AVIT
AARUPADAI VEEDU INSTITUTE OF TECHNOLOGY
VINAYAKA MISSION'S RESEARCH FOUNDATION
(Deemed to be University under section 3 of the UGC Act 1956)
Accredited by NAAC
Approved by AICTE

DEPARTMENT OF MECHANICAL ENGINEERING

THERMAL ENGINEERING

REGULATIONS-2021

LAB MANUAL

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DEPARTMENT OF MECHANICAL ENGINEERING

THERMAL ENGINEERING

LIST OF EXPERIMENTS

1. Load Test on a four stroke Single cylinder diesel engine.
2. Load Test on a four stroke twin cylinder diesel engine.
3. Performance and Emission test of a four stroke multi-cylinder Petrol engine.
4. Performance and Emission test of a four stroke multi-cylinder Diesel engine.
5. Morse Test on a multi-cylinder petrol engine.
6. Performance test of a bio-fuel on a variable compression ratio engine.

DEPARTMENT OF MECHANICAL ENGINEERING

THERMAL ENGINEERING

Exp.No	Date	Title of the Experiment	Page.No	Marks Obtained (10)	Signature

DEPARTMENT OF MECHANICAL ENGINEERING

ENGINEERING THERMODYNAMICS

SAFETY PRECAUTIONS

1. Wear tight fitting clothes and thick leather shoes.
2. Incase of any injury, use the first aid kit.
3. Report any fault (or) damage in the equipment to inform the lab incharge.
5. Do not conduct an experiment without the complete knowledge of its operating procedure.
6. Do not start an engine with load applied to it.
7. Check the availability of fuel before starting an engine.
8. Remove the crank handle immediately after starting the engine.
9. Do not stretch your hands in the rotary parts of the engine.
10. Do not touch exhaust pipe of the engines as they may cause injuries.
11. Always supply cooling water while running an engine.
12. Use stop watches, thermometers and accessories carefully.
13. Do not wear watches (or) bracelets while working in the equipments.
14. Do not remove safety guards or parts of any equipment.

STUDY OF INTERNAL COMBUSTION (IC) ENGINE

HEAT ENGINE:

A heat engine is a machine, which converts heat energy into mechanical energy. The combustion of fuel such as coal, petrol, and diesel generates heat. This heat is supplied to a working substance at high temperature. By the expansion of this substance in suitable machines, heat energy is converted into useful work.

Heat engines can be further divided into two types:

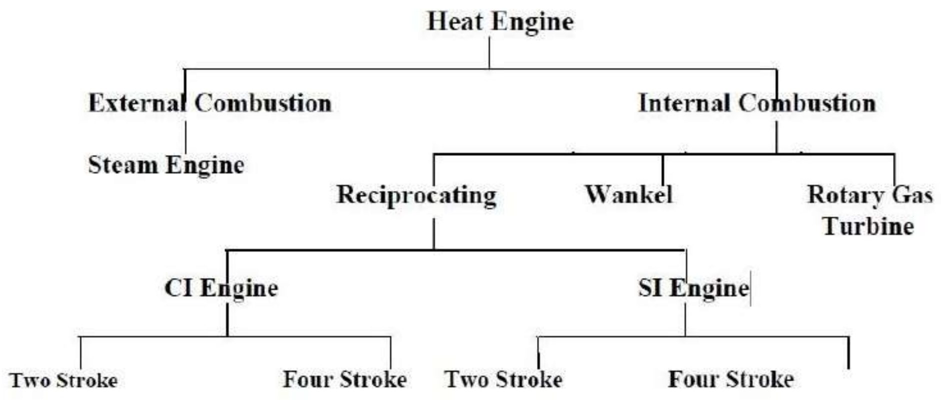
(i)External combustion and

(ii) Internal combustion.

In a steam engine the combustion of fuel takes place outside the engine and the steam thus formed is used to run the engine. Thus, it is known as external combustion engine.

In the case of internal combustion engine, the combustion of fuel takes place inside the engine cylinder itself.

TYPES OF HEAT ENGINES:



Spark Ignition (Carburetor Type) IC Engine:

In this engine liquid fuel is atomized, vaporized and mixed with air in correct proportion before being taken to the engine cylinder through the intake manifolds. The ignition of the mixture is caused by an electric spark and is known as spark ignition.

Compression Ignition (Diesel Type) IC Engine:

In this only the liquid fuel is injected in the cylinder under high pressure.

CONSTRUCTIONAL FEATURES OF IC ENGINE:

The cross section of IC engine is shown in Fig. 1. A brief description of these parts is given below.

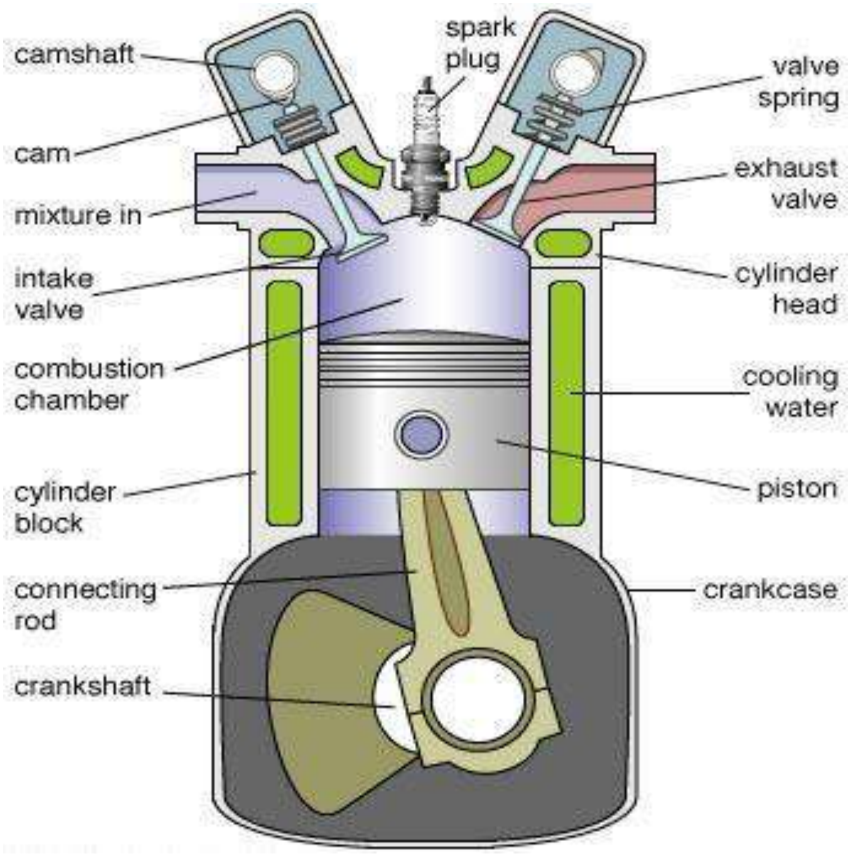


Fig. 1 Cross-Section of a Diesel Engine

Cylinder:

The cylinder of an IC engine constitutes the basic and supporting portion of the engine power unit. Its major function is to provide space in which the piston can operate to draw in the fuel mixture or air (depending upon spark ignition or compression ignition), compress it, allow it to expand and thus generate power. The cylinder is usually made of high-grade cast iron. In some cases, to give greater strength and wear resistance with less weight, chromium, nickel and molybdenum are added to the cast iron.

Piston:

The piston of an engine is the first part to begin movement and to transmitpower to the crankshaft as a result of the pressure and energy generated by the combustion of the fuel. The piston is closed at one end and open on the other end to permit direct attachment of the connecting rod and its free action.

