ST. ANNE’S COLLEGE OF ENGINEERING AND TECHNOLOGY
(Accredited by NAAC, Approved by AICTE, New Delhi. Affiliated to Anna University, Chennai)
ANGUCHETTYPALAYAM, PANRUTI – 607 106.

DEPARTMENT OF MECHANICAL ENGINEERING

ME3461-THERMAL ENGINEERING LAB
LAB MANUAL

NAME :

REG.NO :

BRANCH :

BATCH :

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LIST OF EXPERIMENTS

CYCLE – I (I.C. ENGINE LAB)

1. Determination of Flash Point and Fire Point of various fuels / lubricants.
2. Valve timing diagram of four cycle diesel engine
3. Port timing diagram of 2 stroke petrol engine
4. Actual p-v diagrams of IC engines (four stroke & two stroke)
5. Study of IC Engine

CYCLE – II (I.C. ENGINE LAB)

6. Performance Test on 4 – stroke Diesel Engine.
7. Heat Balance Test on 4 – stroke Diesel Engine.
8. Morse Test on Multi-cylinder Petrol Engine.
9. Retardation Test on a Diesel Engine.

CYCLE – III (STEAM LAB)

10. Study on Steam Generators and Turbines.
11. Performance and Energy Balance Test on a Steam Generator.
12. Performance and Energy Balance Test on Steam Turbine.

FLASH AND FIRE POINT

[CLEVEL AND OPEN CUP APPARATUS]

Ex.No: **Date:**

Aim:

To determine the flash and power point temperatures of the given sample of Lubricating oil using Cleveland open cup apparatus.

Apparatus Required:

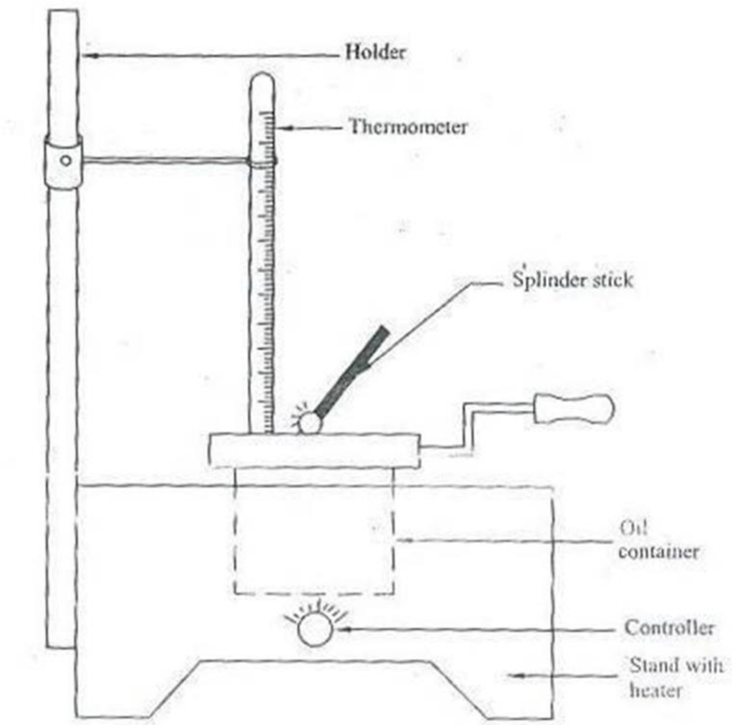
1. Cleveland open cup apparatus
2. Thermometer
3. Splinter sticks
4. Sample of oil

Theory and Definition:

The flash point of the lubricating oil is defined as the lowest temperature at which it forms vapors and produces combustible mixture with air. The higher flash point temperature is always desirable for any lubricating oil. If the oil has the lower value of flash point temperatures, it will burn easily and forms the carbon deposits on the moving parts. The minimum flash temperature of the oil used in IC engines varies from 200°C to 250°C. When the oil is tested using the open cup apparatus, the temperature is slightly more than the above temperatures. The flash and fire point temperatures may differs by 20°C to 60°C when it is tested by open cup apparatus. However, a greater difference may be obtained if some additives are mixed with oil. The flash and fire power point temperatures depends upon the volatility of the oil.

