the Crank and helps in converting reciprocating to rotational motion.
6. **Crank:** It converts the reciprocating to rotating motion. It also contains balance mass and crankshaft.
7. **Crank case:** It houses the lubricant, lubricating system with oil pan and protects the base of the engine.
8. **Valves:** Regulates the flow of air into and outside the combustion chamber in a 4 stroke engine.
9. **Ports:** Regulates the flow of air into and outside the combustion chamber in a 2 stroke engine.
10. **Fins:** These are provided in an air cooled engine to facilitate engine cooling.
11. **Gear Box:** Contains set of gears for different speed setup.
12. **Carburetor:** Mixes air and fuel in proportion in a petrol engine for proper firing.
13. **Spark plug:** Provided in a petrol engine in order to inflame the fuel.
14. **Fuel Injector:** Provided in a Diesel engine to spray the fuel in atomized form in order to facilitate burning.

Resource Required:

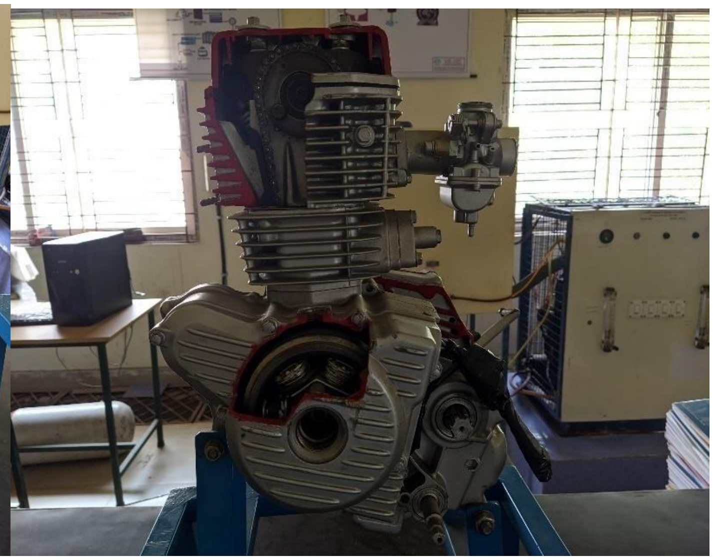
Sl. No:	Description	Specification	Quantity
01	2 Stroke Petrol engine	--	01
02	4 Stroke Petrol engine	--	01
03	2 Stroke Diesel engine	--	01
04	4 Stroke Diesel engine	--	01

Precautions:

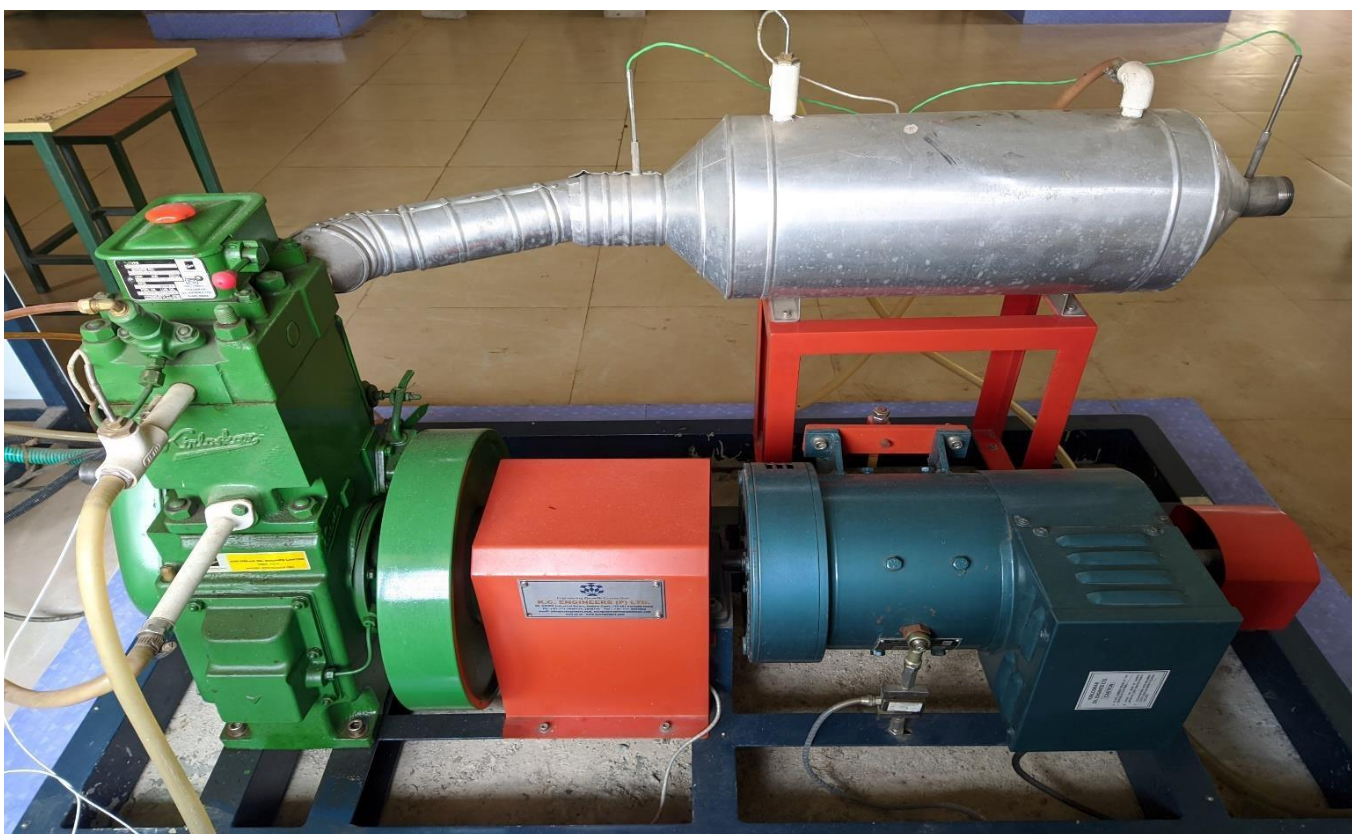
1. Do not insert hands into openings or sharp edges of the engine block.
2. Maintain all other safety measures as required.

Experimental setup:

2 Stroke Petrol Engine

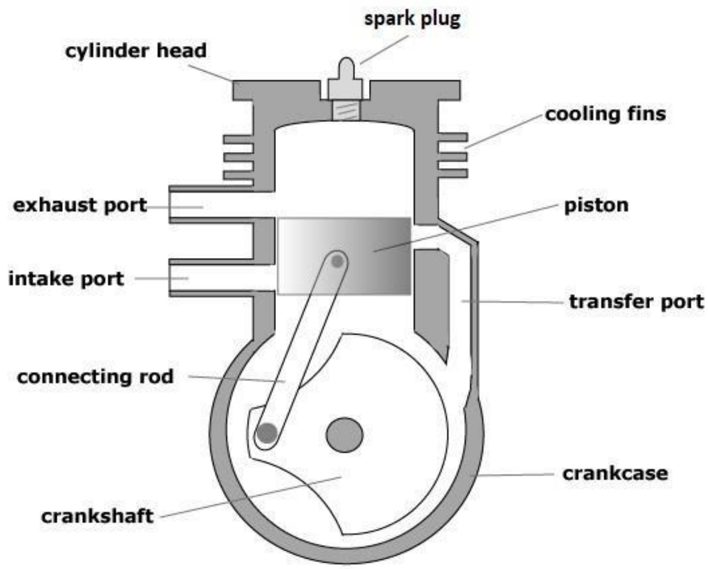


4 Stroke Petrol Engine



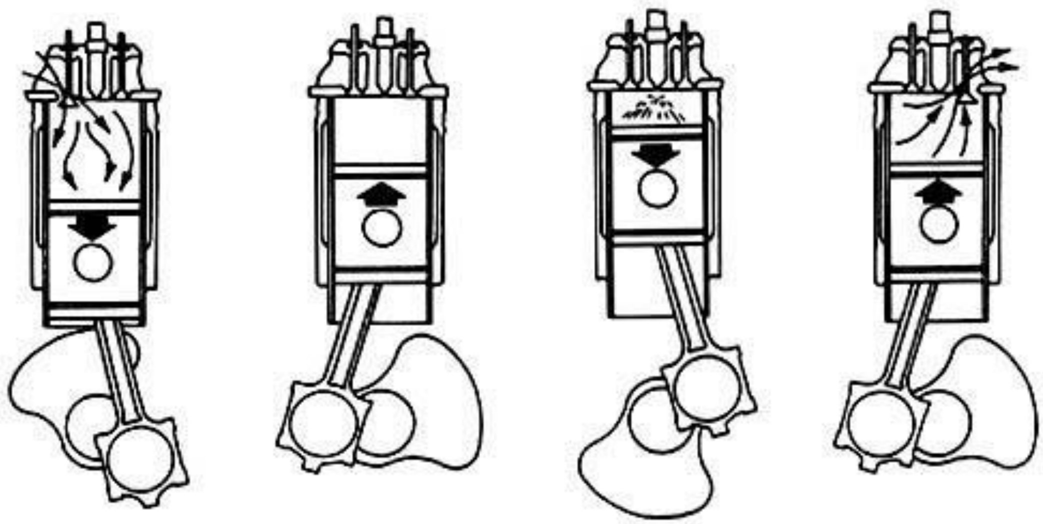
4 Stroke Diesel Engine

Observation:



2 STROKE ENGINE

1. **<u>2 Stroke Petrol Engine:</u>**
   In a 2 stroke petrol engine spark plug is used to ignite the fuel.
   In this engine suction and exhaust strokes are eliminated. Here instead of valves, ports are used. The exhaust gases are driven out from the engine cylinder by fresh charge of fuel entering the cylinder nearly at the end of working stroke.
   During the upward stroke of the piston the air fuel mixture is compressed at the same time fresh air fuel mixture enters the crank chamber through butterfly valve. During this the transfer port exhaust port closes. The mixture is compressed producing an explosive charge. Ignition takes place at the end of the stroke. The piston then travels downwards due to expansion of the gases and near the end stroke the piston uncovers the exhaust port and the exhaust gases escape through the port.
   The transfer port then uncovers letting fresh air fuel mixture compressed in the crank chamber upwards by the hump provided on the piston head. The fresh charge also helps in removing the exhaust gases from the chamber.
   The piston again starts moving from BDC towards TDC and the charge is compressed again when the exhaust and transfer ports are closed by movement of piston.
2. **<u>2 Stroke Diesel Engine:</u>**
   In a 2 stroke diesel engine injector is used to spray the fuel.
   In this engine suction and exhaust strokes are eliminated. Here instead of valves, ports are used. The exhaust gases are driven out from the engine cylinder by fresh charge of fuel entering the cylinder nearly at the end of working stroke.
   During the upward stroke of the piston the air is compressed at the same time fresh air enters the crank chamber through butterfly valve. During this the transfer port exhaust port closes. The mixture is compressed raising temperature of air to ignition limits. The fuel is then sprayed with help of injector. Ignition takes place at the end of the stroke due to compression heat produced. The piston then travels downwards due to expansion of the gases and near the end stroke the piston uncovers the exhaust port and the exhaust gases escape through the port.
   The transfer port then uncovers letting fresh air compressed in the crank chamber upwards by the hump provided on the piston head. The fresh charge also helps in removing the exhaust gases from the chamber.
   The piston again starts moving from BDC towards TDC and the air is compressed again when the exhaust and transfer ports are closed by movement of piston.



4 STROKE ENGINE

3. **<u>4 Stroke Petrol engine</u>**

   4 stroke engines has two cycles each consisting of 2 half cycles representing a stroke. The suction and compression is completed in one cycle and expansion and exhaust completed in one cycle.

   Suction: The piston at T.D.C moves downwards thus creating a pressure difference inside the chamber. The rocker management opens the inlet valve at the time thus inserting fresh air fuel mixture inside the chamber. The stroke comes to an end when the piston reaches B.D.C.

   Compression: The piston from B.D.C starts moving towards T.D.C thus compressing the air fuel mixture as both the valves will be closed at that time. Just before the piston reaches the T.D.C the spark plug starts the spark thus igniting the mixture. The stroke comes to an end as the piston reaches T.D.C.

   Expansion: The mixture after burning expands thus pushing the piston downwards towards the B.D.C giving us the required power stroke. The valves still remain closed facilitating the expansion process. The stroke ends when piston reaches B.D.C.

   Exhaust: The piston starts travelling upwards towards the T.D.C. the exhaust valve opens during this time thus creating a pressure difference again, hence pushing all the burnt gases out of the chamber.

4. **<u>4 Stroke Diesel engine</u>**

   4 stroke engines has two cycles each consisting of 2 half cycles representing a stroke. The suction and compression is completed in one cycle and expansion and exhaust completed in one cycle.

   Suction: The piston at T.D.C moves downwards thus creating a pressure difference inside the chamber. The rocker management opens the inlet valve at the time thus inserting fresh air inside the chamber. The stroke comes to an end when the piston reaches B.D.C.

   Compression: The piston from B.D.C starts moving towards T.D.C thus compressing the air fuel mixture as both the valves will be closed at that time. Just before the piston reaches the T.D.C the spark plug starts the spark thus igniting the mixture. The stroke comes to an end as the piston reaches T.D.C.

   Expansion: The mixture after burning expands thus pushing the piston downwards towards the B.D.C giving us the required power stroke. The valves still remain closed facilitating the expansion process. The stroke ends when piston reaches B.D.C.

Exhaust: The piston starts travelling upwards towards the T.D.C. the exhaust valve opens during this time thus creating a pressure difference again, hence pushing all the burnt gases out of the chamber.

Resource used:

Sl. No:	Description	Specification	Quantity

Precautions followed:

Observation:

Conclusion and recommendations if any:

Practical related Questions.

1. What is a 2 stroke engine?
2. What is a 4 stroke engine?
3. Differentiate between petrol and diesel engine
4. What is the use of spark plug?
5. What is crank?

Space for answers

Assessment scheme:

Conduct of Experiment (6 Marks)	Theory knowledge acquired (6 Marks)	Record (5 Marks)	Viva- voce (5 Marks)	Attendance (3 Marks)	Total (25 Marks)

Signature of the subject faculty **Signature of HOD, Mechanical**

Experiment No 2: Determine the brake thermal efficiency of a single cylinder petrol engine.

Practical significance:

By knowing about the calculation process related to petrol engine students will be familiar with the industry standards and test the engine characteristics for its various loading criteria.

Relevant theory:

Petrol engines are basically used for small vehicles such as mopeds, bikes and also small 4 wheelers cars. Fresh air fuel mixture is burnt inside the combustion chamber of the engine in order to produce power for running the vehicle. It consists of both 2 stroke and 4 stroke engines.