The materials used for pistons are grey cast iron, cast steel and aluminum alloy. However, the modern trend is to use only aluminum alloy pistons in the tractor engine.

Piston Rings:

These are made of cast iron on account of their ability to retain bearing qualities and elasticity indefinitely. The primary function of the piston rings is to retain compression and at the same time reduce the cylinder wall and piston wall contact areato a minimum, thus reducing friction losses and excessive wear.

Compression rings are usually plain one-piece rings and are always placed in the grooves nearest the piston head. Oil rings are grooved or slotted and are located either in the lowest groove above the piston pin or in a groove near the piston skirt. Their function is to control the distribution of the lubricating oil to the cylinder and piston surface in order to prevent unnecessary or excessive oil consumption.

Piston Pin:

The connecting rod is connected to the piston through the piston pin. It is madeof case hardened alloy steel with precision finish. There are three different methods to connect the piston to the connecting rod.

Connecting Rod:

This is the connection between the piston and crankshaft. The end connecting thepiston is known as small end and the other end is known as big end. The big end has two halves of a bearing bolted together. The connecting rod is made of drop forged steel and the section is of the I-beam type.

Crankshaft:

This is connected to the piston through the connecting rod and converts the linearmotion of the piston into the rotational motion of the flywheel. The journals of the crankshaft are supported on main bearings, housed in the crankcase. Counter-weights and the flywheel bolted to the crankshaft help in the smooth running of the engine. The Crankshaft as shown in Figure 2.0.

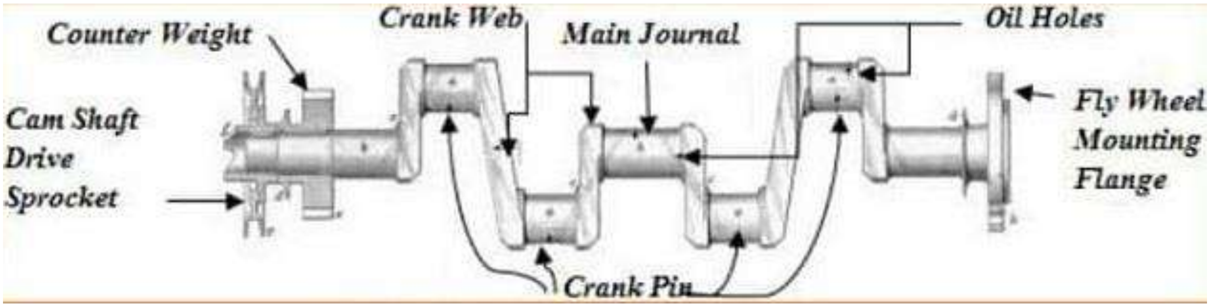


Figure 2.0 Crankshaft

Engine Bearings:

The crankshaft and camshaft are supported on anti-friction bearings. These bearings must be capable of withstanding high speed, heavy load and high temperatures. Normally, cadmium, silver or copper lead is coated on a steel back to give the above characteristics. For single cylinder vertical/horizontal engines, the present trend is to use ball bearings in place of main bearings of the thin shell type.

Valves:

To allow the air to enter into the cylinder or the exhaust, gases to escape from thecylinder, valves are provided, known as inlet and exhaust valves respectively. The valves are mounted either on the cylinder head or on the cylinder block.

Camshaft:

The valves are operated by the action of the camshaft, which has separate cams for the inlet, and exhaust valves. The cam lifts the valve against the pressure of the spring and as soon as it changes position the spring closes the valve. The cam getsdrive through either the gear or sprocket and chain system from the crankshaft. It rotates at half the speed of the camshaft.

Flywheel:

This is usually made of cast iron and its primary function is to maintain uniform engine speed by carrying the crankshaft through the intervals when it is not receiving power from a piston. The size of the flywheel varies with the number of cylinders and the type and size of the engine. It also helps in balancing rotating masses.

STUDY OF WORKING PRINCIPLES OF OPERATION OF IC ENGINES

FOUR-STROKE CYCLE DIESEL ENGINE

In four-stroke cycle engines there are four strokes completing two revolutions of the crankshaft. These are respectively, the suction, compression, power and exhaust strokes. In Fig. 3, the piston is shown descending on its suction stroke. Only pure air is drawn into the cylinder during this stroke through the inlet valve, whereas, the exhaust valve is closed. These valves can be operated by the cam, push rod and rocker arm.The next stroke is the compression stroke in which the piston moves up with both the valves remaining closed. The air, which has been drawn into the cylinder during the suction stroke, is progressively compressed as the piston ascends. The compression ratio usually varies from 14:1 to 22:1. During the fuel injection period, the piston reaches the end of its compression stroke and commences to return on its third consecutive stroke, viz., power stroke. During this stroke the hot products of combustion consisting chiefly of carbon dioxide, together with the nitrogen left from the compressed air expand, thus forcing the piston downward. This is only the working stroke of the cylinder.

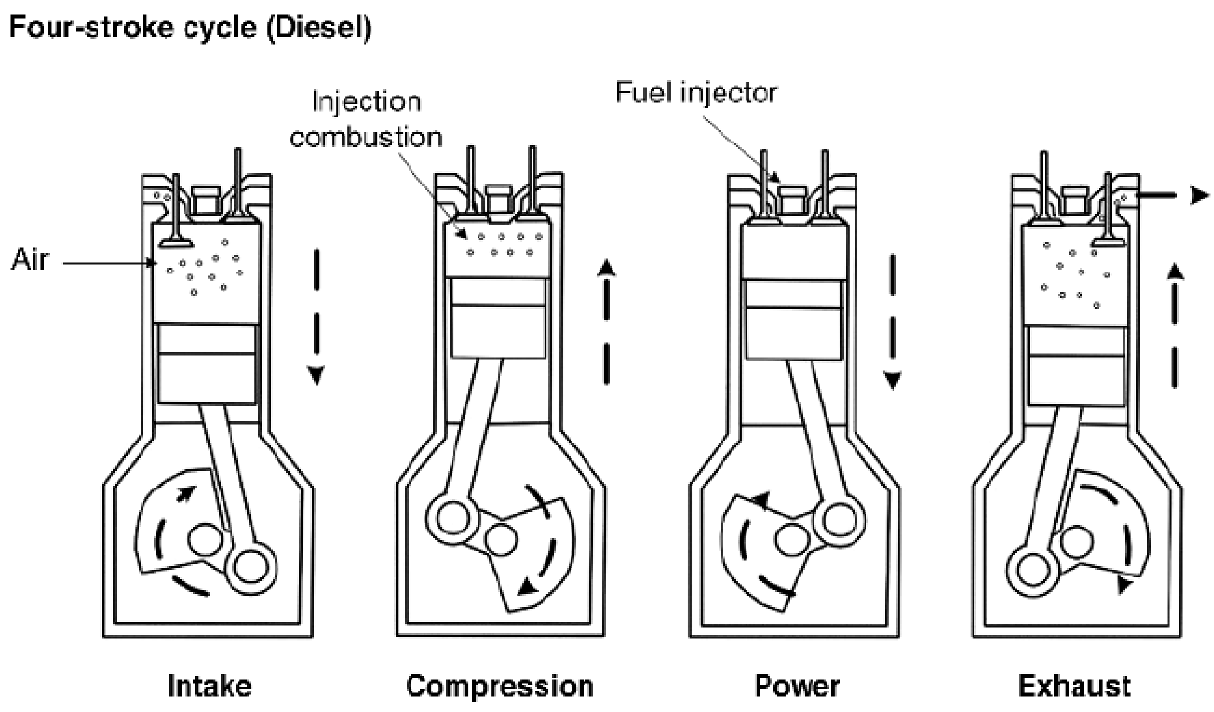


Figure 3.0 Principle of Operations of Four Stroke cycle Diesel Engine

TWO-STROKE CYCLE DIESEL ENGINE:

The cycle of the four-stroke of the piston (the suction, compression, power and exhaust strokes) is completed only in two strokes in the case of a two-stroke engine. The air is drawn into the crankcase due to the suction created by the upward stroke of the piston. On the down stroke of the piston it is compressed in the crankcase, The compression pressure is usually very low, being just sufficient to enable the air to flow into the cylinder through the transfer port when the piston reaches near the bottom of its down stroke.

