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LECTURE NOTES

BASIC MECHANICAL ENGINEERING

(BT-203)

Year : I Semester : I/II

UNIT-V

RECIPROCATING MACHINES

Part 1-CONSTRUCTION OF I.C. ENGINES

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CHAPTER NO. 1
Construction of I.C. Engines

1.1 INTRODUCTION

Any machine which derives heat energy from the combustion of fuel and coverts part of this energy into mechanical work is known as a heat engine. Heat engines are mainly divided into two groups, viz., external combustion engine and internal combustion engine.

In the case of external combustion engines, the combustion of fuel takes place outside the cylinder as in the case of steam engines. The other examples of external combustion engines are hot air engine, steam turbines and closed cycle gas turbines. In external combustion engines, first the heat of combustion is transferred to the working fluid outside the cylinder and then the fluid is expanded to develop the power.

The other types of engines, which are extensively used in practice, are internal combustion engines. In internal combustion engines, the combustion of fuel in the presence of air takes place inside the cylinder and products of combustion directly act on piston to develop the power. The internal combustion engines are further classified as petrol engines, diesel engines and gas engines according to the type of fuel used. These are commonly used for road vehicles, locomotives and several industrial applications. The maximum capacity of these engines is limited.

Compared to steam engines (external combustion engines), the I.C. engines are noted for:

- High overall efficiency. The efficiency of I.C. engines ranges from 30 to 35% whereas efficiency of steam engines lies between 15- 20%.
- compact and small size.

- low weight to power ratio.
- easy and quick starting. In steam engines, firing of the boiler and generation of steam takes sufficient time.
- less maintenance and operating cost.

The important applications of IC engines are: -

- Road vehicles, locomotives, ships and aircraft. As such LC. engines enable passengers and cargos to cross lands, oceans and skies
- Portable stand by units for power generation in case of scarcity of electric power.
- Extensively used in farm tractors, lawn movers, concrete mixing devices and motor boats.

1.2 CLASSIFICATION OF IC ENGINES

The internal combustion engines are classified according to:

1. Number of strokes. They are divided into the following groups.

   (a) Two-stroke engines. In two-stroke engines, there is one power stroke in every two strokes or one rotation of the crankshaft.

   (b) Four-stroke engines. In four-stroke engines, there is one power stroke in every four strokes or one during two rotations of the crankshaft.

2. Cycle of operation. They are divided into the following groups:

   (a) Otto-cycle. (b) Diesel cycle. (c) Dual cycle.

3. The fuel used. On this basis they are classified as:

   (a) Petrol engines. (b) Diesel engines or heavy oil engines. (c) Gas engines.

4. The method of ignition. On this basis, they are divided into the two following classes,

   (a) Spark ignition engines. (S.I. engines) (b) Compression ignition engines. (C.I. engines).

5. The method of cooling. On this basis they are classified into two groups.

   (a) Air-cooled engines. (b) Water-cooled engines.

6. The method of governing

   (a) Quantity governing. (b) Quality governing. (c) Hit and Miss-governing.

7. The use of engines. The following is the classification on this basis:

   (a) Stationary engines. (b) Automobile engines or engines for road vehicles. (c) Marine engines. (d) Aero-engines. (e) Locomotive engines.

8. The arrangement of the cylinders. They can be classified as given below:

   (a) Inline engine. All the cylinders are arranged in a line and the power is taken from a single crankshaft., This arrangement is used in automobiles.

   (b) V-type. It is a combination' of two inline engines set at an angle. The angle of V may vary from 30° to 75°. The length of the crankshaft of V-type engine is half of the crankshaft used for inline engine. This type is also used in automobiles.

   (c) Opposed piston engine. The pistons reciprocate in a common cylinder having common combustion chamber at the centre. Opposed piston type is used in small air crafts and in some diesel installations.

   (d) Radial engines. All the cylinders are set along the radius of a circle. The connecting rods point towards the centre of the circle. The connecting rods of all the pistons work on a single crank pin which rotates around the centre of the circle. The radial engine occupies little floor space and simplifies the balancing problems. This type was popular in aircrafts.