Description:

The Cleveland open cup apparatus consists of a cylindrical cup of standard size. It is held in position in the metallic holder which is placed on a wire gauge. It is heated by means of an electric heater housed inside the metallic holder. A provision is made on the top of the cup to hold the thermometer. A standing filling mark is done on the inner side of the cup and the sample of oil is filled up to the mark. This apparatus will give more accurate results than the pensky martens closed cup apparatus.



S.No	Temperature of oil in °C	Observation

Procedure:

1. Clean the cup and fill it with the given sample of oil up to the filling mark.
2. Insert the thermometer in the holder. Make sure that the thermometer should not touch the metallic cup.
3. Heat the oil by the means of electric heater so that the sample of oil gives out vapour at the rate of 10°C per minute.
4. When the oil gives out vapor, introduce the test flame above the oil, without touching the surface of the oil and watch for flash with flickering sound.
5. introducing the test flame should not continued at regular intervals until the flash is observed with peak flickering sound. The temperature corresponding to this flickering sound is noticed and it is the flash point temperature of the given sample of oil.
6. Continue the process of heating and introducing the test flame until the oil will begins to burn continuously and observe the temperature. This is the fire pint temperature of the given sample of oil.
7. Repeat the test twice or thrice with fresh sample of oil and observe the results.
8. The observations are tabulated.

Result:

The flash and fire point temperatures of the given sample of oil were determined using Cleveland open cup apparatus.

The flash point temperature of the given sample of oil is _____°C

The fire point temperature is of the given sample of oil is _____°C

VALVE TIMING DIAGRAM OF A SINGLE CYLINDER FOUR STROKE COMPRESSION IGNITION ENGINE

Ex.No: **Date:**

AIM:

To draw the valve timing diagram of the four stroke compression ignition engine.

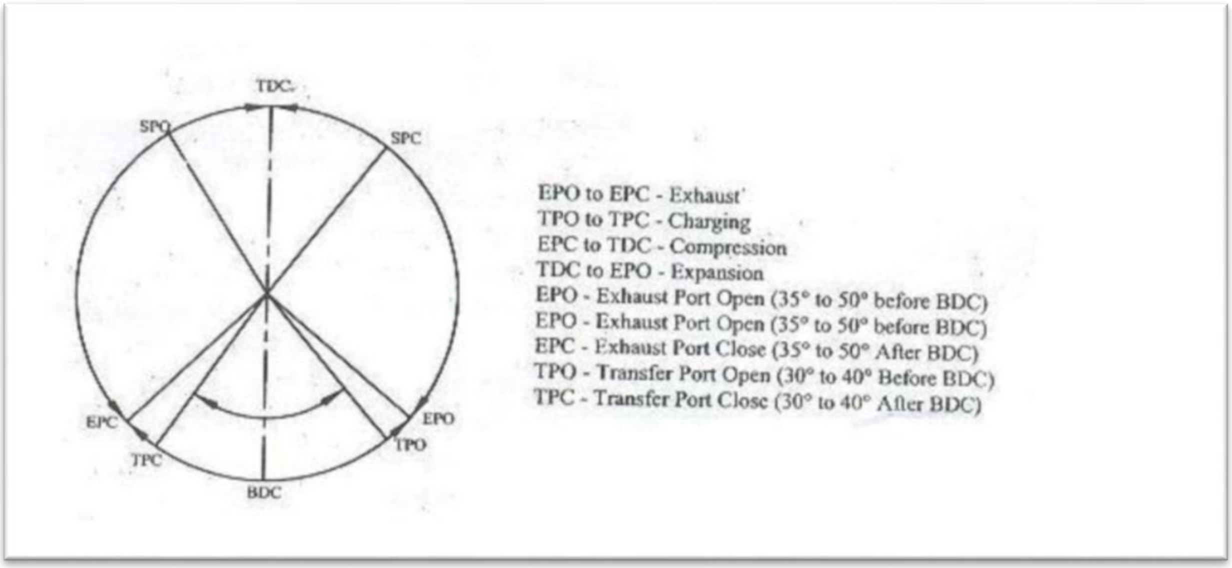
REQUIREMENTS:

1. Experimental engine
2. Measuring tape
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



OBSERVATION AND TABULATION:

CIRCUMFERENCE OF FLYWHEEL=

S.No	Events	Port position	Distance from dead center (cm)	Angle (degrees)
1.	EPO	Before BDC		
2.	EPC	After BDC		
3.	TPO	Before BDC		
4.	TPC	After BDC		

FORMULA:

$$Angle = (360 \times l)/2\pi R$$

Where,

$2\pi R$= Circumference of flywheel.

l= Arc length. (m)

Valve overlap = Angle between IVO & EVO (degree).

Angle through which inlet valve open,

x= 180-IVO+IVC

Time duration for inlet valve open,

T= (x/360) × (60/1500)

Angle through which exhaust valve open,

x= 180-EVO+EVC

Time duration for exhaust valve open,

T= (x/360) × (60/1500)

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 Which ever is nearer and calculate their respective angles.
7. Draw the valve timing diagram and indicate the valve opening and closing periods.

CALCULATIONS:

RESULT:

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

REVIEW QUESTIONS:

1. How the valves are different from ports?
2. What are the advantages of four stroke engines over two stroke engines?
3. Why four stroke engines are more fuel efficient than two stroke engines?
4. Explain the lubrication system of four stroke engines.
5. What do you mean by valve overlap? What are their effects in SI engines?
6. How the cylinder numbers assigned in multi-cylinder I.C. engines?
7. Give firing order for a four and six cylinder engines.
8. Explain how the correct direction of rotation is found before starting the valve timing experiment.
9. How do you identify an engine is working on two stroke or four stroke principle?
10. How do you identify whether it is petrol or diesel engine?

PORT TIMING DIAGRAM OF SINGLE CYLINDER TWO STROKE SPARK IGNITION ENGINE (PETROL ENGINE)

Ex.No: **Date:**

AIM:

To draw the port timing diagram of a two stroke spark ignition engine.

APPARATUS REQUIRED:

1. A two stroke petrol engine 2. Measuring tape 3. Chalk

BRIEF THEORY OF THE EXPERIMENT:

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 are present in the two stroke cycle engine.

1. Inlet port
2. Transfer port
3. Exhaust port

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

The port timing diagram gives an idea about how various operations are taking place in an engine cycle. The two stroke engines have inlet and transfer ports to transfer the combustible air fuel mixture and an exhaust port to transfer exhaust gas after combustion. The sequence of events such as opening and closing of ports are controlled by the movements of piston as it moves from TDC to BDC and vice versa. As the cycle of operation is completed in two strokes, one power stroke is obtained for every crankshaft revolution.

Two operations are performed for each stroke both above the piston (in the cylinder) and below the piston (crank case). When compression is going on top side of the piston, the charge enters to the crank case through inlet port. During the downward motion, power stroke takes place in the cylinder and at the same time, charge in the crank case is compressed and taken to the cylinder through the transfer port. During this period exhaust port is also opened and the fresh charge drives away the exhaust which is known scavenging.

As the timing plays major role in exhaust and transfer of the charge, it is important to study the events in detail. The pictorial representation of the timing enables us to know the duration and instants of opening and closing of all the ports. Since one cycle is completed in one revolution i.e. 360 degrees of crank revolution, various positions areshown in a single circle of suitable diameter.

FORMULA:

Angle made with flywheel,

$$\theta = (Distance\ from\ dead\ center/circumference\ of\ flywheel) \times 360$$

Angle through which exhaust port open,

x= EPO+EPC

Time duration at which exhaust port open,

T=(x/360) × (60/2000)

