THERMAL ENGINEERING LAB MANUAL

(For II Year B. Tech II Semester (R-20), (Mechanical Engineering)

DEPARTMENT OF MECHANICAL ENGINEERING
SRI VENKATESWARA COLLEGE OF ENGINEERING AND TECHNOLOGY
(AUTONOMOUS)
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Name of the student: ______________________________

Roll Number: ______________ Branch: ______________

Name of the Laboratory: ___________________________

Year & Sem: _______________ Academic Year: _______

SRI VENKATESWARA COLLEGE OF ENGINEERING AND TECHNOLOGY (AUTONOMOUS)
R.V.S. NAGAR, CHITTOOR-517 127, ANDHRA PRADESH
DEPARTMENT OF MECHANICAL ENGEERING

Vision of Mechanical Engineering

Providing excellent technical education in Mechanical Engineering with the help of state of art infrastructure and carvethe youth to suit the global needs.

Mission of Mechanical Engineering

Provide excellent Teaching-Learning process using state of art facilities to help a holistic growth in the disciplines of Thermal, Design, Manufacturing, Management and Quality areas with an emphasis on practical applications. Stimulate innovative thinkingleading to higher learning.

Programme Educational Objectives (PEO's) of UG:

PEO1	Pursue higher education in the varied fields of mechanical engineering and management.
PEO2	Secure a career placement in core and allied areas
PEO3	Develop skills to undertake entrepreneurship and lifelong learning

PROGRAMME SPECIFIC OUTCOMES (PSOs) of UG

PSO1	Apply the knowledge of manufacturing, thermal and industrial engineering to formulate, analyze and provide solutions to the problems related to mechanical systems
PSO2	Apply the design concepts and modern engineering software tools to model mechanical systems in various fields such as machine elements, thermal, manufacturing, industrial and inter-disciplinary fields.

DO'S

- Wear uniform, shoes & safety glasses
- Please follow instructions precisely as instructed by your supervisor.
- If any part of the equipment fails while being used, report it immediately to your supervisor.
- Students should come with thorough preparation for the experiment to be conducted.
- Students will not be permitted to attend the laboratory unless they bring the practical recordfully completed in all respects pertaining to the experiment conducted in the previous class.
- All the calculations should be made in the observation book. Specimen calculations for oneset of readings have to be shown in the practical record.
- Wherever graphs are to be drawn, A-4 size graphs only should be used and the same shouldbe firmly attached to the practical record.
- Practical record should be neatly maintained.
- Students should obtain the signature of the staff-in-charge in the observation book aftercompleting each experiment.
- Theory regarding each experiment should be written in the practical record before procedurein your own words.

DONT'S

- Do not touch hot work piece
- Do not start the experiment unless your setup is verified & approved by your supervisor.
- Do not leave the experiments unattended while in progress.
- Do not crowd around the equipment's & run inside the laboratory.
- Don't wear rings, watches, bracelets or other jewellery
- Don't wear neck ties or loose turn clothing of any kind.
- Do not eat or drink inside labs.
- Do not wander around the lab and distract other students
- Do not use any machine that smokes, sparks, or appears defective

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Signature of the Faculty In-charge with date

1. Determination of Flash point and Fire point of a given sample fuel using
   i. Abel's Apparatus
   ii. Pensky Marten's Apparatus.

(i) ABEL'S FLASH AND FIRE POINT TEST

AIM:

To determine the flash and fire point of the given sample fuel using Abel's apparatus closed cup methods.

APPARATUS:

Abel's apparatus,

Thermo meter (0-110^{0}C)

THEORY:

This method determines the closed cup flash and fire points of petroleum products and mixtures to ascertain whether they give off inflammable vapours below a certain temperature.

FLASH POINT

It is the lowest temperatures of the oil, at which, application of test flame causes the vapour above the sample to ignite with a distinct flash inside the cup.

.

FIRE POINT:

It is the lowest temperature of the oil, at which, application of test flame causes burning for a period of about five seconds.

DESCRIPTION

The apparatus consists of a brass cup and cover fitted with shutter mechanism, test flame arrangement, hand stirrer, thermometer socket. The brass cup is heated by water bath (with energy regulator), fitted with a funnel and overflow pipe.

PROCEDURE

1. Clean the oil cup and fill the up to the mark with the sample oil.
2. Insert the thermometer into the oil cup through the provision to note down the oil temperature.
3. Using the Energy regulator, control the power supply given to the heater and rate of heating
4. The oil is heated slowly when temperature of oil rises; it is checked for the flash point for every one-degree rise in temperature.

5. After determining the flash point, the heating shall be further continued. The temperature at which time of flame application that causes burning for a period at least 5 seconds shall be recorded as the fire point.
6. Repeat the experiment 2 or 3 times with fresh sample of the same oil
7. Take the average value of flash and fire points.

PRECAUTIONS:

1. Stir the oil bath continuously to maintain the uniform temperature of sample oil.
2. The bluish halo that some time surrounds the test flame should not be confused with true flash

OBSERVATIONS:

S.No	Sample oil	Flash Point	Fire Point
		^{0}C	^{0}C

RESULT

The flash point of the given sample fuel is observed at -------- ^0C

The fire point of the given sample fuel is observed at ----------- ^0C

(ii) PENSKY MARTEN'S FLASH AND FIRE POINT TEST

AIM

To determine the flash and fire point of the given sample fuel using Pensky Marten's apparatus by both open and closed cup methods.

APPARATUS

Pensky Marten's apparatus,

Thermometer (0-110^{0}C).

THEORY

This method determines the closed cup and open cup flash and fire points of petroleum products and mixtures to ascertain whether they give off inflammable vapours below a certain temperature.

Flash Point & Fire point.

It is the lowest temperatures of the oil at which application of test flame causes the vapour above the sample to ignite with a distinct flash inside the cup.

It is the lowest temperature of the oil, at which, application of test flame causes burning for a period of about five seconds.

DESCRIPTION

The apparatus consists of a brass cup and cover fitted with shutter mechanism without shutter mechanism (open cup), test flame arrangement, hand stirrer (closed cup),thermometer socket, etc., heated with energy regulator, a thermometer socket made of copper.

PROCEDURE

1. Clean the oil cup thoroughly and fill the oil cup with the sample oil to be tested up to the mark.
2. Insert the thermometer into the oil cup through a provision, which measures the rise of oil temperature.
3. Using the Energy regulator, control the power supply given to the heater and rate of heating
4. The oil is heated slowly when temperature of oil rises; it is checked for the flash point for every one degree rise in temperature.

5. After determining the flash point, the heating shall be further continued. The temperature at which time of flame application which causes burning for a period at least 5 seconds shall be recorded as the fire point.
6. . Repeat the experiment 2 or 3 times with fresh sample of the same oil
7. Take the average value of flash and fire points.

PRECAUTIONS

1. Stir the oil bath continuously to maintain the uniform temperature of sample oil.
2. The bluish halo that some time surrounds the test flame should not be confused with true flash

OBSERVATIONS

S.No	Sample oil	Flash Point	Fire Point
		^{0}C	^{0}C

RESULT

The flash point of the given sample fuel is observed at __________ 0 *C*

The fire point of the given sample fuel is observed at ______________ 0 *C*

2. DETERMINATION OF VISCOSITY OF LUBRICATING OIL USING

(i) REDWOOD VISCOMETER –I

AIM

To determine the viscosity in Redwood seconds of the given sample oil and to plot the variation of Redwood seconds, kinematic and dynamic viscosity with respect to temperature.

APPARATUS

1. Redwood viscometer-I
2. Stopwatch
3. Thermometer (0-110^{0}C)
4. Measuring flask. (50 c.c.)

THEORY:

The viscosity of given oil is determined as the time of flow in Redwood seconds. The viscosity of a fluid indicates the resistance offered to shear under laminar condition. Dynamic viscosity of a fluid is the tangential force on unit area of either of two parallel planes at unit distance apart when the space between the plates is filled with the fluid and one of the plate's moves relative to the other with unit velocity in its own plane. The unit of dynamic viscosity is dyne-sec/cm^2. Kinematic viscosity of a fluid is equal to the ratio of the dynamic viscosity and density of the fluid. The unit of kinematic viscosity is cm^2/sec

DESCRIPTION

Redwood viscometer-I consists of a water bath and oil bath, both provided with two thermometers inside them. There is a ball valve, which is located at center of oil bath to flow of oil through the orifice. A heater with regulator is fixed for heating purpose.

PROCEDURE:

1. Clean the oil cup with a suitable solvent thoroughly and dry it using soft tissue paper.

2. Keep the ball valve in its position so as to keep the orifice closed.

3. The water is taken into the water bath and the oil whose viscosity is to be determined is taken into the oil cup up to the mark.