   (e) Rotary engine. The engine consists of three-sided convex-type piston rotating in a cylinder. This type of engine is known as 'Wankel' engine. It is of high speed-type, light in weight and works on spark ignition system.

1.3 PARTS OF IC ENGINE

The arrangements of different IC engine parts are shown in Fig. 1.1. The purpose of each part is described in short as follows:

(a) Cylinder. The cylinder of an I.C. engine is considered as the main body of the engine in which piston reciprocates to develop power. It has to withstand very high pressures (about 70 bar) and temperatures (about 2200°C) because there is direct combustion inside the cylinder. Therefore, its material should be such that it can retain strength at high temperatures, should be good conductor of heat and should resist to rapid wear and tear due to reciprocating parts. Generally ordinary cast iron is used, but in case of heavy-duty engines, alloy steels are used. Sometimes, when engine blocks are heavy and for easy maintenance, sleeves or liners are inserted into the cylinders which can be replaced when worn out. Liners are generally made of Nickel chrome iron.

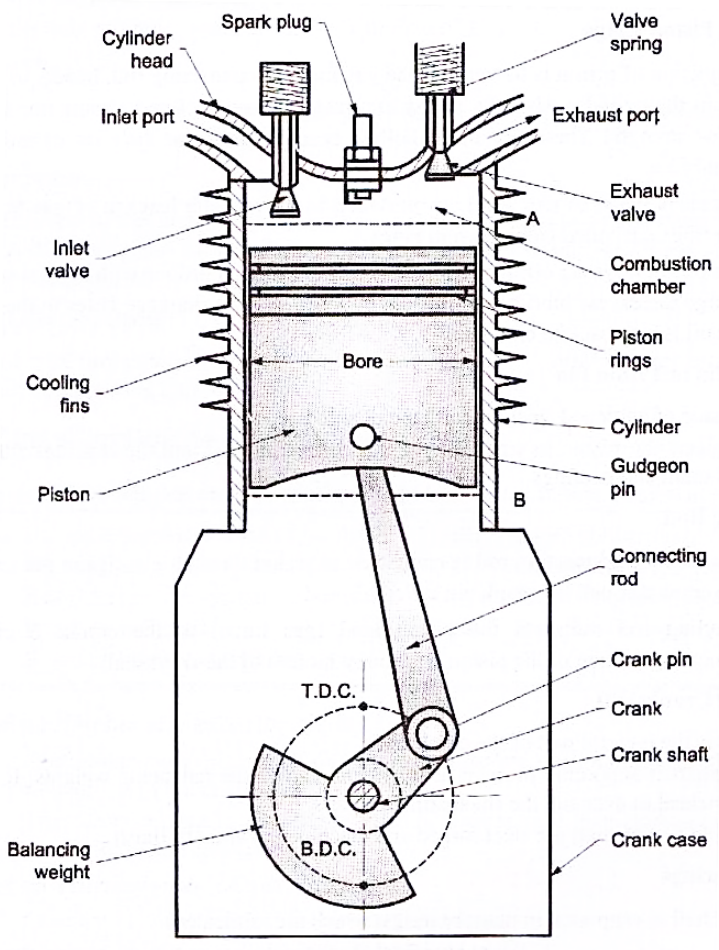

Fig.1.1 Different IC engine parts

(b) Cylinder head. The cylinder head closes one end of the cylinder. It houses the inlet and exhaust valves through which the charge is taken inside the cylinder and burned gases are exhausted to the atmosphere from the cylinder. Cylinder head is usually cast as one piece and bolted to the top

of the cylinder. A copper and asbestos gasket are provided between the cylinder and cylinder-head to obtain a gas-tight joint. The material used for the cylinder-head is also cast iron.

(c) Combustion Chamber. It is the space between the cylinder head and the piston top where combustion takes place.

(d) Piston and Piston Rings. The functions of the piston are to compress the charge during compression stroke and to transmit the gas force to the connecting rod and then to the crank during power stroke. The pistons of I.C. engines are usually made of cast iron, cast steel and aluminium alloy. The aluminium alloy has the advantage of higher thermal conductivity and lower specific gravity. Piston is the heart of the engine.