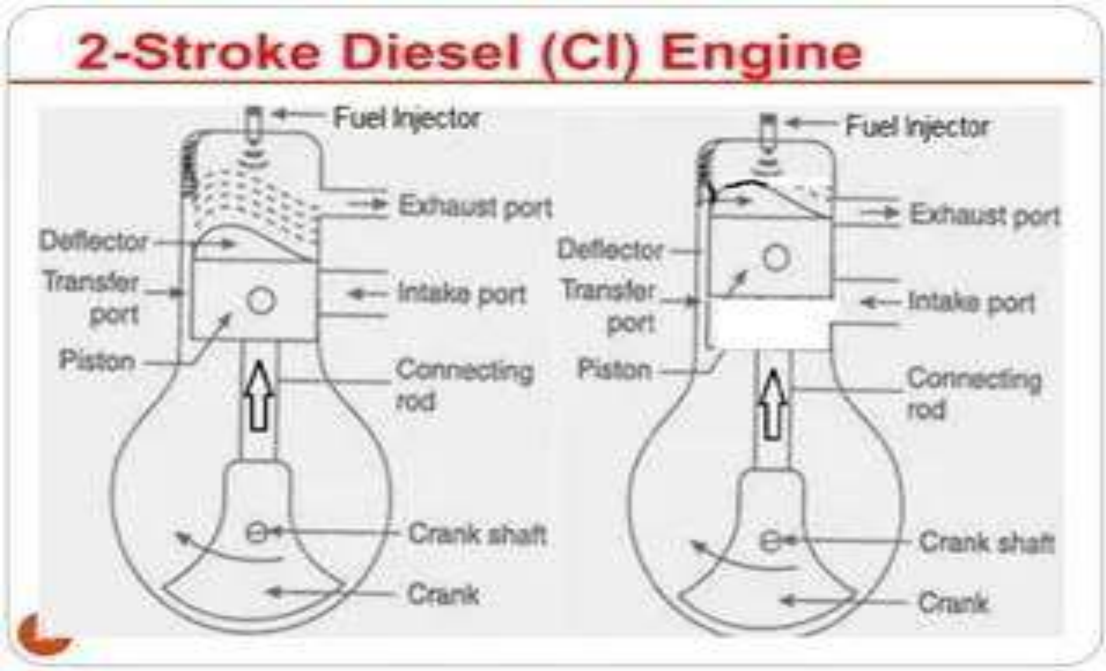


Figure 4.0 Principle of Operations of Two Stroke cycle Diesel Engine

FOUR-STROKE SPARK IGNITION ENGINE

In this gasoline is mixed with air, broken up into a mist and partially vaporized in a carburetor (Fig. 5). The mixture is then sucked into the cylinder. There it is compressed by the upward movement of the piston and is ignited by an electric spark. When the mixture is burned, the resulting heat causes the gases to expand. The expanding gases exert a pressure on the piston (power stroke). The exhaust gases escape in the next upward movement of the piston. The strokes are similar to those discussed under four-stroke diesel engines. The various temperatures and pressures are shown in Fig. 6. The compression ratio varies from 4:1 to 8:1 and the air-fuel mixture from 10:1 to 20:1.

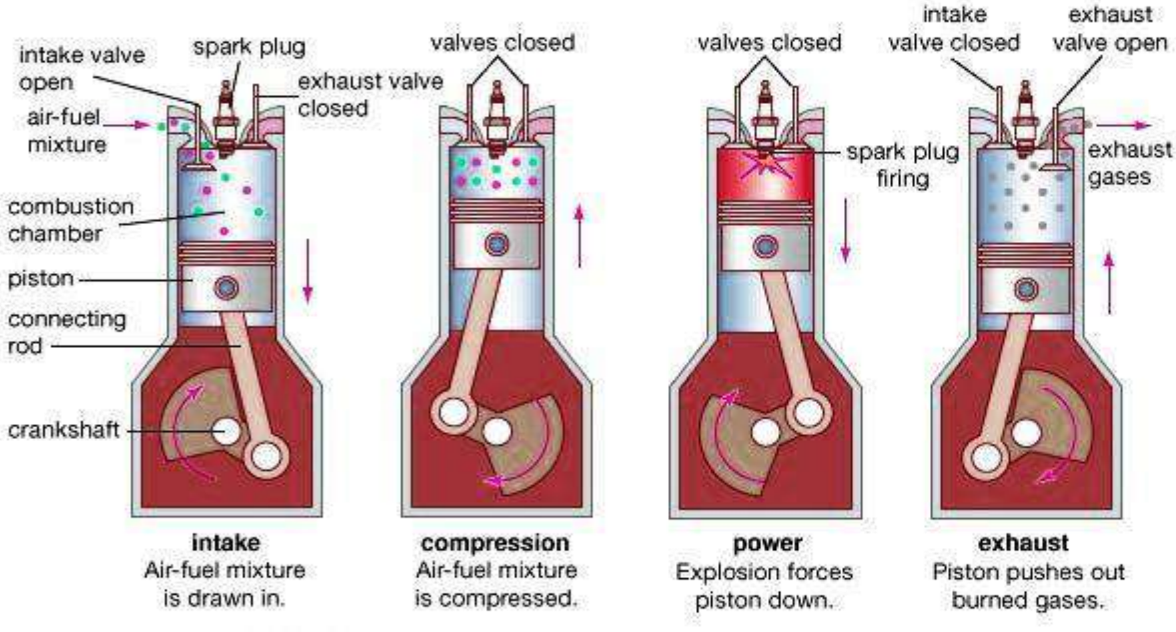


Figure 5.0 Principle of Operation of Four Stroke cycle Petrol Engine

TWO-STROKE CYCLE PETROL ENGINE

The two-cycle carburetor type engine makes use of an airtight crankcase for partially compressing the air-fuel mixture (Fig. 6). As the piston travels down, the mixture previously drawn into the crankcase is partially compressed. As the piston nears the bottom of the stroke, it uncovers the exhaust and intake ports. The exhaust flows out, reducing the pressure in the cylinder. When the pressure in the combustion chamber is lower than the pressure in the crankcase through the port openings to the combustion chamber, the incoming mixture is deflected upward by a baffle on the piston. As the piston moves up, it compresses the mixture above and draws into the crankcase below a new air-fuel mixture. The, two-stroke cycle engine can be easily identified by the air-fuel mixture valve attached to the crankcase and the exhaust Port located at the bottom of the cylinder.