4. Note down the time taken in Redwood seconds for a collection of 50 *cc.* of oil with a stopwatch at the room temperature without supply of electric supply.
5. Heat the bath and continuously stir it taking care to see that heating of the bath is done in a careful and controlled manner.
6. When the desired temperature is reached, place the cleaned 50 c.c. Flask below the orifice in position.
7. Remove the ball valve and simultaneously start a stopwatch. Note the time of collection of oil up to the 50 c.c. Mark.
8. During the collection of oil don't stir the bath. Repeat the process at various temperatures

S.No.	Oil Temperature	Time for collecting 50 cc of oil	Kinematic viscosity, $\gamma = (At - \frac{B}{t}) \times 10^{-6}$	Density (ρ)	Absolute viscosity (μ = ν x ρ)
	^{0}C	Sec	m^2/Sec	kg/m^3	N-Sec/m^2

FORMULAE:

$$Kinematic\ Viscosity\ \ \gamma = \left(At - \frac{B}{t} \right) \times 10^{-6} in\ \frac{m^2}{Sec}$$

Where

γ = Kinematic viscosity of the oil in centistokes

t =Time of flow in seconds

A and B are instrument constants. The value of,

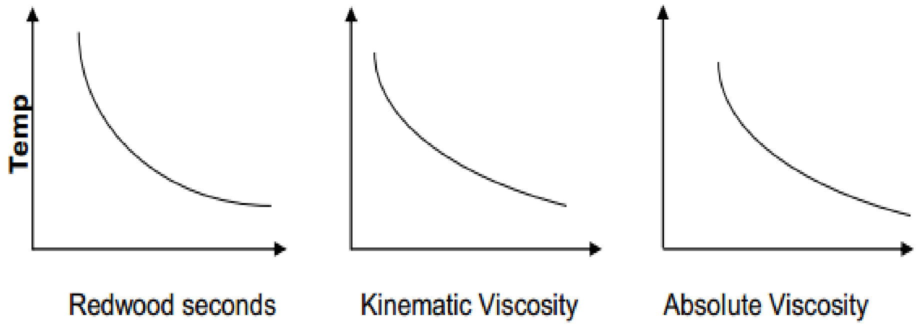
A = 0.264 m^2/sec^2 and B = 190 m^2, when, t = 40 to 85 seconds

A = 0.247 m^2/sec^2 and B = 65 m^2, when, t = 85 to 2000 seconds

GRAPHS DRAWN

1. Redwood seconds *Vs* . temperature
2. Kinematic Viscosity *Vs* . temperature
3. Absolute Viscosity *Vs* . temperature

MODEL GRAPHS



PRECAUTIONS:

1. Stir the water continuously so that the temperature of the oil and water are equal.
2. Before collecting the oil at a temperature, check whether the oil is up to the Indicator in the oil cup.
3. Always take the readings at a stable temperature
4. Ensure proper setting of the ball valve to avoid leakage.

RESULT:

Variation of Redwood seconds, absolute viscosity and Kinematic viscosity with temperature, were observed and found to be decreasing with temperature.

2. DETERMINATION OF VISCOSITY OF LUBRICATING OIL USING

(ii) SAYBOLT VISCOMETER

AIM:

To determine the viscosity in Saybolt seconds of the given sample oil and to plot the variation of Saybolt seconds, kinematic and dynamic viscosity with temperature.

INSTRUMENTS:

1. Saybolt viscometer,
2. Stop watch,
3. Thermometer (0-110^{0}C),
4. Measuring flask (60 cc)

THEORY:

The viscosity of given oil is determined as the time of flow in Saybolt seconds. The viscosity of a fluid indicates the resistance offered to shear under laminar condition. Dynamic viscosity of a fluid is the tangential force on unit area of either of two parallel planes at unit distance apart when the space between the plates is filled with the fluid and one of the plate's moves relative to the other with unit velocity in its own plane. The unit of dynamic viscosity is dyne-sec/cm^2. Kinematic viscosity of a fluid is equal to the ratio of the dynamic viscosity and density of the fluid. The unit of kinematic viscosity is cm^2sec.

DESCRIPTION:

Saybolt viscometer consists of a water bath and oil bath, both provided with two thermometers inside them. There is a ball valve, which is located at center of oil bath to flow of oil through the orifice. A heater with regulator is fixed for heating purpose.

PROCEDURE:

1. Clean the oil cup with a suitable solvent thoroughly and dry it using soft tissue paper.

2. . Keep the cork in its position so as to keep the orifice closed.

3. The water is taken into the water bath and the oil whose viscosity is to be determined is taken into the oil cup up to the mark.

4. Before switch on the electric supply, at room temperature note down the time taken in Saybolt seconds for a collection of 60 c.c. of oil with a stop watch.

5. Heat the bath and continuously stir it taking care to see that heating of the bath is done in a careful and controlled manner.

6. When the desired temperature is reached, place the cleaned 60 c.c. flask below the orifice in position.

7. Remove the cork valve and simultaneously start a stopwatch. Note the time of collection of oil up to the 60 c.c. Mark.
8. During the collection of oil don't stir the bath.
9. Repeat the process at various temperatures.

S.No.	Oil Temperature	Time for collecting 60 cc of oil	Kinematic viscosity, $\gamma = (At - \frac{B}{t}) \times 10^{-6}$	Density (ρ)	Absolute viscosity (μ = ν x ρ)
	^{0}C	Sec	m^2/Sec	kg/m^3	N-Sec/m^2

FORMULAE:

Kinematic Viscosity $\gamma = \left(At - \frac{B}{t}\right) \times 10^{-6}\ in\ \frac{m^2}{Sec}$

Where

γ = Kinematic viscosity of the oil in centistokes

t =Time of flow in seconds

A and B are instrument constants. The value of,

A = 0.264 m^2/sec^2 and B = 190 m^2, when, t = 40 to 85 seconds

A = 0.247 m^2/sec^2 and B = 65 m^2, when, t = 85 to 2000 seconds

GRAPHS DRAWN

1. Saybolt seconds *Vs* . temperature
2. Kinematic Viscosity *Vs* . temperature
3. Absolute Viscosity *Vs* . temperature

PRECAUTIONS:

1. Stir the water continuously so that the temperature of the oil and water are equal.
2. Before collecting the oil at a temperature, check whether the oil is up to the Indicator in the oil cup.
3. Always take the readings at a stable temperature
4. Ensure proper setting of the ball valve to avoid leakage.

RESULT:

Variation of Saybolt seconds, absolute viscosity and Kinematic viscosity with temperature, were observed and found to be decreasing with temperature.

3.(i) Study of Bomb calorimeter to determine the Calorific value of solid fuels.

AIM

To determine the water equivalent of the calorimeter using the given sample of solid or liquid fuel of known calorific value (or) To determine the calorific value of the given solid or liquid fuel if the water equivalent of the calorimeter known.

APPARATUS

Bomb, water jacket, stirrer, calorimeter vessel, combined lid, sensitive thermometer, analytical balance with weight box, oxygen cylinder with pressure gauge, fuse wire, cotton thread, firing unit, regulating valve and crucible hand pellet press

PRINCIPLE OF OPERATION

A Bomb Calorimeter will measure the amount of heat generated when matter is burnt in a sealed chamber (Bomb) in an atmosphere of pure oxygen gas. A known amount of the sample of fuel is burnt in the sealed bomb, the air in the bomb being replaced by pure oxygen under pressure. The sample is ignited electrically. As the sample burns heat is produced and rises in the temperature. Since the amount of heat produced by burning the sample must be equal to the amount of heat absorbed by the calorimeter assembly, and rise in temperature enables the determination of heat of the combustion of the sample. If

W = Water equivalent of the calorimeter assembly in calories per degree centigrade.

T = Rise in temperature (registered by a sensitive thermometer) in degrees centigrade.

H = Heat of combustion of material in calories per gram.

M = Mass of sample burnt in grams.

Then $W \times T = H \times M$

If the water equivalent of the calorimeter is to be determined, a substance like Benzoic acid has a stable calorific value can be burnt in the bomb. Assuming the calorific value of Benzoic acid and water equivalent can be determined.

CALORIFIC VALUE

Gross or higher calorific value: The total amount of heat produced when one unit mass of fuel has been burnt completely and the products of combustion have been cooled to room temperature.

Net or Lower Calorific Value: The net heat produced when unit mass of fuel is burnt completely and the products are permitted to escape.

LCV = HCV – Latent heat of water vapour formed

PROCEDURE:

1. About 0.5 to 1 *grm* of finely ground benzoic acid (Preferably compressed into a pellet) is accurately weighed and taken into crucible.

2. Place the bomb lid on the stand provided and stretch pieces of fuse wire across the electrodes (metal rods) provided in the lid tie about 5 *cm* of sewing cotton round the wire.

3. Place the crucible in position and arrange the loose end of the cotton thread to contact the Benzoic acid pellet in the crucible.

4. About 10 *ml* of distilled water are introduced into the bomb to absorb vapors ofsulphuric acid and nitric acids formed during the combustion and lid of the bomb is screwed

5. Charge the bomb slowly with oxygen from the oxygen cylinder to a pressure of 25 atm. close the value and detach the bomb from the oxygen supply.

6. Fill the calorimeter vessel with sufficient water to submerge the cap of the bomb to a depth of at least 2mm leaving the terminals projecting lower the bomb carefully in the calorimeter vessel and after ascertaining that it is gas tight, connect the terminals to the ignition circuit.

7. Adjust the stirrer and place the temperature sensor and cover in position. Start the stirring mechanism, which must be kept in continuous operation during the experiment after stirring for 5 minutes note the temperature reading of the calorimeter. Close the circuit momentarily to fire the charge and continue the observations of the temperature at an interval of one minute till the rate of change of temperature becomes constant.

8. Afterwards stop the stirrer and remove the power supply to the firing unit. Remove the bomb from the calorimeter and relax the pressure by opening the value. Verify that the combustion is complete and washout the contents of the bomb clean and dry.

9. Calculate the calorific value of the fuel or water equivalent of the calorimeter.

OBSERVATIONS:

Weight of the empty crucible (W_1)	=	gm
Weight of the empty crucible + Benzoic acid pellet (W_2)	=	gm
Weight of the benzoic acid pellet ($W_2 - W_1$)	=	gm
Weight of water taken in the calorimeter ($W3$)	=	gm
Temperature of the water just before firing (t_1)	=	^{0}C
Temperature of the water after firing (t_3)	=	^{0}C

CALCULATIONS:

Heat produced by burning of benzoic acid + Heat produced by burning of fuse wire and cotton wire etc = Heat absorbed by calorimeter.

$$(W_2 - W_1) \times C_v = (W_3 - W_e)\ X\ C_{PW}\ X\ (t_2 - t_1)$$

PRECAUTIONS:

1. Sample should not exceed 1 *gms* .
2. Don't charge with more oxygen than is necessary.
3. Don't fire the bomb if gas bubbles are leaking from the bomb when it is submerged in water.