The piston rings are housed in the circumferential grooves provided on the outer surface of the piston. It gives gastight fitting between the piston and the cylinder and prevents the leakage of high-pressure gases. These are made of special grade cast iron. This material retains its elastic property at very high temperature. The upper piston rings are called the compression rings and the lower piston rings are called the oil control rings.

(e) Connecting Rod. It is usually a steel forging of circular, rectangular, I, T, or H section and is highly polished for increased endurance strength. Its small end forms a hinge and pin joint with the piston and its big end is connected to the crank by crank pin. It has a passage for the transfer of lubricating oil from the big end bearing to small end bearing (gudgeon pin).

(f) Crank and Crankshaft. Both crank and crankshaft are steel forgings machined to a smooth finish. The two are held together by means of a key. Crankshaft is supported in main bearings and has a heavy wheel, called flywheel, to even out the fluctuations of torque. The power required for any useful purpose is taken from crankshaft only. The crankshaft is the backbone of the engine.

(g) Piston Pin or Wrist Pin. The piston pin provides the bearing for the oscillating small end of the connecting rod.

(h) Inlet Manifold. It is the passage which carries the charge to combustion chamber.

(i) Exhaust Manifold. It is the passage which carries the exhaust gases from combustion chamber to the atmosphere.

(j) Crank case. It is the base which holds the cylinder and crankshaft. It also serves as the sump for the lubricating oil.

(k) Cooling Fins. The fins are provided as shown in Fig. 1.1 and are used for cooling the engine.

(l) Flywheel. It is a wheel mounted on the crankshaft (not shown in Fig 1.1.) which stores excess energy during the power stroke and returns that energy during the other strokes and maintains a fairly constant output torque on the crankshaft (reduces cyclic variation of speed).

(m) Governor. It is run by a drive from the crankshaft. The function of the governor is to regulate the charge in case of petrol engine and amount of fuel in case of Diesel engine to maintain the speed of the engine constant, when the load requirement varies.

(n) Carburetor. The function of the carburetor is to supply the uniform air-fuel to the cylinder of a petrol engine through the intake manifold. The mass of the mixture entering the cylinder is controlled by a throttle valve.

(o) Spark Plug. The function of the spark plug is to initiate the mixture after completing the compression in the petrol engine, it is generally mounted in the cylinder head. This is only used in petrol engine.

(p) Fuel Pump. It forces the fuel oil at high pressure through fuel nozzle into the cylinder at the end of compression stroke in diesel engine.

(q) Fuel Injector/Nozzle. The function of fuel nozzle is to break-up the oil into a fine spray as it enters the cylinder of diesel engine.

(r) Valves:
(i) Inlet Valve. This valve controls the admission of the charge into-the petrol engine or air into diesel engine during suction stroke of the engine.

(ii) Exhaust Valve. The removal of exhaust gases after doing work on the piston, is controlled by this valve. Both valves are kept enclosed by the valve springs.

(s) Cam-shaft. The function of the cam shaft is to operate the intake and exhaust valves. through the cams, cam followers, push rods and rocker arms. The cam shaft is driven positively from the crankshaft at half the speed of the crankshaft.

(t) Cam and Cam-follower. It is made of a required profile to give desired motion to the valve through the follower.

(u) Push-rod and Rocker Arm. The motion of the cam is transmitted to the valve through the push rod and rocker arm. These links together are also known as valve gear.

(v) Ports:
(i) Suction/Inlet & Exhaust port: In two stroke engine the ports are provided for charge inlet and exhaust outlet. Both ports are uncovered and closed by the moving piston.

(ii) Transfer port: In two stroke engine the transfer port is used for transfer of charge from crankcase to cylinder.

1.4 IC ENGINES TERMINOLOGY

The following terminology is commonly used in I.C. engines (Fig. 1.2 and 1.3).