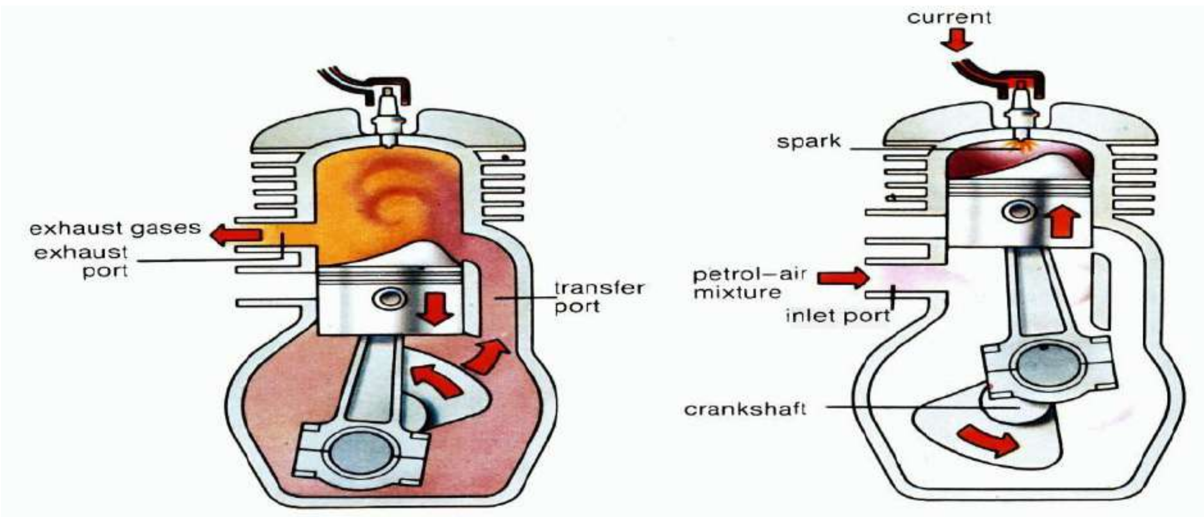


Figure 5.0 Principle of Operation of Two Stroke cycle Petrol Engine

Date: **EXPERIMENT NO. 1**

LOAD TEST ON A FOUR STROKE SINGLE CYLINDER DIESEL ENGINE

Aim :

To conduct a load test on a single cylinder diesel engine to determine the following at various load conditions.

1. Brake Power of the engine
2. Indicated Power of the engine
3. Total Fuel Consumption
4. Specific Fuel Consumption
5. Mechanical efficiency
6. Brake Thermal Efficiency
7. Indicated Thermal Efficiency

Apparatus required :

1. Single Cylinder Diesel Engine Experimental Setup.
2. Stop Watch
3. Measuring Tape
4. Tachometer
5. Spring Balance

Description:

A performance test is conducted on a single cylinder diesel to study the characteristics of the engine at different loads. The engine is equipped with a rope brake arrangement to measure the brake power of the engine applying various loads. The engine is provided with a fuel tank of capacity 5 litres and a simple fuel measuring arrangement. The fuel is measured by a 100 cc x 0.1 cc burette with a three way cock arrangement to close and measure the time taken by the fuel to flow from the burette. A large air tank is fitted with a orifice plate of 20mm dia and a manometer to measure the rate of flow of air sucked by the engine. A dial type thermometer is counted on the panel board to read the temperature of the exhaust gases.

OBSERVATION TABULATION

Sl.No	Percentage of load	Calculated Load (Newtons)	Applied Load		Time taken for 10 cc fuel consumption (Secs)		
			Kg	N	T_1	T_2	T_{avg}
1	No Load						
2	20 %						
3	40 %						
4	60 %						
5	80%						
6	100%						

CALCULATION TABULATION

Sl. No	Load (N)	Brake Power (Kw)	Total Fuel Consumption (Kg/hr)	Input Power (KW)	Specific Fuel Consumption (Kg/ Kwh)	Friction Power (KW)	Indicated Power (KW)	Brake Thermal Efficiency (%)	Indicated Thermal Efficiency (%)	Mechanical Efficiency (%)	Brake Mean Effective Pressure (Bar)	Indicated Mean Effective Pressure (BAR)

Specification :

Type of engine	:	Single Cylinder Four Stroke Diesel Engine
Type of cooling	:	Water Cooled
Brake power	:	5 h.p.
Speed	:	1500 r.p.m.
Bore diameter	:	80 mm
Stroke length	:	110 mm
Type of loading	:	Rope Brake Dynamometer
Rope diameter	:	15 mm
Orifice plate of air tank	:	20 mm

Formulae used :

Maximum Load Calculation :

The maximum load the engine could withstand is calculated based on its specified brake power.

$$\text{Max. Load} = \frac{P \times 60}{2 \times \pi \times R \times N \times 9.81} \quad \text{Kg}$$

R - Effective radius of the brake drum in m.

N - Speed of the Engine in r.p.m

P - Specified Brake Power of the Engine in KW.

Brake Power :

Brake horsepower is the measure of an engine's horsepower without the loss in power caused by the gearbox, generator, differential, water pump, and other auxiliary components such as alternator, power steering pump, muffled exhaust system, etc.

$$BP = \frac{2 \times \pi \times R \times N \times (W - S)}{60 \times 1000} \quad \text{KW}$$

Model Calculation:

Total Fuel Consumption :

It is the mass of fuel consumed at particular load per hour.

$$TFC = \frac{10 \times s.g. \times 3600}{t \times 1000} \quad kg / Hr.$$

ρ - Density of fuel in kg/m^3

t - Average time taken for 10 cc fuel consumption in secs.

Specific Fuel Consumption :

It is defined as the mass of fuel consumed per hour per Brake Power of the engine.

$$SFC = \frac{TFC}{BP} \quad Kg/KW\text{–}hr.$$

Fuel Power or Heat Supplied :

It is the heat supplied by the fuel .

$$HS = \frac{TFC \times CV}{3600} \quad KW.$$

CV - Calorific Value of Fuel in KJ / Kg.

Frictional Power :

Friction power is determined by Willan's Line Method.

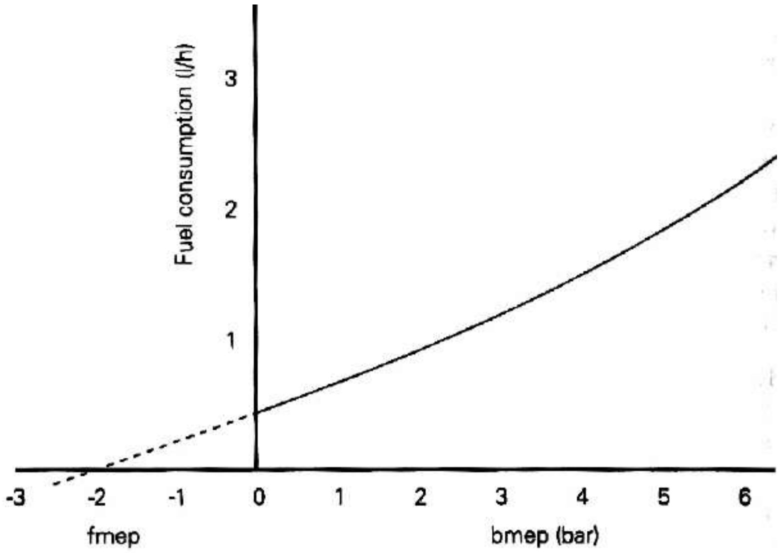
The concept of the Willann's line method is based on the fact that for any constant engine speed, the dependence of hourly fuel consumption vs engine brake power may be described with a suitable accuracy by a polynomial trend line of type

$$\mathbf{y=ax^2 + bx + c}.$$

It is assumed that this curve, extrapolated down to zero value of fuel consumption, intersects with the brake power axis at a point, which is taken as the mechanical losses value at the given engine speed .