RESULT

Water equivalent of calorimeter (W_e) = ------------------- *gm*

Calorific value of sample (C_v) = ------------------- *Cal/ gm*

3. (ii) Study of Junker's gas calorimeter to determine the Calorific value of fuels

AIM

To find the calorific value of given gaseous fuel

.**APPARATUS**

i. Calorimeter
   - a) Main calorimeter body
   - b) Three thermometers

ii. Gas flow meter
   - a) Main gas flow meter body
   - b) Inlet / outlet nozzles
   - c) Union net with washer for thermometers

iii. Pressure governor
   - a) Pressure governor body
   - b) Balancing beam arrangement
   - c) Counter balance tube
   - d) Inlet and outlet union nuts with washers and

iv. Jars 2000 *ml* & 50 *ml*

PROCEDURE:

1. Pour water into the governor till water starts overflowing through the overflow passage.

2. Replace and tighten the over flow nut.

3. Insert three thermometers provided with calorimeter into the rubber corks

4. Insert rubber corks with thermometers into their places in calorimeter

5. Insert burner into its support rod in the bottom of the calorimeter and turn the knurled knob so that the burner is fixed tightly. The burner must go into the center of the calorimeter body.

6. Connect the calorimeter, the flow meter and the pressure governor as shown in figure using rubber tubing provided. Do not connect gas supply line. Take care to see that the water regulator of calorimeter is in OFF position.to the ignition circuit.

7. Turn water regulator knob on calorimeter to ON position. Allow water to flow through the calorimeter from overhead tank/ tap. Allow water to flow for 3 to 4 min into laboratory sink, through the calorimeter.

8. Ensure that outlet tap of governor is closed. Connect gas supply line to governor inlet. Remove burner from calorimeter then open governor outlet tap. Allow gas to pass through the burner.
9. Light up the burner by holding a lighted match stick near the mesh at the top.
10. Adjust the air regulator sleeve at the bottom of the burner to get a blue, non-luminous flame. Fix the lighted burner back into position.
11. Adjust water regulator on calorimeter to get a temperature difference of 12^0C to 15^0C between the inlet water & outlet water as indicated by the respective Thermometers at the top of the calorimeter.
12. Allow 20 to 30 min for outlet water temperature to become steady
13. Measure the water flow rate with the help of measuring jar. Simultaneously, note the flow meter reading.
14. Note down the inlet &outlet water temperatures
15. Repeat the test with same volume of gas 3 or 4 times and take average temperatures of inlet and outlet water.

CALCULATIONS

The formula to be used to calculate the calorific value to the test gas is as follows

$$CV = \frac{V_w}{V_G} \times (T_2 - T_1) \times 1000$$

Where

C.V = calorific value of gas in $Kcal/m^3$

V_G = volume of gas in liters consume during test period

V_w = volume of water in liters passed

RESULT: The calorific value of the given Fuel --------------------- kJ/m^3

4-PORT TIMING DIAGRAM OF TWO STROKE PERTROL (S.I) ENGINE

AIM:

To draw the port timing diagram of given two stroke petrol (S.I) engine .

EQUIPMENTS REQUIRED:

1. Two stroke petrol engine
2. Measuring tape or scale
3. Chalk

BRIEF THEORY AND DESCRIPTION:

i. In the case of two stroke cycle engines the inlet and exhaust valves are not present. Instead, the slots are cut on the cylinder itself at different elevation and they are called ports. There are three ports present in the two stroke cycle engine.
   1. Inlet port
   2. Transfer port
   3. Exhaust port

ii. The diagram which shows the position of crank at which the above ports are open and close are called as port timing diagram

iii. The extreme position of the piston at the bottom of the cylinder is called " Bottom Dead centre " [BDC] . The extreme position of the piston at the top of the cylinder is called "Top dead centre " [TDC]

iv. In two stroke petrol engine the inlet port open when the piston moves from BDC to TDC and is closed when the piston moves from TDC to BDC.

v. The transfer port is opened when the piston is moved from TDC to BDC and the fuel enters into the cylinder through this transport from the crank case of the engine. The transfer port is closed when piston moves from BDC to TDC. The transfer port opening and closing are measured with respect to the BDC.

vi. The exhaust port is opened, when the piston moves from TDC to BDC and is closed when piston moves from BDC to TDC. The exhaust port opening and closing are measured with respect to the BDC.

PROCEDURE:

1 Remove the ports cover and identify the three ports.

2 Mark the TDC and BDC position of the fly wheel. To mark this position follow the same procedure as followed in valve timing diagram.

3 Rotate the flywheel slowly in usual direction (usually clockwise) and observe the movement of the piston.

4 When the piston moves from BDC to TDC observe when the bottom edge of the piston. Just uncover the bottom end of the inlet port. This is the inlet port opening (IPO) condition , make the mark on the flywheel and measure the distance from TDC.

5 When piston moves from TDC to BDC observe when the bottom edge of the piston completely covers the inlet port. This is the inlet port closing (IPC) condition. Make the mark on the flywheel and measure the distance from TDC.

6 When the piston moves from TDC to BDC, observe, when the top edge of the piston just uncover the exhaust port. This is the exhaust port opening [EPO] condition. Make the mark on the flywheel and measure the distance from BDC.

7 When the piston moves from BDC to TDC, observe, when the piston completely cover the exhaust port, This is the exhaust port closing condition [EPC] . Make the mark on the flywheel and measure the distance from BDC.

8 When the piston moves from TDC to BDC observe, when the top edge of the piston just uncover the transfer port. This is the transfer port opening [TPO] condition. Make the mark on the flywheel and measure the distance from BDC.

9 When the piston moves from BDC to TDC, observe, when the piston completely covers the transfer port. This is the transfer port closing [TPC] condition. Make the mark on the flywheel and measure the distance from BDC.

Note:

1. The inlet port opening distance and closing distance from TDC are equal
2. The exhaust port opening distance and closing distance from BDC are equal
3. The transfer port opening distance and closing distance from BDC are equal

FORMULA:

$$\text{Angle} = \frac{L \times 360}{X} \text{ Degrees}$$

Where,

L - Distance from nearest dead center in mm

X- Circumference of the Flywheel in mm

OBSEVATIONS:

Sl. No.	Event	Position of crank w.r.to TDC or BDC	Distance in mm	Angles in Degrees
1	IPO	Before TDC		
2	IPC	After TDC		
3	TPO	Before BDC		
4	TPC	After BDC		
5	EPO	Before BDC		
6	EPC	After BDC		

DIAGRAM

RESULT:

The given two stroke petrol engine is studied and the port timing diagram is drawn for the present set of values.

5-VALVE TIMING DIAGRAM OF A FOUR STROKE SINGLE CYLINDER DIESEL ENGINE

AIM:

To draw the valve timing diagram of the four stroke Single Cylinder compression ignition (or) diesel engine.

EQUIPMENTS REQUIRED:

1. Four stroke diesel engine
2. Measuring tape or scale
3. Chalks

BRIEF THEORY OF THE EXPERIMENT:

The valve timing diagram gives an idea about how various operations are taking place in an engine cycle. The four stroke diesel engines have inlet valve to supply air inside the cylinder during suction stroke and an exhaust valve to transfer exhaust gas after combustion to the atmosphere. The fuel is injected directly inside the cylinder with the help of a fuel injector. The sequence of events such as opening and closing of valves which are performed by cam- follower-rocker arm mechanism in relation to the movements of the piston as it moves from TDC to BDC and vice versa. As the cycle of operation is completed in four strokes, one power stroke is obtained for every two revolution of the crankshaft.

The suction, compression, power and exhaust processes are expected to complete in the respective individual strokes. Valves do not open or close exactly at the two dead centers in order to transfer the intake charge and the exhaust gas effectively. The timing is set in such a way that the inlet valve opens before TDC and closes after BDC and the exhaust valve opens before BDC and closes after TDC. Since one cycle is completed in two revolutions i.e 720 degrees of crank rotations, various events are shown by drawing spirals of suitable diameters. As the timing plays major role in transfer of the charge, which reflects on the engine performance, it is important to study these events in detail

PROCEDURE:

1. Mark the direction of rotation of the flywheel. Always rotate only in clockwise direction when viewing in front of the flywheel.
2. Mark the Bottom Dead Center (BDC) position on the flywheel with the reference point when the piston reaches the lowermost position during rotation of the flywheel.

3 Mark the Top Dead Center (TDC) position on the flywheel with the reference point when the piston reaches the top most position during the rotation of flywheel.

4 Identify the four strokes by the rotation of the flywheel and observe the movement of inlet and exhaust valves.

5 Mark the opening and closing events of the inlet and exhaust valves on the flywheel.

6 Measure the circumferential distance of the above events either from TDC or from BDC whichever is nearer and calculate their respective angles.

7 Draw the valve timing diagram and indicate the valve opening and closing periods

FORMULA:

$$\text{Angle} = \frac{L \times 360}{X} \text{ Degrees}$$

Where,

L - Distance from nearest dead center in mm

X- Circumference of the Flywheel in mm

OBSEVATIONS:

Sl. No.	**Description**	**Distance in mm**	**Angles in Degrees**
1	IVO Before TDC		
2	IVC After BDC		
3	EVO Before BDC		
4	EVC After TDC		

DIAGRAM

RESULT:

The given four stroke compression ignition engine is studied and the valve timing diagram is drawn for the present set of values.

6. (i) PERFORMANCE TEST ON A 4-STROKE SINGLE CYLINDER DIESEL ENGINE

AIM:

To conduct a constant speed load test on a single cylinder, 4-stroke diesel engine and draw the characteristic curves

ENGINE SPECIFICATIONS:

4-Stroke, single cylinder, water cooled diesel engine.