When the piston goes downward from T.D.C to B.D.C the air-fuel mixture is sucked inside the cylinder. During the compression process the admitted charge gets heated and pressure rises considerably to raise the temperature up to flash point of petrol. Just when the piston reaches T.D.C stating the completion of compression process the spark plug is ignites the charge giving rise to expansion stroke and piston moves from T.D.C to B.D.C. After completion of the expansion stroke the piston moving from B.D.C to T.D.C pushes away the burnt gases out from the chamber getting it ready for the next iteration.

Experimental setup:

The single cylinder petrol engine is connected with a rope brake dynamometer attached to dead weight type load gauge to show the load applied on the engine.

Resource required:

Sl. No:	Description	Specification	Quantity
01	4 Stroke Petrol engine	Honda G200 197cc	01
02	Panel board arrangement	Rpm display meter	01
		Temperature indicator	01
		Mains on/off switch	01
		Switch for solenoid operation	01
03	Rope brake loading arrangement		01
04	Electrical actuated solenoid valve		01
05	Air intake measuring arrangement	Water operated U-Tube manometer	01
06	Sturdy base frame		01
07	Fuel flow measuring instrument	Burette 25ml	01

Procedure:

1. Fill fuel in petrol tank and open valve ensuring fuel flows into the pipeline. Ensure no air bubbles.
2. Press solenoid switch to fill burette with petrol.
3. Open valve to supply fuel to engine.
4. Fill manometer with fluid (water) up to half height.
5. Turn engine switch to on position.
6. Close the choke and open the fuel cock.
7. Ensure cooling water supply is on.
8. Pull the start grip to start engine and run it for 2-3 minutes under no load condition.
9. Start applying load by tightening the rope.
10. Close the petrol supply valve and press solenoid actuation switch. Note down time taken to consume 10 ml of petrol with help of stopwatch.
11. Open the petrol supply valve and press solenoid switch to fill the burette.
12. Note down reading of manometer.
13. Repeat the process for different loading conditions.
14. After experiment is over release the load to no load condition.
15. Turn off the engine.
16. Close the fuel and cooling water supply.

Formulae for calculation :

Brake power:

$$BP = \frac{2\pi N\,(W1-W2)}{60 \text{ X } 1000} \times \frac{Db+Dr}{2} \times g \text{ KW}$$

Fuel consumption:

$$W_f = \frac{X}{t} \times \frac{\text{Density of fuel}}{10^6} \text{ kg/sec}$$

Specific Fuel consumption:

$$= \frac{\text{Fuel consumption}}{\text{BHP}} \frac{\text{kg}}{\text{BP sec}}$$

Brake thermal efficiency:

$$= \left(\frac{BP}{Hf} \times 100\right)$$

Data:

Designation	Nomenclature	Values
D	Bore of the engine cylinder	0.067 m
L	Stroke of the engine cylinder	0.056 m
a_o	Cross-sectional area of orifice	$7.85 \times 10^{-5} m^2$
ρ_m	Density of air	$1.293 kg/m^3$
ρ_a	Density of water	$1000 kg/m^3$
C_d	Coefficient of discharge	0.64
d_B	Diameter of brake drum	200 mm
d_R	Diameter of rope	10 mm
	Density of fuel	

Nomenclature:

X	Volume of fuel consumed in ml
t	Time taken for X in sec
W_r	Mass of fuel supplied in kg/hr
C_v	Calorific value of petrol
H	Total pressure head in m
h	Manometer difference in m
a_o	Cross-sectional area of orifice
C_d	Coefficient of discharge
ρ_a	Density of air
ρ_m	Density of manometer fluid
D	Bore of engine
L	Stroke of engine
IP	Indicated power developed inside combustion chamber

Precautions and maintenance instructions:

1. Always check the oil level in engine before starting and make sure sufficient oil is present.
2. Change oil as engine completes 100 hours of running or 1 year whichever is earlier.
3. Fuel tank and fuel line should be clean and free from dust particles.

Resource used:

Sl. No:	Description	Specification	Quantity

Actual procedure followed:

Precautions followed:

Observation Table:

Sl. No:	W_1 in Kg	W_2 in Kg	X in ml	t in sec	h_1 in cm	h_2 in cm	R.P.M

Calculation:

Result:

Interpretation of results:

Conclusion and recommendations if any:

Practical related Questions:

Space for answers:

Assessment scheme:

Conduct of Experiment (6 Marks)	Observation and calculation (6 Marks)	Record (5 Marks)	Viva- voce (5 Marks)	Attendance (3 Marks)	Total (25 Marks)

Signature of the subject faculty **Signature of HOD, Mechanical**

Experiment No 3: Determine the brake thermal efficiency of a single cylinder Diesel engine.

Practical significance:

By knowing about the calculation process related to Diesel engine students will be familiar with the industry standards and test the engine characteristics for its various loading criteria.

Relevant theory:

Diesel engines are basically used for large vehicles such as trucks, bus, heavy earth movers, diesel locomotives etc.

The engine uses diesel as a fuel. When the piston goes downward from T.D.C to B.D.C the air is sucked inside the cylinder. During the compression process the admitted air gets heated and pressure rises considerably to raise the temperature up to flash point of diesel. Just when the piston reaches T.D.C stating the completion of compression process the diesel fuel is sprayed in atomized form at high pressure from an injector giving rise to expansion stroke and piston moves from T.D.C to B.D.C. After completion of the expansion stroke the piston moving from B.D.C to T.D.C pushes away the burnt gases out from the chamber getting it ready for the next iteration.

Experimental setup:

The single cylinder Diesel engine is connected with a rope brake dynamometer attached to dead weight type load gauge to show the load applied on the engine.

Resource required:

Sl. No:	Description	Specification	Quantity
01	4 Stroke Diesel engine	1500 RPM with governor mechanism	01
02	Rpm display meter		01
03	Temperature indicator		01
04	Switch for solenoid operation		01
05	Rope brake loading arrangement		01
06	solenoid valve		01
07	Air intake measuring arrangement	Water operated U-Tube manometer	01
08	Sturdy base frame		01
09	Fuel flow measuring instrument	Burette 50ml	01
10	Flow Rotameter		01

Procedure:

1. Fill fuel in petrol tank and open valve ensuring fuel flows into the pipeline. Ensure no air bubbles.
2. Rotate solenoid switch to fill burette with petrol.
3. Open valve to supply fuel to engine.
4. Fill manometer with fluid (water) up to half height.
5. Adjust the flow rate of water for calorimeter and engine jacket.
6. Start the engine and run it for 2-3 minutes under no load condition.
7. Measure the speed of the engine.
8. Start applying load by tightening the rope.
9. Close the petrol supply valve and rotate solenoid actuation switch. Note down time taken to consume 10 ml of Diesel with help of stopwatch.
10. Open the Diesel supply valve and press solenoid switch to fill the burette.
11. Measure flow of cooling water from calorimeter from engine jacket with help of flow rotameter.
12. Note down reading of manometer.
13. Repeat the process for different loading conditions.
14. After experiment is over release the load to no load condition.
15. Turn off the engine.
16. Close the fuel and cooling water supply.