1. Bore. The inside diameter of the cylinder is known as bore.

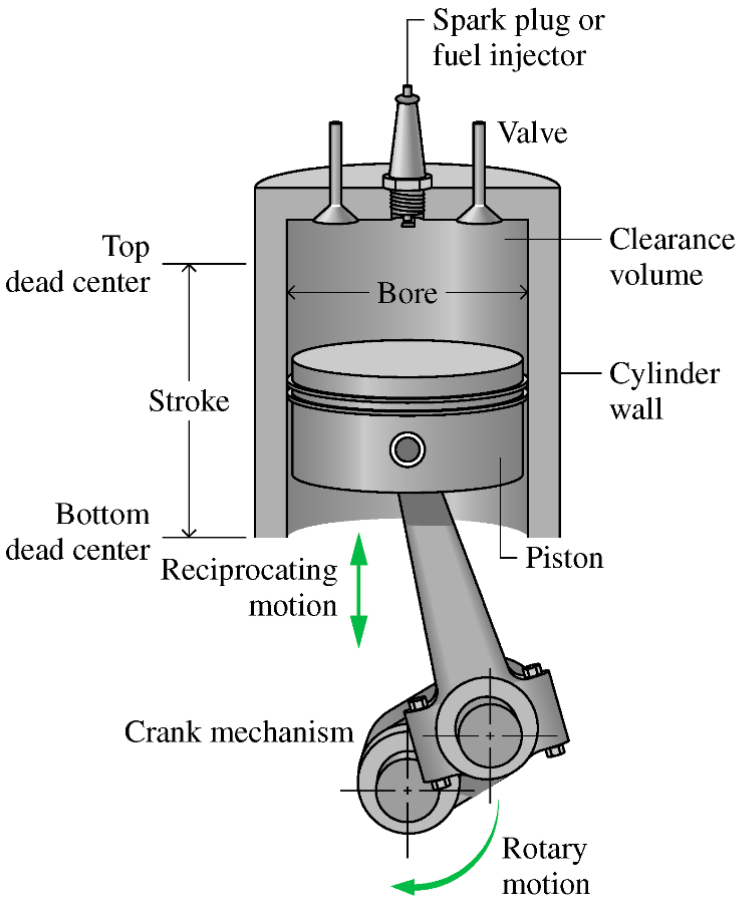

Fig. 1.2 Nomenclature for IC engines

2. Stroke. The maximum distance travelled by the piston in the cylinder in one direction is known as stroke and it is equal to twice the radius of the crank. The distance between TDC to BDC is known as "stroke/stroke length".

3. Top Dead Centre (TDC). The extreme position of the piston at the top of the cylinder (head end side) is called "top dead entre" (TDC) position. In the case of horizontal engines this is known as "inner dead centre" (IDC) position.