Make	: Kirloskar Model AV1
Bore	: 80 mm
Stroke	: 110 mm
Cubic capacity	: 553cc
Rated Speed	: 1500 rpm
Max. Brake Power	: 3.7 kW(5 HP)
Compression ratio	:16.5 :1
Fuel	: High speed diesel oil
Calorific value	: 43,400 kJ / kg
Specific gravity of oil	: 0.8275
Air tank orifice diameter	: 20 mm
Type of loading	: Brake drum dynamometer
Rope diameter	:15 mm
Equivalent brake drum diameter	: 360 mm

PROCEDURE:

1. Check the fuel level.
2. Check the lubricating oil level
3. Open the three way cock, so that fuel flows to the engine directly from the tank.
4. Open the cooling water valves and ensure water flows through the engine.
5. Start the engine and allow running on no load condition for few minutes.
6. Adjust the engine speed by screwing or unscrewing the governor nut.
7. Allow the cooling water in the brake drum and adjust it to avoid spilling.
8. Allow the engine to run at this load for few minutes
9. First, switch -ON the MCB (Mains) of the control panel at the right bottom side .
10. Note down the following readings at NO load.
    a) Time taken for quantity ‘q’ (5 cc) of fuel consumption.

b) Manometer reading i.e. difference in water columns.

c) Engine speed.

11. Repeat the above procedure at different loads.
12. Stop the engine at NO load by cutting of the fuel supply.

FORMULAE:

1. I) Torque T = (W – S) X R

W = Load = $(w + w_h)$ Kg

w = Dead weight (kg)

w_h = Hanger weight = 1 kg

R = Equivalent radius of brake drum = 0.180 m

S = Spring balance reading (kg)

ii) Mass of fuel consumption, $m_f = \frac{q}{t} \times \frac{\rho}{1000}$ kg/sec.

Where, q = Fuel consumption (5 cc)

t = Time taken for 5 cc of fuel consumption (sec.)

ρ = Density of Diesel (gm/cc) = 0.8275 gm / cc

Tabulation:

S.No	Speed (N)	Time (t) for 5cc	Load (N)			Torque	Manometer Reading		
			Weight ($W=w+w_h$)	Spring balance load (S)	Net Load (W- S)X9.81	$N \times R_e$	h_1	h_2	$h=(h_1+h_2) \times 10^{-3}$
	rpm	Sec	kg	kg	N	N-m	mm	mm	m
1.									
2.									
3.									
4.									
5.									
6.									

S.No	FC $\times 10^{-4}$	FP	BP	IP	Efficiencies			H_a	$V_a \times 10^{-3}$	$V_s \times 10^{-3}$	η_v	A/F	BSFC	ISFC
					η_b	η_i	η_m							
	kg /sec	kW	kW	kW	%	%	%	m of air	m^3/s	m^3/s	%		Kg/kW-hr	Kg/kW-hr
1.														
2.														
3.														
4.														
5.														
6.														

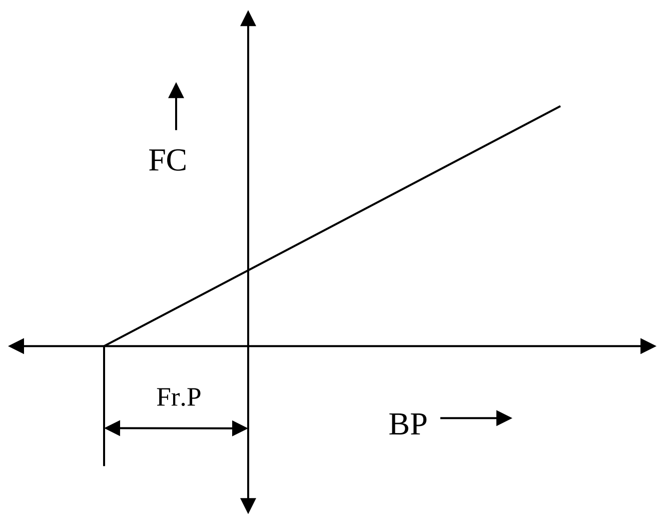
2. Heat Input (Fuel power), HI = $m_f \times$ Calorific value of fuel kW

3. Brake power, BP = $\frac{2\pi NT}{60 \times 1000}$ kW

T = (W – S) x Re N-m

4. Frictional power, F_rP (from Willan's line graph)

Draw a graph between BP Vs FC



1. Indicated power ,IP = BP + F_rP kW

2. Brake thermal efficiency , $\eta_b = \frac{BP}{HI} \times 100$

3. Indicated thermal efficiency, $\eta_i = \frac{IP}{HI} \times 100$

4. Mechanical efficiency , $\eta_m = \frac{BP}{IP} \times 100$

5. Brake specific fuel consumption, BSFC = $\frac{m_f}{BP} \times 3600$ kg/ kW- hr

6. Actual volume of air intake, $V_a = C_d A_o \sqrt{2gH_a}$ m^3 /sec.

Where, H_a = Head of air = $h_w \times \frac{\rho_w}{\rho_a}$ m

h_w = Head of water column (m)

ρ_w = Density of water = 1000 kg/m^3

ρ_a = Density of air = $\frac{P_a}{RT}$ =1.16 kg/m^3

P_a = Atmospheric pressure = 1.01325 $\times 10^5$ N/m^2

R = Gas constant for air = 287 J/kg K

T_a = Room temperature (°K)

C_d = Co-efficient of discharge of orifice meter = 0.62

A_o = Cross sectional area of Orifice = $\frac{\pi d^2}{4}$ m^2

d = diameter of the orifice =0.02 m

7. Theoretical volume of air intake, V_s = $\frac{\pi}{4} D^2 \times L \times \frac{N}{60 \times 2}$ m^3/sec

   Where, D = Bore diameter = 80 mm

   L = Stroke length =110 mm

8. Volumetric efficiency, $\eta_v = \frac{V_a}{V_s} \times 100$

9. Air fuel ratio, A/F = $\frac{V_a \times \rho_a}{m_f}$

GRAPHS:

1. BP Vs η_v
2. BP Vs η_{Bth}
3. BP Vs η_{Ith}
4. BP Vs η_{mech}
5. BP Vs BSFC

RESULT:

The constant speed load test on a single cylinder, 4-stroke diesel engine was conducted and performance curves were drawn.

6. (ii) HEAT BALANCE TEST ON A SINGLE CYLINDER 4-STROKE DIESEL ENGINE

AIM:

To conduct a heat balance test on a single cylinder 4-stroke diesel engine and draw a heat balance sheet.

ENGINE SPECIFICATIONS:

4-Stroke, single cylinder, water cooled diesel engine.

Make	: Kirloskar Model AV1
Bore	: 80 mm
Stroke	: 110 mm
Cubic capacity	: 553cc
Rated Speed	: 1500 rpm
Max. Brake Power	: 3.7 kW(5 HP)
Compression ratio	:16.5 :1
Fuel	: High speed diesel oil
Calorific value	: 43,400 kJ / kg
Specific gravity of oil	: 0.8275
Air tank orifice diameter	: 20 mm
Type of loading	: Brake drum dynamometer
Rope diameter	:15 mm
Equivalent brake drum diameter	: 360 mm

PROCEDURE:

1. Check the fuel level.
2. Check the lubricating oil level
3. Open the three way cock, so that fuel flows to the engine directly from the tank.
4. Open the cooling water valves and ensure water flows through the engine.
5. First, switch -ON the MCB (Mains) of the control panel at the right bottom side.

6. Start the engine and allow running on no load condition for few minutes.
7. Adjust the engine speed by screwing or unscrewing the governor nut.
8. Allow the cooling water in the brake drum and adjust it to avoid spilling.
9. Note down the following readings at NO load.
   a) Time taken for quantity ‘q’ (5 cc) of fuel consumption.
   b) Manometer reading i.e. difference in water columns.
   c) Engine speed.
   d) Weight on the hanger
   e) Spring balance
   f) Flow of Cooling water through Calorimeter
   g) Flow of Cooling water through Engine
   h) Inlet and outlet temperatures of engine cooling water
   i) Inlet and outlet temperatures of calorimeter cooling water
   j) Inlet and outlet temperatures of exhaust gases
   k) Ambient temperate
10. Repeat the above procedure at different loads
11. Stop the engine at NO load by cutting of the fuel supply.

FORMULAE:

1. Mass of fuel consumption, $m_f = \frac{q}{t} \times \frac{\rho}{1000}$ kg/sec.

   Where, q = Fuel consumption (5 cc)

   t = Time taken for 5 cc of fuel consumption (sec.)