Formulae:

Brake power:

$$BP = \frac{2\pi NT}{60 \text{ X } 1000} \text{ KW} = \frac{(W-S)\times 10\times 2\pi NDb}{60000}$$

Total Fuel consumption:

$$TFC = \frac{\text{INITIAL READING} - \text{FINAL READING}}{\text{TIME (t)}} \times \frac{\text{SPECIFIC GRAVITY}}{1000}$$

Specific Fuel consumption:

$$= \frac{TFC}{BHP} \times 3600 \ \frac{kg}{KWH}$$

Brake thermal efficiency:

$$= \left(\frac{BP}{TFC \times CV} \times 100 \right)$$

Data:

Designation	Nomenclature	Values
	Specific gravity of fuel	0.80
CV	Calorific value	42500 kJ/Kg
	Diameter of orifice	25 mm
C_d	Coefficient of discharge	0.62
ρ_a	Density of air	1.178 KJ/m^3
	Specific heat of water	1.2 KJ/Kg K
	Specific heat of exhaust gas	1.05 KJ/KG C
	Effective diameter of drum pulley	220 mm

Nomenclature:

H1	Water level in right limb of manometer
H2	Water level in left limb of manometer
t	Time for consumption of 10 ml of fuel
TFC	Total fuel consumption
BP	Brake power
W	Load on dead weight no 1
S	Load on dead weight no 2
n	Speed in RPM
D_b	

Precautions and maintenance instructions:

4. Always check the oil level in engine before starting and make sure sufficient oil is present.
5. Change oil as engine completes 100 hours of running or 1 year whichever is earlier.
6. Fuel tank and fuel line should be clean and free from dust particles.

Resource used:

Sl. No:	Description	Specification	Quantity

Actual procedure followed:

Precautions followed:

Observation Table:

Sl. No:	W in Kg	S in Kg	X in ml	t in sec	H1 in cm	H2 in cm	R.P.M

Calculation:

Result:

Interpretation of results:

Conclusion and recommendations if any:

Practical related Questions:

Space for answers:

Assessment scheme:

Conduct of Experiment (6 Marks)	Observation and calculation (6 Marks)	Record (5 Marks)	Viva- voce (5 Marks)	Attendance (3 Marks)	Total (25 Marks)

Signature of the subject faculty **Signature of HOD, Mechanical**

Experiment no 4: Determine the B.H.P, I.H.P and BSFC of a multi-cylinder engine by Morse Test

Relevant theory:

The Morse test consists of obtaining indicated power of the engine without any elaborate equipment. The test consists of making inoperative, in turn, each cylinder of the engine and noting the reduction in brake power developed. With a gasoline engine each cylinder is rendered inoperative by shorting the spark plug of the cylinder; with a diesel engine by cutting off the supply of fuel to each cylinder. It is assumed that pumping and friction lasses are the same when the cylinder is inoperative as well as during firing. This test is applicable only to multi cylinder engines.

In this test the engine is first run at the required speed by adjusting the throttle in SI engine or the pump rack in CI engine and the output is measured. The throttle rack is locked in this position. Then, one cylinder is cut out by short circuiting the spark plug in the SI engine or by disconnecting the injector in the CI engine. Under this condition all the other cylinders will motor the cut out cylinder and the speed and output drop. The engine speed is brought to its original value by reducing the load. This will ensure that the frictional power is the same while the brake power of the engine will be with one cylinder less.

Experimental setup:

Engine and Hydraulic Dynamometer mounted on a MS channel frame along with a panel board consisting of all other equipments required for the experiment.

Resource required:

Sl. No:	Description	Specification	Quantity
01	Petrol engine	Maruti (MPFI) 3 Cylinder 4C SI engine 1500 RPM, Self start.	01
02	Key start switch		01
03	Battery Indicator		01
04	Temperature indicator		01
05	Solenoid valve	Manual valve	01
06	Sturdy base frame		01
07	Fuel flow measuring instrument	Burette 50ml	01
08	Air intake measuring arrangement	Water operated U-Tube manometer	01
09	Morse test arrangement		01
10	RPM meter		01
11	Oil pressure gauge		01
12	Dynamometer		01
13	Dial type spring balance		01
14	Rotameter		01

Procedure:

1. Fill fuel in petrol tank and open valve ensuring fuel flows into the pipeline. Ensure no air bubbles.
2. Rotate solenoid switch to fill burette with petrol.
3. Open valve to supply fuel to engine.
4. Fill manometer with fluid (water) up to half height.
5. Adjust the flow rate of water for calorimeter and engine jacket.
6. Connect the instrumentation power input plug to a 230 V supply, single phase.
7. Start the engine and run it for 2-3 minutes under idle speed approx 800-1000 RPM.
8. Ensure oil pressure gauge reads 3 kg/cm^2.
9. Increase speed by turning knob until speed indicator reads 1500 RPM.
10. Load engine to full load at rated speed.
11. Cut-off power to one cylinder by potting on the on/off switch provided on panel. Thus engine is running on 2 cylinders only
12. The engine speed reduces which is regulated with help of water inlet valve and hand wheel reducing load slowly so that it bounces back to rated speed.
13. Record spring balance reading.
14. Without changing the setup put back the on/off switch of the cylinder to original position thus increasing speed.
15. Put on the on/off switch of the second cylinder and repeat step 12 if needed.
16. Record spring balance reading.
17. Repeat procedure 14, 15, and 16 again for third cylinder.
18. Put the engine to original condition again and turn off the engine.
19. Disconnect the power connection to the panel.

Note: Always only one cylinder should be cutoff at a time

Formulae:

BHP when three cylinders are working = A

BHP of 2 cylinders when first cylinder is cutoff = B1

BHP of 2 cylinders when second cylinder is cutoff = B2

BHP of 2 cylinders when third cylinder is cutoff = B3

IHP of first cylinder = IHP1 = A – B1

IHP of second cylinder = IHP2 = A – B2

IHP of third cylinder = IHP3 = A – B3

Total IHP of the engine = IHP1 + IHP2 + IHP3

Brake power = $\frac{2\pi NT}{4500}$ where, N = speed

T = torque = r × s

r = radius = 0.32 m

S = spring balance reading.

Weight of fuel consumed = $\frac{X \times 0.72 \times 3600}{t \times 1000}$

Specific fuel consumption = $\frac{\text{Weight of fuel consumed}}{\text{BHP}}$ in kg/hr

Data:

Designation	Nomenclature	Values
	Density of fuel	0.72 gms/cc
	Full load condition	10kg
	3/4 load condition	7.5 kg
	Half load condition	5 kg
	Rated speed	1500 RPM
	Bore	68.5 mm
	Stroke	72mm
	Orifice diameter	17mm
	Radius	0.32 m

Nomenclature:

H1	Water level in right limb of manometer
H2	Water level in left limb of manometer
t	Time for consumption of 10 ml of fuel
X	Volume of fuel consumed
N	Speed of the engine
T	Torque of the engine
BSFC	Brake specific fuel consumption
BHP	Brake horse power
IHP	Indicated horse power
S	Spring balance reading

Precautions and maintenance instructions:

1. Always check the oil level in engine before starting and make sure sufficient oil is present.
2. Change oil as engine completes 100 hours of running or 1 year whichever is earlier.
3. Fuel tank and fuel line should be clean and free from dust particles.

Resource used:

Sl. No:	Description	Specification	Quantity

Actual procedure followed:

Precautions followed:

Observation Table:

Sl. No:	W in Kg	S in Kg	X in ml	t in sec	Torque	R.P.M

A	B1	B2	B3	IHP1	IHP2	IHP3	TOTAL IHP

Calculation:

Result:

Interpretation of results:

Conclusion and recommendations if any:

Practical related Questions:

Space for answers:

Marking scheme:

Conduct of Experiment (6 Marks)	Observation and calculation (6 Marks)	Record (5 Marks)	Viva- voce (5 Marks)	Attendance (3 Marks)	Total (25 Marks)

Signature of the subject faculty **Signature of HOD, Mechanical**

Experiment no 5: To determine the mechanical efficiency of a two stage air compressor.