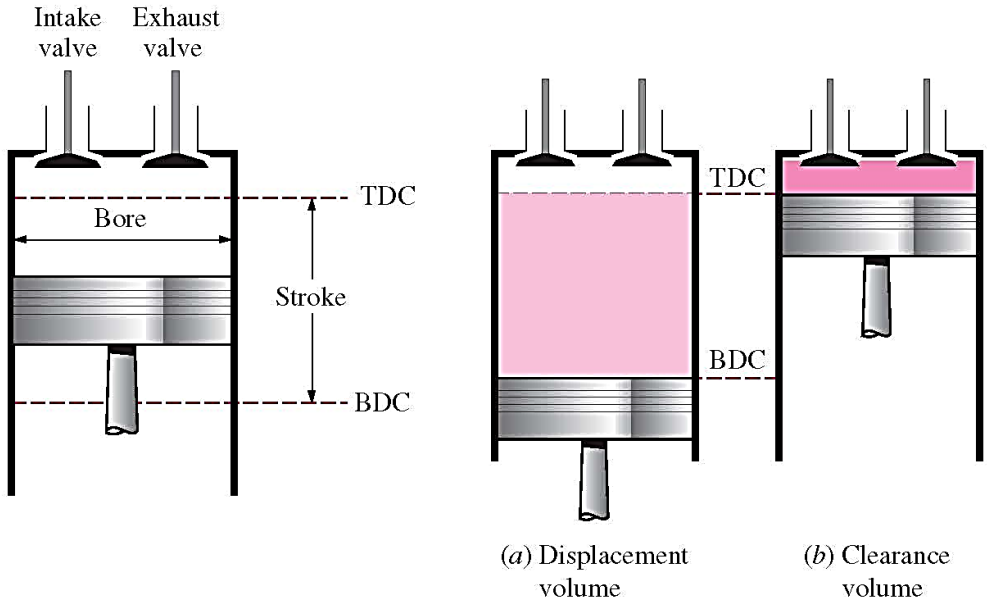

Fig. 1.3 Nomenclature for IC engines

4. Bottom Dead Centre (BDC). The extreme position of the piston at the bottom of the cylinder is called "bottom dead centre" (BDC) position. In case of horizontal engine this is known as "outer dead centre" (ODC) position.

5. Clearance Volume. The volume contained in the cylinder above the top of the piston when the piston is at TDC, is called the clearance volume and is denoted by Vc·

6. Piston Displacement or Swept Volume. The volume swept through by the piston in moving between TDC and BDC is defined as the piston displacement or swept volume and it is denoted by Vs. Therefore, cylinder volume = (Vc+Vs).

7. Compression Ratio. The ratio of the volume when the piston is at BDC to the volume when the piston is at TDC is called the compression ratio and it is denoted by Rc.

$$R_c = {}^{V_1}/_{V_c} = \frac{V_s + V_c}{V_c}$$

QUESTIONS FOR EXAMINATION

Q.1. What is IC Engine?

Ans. *See Section 1.1.*

Q.2. Write down classification of IC Engine.

Ans. *See Section 1.2.*

Q.3. State various terminology in I.C. engines.

Ans. *See Section 1.4.*

Q.4. Write down the principle parts/Components/Constructional detail of an IC Engine.

Ans. *Write all parts mentioned in section 1.3.*

Q.5. Write down the principle parts/Components/Constructional detail of 4-Stroke S.I./Petrol Engine.

Ans. *Write all parts mentioned in section 1.3* ***except*** *(a) Fuel Pump, (b) Fuel Injector/Nozzle, (c) Ports. (****Fig. 1.4)***

Q.6. Write down the principle parts/Components/Constructional detail of 4-Stroke C.I./Diesel Engine.

Ans. *Write all parts mentioned in section 1.3* ***except*** *(a) Spark Plug (b) carburettor (c) Ports. (****Fig. 1.5)***

Q.7. Write down the principle parts/Components/Constructional detail of 2-Stroke S.I./Petrol Engine.

Ans. *Write all parts mentioned in section 1.3* ***except*** *(a) Fuel Pump (b) Fuel Injector/Nozzle, (c) Valves (d) Cam-shaft, (e) Cam and Cam-follower (f) Push-rod and Rocker Arm. (****Fig. 1.6)***

Q.8. Write down the principle parts/Components/Constructional detail of 2-Stroke C.I./Diesel Engine.

Ans. *Write all parts mentioned in section 1.3* ***except*** *(a) Spark Plug (b) carburettor (c) Valves (d) Cam-shaft, (e) Cam and Cam-follower (f) Push-rod and Rocker Arm. (****Fig. 1.7)***