Angle through which transverse port open,

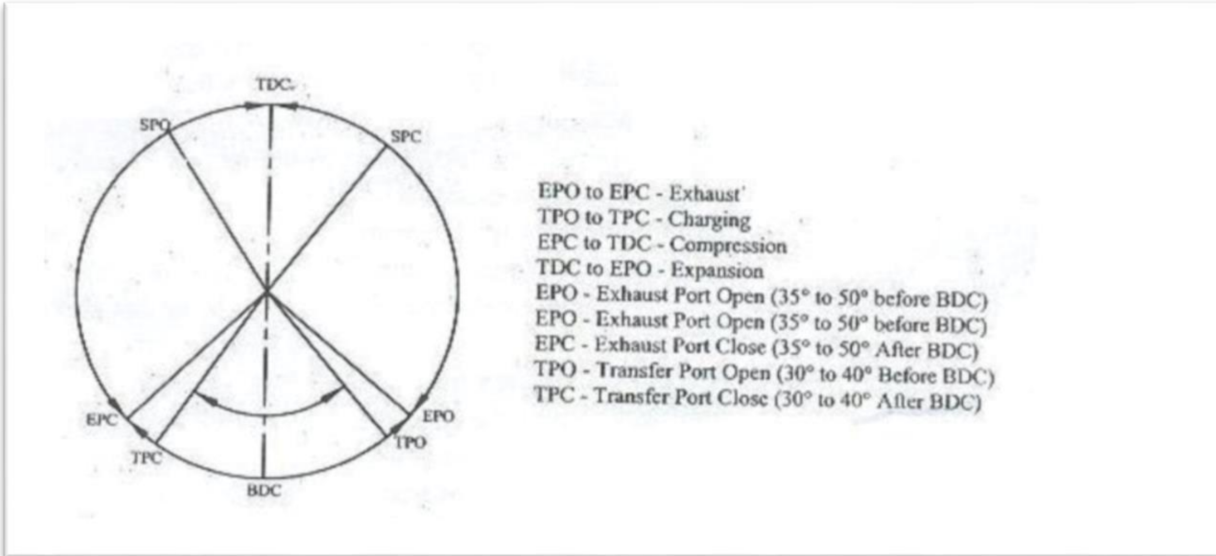
x=TPO+TPC

Time duration for transverse port open,

T=(x/360) × (60/2000)

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.



OBSERVATION AND TABULATION:

Circumference of flywheel =

S.No	Events	Port position	Distance from dead center (cm)	Angle (degree)
1.	EPO	Before BDC		
2.	EPC	After BDC		
3.	TPO	Before BDC		
4.	TPC	After BDC		

CALCULATIONS:

RESULT:

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

REVIEW QUESTIONS:

1. What is the difference between valves and ports?
2. How does the opening and closing of ports happen in two stroke engines?
3. What is the use of transfer port?
4. Give reason for larger exhaust port diameter than the transfer port.
5. What do you mean by scavenging?
6. What is the pressure developed in crank case?
7. What are the problems associated with two stroke engines?
8. What are the advantages of two stroke engines?
9. How are two stroke engines lubricated? Give the name.
10. Define compression ratio. Give the range of compression ratio for petrol and diesel engines.

Performance Test on Single Cylinder Four Stroke Diesel engine With Electrical Loading Test

Aim:

To conduct performance test on single cylinder 4 stroke petrol engine.

Apparatus Required:

Engine setup.

Stopwatch.

Formula:

i. $Brake\ power(BP) = \frac{V\ I\ n}{1000}$

ii. $Total\ fuel\ consumption(TFC) = \frac{0.74 \times 10^{-3}}{t}$

iii. $Fuel\ power(IP) = BP + friction\ power$

iv. $Fuel\ power(FP) = TFC \times CV$

v. $Indicated\ thermal\ efficiency = \frac{BP}{IP} \times 100$

vi. $Mechanical\ efficiency = \frac{BP}{IP} \times 100$

vii. $Brake\ thermal\ efficiency = \frac{BP}{FP} \times 100$

viii. $Specific\ fuel\ consumption(SFC) = \frac{TFC}{BP}$

Procedure:

1). Start the engine at no load condition

2).Apply loads on the engine and then adjust the rated speed of the engine. Allow The engine to attain steady state.

3). Time taken for 10cc of fuel consumption is measured.

4). Repeat the procedure for loads.