   ρ = Density of Diesel (gm/cc) = 0.8275 gm / cc

2. Heat Input (Fuel power), HI = $m_f \times$ Calorific value of fuel kW

3. Brake power, BP = $\frac{2\pi NT}{60 \times 1000}$ kW

   T = (W – S) x 9.81 x Re N-m

   BP = Brake power = 5 $\times$ 0.736 kW

   N = Engine speed = 1500 rpm

   W = Load = ($w + w_h$) kg

   w = Dead weight (kg)

   w_h = Hanger weight = 1 kg

   Re = Equivalent radius of brake drum = 0.187 m

S = Spring balance reading (kg)

4. Heat carried by cooling water, $Q_w = m_w C_{pw} (T_{w2} – T_{w1})$ kW

Where, $T_{w1} = T_1$ = Inlet temperature of engine cooling water (^{0}C)

$T_{w2} = T_2$ = Outlet temperature of engine cooling water (^{0}C)

C_{pw} = Specific heat of water = 4.187 kJ/kg K

m_w = mass flow rate of cooling water = $\frac{5}{t_W}$ kg/sec

t_w = Time taken for flow of 5 liters of water

5. 2. Heat carried by exhaust gas $Q_{eg} = m_g C_{pg} (T_g - T_a)$ kW

Where, $T_g = T_4$ = Exhaust gas temperature (^{0}C)

$T_a = T_6$ = Atmospheric temperature (^{0}C)

Specific heat of exhaust gas is determined by equating

Heat lost by exhaust gas = Heat carried by cooling water

$$m_g C_{pg} (T_5 – T_6) = m_{wc} C_{pw} (T_3 – T_1)$$

C_{pg} = Specific heat of exhaust gas = 1.1 kJ/kg K

m_g = Mass flow rate of exhaust gas = $m_f + m_a$

m_a= Mass flow rate of air = V_a x ρ_a = $C_d A_o \sqrt{2gH_a} \times \rho_a$ (kg/sec)

C_d= Co-efficient of discharge of orifice meter = 0.62

A_o= Area of orifice meter = $\frac{\pi}{4} d^2$ m^2

d = Diameter of orifice = 20 mm

H_a = Head of air column = $h_w \times \frac{\rho_w}{\rho_a}$ m

h_w = Head of water column (m)

ρ_w = Density of water = 1000 kg/m^3

ρ_a = Density of air = $\frac{p_a}{RT_a}$ kg/m^3

p_a = Atmospheric pressure = 1.01325×10^5 N/m^2

R = Characteristic gas constant of air = 287 J/kg K

6. Percentage of Brake power, % BP = $\frac{BP}{HI} \times 100$

7. Percentage of heat carried by cooling water, $\%Q_w = \frac{Q_w}{HI} \times 100$

8. Percentage of heat carried by exhaust gas, $\%Q_{eg} = \frac{Q_{eg}}{HI} \times 100$

9. Percentage of unaccounted loss = $100 - (\%BP + \%Q_w + \%Q_{eg})$

Model Calculation

Heat Balance Sheet:

Graph:

1. BP Vs % losses

RESULT:

The heat balance test on a single cylinder 4-stroke diesel engine was conducted and the results were shown in the observation table.

Tabulation:

S.No	Speed (N)	Time (t) for 5cc	Load (Kg)			Manometer Reading			Engine cooling water Temperature		Calorimeter reading Temperature		Exhaust gases Temperature		Ambi. Temper
			Weight ($W=w+w_h$)	Spring balance load (S)	Net Load (W- S)	h_1	h_2	$h=(h_1+h_2) \times 10^{-3}$	I/P	O/P	I/P	O/P	I/P	O/P	
	rpm	Sec	Kgs	Kgs	Kgs	mm	mm	m of water	$T_1\ {}^0C$	$T_2\ {}^0C$	$T_1{}^0C$	$T_3{}^0C$	$T_4{}^0C$	$T_5{}^0C$	$T_6{}^0C$
1.															
2.															
3.															
4.															
5.															
6.															

Heat Balance Sheet on Seconds Basis

S.No	Mass of fuel consumption (m_f)	Heat supplied by the fuel(HI)	Heat in Brake power (BP)	Heat carried by engine cooling water(Q_w)	Heat carried by exhaust gases (Q_g)	% of BP	% of Q_w	% of Q_{eg}	% of Unaccou-ntable Loss
	Kg/sec	kJ/Sec	kJ/Sec	kJ/Sec	kJ/Sec				
1.									
2.									
3.									
4.									
5.									
6.									

7. RETARDATION TEST ON A 4-STROKE SINGLE CYLINDER DIESEL ENGINE

AIM: To conduct a retardation test on a single cylinder, 4-stroke diesel engine and to calculate frictional power developed by the engine.

EQUIPMENTS REQUIRED:

1. 4-Stroke, single cylinder diesel engine with rope brake dynamometer.
2. Stop watch

ENGINE SPECIFICATIONS:

Make	: Kirloskar Model AV1
Bore	: 80 mm
Stroke	: 110 mm
Cubic capacity	: 553cc
Rated Speed	: 1500 rpm
Max. Brake Power	: 3.7 kW(5 HP)
Compression ratio	:16.5 :1
Fuel	: High speed diesel oil
Calorific value	: 43,400 kJ / kg
Specific gravity of oil	: 0.8275
Air tank orifice diameter	: 20 mm
Type of loading	: Brake drum dynamometer
Rope diameter	:15 mm
Equivalent brake drum diameter	: 360 mm

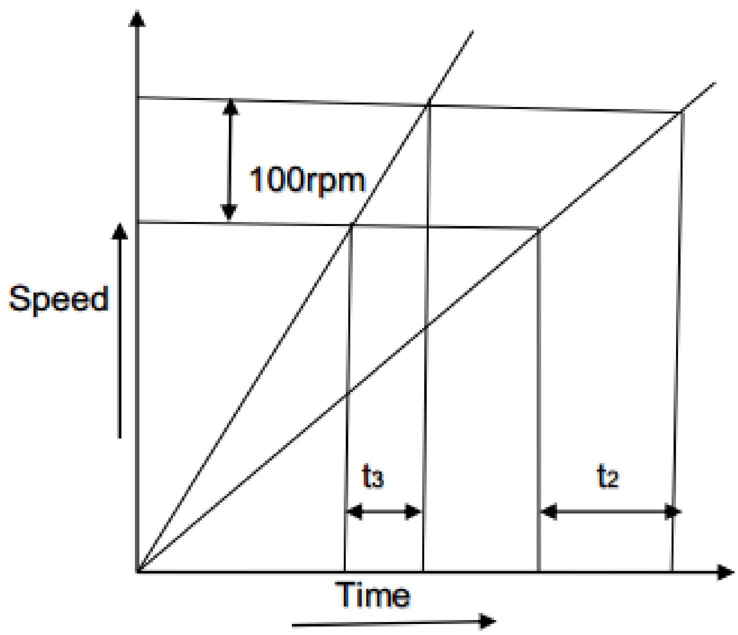
THEORY:

The frictional power of an I.C. engine is determined by the following methods

1. Willian's line method
2. Indicator area method
3. Retardation test
4. Motoring test
5. Morse test.

RETARDATION TEST:

This test involves the method of retarding the engine by cutting the fuel supply. When the engine is stopped suddenly its retardation in speed is directly related to the frictional resistance inside the engine. The engine is made to run at no load and rated speed .when the engine is running under steady operating conditions the supply of fuel is cut off and simultaneously the time of fall in speeds by say 20% , 40%, 60% , 80% of the rated speed is recorded. The tests are repeated once again with 50% load on the engine. A graph connecting time for fall in speed (x- axis) and speed (y – axis) at no load as well as 50 % load conditions is drawn as shown in fig.



Graph for retardation Test

In this set up to stop the engine running from supply of fuel a valve is provided. As the engine has run for sufficient time, the valve is cutoff and at the same time digital timer is switched on. Time for reduction in speed till a particular speed is noted.

PROCEDURE:

1. Check the fuel level and lubricating oil level
2. Open the three way cock, so that fuel flows to the engine directly from the tank.
3. Open the cooling water valves and ensure water flows through the engine.
4. First, switch -ON the MCB (Mains) of the control panel at the right bottom side .

5. Start the engine and allow running on no load condition for few minutes.
6. After initial worm up the engine, cut of the fuel supply using (cut off valve) at no load.
7. Allow the cooling water in the brake drum and adjust it to avoid spilling.
8. Allow the engine to run at this load for few minutes
9. The supply of fuel is cut off and simultaneously the time of fall in speeds by say 20%, 40%, 60%, 80% of the rated speed is recorded by using digital timer and digital RPM indicator.
10 The above procedure is followed for 50% load (i.e 7Kg).

OBSERVATIONS:

S.No.	No load condition		Half load condition(7Kg)		BP	F_rP	IP	η_m
	Drop in Speed (RPM)	Time t_2 (Sec)	Drop in Speed (RPM)	Time t_3 (Sec)				
1.	1400 to 1050		1400 to 1050					
2.	1400 to 750		1400 to 750					
3.	1400 to 550		1400 to 550					

FORMULAS USED

1. Brake power at half load, BP = $\frac{2\pi NT}{60\times1000}$ kW

   Where, T = $\frac{(W - S)max}{2}\times R\times 9.81$ N-m

2. Frictional power, F_rP = $BP\times\frac{t_3}{t_2 - t_3}$ kW

   Where, t_2 = Retardation time at no load

   t_3 = Retardation time at 50% load

3. Indicated power, IP = BP + F_rP kW

5. Mechanical efficiency, $\eta_m = \frac{BP}{IP} \times 100$

PRECAUTIONS:

1. Don’t start or stop the engine with load.
2. Don’t forget supply of cooling water to the engine.
3. After starting the engine remove the handle carefully from the shaft.
4. Take the time carefully for dropping of the speed

MODEL CALCULATION

GRAPH

1. Speed Vs Time (No Load and Half Load)

RESULT

The retardation test was conducted on a single cylinder 4-stroke diesel engine and the frictional power was found.

8. MORSE TEST ON A MULTI-CYLINDER PETROL ENGINE

AIM

To conduct Morse Test on a multi-cylinder petrol engine and determine the frictional power and Mechanical efficiency for the engine.

APPARATUS REQUIRED

1. 4 - Stroke, 4- cylinder, water cooled petrol engine with a hydraulic dynamometer with provision to cut off ignition to each cylinder independently
2. Stop watch
3. Tachometer

ENGINE SPECIFICATIONS:

Make	: Premier
No of cylinders	: 4
Bore	: 68 mm
Stroke	: 75 mm
Rated Speed	: 1500 rpm
Max. Brake Power	: 7.35 kW(10 HP)
Compression ratio	:7.8 :1
Fuel	: Petrol
Calorific value	: 47,100 kJ / kg
Specific gravity of oil	: 0. 716
Air tank orifice diameter	: 20 mm
Type of loading	: Hydraulic dynamometer

PROCEDURE

1. Check the lubrication oil level, fuel level, cooling water system and battery terminals before starting.
2. Start the engine and allow it to run for about 10 minutes at the rated speed to warm up.