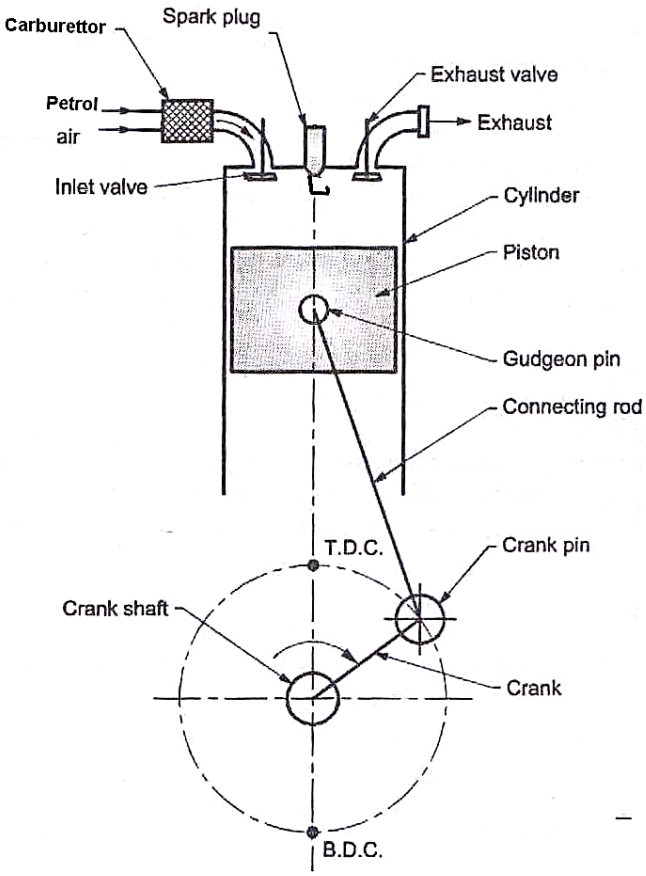

Fig. 1.4 Four-Stroke S.I./Petrol Engine.

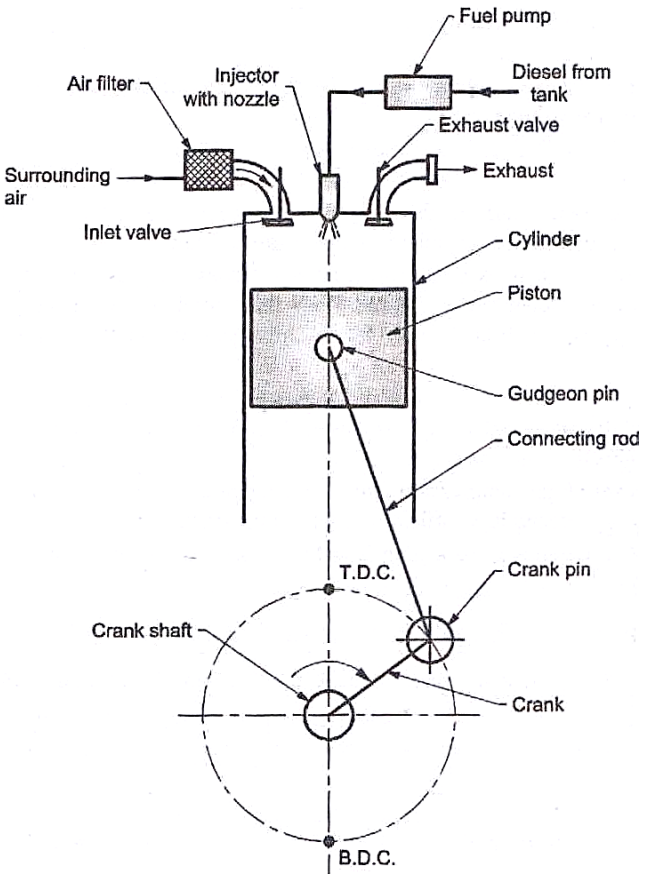

Fig. 1.5 Four Stroke C.I./Diesel Engine.

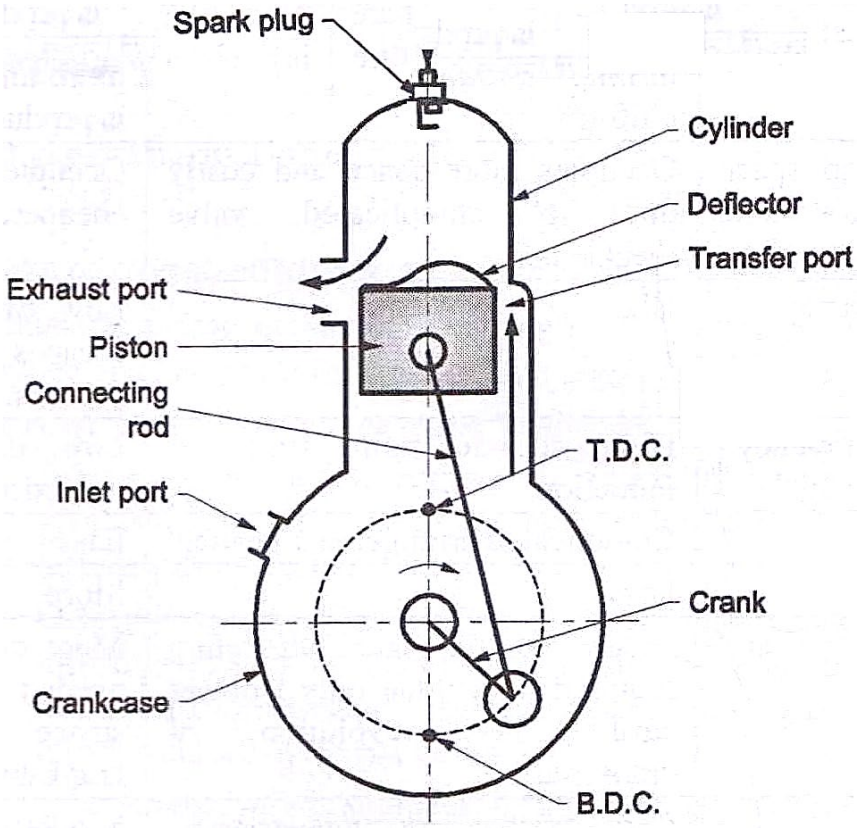

Fig. 1.6 Two-Stroke S.I./Petrol Engine.

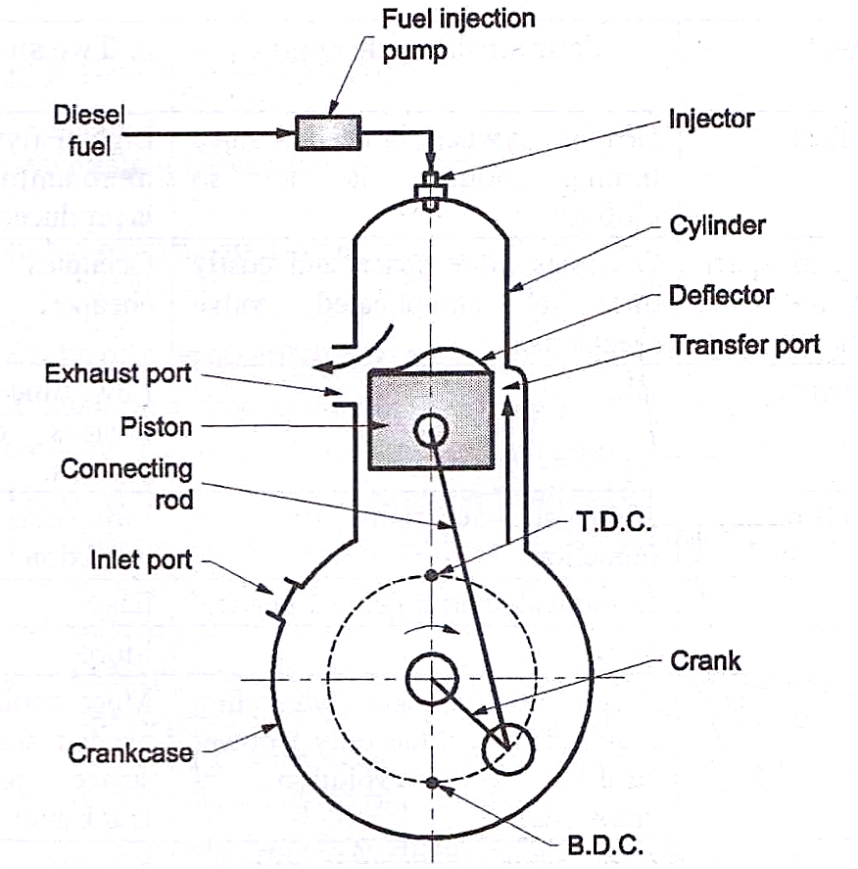

Fig. 1.7 Two-Stroke C.I./Diesel Engine.

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