Relevant 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.

Experimental setup:

Resource required:

Sl. No:	Description	Specification	Quantity
01	Air compressor	.	01
02	Key start switch		01
03	Temperature indicator		01
04	Sturdy base frame		01
05	RPM meter		01
06	Pressure gauge		01

Procedure:

1. Check for electrical circuit and start the compressor.
2. When the piston moves downward the pressure inside the cylinder falls below the atmospheric pressure.
3. Due to this pressure difference the I.V. gets opened and the air is sucked into the cylinder.
4. 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.
5. 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 up to the required limit.
6. 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.

Formulae:

Mechanical efficiency of compressor,

$$\eta_{mech} = {}^{I.P}/_{B.P}$$

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

Work done by the compressor,

$$W = \frac{n}{n-1} mRT_1 \left\{ \left(\frac{p_2}{p_1}\right) \left(\frac{n}{n-1} - 1\right) \right\}$$

$$B.P = \frac{W \times N}{2000} kW$$

Where W = Work done

N = Number of revolution in RPM

P1 = Pressure of air at the inlet of the compressor

P2 = Pressure of the air at the outlet of the compression

T1 = Absolute temp. of air the inlet of the compressor

T2 = Absolute temp. of air the outlet of the compressor

Precautions and maintenance instructions:

1. Check for any electrical misconnection.
2. Check for pipelines carrying air.

Resource used:

Sl. No:	Description	Specification	Quantity

Actual procedure followed:

Precautions followed:

Observation Table:

SL. NO.	P1	P2	T1	T2	I.P	B.P	MECH EFFICIENCY

Calculation:

Result:

Interpretation of results:

Conclusion and recommendations if any:

Practical related Questions:

Space for answers:

Marking scheme:

Conduct of Experiment (6 Marks)	Observation and calculation (6 Marks)	Record (5 Marks)	Viva- voce (5 Marks)	Attendance (3 Marks)	Total (25 Marks)

Signature of the subject faculty **Signature of HOD, Mechanical**

Experiment No 6: Study of pressure measuring devices (Manometer, Bourdon tube pressure gauge)

Practical significance:

Students will be able to know how to use the pressure measuring devices and learn taking readings related for the experiment.

Relevant theory:

The pressure of a fluid is measured by the following devices:

1. **Manometers** 2. **Mechanical Gauges**.

Manometers: Manometers are defined as the devices used for measuring the pressure at a point in a fluid by balancing the column of fluid by the same or another column of the fluid. They are classified as:

(a) Simple Manometers **(b) Differential Manometers.**

Mechanical Gauges: Mechanical gauges are defined as the devices used for measuring the pressure by balancing the fluid column by the spring or dead weight. The commonly used mechanical pressure gauges are : **(a) Diaphragm pressure gauge,** **(b) Bourdon tube pressure gauge,**

(c) Dead-weight pressure gauge, and (d) Bellows pressure gauge.

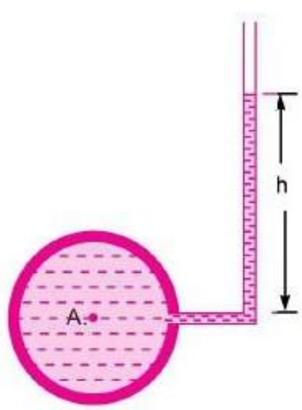
Simple manometers

A simple manometer consists of a glass tube having one of its ends connected to a point where pressure is to be measured and other end remains open to atmosphere. Common types of simple manometers are:

a. **Piezometer,** b. **U-Tube Manometer**

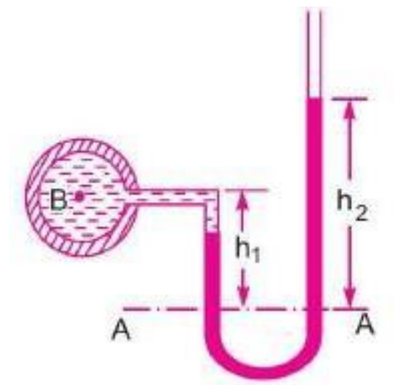
Piezometer: It is the simplest form of manometer used for measuring gauge pressures. One end of this manometer is connected to the point where pressure is to be measured and other end is open to the atmosphere as shown. The rise of liquid gives the pressure head at that point.

$$\rho \times g \times h \; \frac{\mathrm{N}}{\mathrm{m}^2}.$$



U-tube Manometer: It consists of glass tube bent in U-shape, one end of which is connected to a point at which pressure is to be measured and other end remains open to the atmosphere. The tube generally contains mercury or any other liquid whose specific gravity is greater than the specific gravity of the liquid whose pressure is to be measured.

$$p + \rho_1 g h_1 = \rho_2 g h_2$$
$$p = (\rho_2 g h_2 - \rho_1 \times g \times h_1).$$

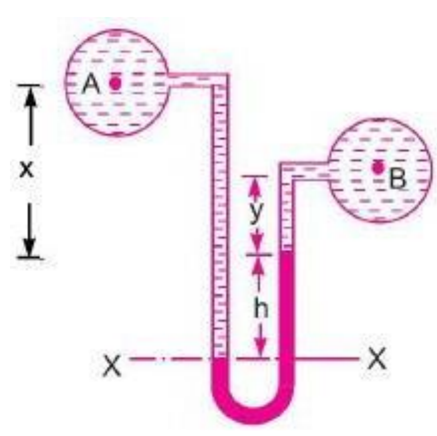


Differential manometers are the devices used for measuring the difference of pressures between two points in a pipe or in two different pipes. A differential manometer consists of a U-tube, containing a heavy liquid, whose two ends are connected to the points, whose difference of pressure is to be measured. Most commonly types of differential manometers are:

1. U-tube differential manometer and 2. Inverted U-tube differential manometer.

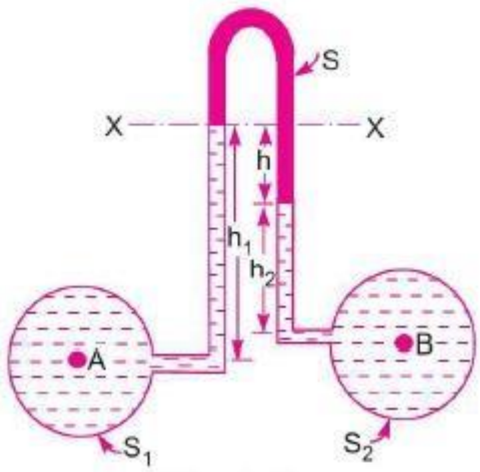
U-Tube Differential Manometer: Consists of a u tube attached to pipelines at both its ends with manometer liquid of heavier sp. Gravity to detect pressure. Basically used to determine pressure between 2 points either on different pipelines or same.

$$p_A - p_B = \rho_g \times g \times h + \rho_1 g x - \rho_1 g(h + x)$$
$$= g \times h(\rho_g - \rho_1).$$

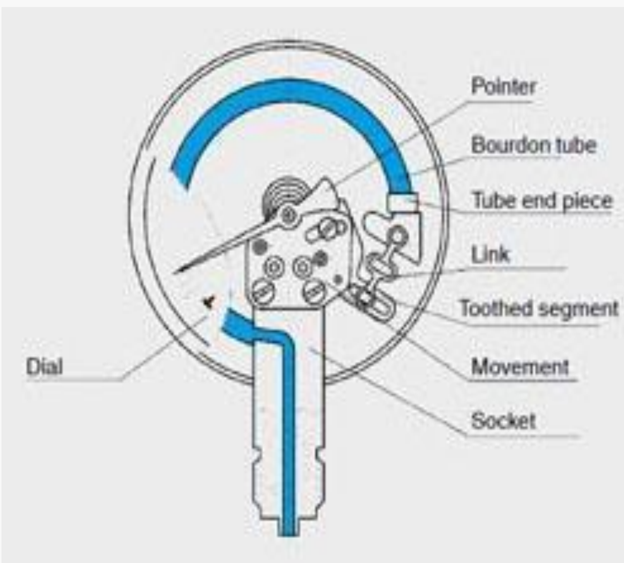


Inverted U-Tube Differential Manometer: Consists of an inverted u-tube containing a light liquid. Used to determine pressure between 2 points either on different pipelines or same.

$$p_A - p_B = \rho_1 \times g \times h_1 - \rho_2 \times g \times h_2 - \rho_s \times g \times h.$$



Bourdon tube pressure gauges are used for the measurement of relative pressures from 0.6 to 7,000 bar. They are classified as mechanical pressure measuring instruments, and thus operate without any electrical power.