Tabulation:

S. No.	Volt meter reading (volts)	Ammeter Reading (amps)	BHP (kW)	Time taken for 10cc fuel consumption (sec)	FHP (kJ/s)	TFC (kg/s)	IHP (kW)	η_{BT}	η_{IT}	η_{mech}	SFC (kg/kWh)

Tabulation:

BHP Vs TFC

BHP Vsη_{BT}

BHP Vsη_{mech}

BHP Vs IP

BHP Vs SFC

Result:

Thus the performance test for single cylinder 4 stroke petrol engine with electrical bulb loading is conducted &the performance curve were drawn.

Heat Balance Test on Single Cylinder Diesel Engine

Aim:

To conduct the heat balance test on single cylinder diesel engine.

Apparatus Required:

1. Stopwatch,
2. Tachometer.

Formula used:

i. $fuel\ consumption(FC) = \frac{10}{t_{fc}} \times e_f$

ii. $brake\ power(BP) = \frac{Electric\ Power}{\eta_{mech}} = \frac{k}{t_e} \times \frac{3600}{\eta_e} \times \frac{1}{\eta_{gen}}$

iii. $heat\ input(H_{in}) = FC \times calorific\ value$

iv. $heat\ carried\ by\ cooling\ water = M_w \times C_{pw} \times (T_{wo} - T_{wi})$

$$M_w = \frac{Q_w}{t} \times density\ of\ water$$

$$C_{pw} = specific\ heat\ of\ cooling\ water$$

$$T_{wo}\ , T_{wi} = inlet, outlet\ temperature\ of\ water$$

v. $heat\ carried\ by\ exhaust\ gas = m_g \times C_{pg} \times \left(T_g - T_a\right)$

$$m_g = FC + air\ flow\ rate$$

$$C_{pg} = specific\ heat\ exhaust\ gas(1.005)$$

vi. $density\ of\ air(\rho_a) = \frac{P_a}{R_a \times T_a}$

$$P_a = atm\ pressure = 1.013 \times 10^5 \left({}^{N}/{}_{m^2}\right)$$

$$R_a = univeral\ gas\ constant = 287 \left({}^{J}/{}_{kgh}\right)$$

$$T_a = room\ temperature\ in\ kelvin$$

vii. $pressure\ interms\ of\ air, \rho_a h_a = \rho_w h_w$

$$h_a = \frac{\rho_w h_w}{\rho_a}$$

viii. $uncounted\ heat = H_{in} - \{BP + heat\ carried\ by\ cooling\ water + heat\ carried\ by\ exhaust\ gas\}$

$$V_a = \sqrt{2g\ h_a}$$

Procedure:

1) Start the engine at no load condition
2) After steady state is reached note down the following
   - i) Speed of the engine.
   - ii) Thetimefor10ccoffuelconsumption
   - iii) Timefor1letofcoolingwatercollection.
   - iv) Air inlet temperature.
   - v) Exhaust gas temperature
   - vi) Cooling water inlet and outlet temperature.
   - vii) Manometer reading.

   Repeat the above procedure for various loads.

Tabulation:

Speed= Temperature=

Dia. Of orifice= η_e= η_{gen}=

S. No.	Voltage (V)	Current (A)	Time taken for 10blinks of energy meter (sec)	Time taken for 10cc of fuel consumed (sec)	Mano metric reading (mm)			Temperature of cooling water (ºC)		Exhaust gas temp. (ºC)	Time for collecting of 1lit. of water (sec)
					h_1	h_2	h_1-h_2	Entry	Exit		

Resultant tabulation:

S. No.	FC (kg/sec) $\times 10^{-4}$	FP (kW)	Brake power		Heat carried by cooling water		Heat carried by exhaust gas		Heat unaccounted	
			kW	%	kW	%	kW	%	kW	%

Result:

Thus the heat balance test on given single cylinder diesel engine was carried out and the heat balance chart was drawn.

Performance test on Multi cylinder Petrol engine

Aim:

To determine the frictional power and mechanical efficiency of the multi-cylinder petrol engine.

Apparatus Required:

Stopwatch

Taco meter.