3. Load the engine at full load and maintain the speed at rated rpm i.e., 1500 rpm by adjusting the throttle (accelerator) and dynamometer loading wheel.
4. Allow the engine to stabilize for few minutes.
5. Cut- off ignition to cylinder 1 by lifting the respective switch.
6. Without disturbing the throttle valve position, decrease the load on the engine, until the original speed is restored. Note the dynamometer reading
7. Restore ignition to the first cylinder by closing the switch.
8. Repeat the above procedure by cutting off ignition to each of the cylinders (2, 3, and 4).

PRECAUTIONS

1. Before starting and stopping the engine all loads must be released.
2. The cooling water must be circulated in sufficient quantity.

FORMULAE

Brake power, BP = $\frac{2\pi N \times WL}{60000}$ Kw

Where, W = Dynamometer load (kg)

N = Engine speed (rpm)

L = Length of Arm = 320 mm

Indicated power of cylinder 1, $IP_1 = BP - BP_{234}$ kW

Indicated power of cylinder 2, $IP_2 = BP - BP_{134}$ kW

Indicated power of cylinder 3, $IP_3 = BP - BP_{124}$ kW

Indicated power of cylinder 4, $IP_4 = BP - BP_{123}$ kW

Total indicated power, $IP = IP_1 + IP_2 + IP_3 + IP_4$ kW

Frictional power, $F_rP = IP - BP$ kW

Mechanical efficiency, $\eta_m = \frac{BP}{IP} \times 100$

Mass fuel consumption, $m_f = \frac{q}{t} \times \frac{\rho}{1000}$ kg/s

Where, q = Fuel consumption (5 cc)

t = Time taken for 5 cc of fuel consumption in seconds

ρ = Density of petrol (gm/cc) = 0.71 gm / cc

Heat Input, HI = FC $\times$ CV (kW)

Brake thermal efficiency, $\eta_b = \frac{BP}{HI} \times 100$

Indicated thermal efficiency, $\eta_i = \frac{IP}{HI} \times 100$

Brake specific fuel consumption, BSFC = $\frac{m_f}{BP} \times 3600$ kg / kW-hr

TABULATION:

S.No.	Condition	Dynamometer load(W)	Power output BP	IP	FP	η_m
		kgs	**kW**	**kW**	**kW**	**%**
1.	All cylinders firing	W =	BP =			
2.	Cylinder 1 cut-off	W_1 =	BP_{234} =			
3.	Cylinder 2 cut-off	W_2 =	BP_{134} =			
4.	Cylinder 3 cut-off	W_3 =	BP_{124} =			
5.	Cylinder 4 cut-off	W_4 =	BP_{123} =			

MODEL CALCULATION:

RESULT

The Morse test was conducted on a multi-cylinder petrol engine and the frictional power is =____________________

9. PERFORMANCE TEST ON A SINGLE CYLINDER 2- STROKE PETROL ENGINE WITH ALTERNATOR

AIM:

To conduct a load test on a single cylinder 2-stroke petrol engine and study its performance under various loads.

APPARATUS REQUIRED:

1. 2-Stroke, Single Cylinder Petrol Engine with Resistance load bank
2. Stop watch
3. Tachometer

SPECIFICATIONS:

Make	: Bajaj
Bore	: 57 mm
Stroke	: 57 mm
R.P.M	: 3000 rpm
Output	: 3 kW
Fuel	: Petrol
Specific gravity	: 0.716
Calorific value	: 44,000 kJ/kg
Lubrication	: 3% mixture of self mixing oil petrol

DESCRIPTION:

This Petrol engine is an air cooled, single cylinder, Vertical, 2-stroke engine. The engine is kick started. The petrol engine is coupled to a Resistance load dynamometer to absorb the power produced. The dynamometer is provided with load controller switches for varying the load. Fuel consumption is measured with a burette and a stop watch. A three-way cork, which regulates the flow of petrol from the tank to the engine.

PROCEDURE:

1. Check the fuel level.
2. Check the lubricating oil level.
3. Open the three way cock, so that the fuel flows to the engine.
4. Start the engine.

5. Adjust the speed by screwing in or out of the governor nut.
6. Load the engine, by switching on the resistance from the load bank
7. Note down the following readings at NO load.
   a) Speed.
   b) Voltmeter and ammeter readings.
   c) Time taken for 5cc of petrol consumption.
7. Load the engine, by switching on the resistance from the load bank.
8. Repeat the above procedure at different loads.
9. Stop the engine after removing load on the engine

FORMULAE:

1. Brake power, BP = $\frac{V \times I}{1000 \times \eta_g}$ kW

   Where, V = Voltmeter reading (Volts)

   I = Ammeter reading (Amperes)

   η_g = Alternator efficiency = 80%

2. Mass of fuel consumption, $m_f = \frac{q}{t} \times \frac{S}{1000}$ kg/sec.

   Where, q = Fuel consumption (5 cc)

   t = Time taken for 5 cc of fuel consumption (sec.)

   S = Specific gravity of petrol = 0.71

3. Heat Input, HI = $m_f \times$ Calorific value of fuel kW

4. Frictional power, F_rP (from Willan's line graph)

5. Indicated power ,IP = BP + F_rP kW

6. Brake thermal efficiency , $\eta_b = \frac{BP}{HI} \times 100$

7. Indicated thermal efficiency, $\eta_i = \frac{IP}{HI} \times 100$

8. Mechanical efficiency , $\eta_m = \frac{BP}{IP} \times 100$

9. Brake specific fuel consumption, BSFC = $\frac{m_f}{BP} \times 3600$ kg/ kW- hr

10. Actual volume of air intake, $V_a = C_d\ A_o\ \sqrt{2gH_a}$ m^3 /sec.

Where, H_a = Head of air = $h_w \times \frac{\rho_w}{\rho_a}$ m

h_w = Head of water column (m)

ρ_w = Density of water = 1000 Kg/m^3

ρ_a = Density of air = $\frac{P_a}{RT}$ =1.16 Kg/m^3

P_a = Atmospheric pressure = 1.01325×10^5 N/m^2

R = Gas constant for air = 287 J/Kg K

T_a = Room temperature (°K)

C_d = Co-efficient of discharge of orifice meter = 0.62

A_o = Cross sectional area of Orifice = $\frac{\pi d^2}{4}$ m^2

d = diameter of the orifice =0.02 m

11. Theoretical volume of air intake, V_s = $\frac{\pi}{4} D^2 \times L \times \frac{N}{60 \times 2}$ m^3/sec

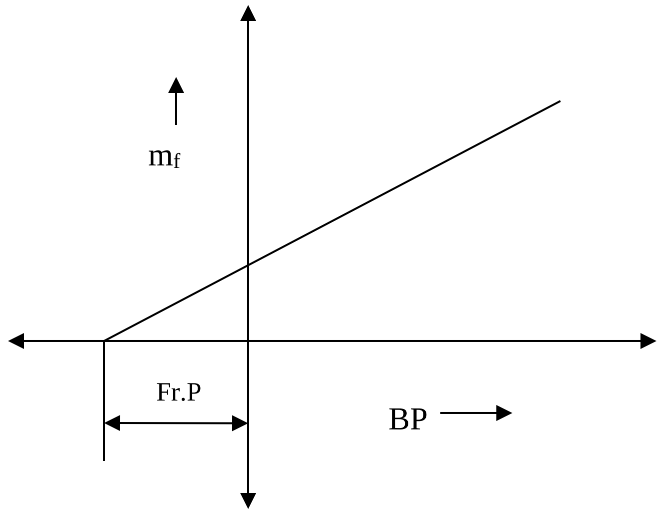
Where, D = Bore diameter = 57 mm

L = Stroke length =57 mm

12. Volumetric efficiency, $\eta_v = \frac{V_a}{V_s} \times 100$

13. Air fuel ratio, A/F = $\frac{V_a \times \rho_a}{m_f}$

Draw a graph between BP Vs FC



MODEL CALCULATION

GRAPHS:

1. BP Vs η_{Bth}
2. BP Vs η_{Ith}
3. BP Vs η_{mech}
4. BP Vs BSFC

RESULT:

The performance test on a single cylinder 2-stroke petrol engine with alternator was conducted and the performance characteristics were found.

Tabulation:

S.No	Speed (N)	Time (t) for 5cc	Load on the resistance load bank		Manometer Reading		
			Voltage	Current	h_1	h_2	$h=(h_1+h_2)\times10^{-3}$
	rpm	Sec	Volts	amps	mm	mm	m
1.							
2.							
3.							
4.							
5.							
6.							

S.No	FC $\times10^{-4}$	FrP	BP	IP	Efficiencies			H_a	V_a $\times10^{-3}$	V_s $\times10^{-3}$	η_v	A/F	BSFC	ISFC
					η_b	η_i	η_m							
	Kg /sec	kW	kW	kW	%	%	%	m of air	m^3/s	m^3/s	%		Kg/kW-hr	Kg/kW-hr
1.														
2.														
3.														
4.														
5.														
6.														

10.PERFORMANCE TEST ON REFRIGERATION TEST RIG

AIM:

To conduct a performance test on a refrigerator with Freon 12 refrigerant to determine the coefficient of performance

EQUIPMENT /APPARATUS:

1. Refrigeration test rig
2. Measuring jar
3. Stop watch

SPRCIFICATIONS:

Make	:	Altech
Compressor	:	1 / 3 Ton of refrigeration
Condenser	:	Air Cooled
Expansion Device	:	i) Capillary Tube
		ii) Solenoid Valve
Evaporator Coil	:	Immersed in water Tank of stainless steel
Refrigerant	:	Freon – 22.

DESCRIPTION:

The test rig consists of a hermetically sealed compressor. The compressed refrigerant from the compressor is sent to an air cooled condenser and the condensate in liquid form is sent to the expansion valve /capillary tube for throttling. Due to throttling temperature of the refrigerant falls and the cold refrigerant absorbs heat from the water in the evaporator tank. The refrigerant is then returned to the compressor.