Bourdon tubes are radially formed tubes with an oval cross-section. The pressure of the measuring medium acts on the inside of the tube and produces a motion in the non-clamped end of the tube. This motion is the measure of the pressure and is indicated via the movement.

Resource required:

Sl. No:	Description	Specification	Quantity
01	Differential manometer		
02	U-Tube manometer		
03	Inclined U-Tube manometer		
04	Piezometer		
05	Bourdon tube pressure gauge		

Procedure:

1. Fill the sump tank
2. Keep by-pass valve to maximum opening.
3. Start the pump keep it running for some times.
4. Open inline valve slowly in order to circulate water through the pipe.
5. Carefully open the respective valves on distributing box and pipeline and purge out all air from manometer
6. Now apparatus is ready for experiment.
7. Keep flow constant through circuit.
8. Operate individual valve for each manometer one by one by closing the by-pass valve.
9. Open the by-pass valve again to maximum opening.
10. Stop the pump.
11. Empty the sump and clean any debris.

Nomenclature:

P_A	Pressure at point A
P_B	Pressure at point B
ρ_1	Density at point 1
ρ_2	Density at point 2
ρ_S	Density at point 3
g	Acceleration due to Gravity

Precautions and maintenance instructions:

1. Always ensure 240 V 1∅ supply.
2. Make sure no leakage in tanks.
3. Check all valves, bends and joints for leakage.
4. Always drain the water if not in use to prevent scaling.

Resource used:

Sl. No:	Description	Specification	Quantity

Actual procedure followed:

Precautions followed:

Result:

Interpretation of results:

Conclusion and recommendations if any:

Practical related Questions:

Space for answers:

Assessment scheme:

Conduct of Experiment (6 Marks)	Theory knowledge acquired (6 Marks)	Record (5 Marks)	Viva- voce (5 Marks)	Attendance (3 Marks)	Total (25 Marks)

Signature of the subject faculty **Signature of HOD, Mechanical**

Experiment No 7: Verification of Bernoulli's Theorem.

Practical significance:

The significance of Bernoulli's principle can now be summarized as "total pressure is constant along a streamline". If the fluid flow is irrational, the total pressure on every streamline is the same and Bernoulli's principle can be summarized as "total pressure is constant everywhere in the fluid flow"

Relevant theory:

Bernoulli's theorem states that "The total mechanical energy of the moving fluid comprising the gravitational potential energy of elevation, the energy associated with the fluid pressure and the kinetic energy of the fluid motion, remains constant."

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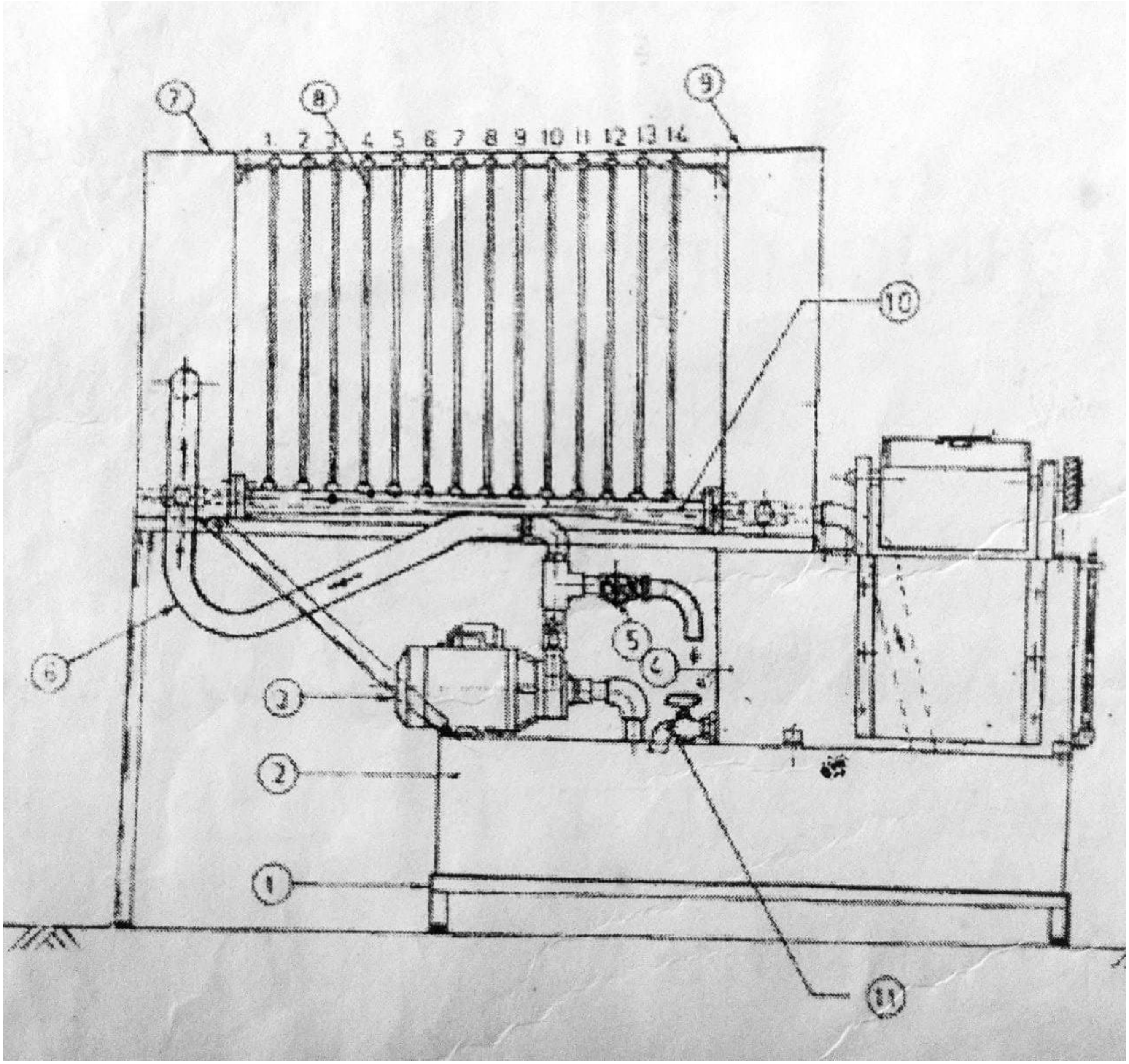
Experimental setup:

The apparatus consists of an inlet tank and outlet tank connected by a flow channel. The channel tapers for a length of 40 cm and gradually enlarges in a length of 30 cm, on top of the flow channel piezometer tubes are fixed at a distance of 10 cm for the measurement of pressure head. To regulate the flow into the inlet tank and out of the outlet, valves are provided. The flow can be obtained by controlling inlet and outlet valves suitably. After a while a steady state condition will be reached.