Engine Specification:

Maximum HP	: 10HP at 1500 RPM
Cycle of operation	: FOUR STROKE
No. of cylinders	: FOUR
Capacity	: 1489 cc
Compression ratio	: 7.2: 1
Firing order	: 1 3 4 2
Cylinder bore	: 73. 02 mm
Stroke length	: 88 .90 mm
Battery negative	: earth
Battery positive	: Solenoid switch

Procedure:

1. Disengage the clutch rod before starting.
2. The engine is started on no load and engages the clutch.
3. The engine is allowed to run for 2 to 3 minutes for initial warm up.
4. Apply required load on the dynamometer.
5. Adjust the speed of the engine to at 1500rpm by giving acceleration.
7. Measure the engine speed.
8. Now cut-off the ignition supply to the cylinder-1(by opening the Morse switch -1)
9. Now the speed and out put the engine drops.
10. Then the engine speed is brought to its original value by reducing the load. Now note down the value of speed and load
11. Similarly cut-off the cylinders 2, 3 and 4 respectively. And find the corresponding value load and speed of the engine.

Formula:

1. $max.load = W_{max} = \frac{BP \times 2000}{N \times 0.73}\ kg$

   Where,

   BP- Brake Power = 7.36 kW

   N- Speed of engine =1500 rpm

2. $brake\ power = \frac{W \times N \times 0.736}{2000}\ kW$

   Where,

   W- Dynamometer speed.

N- Engine speed. (rpm)

3. $Indicated\ power\ of\ cylinder, (i) IP_1 = BP - BP_1, (ii) IP_2 = BP - BP_2$
4. $Indicated\ power (IP) = IP_1 + IP_2 + IP_3 + IP_4\ in\ kW$
5. $Frictional\ power (FP) = IP - BP$
6. $mechanical\ efficiency (\eta_m) = \frac{BP}{IP} \times 100$

Tabulation:

S. No.	Condition of cylinder	Load (kg)	Time taken for 10cc fuel consumption (sec)	Total fuel consumption $\times 10^{-4}$(kg/sec)	Brake power (kW)	Indicated power (kW)	η_{mech} (%)

Result:

Thus the Morse test was conducted in the multi cylinder petrol engine and the performance characteristics was found.

Retardation test on a slow speed diesel engine

Aim:

To conduct a retardation test & determine the frictional power of the single cylinder diesel engine.

Apparatus required:

1. Stop watch.
2. Tachometer.

Formula:

1. $frictional\ torque, (T_f) = \frac{T_e \times t_1}{t_o - t_1}$
2. $T_e = W \times R_e$

   Where,

   $$R_e = \left(radius\ of\ drum + \frac{thickness}{2}\right) = 0.21m + \left(\frac{0.03}{2}\right)$$

3. $fuel\ consumption (F_c) = \frac{10}{T} \times \rho_f \left({}^{kg}/_{sec}\right)$

   Where,

   $T = time\ taken\ for\ 10cc\ of\ fuel.$

   $\rho_f = density\ of\ fuel.$

4. $specific\ fuel\ consumption (SFC) = \frac{FC}{BP}; BP = \frac{2\pi \times T_e}{60 \times 1000}$
5. $Indicated\ power (IP) = BP + FP$
6. $brake\ thermal\ efficiency, (\eta_{BT}) = \frac{BP}{FP}$
7. $indicated\ thermal\ efficiency, (\eta_{IT}) = \frac{IP}{FP}$
8. $mechanical\ efficiency, (\eta_{mech}) = \frac{BP}{IP}$

Tabulation:

No load condition Speed=

Load (kg)	Time taken for 10cc of fuel consumption (sec)	Time taken to reduce the speed from N_1 to N_2 rpm (sec)		
		T_1	T_2	T_0

With 5 kg load condition speed=

Load (kg)	Time taken for 10cc of fuel consumption (sec)	Time taken to reduce the speed from N_1 to N_2 rpm (sec)			T_e (N-m)	T_f(N-m)	Fr. P (kW)
		T_1	T_2	T_0			

Result:

The retardation test was conducted on a single cylinder 4- stroke diesel engine. Frictional power was find to be ________.