Mechanical Engineering Department
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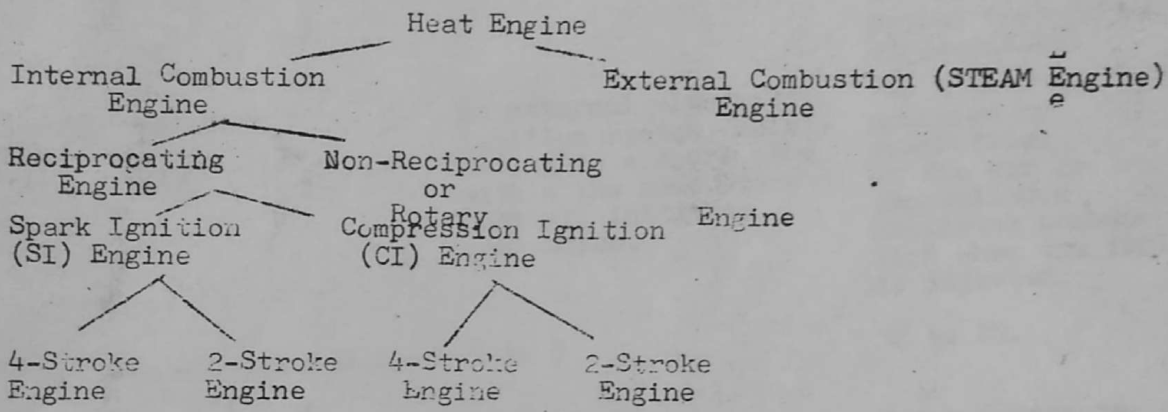
ME : 309 I. C. ENGINES

The role played by Internal Combustion Engines in modern Civilization is very significant. As a matter of fact the rise in civilazation may be closely tied to improvements in transportation, the developments of which in turn are closely tied with the developments in internal combustion engines. Developments pertaining to transportation have enabled peoples of the world to exchange their goods more freely, to travel widely and to understand better the customs and traditions of other nations. With the advent of more rapid forms of transportation, greater exchange has resulted and more people have profited. Cultural and scientific gains have been particularly gratifying.

Internal Combustion (I.C) Engine can be classified under the broad heading - Heat Engine. Heat Engine is a device which converts the chemical energy of fuel into the mechanical energy.



The internal combustion engine is a complex apparatus, Figure 1, indicates the multitude of subjects which enter into the design of a combustion engine. It can be seen that a detailed understanding of this type of engine requires a knowledge of many engineering subjects.

In an I. C. Engine, there will be four distinct events taking place in every cycle ofoperation of the engine. They are : (1) Intake, (2) Compression, (3) Power, (4) Exhaust.

In a 4-stroke engine each of the above events requires one stroke of the engine. One stroke of the engine occurs in half a revolution of the crankshaft of the engine. Thus in a 4-stroke engine one complete cycle of operation occurs in every two revolutions of the crankshaft. In other words, there will be only one power stroke in every two revolutions of the crankshaft.

In a 2-stroke engine, the four basic operations viz. intake compression, power and exhaust are accomplished in only 2-strokes of the engine. Thus there will be one power stroke in every one revolution of the crankshaft. Hence a 2-stroke engine theoretically gives double the power output of a comparable (Same cylinder size, same speed, etc.) 4-stroke engine.

A 2-stroke petrol (SI) engine has an inherent draw back of loss of combustible mixture through escape with the exhaust gases and the resultant high fuel comsumption. In spite of its less fuel economy, however, 2-stroke petrol engines are used widely for scooters, motor cycles, outboard motors etc., because of its lightness, simplicity in construction (specially by elimination of valves and valve operating mechanism) greater power output from the same size engine.

Fundamental Differences between SI & CI Engines :

		S. I. Engine	C. I. Engine
1)	Basic Thermodynamic cycle	Otto Cycle	Diesel Cycle
2)	Introduction of fuel	Fuel and air are introducced into the combustion chamber as a gaseous mixture.	Fuel is introduced (at about the end of the compression process) directly into the combustion chambér through a fuel injection nozzle and the air is inducted through the air manifold.
3)	Ignition	An external electrical ignition system, culminating in a spark plug within the combustion chamber, initiates combustion.	The high temp. produced by compression of the air in the cylinder Initiates combustion when the fuel is injected.
4)	Compression ratio range.	5 to 9	12 to 22.
5)	Weight	Light	Heavy (Since it operates at considerably high pressures, must be built with greater strength).