Resource required:

Sl. No:	Description	Specification	Quantity
01	Base frame		01
02	Sump tank		01
03	Water pump set		01
04	Measuring tank		01
05	Gate valve		01
06	Hose pipe		01
07	Supply tank		01
08	Transparent burette		01
09	Delivery tank		01
10	Test section		01
11	Drain cock		01

Procedure:

Outlet valve can he kept closed and the water level in the inlet tank will rise and that in the piezometer tubes will simultaneously rise, as there is no flow. When the outlet valve is opened and steady state is reached' the pressure head at different points along the flow can be recorded. To determine the steady discharge, collect the discharge for sufficient time in measuring tank. Repeat the procedure by changing discharge i. e. by regulating by-pass valve in outlet line of pump.

Formulae for calculation:

$$Qa = \frac{\text{liters of water collected} \times 1000}{\text{time of collection (t)}} \text{ cm}^3\text{/sec}$$

Velocity head = $V^2/2g$ cm

$$A = \frac{\pi}{4} \times d^2 \text{ cm}^2$$

Total head = velocity head + pressure head in cm

Nomenclature:

Qa	Actual discharge cm^3/sec
A	Cross-sectional area cm^2
V	Velocity in cm/sec

Precautions and maintenance instructions:

1. Always ensure 240 V 1∅ supply.
2. Make sure no leakage in tanks.
3. Check all valves, bends and joints for leakage.
4. Always drain the water if not in use to prevent scaling.

Resource used:

Sl. No:	Description	Specification	Quantity

Actual procedure followed:

Precautions followed:

Observation Table:

Sl. No:	Tube no	A	Qa	V	Velocity head	Pressure head	Total head
1	1						
2	2						
3	3						
4	4						
5	5						
6	6						
7	7						

Calculation:

Result:

Interpretation of results:

Conclusion and recommendations if any:

Practical related Questions:

Space for answers:

Assessment scheme:

Conduct of Experiment (6 Marks)	Observation and calculation (6 Marks)	Record (5 Marks)	Viva- voce (5 Marks)	Attendance (3 Marks)	Total (25 Marks)

Signature of the subject faculty **Signature of HOD, Mechanical**

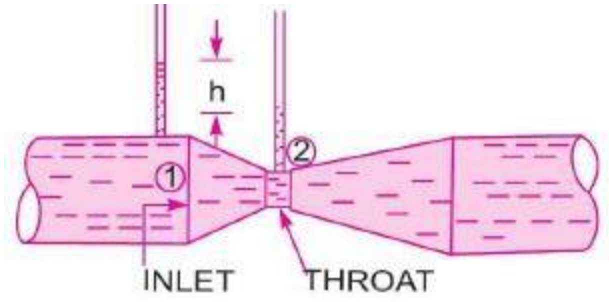
Experiment No 8: Determination of Cd from venturimeter .

Practical significance:

Students will be able to calculate and learn operating venturimeter to find Cd.

Relevant theory:

A venturimeter is a device used for measuring the rate of a flow of a fluid flowing through a pipe. It consists of three parts: (i) A short converging part, (ii) Throat, and (iii) Diverging part. It is based on the Principle of Bernoulli's equation. Expression for rate of flow through venturimeter.



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Experimental setup:

The apparatus consists of Venturimeter fitted in pipeline. The pipeline is connected io pump outlet. At the down stream end of the pipeline, a control valve'is provided to regulate the flow through the Venturimeter. Pressure tappings are taken out from inlet and throat of Venturimeter and are to be connected to a differential manometer. Discharge is taken to the measuring tank.

Resource required:

Sl. No:	Description	Specification	Quantity
01	Base frame		01
02	Sump tank		01
03	Water pump set		01
04	Measuring tank		01
05	Gate valve		01
06	Hose pipe		01
07	Supply tank		01
08	Transparent burette		01
09	Delivery tank		01
10	Test section		01
11	Drain cock		01

Procedure:

1) Pass water (Steady state) through Venturimeter.
2) During a particular observation. the valve position regulating the flow should be maintained constant.
3) Note down the differential manometer readings h' in cm of Hg.
4) Collect water in the measuring tank and measure the discharge.
5) Change the discharge through the Venturimeter by operating flow regulating valve and repeat above procedure to obtain different observations.

Formulae for calculation:

$$\text{Qth} = \frac{\text{a1} \times \text{a2} \times \sqrt{2\text{g h}}}{\sqrt{\text{a1}^2 + \text{a2}^2}} \qquad \text{Qa} = \frac{v}{t} \qquad \text{Cd} = \frac{\text{Actual Discharge}}{\text{Theoretical Discharge}}$$

Nomenclature:

Qa	Actual discharge cm^3/sec
A	Cross-sectional area cm^2
Qth	Theoretical discharge cm^3/sec
g	Acceleration due to gravity
s	Specific gravity of mercury = 13.6
a1	Area at inlet ($\pi/4 \times d1^2$) cm^2
a2	Area at outlet ($\pi/4 \times d2^2$) cm^2
h	Manometer difference in cm

d1	Diameter at inlet in mm
d2	Diameter at outlet in mm

Precautions and maintenance instructions:

1. Always ensure 240 V 1Ø supply.
2. Make sure no leakage in tanks.
3. Check all valves, bends and joints for leakage.
4. Always drain the water if not in use to prevent scaling.

Resource used:

Sl. No:	Description	Specification	Quantity

Actual procedure followed:

Precautions followed:

Observation Table:

Sl. No:	Time for x cm of water	Qa	Manometer difference of HG in cm	Manometer difference of water in cm	Qth	
1						
2						
3						
4						
5						

Calculation:

Result:

Interpretation of results:

Conclusion and recommendations if any:

Practical related Questions:

Space for answers:

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Experiment No 9: Determination of Cc, Cv, Cd from orifice meter.

Practical significance:

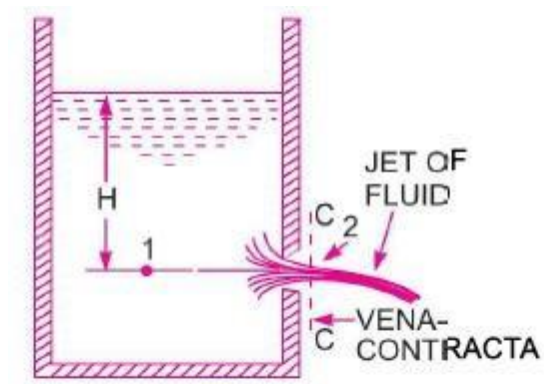
Students will be able to calculate and learn operating orifice meter apparatus to calculate Cd, Cv, Cc.

Relevant theory:

Orifice is a small opening of any cross-section (such as circular, triangular, rectangular etc.) on the side or at the bottom of a tank, through which a fluid is flowing.

The orifices are classified on the basis of their size, shape, nature of discharge and shape of the upstream edge. The following are the important classifications:

1. The orifices are classified as small orifice or large orifice depending upon the size of orifice and head of liquid from the center of the orifice. If the head of liquid from the center of orifice is more than five times the depth of orifice, the orifice is called small orifice. And if the head of liquids is less than five times the depth of orifice, it is known as large orifice.
2. The orifices are classified as (i) Circular orifice, (ii) Triangular orifice, (iii) Rectangular orifice and (iv) square orifice depending upon their cross-sectional areas.
3. The orifices are classified as (i) Sharp-edged orifice and (ii) Bell-mouthed orifice depending upon the shape of upstream edge of the orifices.
4. The orifices are classified as (i) Free discharging orifices and (ii) Drowned or sub-merged orifices depending upon the nature of discharge.