Model Calculation:

According to this method, the mechanical losses are calculated for engine speed of 1500 rpm, where the data for the fuel consumption dependence on the engine brake power is taken from the engine performance tests.



Indicated Power :

The power actually developed inside the cylinder due to the combustion of fuel is called indicated power .

IP = Fr.P + B.P. KW

Mechanical Efficiency :

It is defined as the ratio of Brake Power to Indicated Power.

$$\eta_{MECH} = \frac{B.P}{I.P} \times 100$$

Model Calculation:

Brake Thermal Efficiency :

It is defined as the ratio of brake power to heat supplied by the combustion of fuel (fuel power).

$$\eta_{B.T.} \text{ or } \eta_{overall} = \frac{B.P}{H.S} \times 100$$

Indicated Thermal Efficiency :

It is defined as the ratio of indicated power to heat supplied by the combustion of fuel.

$$\eta_{I.T.} \text{ or } \eta_{thermal} = \frac{I.P}{H.S} \times 100$$

Procedure :

1. Calculate the maximum load that can be applied on the engine from its specifications.
2. Check the engine for fuel availability, lubricant and cooling water connections.
3. Release the load on engine completely and start the engine with no load applied in the brakes.
4. Allow the engine to run for few minutes to attain the rated speed.
5. Adjust the flow of cooling water and maintain steady flow along the cooling water jackets by verifying the outlet.
6. Apply the desired load, from no load slowly and steadily. At the desired load condition take note of the following observations.
   a. Load on the engine.
   b. Speed of the engine.
   c. Time taken for 10 cc of fuel consumption.

7. Repeat the procedure up to desired load condictions and tabulate the readings.
8. Bring the engine back to no load conditions and shut down the engine.

Performance Curves :

Curves are plotted for the following characteristics.

a. Brake Power (BP) vs Total Fuel Consumption (TFC

b. Brake Power (BP) vs) Specific Fuel Consumption (SFC).

c. Brake Power (BP) vs η_{MECH}

d. Brake Power (BP) vs $\eta_{B.T}$

e. Brake Power (BP) vs $\eta_{I.T}$

Result :

The load test was conducted and the characteristic parameters of the engine were calculated and curves were drawn.

Date: **EXPERIMENT NO. 2**

LOAD TEST ON A FOUR STROKE TWIN CYLINDER DIESEL ENGINE

Aim :

To conduct a load test on a twin cylinder diesel engine to determine the following at various load conditions and to draw the performance curves.

1. Brake Power of the engine
2. Indicated Power of the engine
3. Total Fuel Consumption
4. Specific Fuel Consumption
5. Mechanical efficiency
6. Brake Thermal Efficiency
7. Indicated Thermal Efficiency

Apparatus required :

1. Twin Cylinder Diesel Engine Experimental Setup.
2. Stop Watch
3. Measuring Tape
4. Tachometer
5. Spring Balance

Description:

A performance test is conducted on a twin cylinder diesel to study the characteristics of the engine at different loads. The twin cylinder diesel engine is coupled to a 7.5 KVA alternator. The alternator and engine are directly mounted on a common rigir framework. The output of alternator is taken to a bulb loading system through proper means. Necessary measuring equipments like ammeter, voltmeter, energymeter are fitted on the panel board of total capacity of 6 KW. The engine is provided with a fuel tank of capacity 5 litres and a simple fuel measuring arrangement. The fuel is measured by a 100 cc x 0.1 cc burette with a three way cock arrangement to close and measure the time taken by the fuel to flow from the burette. A large air tank is fitted with a orifice plate of 20mm dia and a manometer to measure the rate of flow of air

OBSERVATION TABULATION

Sl.No	Load (Watts)	Voltage(Volts)	Current (Amperes)	Time taken for 10 cc fuel fall (secs)	Time taken for 5 revolutions of energymeter disc (Secs)

CALCULATION TABULATION

Sl. No	Load (Watts)	Brake Power (KW)	Total Fuel Consumption (Kg/hr)	Specific Fuel Consumption (Kg/KW hr)	Input Power (KW)	Frictional Power (KW)	Indicated Power (KW)	Brake Thermal Efficiency %	Mechanical Efficiency %	Indicated Thermal Efficiency %

sucked by the engine. A dial type thermometer is counted on the panel board to read the temperature of the exhaust gases.

Specification :

Type of engine	:	Twin Cylinder Four Stroke Diesel Engine
Type of cooling	:	Water Cooled
Brake power	:	10 h.p.
Speed	:	1500 r.p.m.
Bore diameter	:	80 mm
Stroke length	:	110 mm
Type of loading	:	Alternator With Bulb Loading
Loading capacity	:	6000 W
Orifice plate of air tank	:	20 mm

Formulae used :

Brake Power :

Brake horsepower is the measure of an engine's horsepower without the loss in power caused by the gearbox, generator, differential, water pump, and other auxiliary components such as alternator, power steering pump, muffled exhaust system, etc.

$$BP = V \times I = \frac{n \times 3600}{K \times t} \text{ KW}$$

n - no. of revolutions in energy meter disc

k - Energy meter constant – 300 rev / KW hr

t - time taken for n revolutions of energy meter disc in secs.

Total Fuel Consumption :

It is the mass of fuel consumed at particular load per hour.

$$TFC = \frac{10 \times s.g \times 3600}{t \times 1000} \text{ kg / hr.}$$

s.g - specific gravity of fuel in kg/m^3

t - Average time taken for 10 cc fuel consumption in secs.

Model Calculation:

Specific Fuel Consumption:

It is defined as the mass of fuel consumed per hour per Brake Power of the engine.

$$SFC = \frac{TFC}{BP} \quad Kg/KW\text{–}hr.$$

Input Power or Heat Supplied :

It is the heat supplied by the fuel .

$$HS = \frac{TFC \times CV}{3600} \quad KW.$$

CV - Calorific Value of Fuel in KJ / Kg.

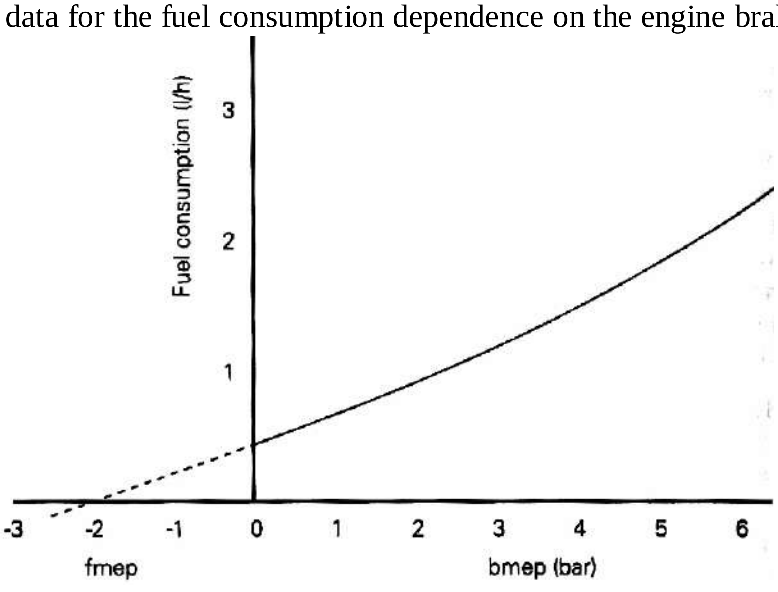
Frictional Power :

The frictional power of an engine is determined by Willan's Line Method. The concept of the Willann's line method is based on the fact that for any constant engine speed, the dependence of hourly fuel consumption vs engine brake power may be described with a suitable accuracy by a polynomial trend line of type

$$\mathbf{y=ax^2 + bx + c}.$$

It is assumed that this curve, extrapolated down to zero value of fuel consumption, intersects with the brake power axis at a point, which is taken as the mechanical losses value at the given engine speed .