Application :

1) Transporhation :

a) By Road : Cars, Buses, Trucks, Scooters, Motor cycles, etc.
b) By Rail : Locomotive engines
c) By Air : Aeroplanes, Helicopters, etc.
d) By Sea : Marine engines.

2) Industry : As a prime mover for electric generators, welding sets grinders, crushers, pumps, compressors, Fork lifts, Mobile cranes, etc.

3) Agriculture : For water pumping-sets, Tractors, all sorts of power driven agricultural implements (harvestors, thrashers, etc.)

4) Earthmoving and construction Equipment : Dumpers, excavators, compressors, welding sets, etc.

5) Defence Equipment :

a) All sorts of transportation vehicles.
b) Tanks, (c) Mobile power plants, signal generators, battery chargers, etc.

S. I. Engine Operating Principles :

1. Intake Stroke : Intake valve open - exhaust valve closed-piston moving down brings in fresh combustible mixture of fuel and air from carburettor.

2. Compression Stroke :

   Both valves closed - combustible charge is compressed by the upward moving piston.

3. Power Stroke :

   Both valves closed - compressed combustible charge is ignited by the spark plug and expanding gases force piston down.

4. Exhaust Stroke :

   Exhaust valve open - intake valve closed, productsof combustion forced out through the exhaust valve by the upward moving piston.

C. I. Engine Operating Principles :

1. Intake stroke :

   Intake valve open - exhaust valve closed - piston moving down brings in fresh air from the atmosphere.

2. Compression stroke :

   Both valves closed - air is compressed by the upward moving piston.

3. Power Stroke :

   Both valves closed - fuel injected into the hot compressed air layer which ignites the fuel and the expanding gases force piston down.

4. Exhaust stroke :

   Exhaust valve open - intake valve closed - products of combustion forced out through the exhaust valve by the upward moving piston.

DEPARTMENT OF MECHANICAL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR
INTERNAL COMBUSTION ENGINES LABORATORY INSTRUCTION SHEET

EXPERIMENT No.

TITLE : LOAD TEST ON A MULTI-CYLINDER DIESEL ENGINE

OBJECT : To perform load test on a Perkins Diesel Engine and to draw performance curves.

EQUIPMENT : Four stroke, four cylinder, water cooled Perkins Diesel Engine coupled to a hydraulic dynamometer; tachometer; stopwatch, fuel measuring device.

THEORY : Brake thermal efficiency of an engine is defined as th ratio of the power available at the shaft to the heat input for the engine.

$$\eta_{bth} = \frac{\text{Power available at shaft}}{\text{Heat input}}$$

BSFC or brake specific fuel consumption is defined as :

$$\text{BSFC} = \frac{\text{Fuel Consumption (kg/hr)}}{\text{BHP (kw)}}$$

These parameters enable us to take a comparative look at different engines from a performance point of view.

Dynamometer Constant (D.C.) = 1500

BHP = (Load x RPM)/D.C.

Calorific Value of fuel = 39,000 kJ/kg

Fuel Density = 0.84 gm/cc

PROCEDURE :

1. Before the engine is started, the cooling water system, the lubricating oil system and the fuel supply system have to be checked.

2. Atmospheric pressure and temperature have to be recorded before starting the test.

3. With a zero load applied (i.e. no water being supplied to the dynamometer), the engine RPM is adjusted to a certain level (e.g. 1000 rpm). This is achieved by adjusting the manual fuel control valve/lever and checking the speed by a tachometer. The dynamomete has to be made horizontal by turning the hand wheel and checking at the leveling pointers; this is needed for every data point recorded. The speed needs to be checked at this point again and necessary adjustment has to be made.