A suitable filter and a transparent rotameter to visually observe the liquid. Refrigerant is fitted in the refrigerant line from condenser to evaporator. A thermocouple is provided to measure the temperature of the water in the evaporator tank. An energy meter is provided to measure the energy input to the compressor. Suitable pressure gauges are provided at the compressor inlet (evaporator outlet),condenser inlet (compressor outlet), condenser outlet (before throttling) and evaporator inlet (after throttling) to study the refrigeration cycle operating between the two pressures. Athermostat is provided for the cutting off the power to compressor when the water temperature reaches asset value. A voltmeter and an ammeter are provided to monitor the inlet power supply. A voltage stabilizer is provided for the protection of compressor. Provisions are provided in the refrigerant pipe lines for charging the test rig with additional refrigerant if necessary. Additional 4 No's of thermocouples are fitted at the condenser and evaporator inlet and outlet for studying the temperature at the 4 points in the refrigeration cycle.

THEORY:

A refrigerator consists of a compressor connected by suitable pipelines to a condenser, a capillary tube and an evaporator. Refrigerant (Freon12) in vapor state from the evaporator is compressed in the compressor and sent to the condenser. Here it condenser's in to liquid and it is then throttled. Due to throttling temperature of refrigerant drops and the cold refrigerant passes through the evaporator absorbing heat from the object to be cooled. The refrigerant is then returned to the compressor and the cycle is completed.

PROCEDURE:

1. Fill up the evaporator tank with a know quantity of water (say 10-15 litres)
2. Switch on the compressor.
3. After about 5 minutes (after steady state had set in) note the initial energy meter reading and water temperature in the evaporator.
4. After a known period of time, say 30 minutes note down the energy meter reading and water temperature.
5. Calculate the actual COP.
6. Note the Refrigerant pressures at compressor inlet (evaporator outlet), condenser inlet (compressor outlet), condenser outlet (before throttling) and evaporator inlet (after throttling) using the pressure gauges.
7. Note the Temperatures at compressor inlet (evaporator outlet), condenser inlet (compressor outlet), condenser outlet (before throttling) and evaporator inlet (after throttling) using the thermocouples provided.
8. Draw pressure- enthalpy diagram.
9. Calculate the theoretical COP.
10. Calculate the relative COP.

PRECAUTIONS:

1. Before noting the water temperature, physically Stir the water to ensure that the temperature is uniform in the water tank.
2. Since COP depends upon the evaporator temperature and condenser temperature, the calculated COP (which is an average value) will be different for varying evaporator, condenser and water temperatures.
3. When the compressor turns off (by the thermostat) or is switched off manually, do not turn on the power immediately. Allow a few minutes for the pressure in the compressor inlet and outlet to equalize. The time delay provided in the voltage stabilizer is for this purpose only. Immediate starting will cause under load on the compressor and may even lead to burn out.

SAMPLE CALCULATIONS:

ACTUAL COP:

Quantity of water in evaporator tank, m = -------- **kg**

Time taken for experiment, t = -------- **hours**

Initial temperature of water, T_0 = -------- **^0C**

Final temperature of water, T_f = -------- **^0C**

Initial energy meter reading, E_0 = --------kWh

Initial energy meter reading, E_f = --------kWh

Refrigerating effect per hour $= \frac{m(T_o - T_f)}{t}$

Energy input $= \frac{(E_f - E_o)}{t} = \cdots\cdots kW$.

Actual Coefficient of Performance, COP $= \frac{refrigerating\ effect}{Energy\ input}$

THEORETICAL COP:

Theoretical COP is calculated from the pressure measured from pressure gauges (evaporator and condenser pressures) and the temperatures measured from four thermocouples located at four points of the thermodynamic cycle (refer figure 1).

S.No	Reading	Temperature, ^0C	Pressure, Psi	Pressure, Bar
1	Condenser inlet			
2	Condenser Outlet			
3	Evaporator Inlet			
4	Evaporator Inlet			

Note: Bar = $\frac{P_{si}}{14.5} + 1$

From P-h diagram for R-12

Enthalpy of refrigerant at evaporator outlet, (before compression) h_1 = ------- kJ/Kg

Enthalpy of refrigerant at condenser inlet, (after compression) h_2 = --------kJ/kg

Enthalpy of refrigerant at condenser outlet, (before throttling) h_3 = --------kJ/Kg

Enthalpy of refrigerant at evaporator inlet, (after throttling) h_4 = --------kJ/Kg

$$\text{Theoretical COP} = \frac{(h_1 - h_4)}{(h_2 - h_1)}$$

$$\text{Relative COP} = \frac{Actual\ cop}{Theoretical\ cop}$$

RESULT:

11. PERFORMANCE TEST ON TWO STAGE RECIPROCATING AIR COMPRESSOR

AIM:

To conduct performance test on reciprocating air compressor, to determine its volumetric efficiency and Isothermal efficiency.

EQUIPMENT /APPARATUS:

1. Two stage air compressor
2. Tachometer 0-2000 rpm
3. Stop watch

DESCRIPTION:

The air compressor is a two stage reciprocating type. The air is sucked from the atmosphere and compressed in the first cylinder. The compressed air then passes through an intercooler in to the second stage cylinder where it is further compressed. The compressed air then goes to the reservoir through a safety valve. This valve operates an electrical switch that shuts off the motor when the pressure exceeds the set limit. The test unit consists of an air chamber containing an orifice plate and a U- tube manometer, the compressor and an induction motor.

SPECIFICATIONS:

Make	: Altec
Dia. of low pressure piston	: 70 mm
Dia. of High Pressure Piston	: 50 mm
Stroke	: 90 mm
Operating Pressure	: 8 kgf / cm^2
Speed	: 700 rpm
Diameter of orifice	: 20 mm
Power	: 3 HP
Energy Meter Constant	: 300 rev/kwh
Belt transmission efficiency	: 95 %
Efficiency of motor	: 80%

PROCEDURE:

1. Close the outlet valve.
2. Fill up the manometer with water upto the half level.

3. Start the compressor and observe the developing pressure slowly.
4. At the particular test pressure the outlet valve is opened slowly and adjusted so that the pressure in the reservoir is maintained constant.
5. Observe the following readings,
   (i) Time taken for 5 revolutions of energy meter disk.
   (ii) Speed of compressor.
   (iii) Manometer readings.
   (iv) Delivery pressure gauge reading.
6. Repeat the procedure for at least five readings.

FORMULAE:

1. Delivery pressure, $P_{d\,(absolute)} = (P_{d\,(gauge)} \times 9.81 \times 10^4 + 1.01325 \times 10^5)$ N / m²
2. Pressure ratio, $R_p = = \frac{P_{d(absolute)}}{P_{a(absolute)}}$
3. Head of air, $h_a = = h_w \times \frac{\rho_w}{\rho_a}$ m meters of water

Where, h_w = head of water (m)

ρ_w = Density of water = 1000 kg / m³

ρ_a = Density of air = P_a / RT =1.16 kg / m³

P_a = Absolute atmospheric pressure (N /m²)

R = 287 J /kg K

T = Room temperature (⁰ K)

4. Actual volume of air delivered, $V_a = C_d A \sqrt{2gh_a}$ m³ /sec.

Where, C_d = Coefficient of discharge = 0.62

A = Area of orifice = $\frac{\pi}{4} d^2$ (m²)

d = Diameter of the orifice (m)

5. Theoretical volume, $V_s = \frac{\pi}{4} D^2 L \frac{N}{60}$ m³ / sec.

Where, D = Low pressure cylinder diameter (m)

L = Low pressure cylinder stroke (m)

N = Speed (rpm)

6. Input power to the compressor, $P = \frac{3600}{n} \times \frac{5}{t} \times \eta_m$ kW

Where, n = energy meter constant

t = time taken for 5 revolutions of energy meter (sec.)

$\acute{\eta}_m$ = Mechanical transmission efficiency = 0.95 x 0.8

7. Isothermal power, P_i = $\frac{P_a V_n \ln(R_p)}{1000}$ kW
8. Volumetric efficiency, $\eta_v = \frac{V_a}{V_s} \times 100$
9. Isothermal efficiency, $\eta_i = \frac{P_i}{P} \times 100$
10. Adiabatic power, P_{ad} = $2\frac{\gamma}{\gamma-1} P_a V_a [(R_p)^{\frac{(\gamma-1)}{2\gamma}} - 1]$ kW
11. Adiabatic efficiency, η_a = P_{ad} / P

MODEL CALCULATION

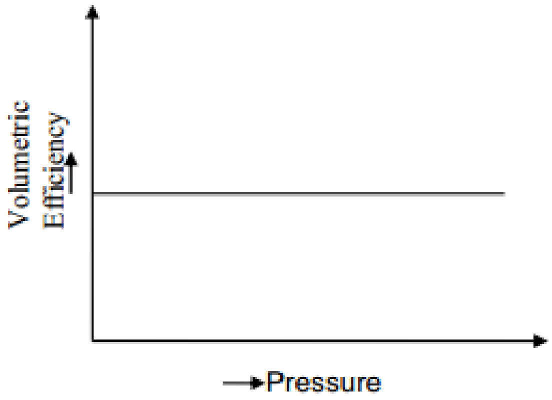
GRAPH:

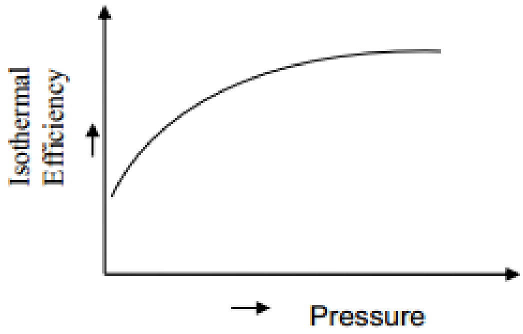
1. Pressure ratio Vs Isothermal efficiency
2. Pressure ratio Vs Adiabatic efficiency
3. Pressure ratio Vs Volumetric efficiency

RESULT:

The performance test on a two stage reciprocating air compressor was conducted and the characteristic curves were drawn.