According to this method, the mechanical losses are calculated for engine speed of 1500 rpm, where the data for the fuel consumption dependence on the engine brake power is taken from the engi



Model C

Indicated Power :

The power actually developed inside the cylinder due to the combustion of fuel is called indicated power .

$$IP = Fr.P + B.P. \quad KW$$

Mechanical Efficiency :

It is defined as the ratio of Brake Power to Indicated Power.

$$\eta_{MECH} = \frac{B.P}{I.P} \times 100$$

Brake Thermal Efficiency :

It is defined as the ratio of brake power to heat supplied by the combustion of fuel (fuel power).

$$\eta_{B.T.} \text{ or } \eta_{overall} = \frac{B.P}{H.S} \times 100$$

Indicated Thermal Efficiency :

It is defined as the ratio of indicated power to heat supplied by the combustion of fuel.

$$\eta_{I.T.} \text{ or } \eta_{thermal} = \frac{I.P}{H.S} \times 100$$

Procedure :

1. Calculate the maximum load that can be applied on the engine from its specifications.
2. Check the engine for fuel availability, lubricant and cooling water connections.
3. Release the load on engine completely and start the engine with no load applied in the brakes.
4. Allow the engine to run for few minutes to attain the rated speed.
5. Adjust the flow of cooling water and maintain steady flow along the cooling water jackets by verifying the outlet.
6. Apply the desired load, from no load slowly and steadily. At the desired load condition take note of the following observations.

i. Load on the engine.
ii. Speed of the engine.
iii. Time taken for 5 revolutions of energy meter disc.
iv. Time taken for 10 cc of fuel consumption.
v. Voltmeter Reading
vi. Ammeter Reading

9. Repeat the procedure up to desired load conditions and tabulate the readings.
10. Bring the engine back to no load conditions and shut down the engine.

Performance Curves :

Curves are plotted for the following characteristics.

1. Brake Power (BP) vs Total Fuel Consumption (TFC
2. Brake Power (BP) vs) Specific Fuel Consumption (SFC).
3. Brake Power (BP) vs η_{MECH}
4. Brake Power (BP) vs $\eta_{B.T}$
5. Brake Power (BP) vs $\eta_{I.T}$

Result :

The load test was conducted and the characteristic parameters of the engine were calculated and curves were drawn.

Date: **EXPERIMENT NO. 3**

PERFORMANCE AND EMISSION TEST OF A FOUR STROKE MULTI-CYLINDER PETROL ENGINE

Aim :

To conduct performance and emission test of a four stroke multi-cylinder petrol engine

Apparatus required :

1. Multi Cylinder Petrol Engine Experimental Setup with Ignition cut-off arrangement.
2. Loading Arrangements.
3. Stop Watch
4. Tachometer

Description:

The performance Test is a test conducted on a multi cylinder petrol engine to measure the indicated power and mechanical efficiency. The engine is made to run at maximum load at certain speed. The brake power is then measured when all cylinders are working. Then one cylinder is made in-operative by cutting-off the ignition to that cylinder. As a result of this the speed of the engine will decrease. Therefore the load on the engine is reduced so that the engine speed is restored to its initial value. The assumption made on the test is that frictional power depends on the speed and not on the load on the engine.

Specification :

Type of engine	:	Multi Cylinder Four Stroke Petrol Engine
Type of cooling	:	Water Cooled
Brake power	:	10 h.p.
Speed	:	1500 r.p.m.
Bore diameter	:	84 mm
Stroke length	:	82 mm
Capacity	:	1800 cc
Compression ratio	:	8.5 : 1.0
Type of loading	:	Hydraulic Dynamometer

TABULATION

Sl.No	Conditions	Load (N)	Speed (rpm)	Brake Power (KW)	Indicated Power (KW)
1	All cylinders are working				
2	First cylinder was cut-off and remaining are working				
3	Second cylinder was cut-off and remaining are working				
4	Third cylinder was cut-off and remaining are working				
5	Fourth cylinder was cut-off and remaining are working				

Note : The speed of the engine should be maintained constant.

Loading capacity	:	6000 w
Orifice plate of air tank	:	20 mm
Make	:	Isuzu

Formulae used :

Brake Power :

Brake horsepower is the measure of an engine's horsepower without the loss in power caused by the gearbox, generator, differential, water pump, and other auxiliary components such as alternator, power steering pump, muffled exhaust system, etc.

$$BP = \frac{W \times N}{C} \quad KW$$

W - Load revolutions in energy meter disc

N - Speed of the engine in r.p.m

C - Dynamometer Constant

Indicated Power :

Indicated power is the theoretical power of a reciprocating engine if it is completely frictionless in converting the expanding gas energy (piston pressure x displacement) in the cylinders. It is calculated from the pressures developed in the cylinders, measured by a device called an engine indicator - hence indicated horsepower. As the piston advances throughout its stroke, the pressure against the piston generally decreases, and the indicator device usually generates a graph of pressure vs stroke within the working cylinder. From this graph the amount of work performed during the piston stroke may be calculated. but is misleading because the mechanical efficiency of an engine means that the actual power output may only be 70% to 90% of the indicated horsepower.

Indicated Power of Cylinder # 1 :

$IP_1 = BP - BP_1$

BP - Brake Power of the engine when all four cylinders are working

BP_1 - Brake Power of the engine when cylinder # 1 is cut-off.

Similarly the Indicated Power of each of the cylinders is calculated.

Total Indicated Power = $IP_1 + IP_2 + IP_3 + IP_4$

Model Calculation:

Mechanical Efficiency :

It is defined as the ratio of Brake Power to Indicated Power.

$$\eta_{MECH} = \frac{B.P}{I.P} \times 100$$

Procedure :

1. Calculate the maximum load that can be applied on the engine from its specifications.
2. Check the engine for fuel availability, lubricant and cooling water connections.
3. Release the load on engine completely and start the engine with no load applied in the brakes.
4. Allow the engine to run for few minutes to attain the rated speed.
5. Adjust the flow of cooling water and maintain steady flow along the cooling water jackets by verifying the outlet.
6. Apply the load and increase the load up to maximum load. Now note the load on the engine and speed of the engine at this maximum load.
7. Cut-off the ignition of first cylinder. Now the speed of the engine will be observed to getting decreased. Reduce the load on the engine until the speed of the engine is maintained the same as before.
8. Bring all the four cylinders in working condition and repeat the same procedure by cutting-off cylinders one after the other and tabulate the load conditions. The engine is made to run at constant speed with variation in load when cylinders are cut-off.
9. Bring the engine back to no load conditions and shut down the engine.

Result :

Performance test is thus conducted on the multi cylinder petrol engine and indicated power developed in each cylinder is determined and mechanical efficiency is calculated.