4. When steady-state is reached, time taken by the engine to consu 20 ~~50~~ ml of fuel is measured by a stopwatch.

5. Gradually increasing loads are applied by opening up the water line to the dynamometer and for each load level the fuel consumptio timeis recorded. The speed (rpm) is maintained constant by adjusti the fuel control lever. For each data point sufficient time should allowed for the system to reach steady-state.

$$\text{fuel consumption} = \frac{V_d \cdot \rho_d (3600)}{\text{time (sec)}} = \frac{kg}{hr}$$

Contd.......2

$$V_d = \frac{20 \times 0.84 \times 3600}{\text{time (sec)} \times 1000} =$$

RESULTS : Plot BHP vs thermal efficiency, BHP vs. FC (kg/hr) and BHP vs. BSFC (kg/kW-hr) and compare these plots with the theoretically expected graphs and discuss the deviations, if any. Tabulate measured and calculated parameters and show one sample calculation.

Serial No.	RPM	LOAD (kg)	Time to consume ~~50~~ 20 ml. of fuel (Sec.)	Exhaust Smoke (%)

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$\eta_{BT} = \frac{B.P}{\dot{m}_f CV}$

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$B.P = \frac{2\pi NT}{60} = \frac{Load \times N}{D.C.}$

INSTRUCTION SHEET

TITLE : To study I.C. Engine Models.

OBJECT: To study the working principles of 4-stroke S.I. Engine, 4-stroke C.I. Engine and 2-stroke S.I/C.I Engine.

2) To identify the main components of I.C. Engines and know their functions with the help of Models.

APPARATUS: Sectioned Models of 4-stroke S.I. Engine, 4-stroke C.I. Engine and 2-stroke S.I./C.I. Engine.

THEORY: 4-stroke S.I. Engine Operating Principles

1) Intake Stroke: Intake valve open-exhaust valve closed-piston moving down brings in fresh combustible mixture of fuel and air from carburettor.

2) Compression stroke: Both valves closed - combustible charge is compressed by the upward moving piston.

3) Power Stroke : Both valves closed - compressed combustible charge is ignited by the spark plug and expanding gases force piston down.

4) Exhaust Stroke : Exhaust valve open - intake valve closed - products of combustion forced out through the exhaust valve by the upward moving piston.

4-Stroke C.I. Engine operating principles

1) Intake stroke : Intake valve open-exhaust valve closed-piston moving down brings in fresh air from the atmosphere.

2) Compression Stroke: Both valves closed - air is compressed by the upward moving piston.

3) Power Stroke: Both valves closed - fuel injected into the hot compressed air layer which ignites the fuel and the expanding gases force piston down.

4) Exhaust Stroke: Exhaust valve open - intake valve closed-products of combustion forced out through the exhaust valve by the upward moving piston.

2-Stroke Engine Operating Principles

In a 2-Stroke engine, the four basic operations viz. intake, compression, power and exhaust are accomplished in only 2-strokes of the engine. Thus there will be one power stroke in every one revolution of the crankshaft. Generally there will not be valves and hence valve operating mechanism in 2-stroke engines. In place of valves there are ports in the cylinder. These ports are covered and uncovered by the moving piston.

The main components of the engine and their function are described below:

Sl.No.	Component	Function
1.	Cylinder Block	To hold the moving piston inside and provide a gas tight combustion chamber in conjunction with the cylinder head.
2.	Crank Case	to house the crankshaft and provide space for lubricating oil.
3.	Piston	to transmit the forces due to expanding gases, to the connecting rod.
4.	Connecting Rod	to convert the reciprocating motion of the piston to the rotary motion with the help of crankshaft.
5.	Crankshaft	to provide rotary motion
6.	Carburettor	to provide air fuel mixture in the required proportion, to the engine during intake (suction) stroke.
7.	Spark Plug	to initiate the combustion process by providing a high tension electrical spark inside the compressed combustible mixture.
8.	Fuel Pumps	to supply the required quantity of fuel at high pressure to the fuel injector.
9.	Fuel Injector	to atomise the fuel and introduce the fuel in the form of fine spray into the hot compressed air layer.
10.	Camshaft	to actuate the intake and exhaust valves and also the fuel pump - case of C.I. Engine.
11.	Inlet valve	to open only during the intake stroke to allow the fresh charge to be inducted.
12.	Exhaust valve	to open only during the exhaust strokes to allow the products of combustion to leave the cylinder.

S. I. Engine Operating Principles :

1. Intake Stroke : Intake valve open - exhaust valve closed-piston moving down brings in fresh combustible mixture of fuel and air from carburettor.