Model Graphs:





ISOTHERMAL EFFICIENCY

.No	Speed (N)	Time (t) for 5 rev. of energy meter	Gauge pressure	Manometer Reading			Isothermal Power	Input power to compressor	η_{iso}
				h_1	h_2	$h=(h_1+h_2)$ $x10^{-3}$			
	rpm	Sec	Kgf/cm^2	mm	mm	m of water			%
1.									
2.									
3.									
4.									
5.									
6.									

VOLUMETRIC EFFICIENCY

S.No	Speed (N)	Time (t) for n	Gauge pressure	Manometer Reading			H_a	V_a x10^{-3}	V_s x10^{-3}	η_{vol}
				h_1	h_2	$h=(h_1+h_2)$ x10^{-3}				
	rpm	Sec	Kgf/cm^2	mm	mm	m of water	m of air	m^3/s	m^3/s	%
1.										
2.										
3.										
4.										
5.										
6.										

12.PERFORMANCE TEST ON A SINGLE CYLINDER 4-STROKE VCR DIESEL ENGINE

AIM:

To conduct performance test on a single cylinder, 4-stroke VCR diesel engine and to draw the characteristic curves

ENGINE SPECIFICATIONS:

Computer Based Four Stroke, Single Cylinder, Variable Compression Ratio, Multi Fuel, Water Cooled,Direct injection, Compression Ignition Engine

Make	: Kirloskar Model AV1
Bore	: 87.5 mm
Stroke	: 110 mm
Connecting rod length	: 234 mm
Cubic capacity	: 553cc
Rated Speed	: 1500 rpm
Max. Brake Power	: 3.5 kW(5 HP)
Compression ratio	:12:1 to 18 :1
Injection Timing	: 24^0 btdc
Fuel	: High speed diesel oil
Calorific value	: 43,400 kJ / kg
Specific gravity of oil	: 0.8275
Air tank orifice diameter	: 20 mm
Rated torque & Arm length	: 2,4,8 kg-m & 185 mm
Type of loading	: Eddy Current Dynamometer
Recommended Fuels	: Diesel, Bio diesel, Various oils blended with diesel

PROCEDURE:

1. Fill up the required quantity of diesel to the fuel tank kept beside the panel.
2. Connect the instrumentation panel to the mains (230 vAC, 50 Hz)
3. Switch ON the PC & open the software.
4. Make sure that the interfacing cable is connected to the PC.
5. Allow the water to the engine head, calorimeter & pressure sensor cooling adopter and also to engine cooling jacket with the help of respective control valves provided.

6. Set the injection pressure and compression ratio to 210 bar and 17.5 respectively before starting the engine.
7. Correct the zero error of the torque indicator
8. Start the engine using diesel as fuel and allow it to run for 20 minutes so as to attain steady state condition.
9. Switch on the digital indicators for reading the temperatures (ambient, exhaust gases, water inlet and outlet) sensed by thermocouples.
10. Measure fuel flow and air flow rates using DP transmitter, Range 0-500 mm WC
11. Then click "start test", select "performance test", give time interval and file name and click on "start test".
12. Observe online readings on the screen which will be logged for every given time interval
13. Load the engine by using load controller for 0 to 24 N-m, all the readings will be logged automatically for the given time interval at each load.
14. Click "stop test" and bring back the load to zero.
15. Change the load as we did in the performance test and for each load repeat procedure no. 13.
16. After all the tests, stop the engine by shutting off the fuel supply by using fuel pump rocker lever and after about 15 min. shut-off the water flow.
17. To view the test report, click "view files", select type of test, click the given file name and view the "report" or "graphs"
18. Repeat the same procedure using PSME40, PSME60 and PSME as a fuels at 210 bar injection pressure.
19. Repeat the above procedure with two more FIPs of 210 bar and 230 bar.
20. Measure the emissions of CO, HC and NO_x using MARS Multi Gas Analyzer (MN-05) and Smoke density using smoke meter for all the above experiments.
21. Repeat the above procedure for compression ratio of 19, FIPs of 210 bar and 230 bar

PRECAUSIONS

1. Check the fuel level.
2. Check the lubricating oil level
3. Open the three way cock, so that fuel flows to the engine directly from the tank.
4. Open the cooling water valves and ensure water flows through the engine.
5. Start the engine and allow running on no load condition for few minutes.
6. Adjust the engine speed by screwing or unscrewing the governor nut.
7. Allow the cooling water in the brake drum and adjust it to avoid spilling.
8. Allow the engine to run at this load for few minutes

9. First, switch -ON the MCB (Mains) of the control panel at the right bottom side .
10. Note down the following readings at NO load.
    d) Time taken for quantity ‘q’ (5 cc) of fuel consumption.
    e) Manometer reading i.e. difference in water columns.
    f) Engine speed.
11. Repeat the above procedure at different loads.
12. Stop the engine at NO load by cutting of the fuel supply.

FORMULAE:

Mass of fuel consumption, $m_f = \frac{q}{t} \times \frac{\rho}{1000}$ kg/sec.

Where, q = Fuel consumption (5 cc)

t = Time taken for 5 cc of fuel consumption (sec.)

ρ = Density of Diesel (gm/cc) = 0.8275 gm / cc

Tabulation:

S.No	Speed (N)	Time (t) for 5cc	Load (Kg)			Manometer Reading		
			Weight ($W=w+w_h$)	Spring balance load (S)	Net Load (W- S)	h_1	h_2	$h=(h_1+h_2)\times10^{-3}$
	rpm	Sec	Kg	Kg	Kg	mm	mm	m
1.								
2.								
3.								
4.								
5.								
6.								

S.No	FC $\times10^{-4}$	FP	BP	IP	Efficiencies			H_a	V_a $\times10^{-3}$	V_s $\times10^{-3}$	η_v	A/F	BSFC	ISFC
					η_b	η_i	η_m							
	Kg /sec	kW	kW	kW	%	%	%	m of air	m^3/s	m^3/s	%		Kg/kW-hr	Kg/kW-hr
1.														
2.														
3.														
4.														
5.														
6.														

1. Heat Input (Fuel power), HI = $m_f \times$ Calorific value of fuel kW

2. Brake power, BP = $\frac{2\pi NT}{60 \times 1000}$ kW

T = (W – S) x Re N-m

W = Load = (w + w_h) Kg

w = Dead weight (kg)

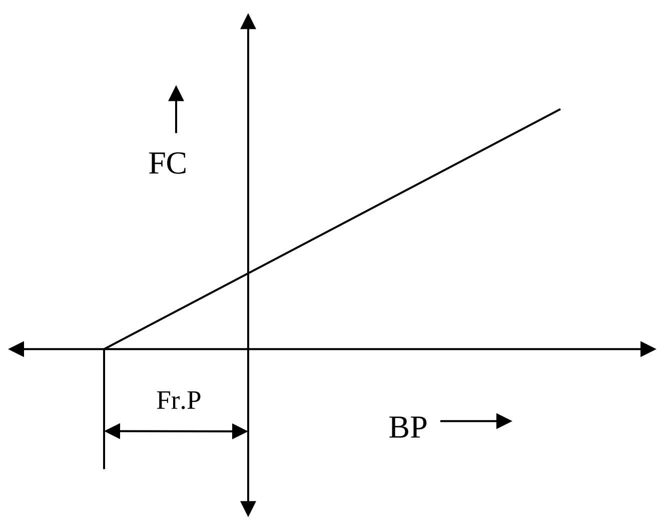
w_h = Hanger weight = 1 kg

R = Equivalent radius of brake drum = 0.180 m

S = Spring balance reading (kg)

3. Frictional power, F_rP (from Willan's line graph)

Draw a graph between BP Vs FC



4. Indicated power ,IP = BP + F_rP kW

5. Brake thermal efficiency , η_b = $\frac{BP}{HI} \times 100$

6. dicated thermal efficiency, $\eta_i = \frac{IP}{HI} \times 100$

7. Mechanical efficiency , $\eta_m = \frac{BP}{IP} \times 100$

8. Brake specific fuel consumption, BSFC = $\frac{m_f}{BP} \times 3600$ kg/ kW- hr

9. Actual volume of air intake, $V_a = C_d\ A_o\ \sqrt{2gH_a}$ m^3 /sec.

Where, H_a = Head of air = $h_w \times \frac{\rho_w}{\rho_a}$ m

h_w = Head of water column (m)

ρ_w = Density of water = 1000 Kg/m^3

ρ_a = Density of air = $\frac{P_a}{RT}$ =1.16 Kg/m^3

P_a = Atmospheric pressure = 1.01325×10^5 N/m^2

R = Gas constant for air = 287 J/Kg K

T_a = Room temperature (°K)

C_d = Co-efficient of discharge of orifice meter = 0.62

A_o = Cross sectional area of Orifice = $\frac{\pi d^2}{4}$ m^2

d = diameter of the orifice =0.02 m

10. Theoretical volume of air intake, $V_s = \frac{\pi}{4} D^2 \times L \times \frac{N}{60 \times 2}$ m^3/sec

Where, D = Bore diameter = 80 mm

L = Stroke length =110 mm

11. Volumetric efficiency, $\eta_v = \frac{V_a}{V_s} \times 100$

12. Air fuel ratio, A/F = $\frac{V_a \times \rho_a}{m_f}$

GRAPHS:

1. BP Vs η_v
2. BP Vs η_{Bth}
3. BP Vs η_{Ith}
4. BP Vs η_{mech}
5. BP Vs BSFC

RESULT:

The constant speed load test on a single cylinder, 4-stroke diesel engine was conducted and performance curves were drawn.