Date: **EXPERIMENT NO. 4**

PERFORMANCE AND EMISSION TEST OF A FOUR STROKE MULTI-CYLINDER DIESEL ENGINE

Aim :

To conduct performance and emission test of a four stroke multi-cylinder Diesel engine

Apparatus required :

1. Multi Cylinder Disel Engine Experimental Setup with Ignition cut-off arrangement.
2. Loading Arrangements.
3. Stop Watch
4. Tachometer

Description:

The performance Test is a test conducted on a multi cylinder Diesel engine to measure the indicated power and mechanical efficiency. The engine is made to run at maximum load at certain speed. The brake power is then measured when all cylinders are working. Then one cylinder is made in-operative by cutting-off the ignition to that cylinder. As a result of this the speed of the engine will decrease. Therefore the load on the engine is reduced so that the engine speed is restored to its initial value. The assumption made on the test is that frictional power depends on the speed and not on the load on the engine.

Specification :

Type of engine	:	Multi Cylinder Four Stroke Diesel Engine
Type of cooling	:	Water Cooled
Brake power	:	10 h.p.
Speed	:	1500 r.p.m.
Bore diameter	:	84 mm
Stroke length	:	82 mm
Capacity	:	1800 cc
Compression ratio	:	8.5 : 1.0
Type of loading	:	Hydraulic Dynamometer

TABULATION

Sl.No	Conditions	Load (N)	Speed (rpm)	Brake Power (KW)	Indicated Power (KW)
1	All cylinders are working				
2	First cylinder was cut-off and remaining are working				
3	Second cylinder was cut-off and remaining are working				
4	Third cylinder was cut-off and remaining are working				
5	Fourth cylinder was cut-off and remaining are working				

Note : The speed of the engine should be maintained constant.

Loading capacity	:	6000 w
Orifice plate of air tank	:	20 mm
Make	:	Isuzu

Formulae used :

Brake Power :

Brake horsepower is the measure of an engine's horsepower without the loss in power caused by the gearbox, generator, differential, water pump, and other auxiliary components such as alternator, power steering pump, muffled exhaust system, etc.

$$BP = \frac{W \times N}{C} \quad KW$$

W - Load revolutions in energy meter disc

N - Speed of the engine in r.p.m

C - Dynamometer Constant

Indicated Power :

Indicated power is the theoretical power of a reciprocating engine if it is completely frictionless in converting the expanding gas energy (piston pressure x displacement) in the cylinders. It is calculated from the pressures developed in the cylinders, measured by a device called an engine indicator - hence indicated horsepower. As the piston advances throughout its stroke, the pressure against the piston generally decreases, and the indicator device usually generates a graph of pressure vs stroke within the working cylinder. From this graph the amount of work performed during the piston stroke may be calculated. but is misleading because the mechanical efficiency of an engine means that the actual power output may only be 70% to 90% of the indicated horsepower.

Indicated Power of Cylinder # 1 :

$$IP_1 = BP - BP_1$$

BP - Brake Power of the engine when all four cylinders are working

BP_1 - Brake Power of the engine when cylinder # 1 is cut-off.

Similarly the Indicated Power of each of the cylinders is calculated.

Total Indicated Power = $IP_1 + IP_2 + IP_3 + IP_4$

Model Calculation:

Mechanical Efficiency :

It is defined as the ratio of Brake Power to Indicated Power.

$$\eta_{MECH} = \frac{B.P}{I.P} \times 100$$

Procedure :

10. Calculate the maximum load that can be applied on the engine from its specifications.
11. Check the engine for fuel availability, lubricant and cooling water connections.
12. Release the load on engine completely and start the engine with no load applied in the brakes.
13. Allow the engine to run for few minutes to attain the rated speed.
14. Adjust the flow of cooling water and maintain steady flow along the cooling water jackets by verifying the outlet.
15. Apply the load and increase the load up to maximum load. Now note the load on the engine and speed of the engine at this maximum load.
16. Cut-off the ignition of first cylinder. Now the speed of the engine will be observed to getting decreased. Reduce the load on the engine until the speed of the engine is maintained the same as before.
17. Bring all the four cylinders in working condition and repeat the same procedure by cutting-off cylinders one after the other and tabulate the load conditions. The engine is made to run at constant speed with variation in load when cylinders are cut-off.
18. Bring the engine back to no load conditions and shut down the engine.

Result :

Performance test is thus conducted on the multi cylinder Diesel engine and indicated power developed in each cylinder is determined and mechanical efficiency is calculated.

Date: **EXPERIMENT NO. 5**

MORSE TEST ON A MULTI CYLINDER PETROL ENGINE

Aim :

To conduct Morse test on a multi cylinder petrol engine in order to determine the indicated power developed in each cylinder of the engine.

Apparatus required :

1. Multi Cylinder Petrol Engine Experimental Setup with Ignition cut-off arrangement.
2. Loading Arrangements.
3. Stop Watch
4. Tachometer

Description:

The Morse Test is a test conducted on a multi cylinder petrol engine to measure the indicated power and mechanical efficiency. The engine is made to run at maximum load at certain speed. The brake power is then measured when all cylinders are working. Then one cylinder is made in-operative by cutting-off the ignition to that cylinder. As a result of this the speed of the engine will decrease. Therefore the load on the engine is reduced so that the engine speed is restored to its initial value. The assumption made on the test is that frictional power depends on the speed and not on the load on the engine.

Specification :

Type of engine	:	Multi Cylinder Four Stroke Petrol Engine
Type of cooling	:	Water Cooled
Brake power	:	10 h.p.
Speed	:	1500 r.p.m.
Bore diameter	:	84 mm
Stroke length	:	82 mm
Capacity	:	1800 cc
Compression ratio	:	8.5 : 1.0
Type of loading	:	Hydraulic Dynamometer

TABULATION

Sl.No	Conditions	Load (N)	Speed (rpm)	Brake Power (KW)	Indicated Power (KW)
1	All cylinders are working				
2	First cylinder was cut-off and remaining are working				
3	Second cylinder was cut-off and remaining are working				
4	Third cylinder was cut-off and remaining are working				
5	Fourth cylinder was cut-off and remaining are working				

Note : The speed of the engine should be maintained constant.

Loading capacity	:	6000 w
Orifice plate of air tank	:	20 mm
Make	:	Isuzu

Formulae used :

Brake Power :

Brake horsepower is the measure of an engine's horsepower without the loss in power caused by the gearbox, generator, differential, water pump, and other auxiliary components such as alternator, power steering pump, muffled exhaust system, etc.

$$BP = \frac{W \times N}{C} \quad KW$$

W - Load revolutions in energy meter disc

N - Speed of the engine in r.p.m

C - Dynamometer Constant

Indicated Power :

Indicated power is the theoretical power of a reciprocating engine if it is completely frictionless in converting the expanding gas energy (piston pressure x displacement) in the cylinders. It is calculated from the pressures developed in the cylinders, measured by a device called an engine indicator - hence indicated horsepower. As the piston advances throughout its stroke, the pressure against the piston generally decreases, and the indicator device usually generates a graph of pressure vs stroke within the working cylinder. From this graph the amount of work performed during the piston stroke may be calculated. but is misleading because the mechanical efficiency of an engine means that the actual power output may only be 70% to 90% of the indicated horsepower.

Indicated Power of Cylinder # 1 :

$$IP_1 = BP - BP_1$$

BP - Brake Power of the engine when all four cylinders are working

BP_1 - Brake Power of the engine when cylinder # 1 is cut-off.

Similarly the Indicated Power of each of the cylinders is calculated.

Total Indicated Power = $IP_1 + IP_2 + IP_3 + IP_4$

Model Calculation:

Mechanical Efficiency :

It is defined as the ratio of Brake Power to Indicated Power.

$$\eta_{MECH} = \frac{B.P}{I.P} \times 100$$

Procedure :

1. Calculate the maximum load that can be applied on the engine from its specifications.
2. Check the engine for fuel availability, lubricant and cooling water connections.
3. Release the load on engine completely and start the engine with no load applied in the brakes.
4. Allow the engine to run for few minutes to attain the rated speed.
5. Adjust the flow of cooling water and maintain steady flow along the cooling water jackets by verifying the outlet.
6. Apply the load and increase the load up to maximum load. Now note the load on the engine and speed of the engine at this maximum load.
7. Cut-off the ignition of first cylinder. Now the speed of the engine will be observed to getting decreased. Reduce the load on the engine until the speed of the engine is maintained the same as before.
8. Bring all the four cylinders in working condition and repeat the same procedure by cutting-off cylinders one after the other and tabulate the load conditions. The engine is made to run at constant speed with variation in load when cylinders are cut-off.
9. Bring the engine back to no load conditions and shut down the engine.

Result :

Morse test is thus conducted on the multi cylinder petrol engine and indicated power developed in each cylinder is determined and mechanical efficiency is calculated.

Date: **EXPERIMENT NO. 6**

PERFORMANCE TEST OF A BIO-FUEL ON A VARIABLE COMPRESSION RATIO ENGINE

Aim :

To conduct a load test on variable compression ratio engine to determine the following at various load conditionsand to draw the performance curves.

1. Brake Power of the engine
2. Indicated Power of the engine
3. Total Fuel Consumption
4. Specific Fuel Consumption
5. Mechanical efficiency
6. Brake Thermal Efficiency
7. Indicated Thermal Efficiency

Apparatus required:

1. VCR Engine Experimental Setup.
2. Stop Watch
3. Measuring Tape

Specification :

Type of engine	Twin Cylinder Four Stroke Diesel Engine
Type of cooling	Water Cooled
Brake power	10 h.p.
Speed	1500 r.p.m.
Bore diameter	80 mm
Stroke length	110 mm
Type of loading	Alternator With Bulb Loading
Loading capacity	6000 W
Orifice plate of air tank	20 mm

OBSERVATION AND TABULATION

Sl.No	Load (Watts)	Voltage(Volts)	Current (Amperes)	Time taken for 10cc fuel fall (secs)	Time taken for 5 revolutions of energymeter disc(Secs)

Formulae used :

Brake Power :

Brake horsepower is the measure of an engine's horsepower without the loss in power caused by the gearbox, generator, differential, water pump, and other auxiliary components such as alternator, power steering pump, muffled exhaust system, etc.

$$BP = V \times I = \frac{n \times 3600}{K \times t} \quad KW$$

n-no. of revolutions in energy meter disc

k-Energy meter constant – 300 rev / KW hr

t-time taken for n revolutions of energy meter disc in secs.

Total Fuel Consumption :

It is the mass of fuel consumed at particular load per hour.

$$TFC = \frac{10 \times s.g \times 3600}{t \times 1000} \quad kg / hr.$$

s.g-specific gravity of fuel in kg/m^3

t-Average time taken for 10 cc fuel consumption in secs.

Specific Fuel Consumption:

It is defined as the mass of fuel consumed per hour per Brake Power of the engine.

$$SFC = \frac{TFC}{BP} \quad Kg/KW\text{–}hr.$$

Input Power or Heat Supplied :

It is the heat supplied by the fuel .

$$HS = \frac{TFC \times CV}{3600} \quad KW.$$

CV-Calorific Value of Fuel in KJ / Kg.

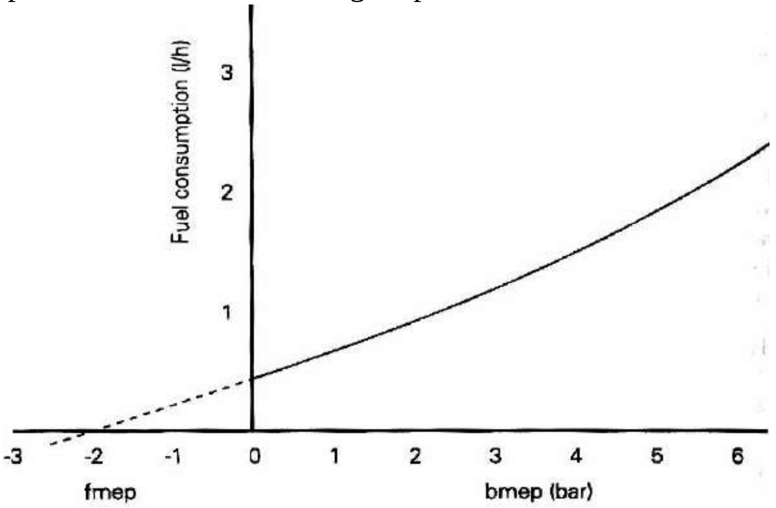
Frictional Power :

The frictional power of an engine is determined by Willan's Line Method. The concept of the Willann's line method is based on the fact that for any constant engine speed, the dependence of hourly fuel consumption vs engine brake power may be described with a suitable accuracy by a polynomial trend line of type

$$y = ax^2 + bx + c.$$

Model Calculation:

It is assumed that this curve, extrapolated down to zero value of fuel consumption, intersects with the brake power axis at a point, which is taken as the mechanical losses value at the given engine speed .According to this method, the mechanical losses are calculated for engine speed of 1500 rpm, where the data for the fuel consumption dependence on the engine brake power is taken from the engine performance tests.



Indicated Power :

The power actually developed inside the cylinder due to the combustion of fuel is called indicated power .

$$IP = Fr.P + B.P. \quad KW$$

Mechanical Efficiency :

It is defined as the ratio of Brake Power to Indicated Power.

$$\eta_{MECH} = \frac{B.P}{I.P} \times 100$$

Brake Thermal Efficiency :

It is defined as the ratio of brake power to heat supplied by the combustion of fuel (fuel power).

$$\eta_{B.T.} \text{ or } \eta_{overall} = \frac{B.P}{H.S} \times 100$$

Indicated Thermal Efficiency :

It is defined as the ratio of indicated power to heat supplied by the combustion of fuel.

$$\eta_{I.T.} \text{ or } \eta_{thermal} = \frac{I.P}{H.S} \times 100$$

Model Calculation:

Procedure :

1. Calculate the maximum load that can be applied on the engine from its specifications.
2. Check the engine for fuel availability, lubricant and cooling water connections.
3. Release the load on engine completely and start the engine with no load applied in the brakes.
4. Allow the engine to run for few minutes to attain the rated speed.
5. Adjust the flow of cooling water and maintain steady flow along the cooling water jackets by verifying theoutlet.
6. Apply the desired load, from no load slowly and steadily. At the desired load condition take note of thefollowing observations.
   a. Load on the engine.
   b. Speed of the engine.
   c. Time taken for 5 revolutions of energy meter disc.
   d. Time taken for 10 cc of fuel consumption.
7. Repeat the procedure up to desired load conditions and tabulate the readings.
8. Bring the engine back to no load conditions and shut down the engine.

Performance Curves :

Curves are plotted for the following characteristics.

1. Brake Power (BP) vs Total Fuel Consumption (TFC
2. Brake Power (BP) vs) Specific Fuel Consumption (SFC).
3. Brake Power (BP) vs η_{MECH}
4. Brake Power (BP) vs $\eta_{B.T}$
5. Brake Power (BP) vs $\eta_{I.T}$

Result:

The load test was conducted and the characteristic parameters of the engine were calculated and curves were drawn.