2. Compression Stroke :

Both valves closed - combustible charge is compressed by the upward moving piston.

3. Power Stroke :

Both valves closed - compressed combustible charge is ignited by the spark plug and expanding gases force piston down.

4. Exhaust Stroke :

Exhaust valve open - intake valve closed, productsof combustion forced out through the exhaust valve by the upward moving piston

C. I. Engine Operating Principles :

1. Intake stroke :

Intake valve open - exhaust valve closed - piston moving down brings in fresh air from the atmosphere.

2. Compression stroke :

Both valves closed - air is compressed by the upward moving piston.

3. Power Stroke :

Both valves closed - fuel injected into the hot compressed air layer which ignites the fuel and the expanding gases force piston down.

4. Exhaust stroke :

Exhaust valve open - intake valve closed - products of combustion forced out through the exhaust valve by the upward moving piston.

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INSTRUCTION SHEET

EXPERIMENT NO.

TITLE MORSE TEST ON A MULTI CYLINDER PETROL ENGINE

OBJECT - To perform 'Morse Test' on a Multi cylinder petrol engine at different speeds and determine I.H.P. and F.H.P and mechanical efficiency of the engine.

EQUIPMENT Mahindra and Mahindra 4- cylinder, water cooled petrol engine coupled to Heenan & Froude Hydraulic Dynamometer.

THEORY In Morse Test, the basic principle consists of rendering inoperative in turn, each cylinder of the engine, and noting the reduction in B.H.P developed.

With a petrol engine each cylinder is rendered inoperative by 'Shorting' the sparking plug of the cylinder; with a Diesel engine, by cutting off the supply of fuel.

For a multi-cylinder engine (say 'n' cylinders) we know that

$$(B.H.P)_n = (I.H.P)_n - (F.H.P)_n \quad \ldots \quad (I)$$

cutting out one cylinder, but maintaining the r.p.m. constant (by decreasing the load on the engine) so as to maintain the F.H.P constant, we can write

$$(B.H.P)_{n-1} = (I.H.P)_{n-1} - (F.H.P)_n \quad \ldots \quad (II)$$

By assuming that the friction losses are the same when the cylinder is inoperative as when working and by deducting equation II from equation I, we can write

$$(B.H.P)_n - (B.H.P)_{n-1} = (I.H.P)_n - (I.H.P)_{n-1}$$

$$= (I.H.P)_{\text{cut. off cylinder.}}$$

TEST PROCEDURE :

1) Check the lubricating oil system, cooling water system and fuel system.

2) Disengage the dynamometer from the engine (by putting the gear in 'neutral' position) and start the engine with the help of starting motor.

3) Engage the dynamometer and allow the water to flow through the dynamometer by opening the inlet and outlet-valves.

4) Load the engine gradually with the help of the dynamometer upto the desired value and maintain the speed constant at the specified value by adjusting the throttle valve.

5) With the help of a wire, short circuit the spark plug of No. 1 cylinder. Then you will see that the speed decreases.

6) Increase the speed by decreasing the load on the dynamometer. (Throttle valve <u>should not</u> be operated)

7) Note the load (spring balance reading) on the dynamometer and record the reading in the observation table.

) Remove the wire and short circuit the spark plug of No. 2 cylinder.

9) Repeat steps (6) and (7)

10) Short circuit the spark plugs of No. 2 and No. 4 cylinders, in turn and repeat steps (6) & (7).

11) After the test is completed, gradually decrease the load, disengage the dynamometer and stop the engine.

12) Stop the cooling water circulation and close the fuel cock.

APPENDIX

Sample calculation

OBSERVATIONS

Sl.No.	Speed R.P.M	Initial load on Dynamometer	LOAD with No.1 cyl. shorted.	with No.2 cyl. shorted.	with No.3 cyl. shorted.	with No.4 cyl. shorted.
1.	1400					
2.	1600					
3.	1800					
4.	2000					
5.	2200					
6.	2400					

RESULTS

Sl.No.	Speed (R.P.M)	I.H.P.	B.H.P.	F.H.P.	Mech. Efficiency
1.	1400				
2.	1600				
3.	1800				
4.	2000				
5.	2200				
6.	2400				