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Experimental setup:

It consists of rectangular tank. which applies water at various heads to orifice. It has a piezo-meter scale for head measurement.orifice mounting plate, X-Y co-ordinate measuring arrangement.overall pipe and inlet valve are also incorporate with the apparatus.

Resource required:

Sl. No:	Description	Specification	Quantity
01	Base frame		01
02	Sump tank		01
03	Water pump set		01
04	Measuring tank		01
05	Gate valve		01
06	Hose pipe		01
07	Supply tank		01
08	Transparent burette		01
09	Delivery tank		01
10	Test section		01
11	Drain cock		01

Procedure:

1. Select an Orifice/Mouthpiece and fix it on the mounting plate.
2. Start supply of water in the tank & adjust suitable head with overflow pipe. Wait for settling of head & ensure little overflow for steady head.
3. Take readings of different head in piezo-meter tube. X & Y co-ordinate of the jet & discharge in the measuring tank.
4. Enter the readings in the observation table.

Formulae for calculation:

Qth = a $\sqrt{2gh}$ Qa = $\frac{v}{t}$ Cd = $\frac{\text{Actual Discharge}}{\text{Theoretical Discharge}}$, Cv = $\frac{X}{\sqrt{4\,h\,y}}$, Cc = $\frac{Cd}{Cv}$

Nomenclature:

Qa	Actual discharge cm^3/sec
A	Cross-sectional area cm^2
Qth	Theoretical discharge cm^3/sec
g	Acceleration due to gravity
x	Horizontal scale reading in cm
y	Vertical scale reading in cm
a	Area at inlet $(\pi/4 \times d^2)$ cm^2
h	Manometer difference in cm
d	Orifice Diameter at inlet in mm
v	Delivered volume in cm^3

Precautions and maintenance instructions:

1. Always ensure 240 V 1∅ supply.
2. Make sure no leakage in tanks.
3. Check all valves, bends and joints for leakage.
4. Always drain the water if not in use to prevent scaling.

Resource used:

Sl. No:	Description	Specification	Quantity

Actual procedure followed:

Precautions followed:

Observation Table:

Sl. No:	Type of orifice	Head "h" in cm above center of orifice	Time in sec for "a" cm height	Horizontal scale "x" in cm	Vertical scale "y" in cm	Discharge "Qth" in cm^3/sec	Qact in cm^3/sec
1							
2							
3							
4							
5							

Calculation:

Result:

Interpretation of results:

Conclusion and recommendations if any:

Practical related Questions:

Space for answers:

Experiment No 10: Determination of Darcy's coefficient from flow through pipe.

Practical significance:

Students will be able to calculate and learn Flow measuring apparatus to calculate Darcy coefficient.

Relevant theory:

Transportation of fluids through pipes is frequently dealt with by engineers, Distribution of water and was for domestic consumption through pipes is an example. Experimental observation Froude on long, straight and uniform diameter pipes or the flow of water indicated that head loss due to friction hf between two sections of the pipe varied in direct portion with it head $V^2/2g$, the distance between the two section, L and inversely with pipe diameter, d introducing a coefficient of proportionality (f) called the friction factor Darcy and Weisbach proposed the following equation for head loss due to friction a pipe:

$$hf = \frac{4flv^2}{2gd}$$

Experimental setup:

The experimental set up consists of:

1. Pipes of different diameters, three pipe 1.5cm, 2 cm and 2.5 cm
2. Two pet-cocks on each side with the help of which flow is regulated.
3. A valve fitted to each pipe with the help of which flow is regulated
4. A U tube manometer connected to the pressure tapping of each pipe.
5. A discharge measuring tank fitted with a piezometer tube and a graduated scale to measure the depth of water collected.

Resource required:

Sl. No:	Description	Specification	Quantity
01	Base frame		01
02	Sump tank		01
03	Water pump set		01
04	Measuring tank		01
05	Gate valve		01
06	Hose pipe		01
07	Supply tank		01
08	Transparent burette		01
09	Delivery tank		01
10	Test section		01
11	Drain cock		01

Procedure:

1. Open the air vessel valve & release the air on manomeric tube and weight the leveling of mercury. After leveling the mercury, close the air vessel valve.
2. Switch on the Power & Start the Motor.
3. Record the diameter "d" of the pipe and the length L between the sections attached to the limbs of U-

tube manometer.

4. Open the supply valve to allow water to flow in one pipe only.

5. Record the initial water level (y) in the piezometer fitted to the discharge measuring tank and start the stop watch and find the depth of water collected for a particular time by recording the final reading (y) of the piezometer.
6. Knowing the area of the measuring tank, flow discharge through the pipe can be obtained.
7. Record the readings of the two limbs of the inverted U tube manometer, the difference of which gives the head loss hf
8. Calculate average velocity through the pipe using the relationship $V = \frac{Q}{a}$, where a-area of cross section of the pipe.
9. The darcy-Weisbach coefficient of friction is calculated using the expression $F = \frac{2gdh}{4LV^2}$
10. Repeat the above steps for different discharge and other pipes of different diameters taking at least 3 reading for every pipe.
11. When experiment is over, switch OFF pump first.
12. Switch OFF power supply to panel.

Formulas for calculation:

$Q = \frac{A(h2-h1)}{t}$ Cm^3/sec $F = \frac{2gdh}{4LV^2}$

Data Required:

Density of Manometer fluid = ρ_m = 13.6 kg/cm^3

Density of Water = Pr = 1.0 kg/cm^3

Area of Tank A = 30cm x 25cm=750 cm

Distance between pressure tapping attached to

Limbs of manometer in each pipe L = 100 cm

Pipe (1) - Diameter of pipe (1/2 inch) Aluminum=1.5cm

Area of pipe (a) = $\frac{\pi}{4}d^2$ = 1.77 cm^2

Pipe (2) - Diameter of pipe (1/2 inch) Copper =1.5cm

Area of pipe (a) = $\frac{\pi}{4}d^2$ = 1.77 cm^2

Pipe (3) - Diameter of pipe (1/2 inch) GI =1.5cm

Area of pipe (a) = $\frac{\pi}{4}d^2$ = 1.77 cm^2

Nomenclature:

h1	Height of manometric fluid in limb 1 in cm
h2	Height of manometric fluid in limb 2 in cm
t	Time in sec
A	Area of the tank in cm^2

a	Area of the pipe in cm^2

Q	Discharge in cm^3
L	Length of the pipe in cm
hf	Head loss due to friction
ρ_m	Density of manometric fluid
ρ_r	Density of water
d	Diameter of pipe in cm

Precautions and maintenance instructions:

1. Do not run the pump at low voltage Le 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.
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.

Resource used:

Sl. No:	Description	Specification	Quantity

Actual procedure followed:

Precautions followed:

Observation Table:

Sl. No:	h1 in cm	h2 in cm	h2-h1	t in sec	Q
1					
2					
3					
4					
5					

Sl. No:	h1 in cm	h2 in cm	R = h2-h1	hf= R×12.6 cm of H_20	V	F
1						
2						
3						
4						
5						

Calculation:

Result:

Interpretation of results:

Conclusion and recommendations if any:

Practical related Questions:

Space for answers: