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LECTURE NOTES

BASIC MECHANICAL ENGINEERING

(BT-203)

Year : I Semester : I/II

UNIT-V
RECIPROCATING MACHINES

Part 3-Four Stroke Diesel Engines

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CHAPTER NO. 3

Working of 4 Stroke Petrol Engines

3.1 INTRODUCTION

All operations are carried out in four strokes of the piston, i.e., two revolutions of the crank shaft. Therefore, the engine is called a four-stroke engine. A large number of internal combustion engines, both petrol and diesel, operate on a four-stroke cycle.

3.2 CONSTRUCTIONAL DETAILS

A four-stroke Diesel engine (compression ignition engine) contains a fuel injector, fuel pump, cylinder, cylinder head, inlet and exhaust valves, piston attached with piston rings, connecting rod, crank shaft, cams, camshaft, etc., as shown in Fig. 3.1. In a four-stroke engine, valves are used instead of ports. There are inlet and exhaust valves. These valves are operated by cams attached on a separate shaft, called a cam shaft. It is rotated at half the speed of a crank shaft.

3.3 OPERATIONS

The travel of the piston from one dead centre to another is called piston stroke and a four-stroke cycle consists of four strokes as suction, compression, expansion and exhaust strokes. The sequence of four strokes is as follows:

1. Intake or suction stroke,
2. Compression stroke,
3. Working or expansion or power stroke and,
4. Exhaust stroke.

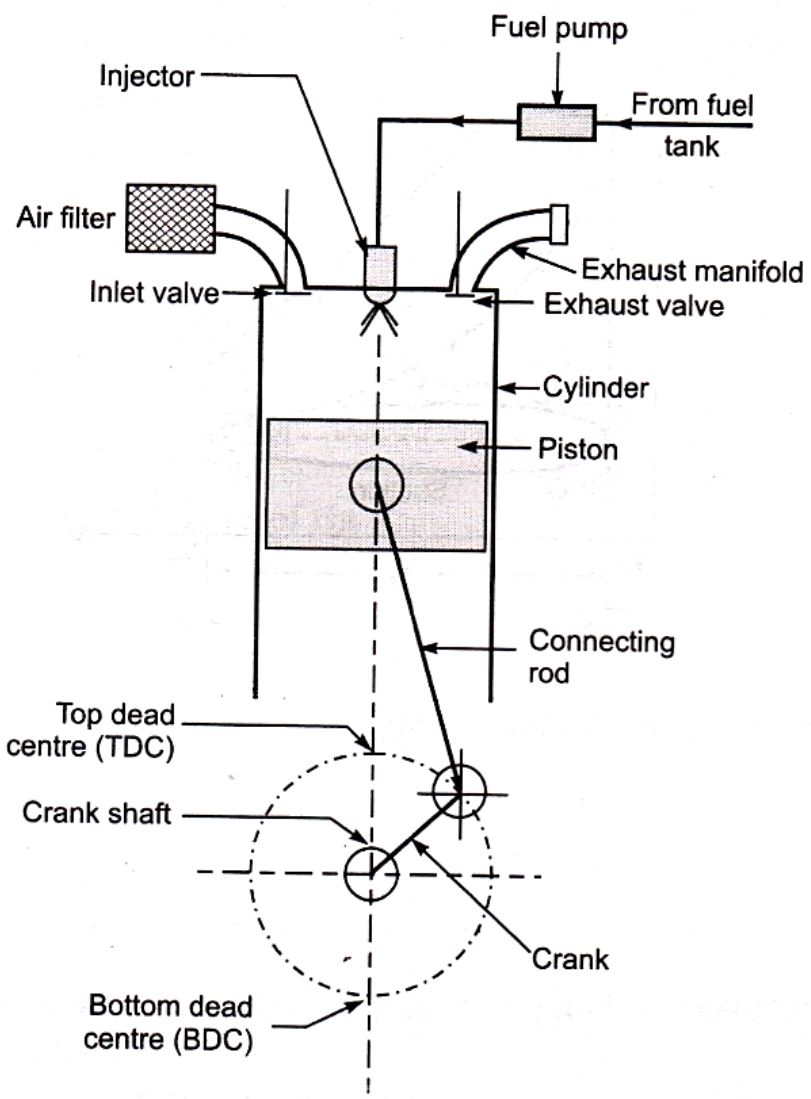


Figure 3.1 Four Stroke Diesel Engine

1. **Suction Stroke** Suppose that the piston is very near to the top dead centre position (T.D.C.) [Fig 3.2 (a)]. During suction stroke the inlet valve is opened and the discharge valve is closed and the piston moves down (i.e. outward) due to rotation of the crankshaft either getting energy from the flywheel or a motor starter. As the piston move, vacuum is created between the piston and cylinder and the pressure in the cylinder drops below atmospheric pressure. The piston moves from the top dead centre to the bottom dead centre, only air rushes inside the cylinder through inlet manifold and valve which is cam operated. The suction process continues till the piston reaches the bottom dead centre position (B.D.C.).

2. **Compression Stroke** During a compression stroke [Fig 3.2 (b)], both the valves are closed and the piston moves from bottom to top dead centre position. The air is compressed up to a compression ratio which depends upon the type and need of the engine. Since both the valves are closed and the piston moves inwards, there is a reduction in volume of the air which results in an increase of pressure and temperate of the cylinder contents. For Diesel engine the compression ratio is 16 to 22 and the pressure and temperature at the end of compression are 28 to 59 bar, and 600°C to 700°C respectively.

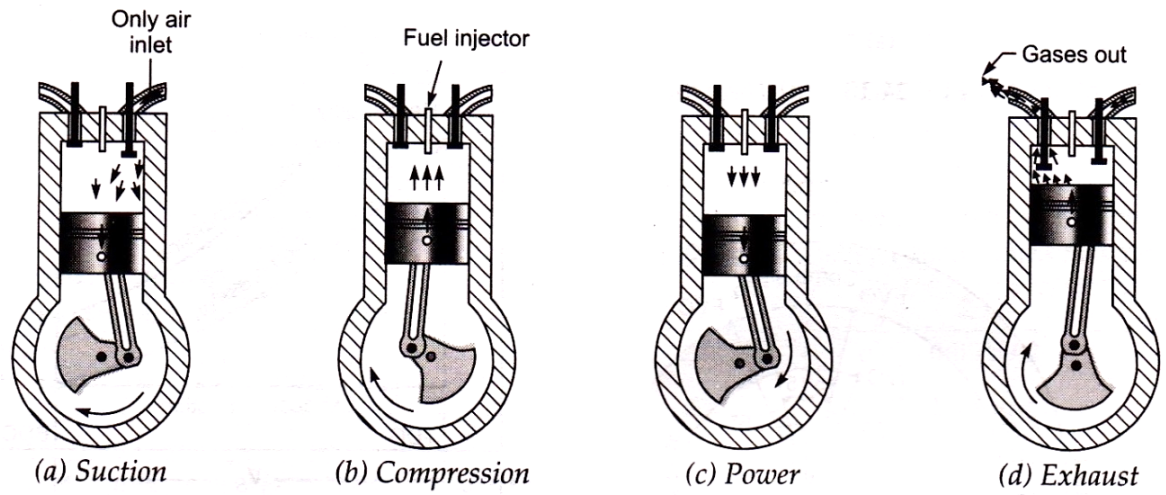


Figure 3.2 Operations of a Four Stroke Diesel Engine

3. **Expansion Stroke** During power stroke [Fig 3.2 (c)], both the valves are closed. The power stroke includes combustion of fuel and expansion of the products of combustion. The combustion starts at the end of the compression stroke when the piston is approaching the T.D.C. position. In C.I engine, one or more jets of fuel, compressed to a pressure of 105-210 bar by an injector pump are injected into the combustion chamber by a fuel nozzle at the end of the compression stroke. The injected fuel is vaporized in the combustion chamber, when the fuel vapor is raised to self-ignition temperature, the combustion then starts automatically and the pressure of the gas however remains constant during combustion.

In modern diesel engine (dual cycle), the injected fuel is vaporized in the combustion chamber, when the fuel vapor is raised to self-ignition temperature, the combustion then starts automatically and there is a

sudden rise of pressure at approximately constant volume. However, the latter part of combustion occurs at almost constant pressure.

The high pressure and the high temperature of the products of combustion, thus obtained, pushes the piston outward from T.D.C. to B.D.C. position for expansion stroke. This reciprocating motion of the piston is converted into rotary motion by the crankshaft, connecting rod and crank mechanism.

4. **Exhaust Stroke** During this stroke, the piston moves from the bottom dead centre to the top dead centre, exhaust valve opens and the inlet valve remains closed [Fig 3.2 (d)]. Burnt gases of the previous stroke are expelled out from the cylinder by upward movement of the piston. At the end of the power stroke the pressure of the gas is about 4-5 bar which is higher than the exhaust manifold pressure.

At the end of the exhaust stroke the inlet valve opens, and the cylinder is ready to receive the fresh air to begin a new cycle.
It is obvious from the above discussions that the crankshaft makes two revolutions during the four strokes, and in these four strokes, there is only one power stroke. This means, that for every two revelations of the crankshaft, there is only one power strike.

3.4 THEORETICAL INDICATOR DIAGRAM (P-V DIAGRAM)

The working of 4-Stroke Diesel cycle engine on p-V diagram as shown in Fig. 3.3.
Process 0-1: In this process fresh air is passed inside the cylinder. The piston moves from top dead centre to bottom dead centre. This comprises the first stroke of the engine.
Process 1-2: In this process the air is compressed and piston is moved to top dead center. This comprises the second stroke of the engine.

Process 2-3: In this process diesel is pumped into the cylinder through fuel pump and the fuel is burnt. This process is of constant volume and increase in pressure.

Process 3-4: In this process the burnt fuel expands itself and exerts pressure on the piston. The piston moves from top dead centre to bottom dead centre. This comprises the third stroke of the engine and the power stroke.

Process 4-1: In this process the burnt gas is exhausted out and the pressure decreases with constant volume.

Process 1-0: In this process the burnt gas is completely moved out of the cylinder by the action of piston. Piston moves from bottom dead centre to top dead centre. This comprises the fourth stroke of the engine.

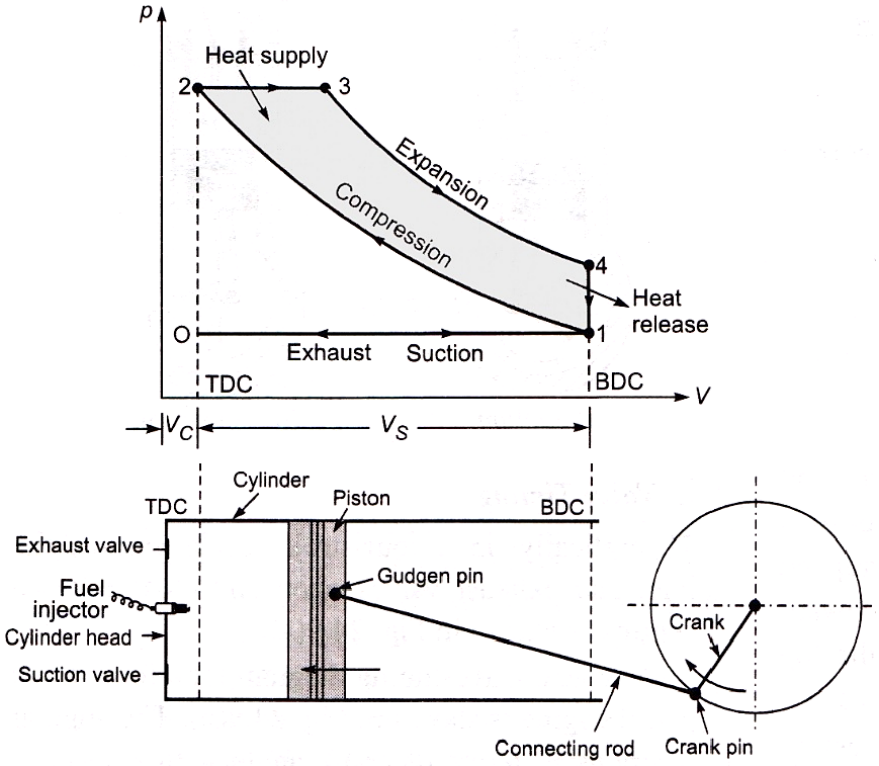


Figure 3.3 P-V Diagram of a Four Stroke Diesel Engine

3.5 ACTUAL INDICATOR DIAGRAM

In the theoretical indicator diagram, all the ideal conditions are assumed but in practice, the actual conditions differ from the ideal as described below (Fig. 3.4.).

The suction stroke is shown by the line 0-1 which lies below the atmospheric pressure line. It is this pressure difference, which makes the fresh air to flow into the engine cylinder.

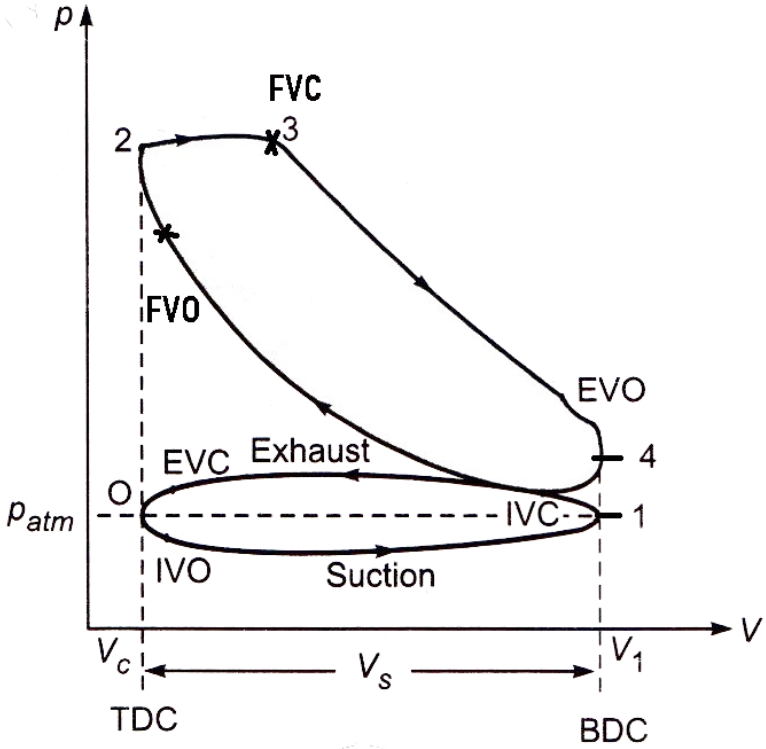


Figure 3.4 Actual indicator diagram (P-V Diagram) of a Four Stroke Diesel Engine

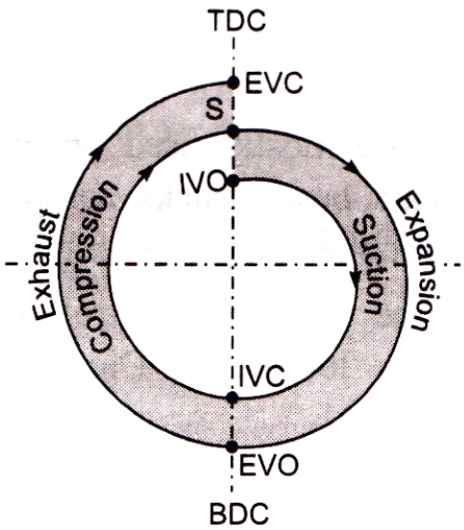
The inlet valve offers some resistance to the incoming air. That is why, the air cannot enter suddenly into the engine cylinder. As a result of this pressure inside the cylinder remains somewhat below the atmospheric pressure during the suction stroke. The compression stroke is shown by the line 1-2 which shows that the inlet valve close (IVC) a little beyond 3 (i.e. BDS). At the end of this stroke, there is an increase of pressure inside the engine cylinder shortly before the end of compression stroke (i.e. TDC) the fuel valve opens (FVO) and the fuel is injected into engine cylinder. The fuel is ignited by high temperature of the compressed air. The ignition suddenly increases volume and temperature of the products of combustion. But the pressure practically remains constant as shown by the line 2-3. The expansion stroke is shown by the line 3-4 in which the exist valve opens a little before 4 (i.e. BDC). Now the burnt gases are exhausted into the

atmosphere through the exit valve. The exhaust stroke is shown by the line 4-0, which lies above the atmospheric pressure line. It is this pressure difference which makes the burnt gases to flow out of the engine cylinder. The exist valve offers some resistance to the outgoing burnt gases. That is why the burnt gases cannot escape suddenly from the engine cylinder. As a result of this pressure inside the cylinder remains somewhat above the atmospheric pressure line during the exhaust stroke.

3.6 VALVE TIMING DIAGRAM

Theoretically, in a four-stroke cycle engine, the inlet and exhaust valves open and close at dead centres as shown in Fig. 3.5.

A typical actual valve-timing diagram for a four-stroke diesel engine is shown in Fig. 3.6. The angular positions in terms of crank angle with respect to TDC and BDC position of piston are quoted on the diagram. When the inlet valve and exhaust valve remain open simultaneously, it is called a valve overlap.



IVO = Inlet valve opens when piston at TDC
IVC = Inlet valve closes, when piston reaches BDC
S = Spark produces, when piston reaches TDC
EVO = Exhaust valve opens when piston at BDC
EVC = Exhaust valve closes, when piston at TDC

Figure 3.5 Theoretical Valve-Timing Diagram for Four-stroke Diesel Engine

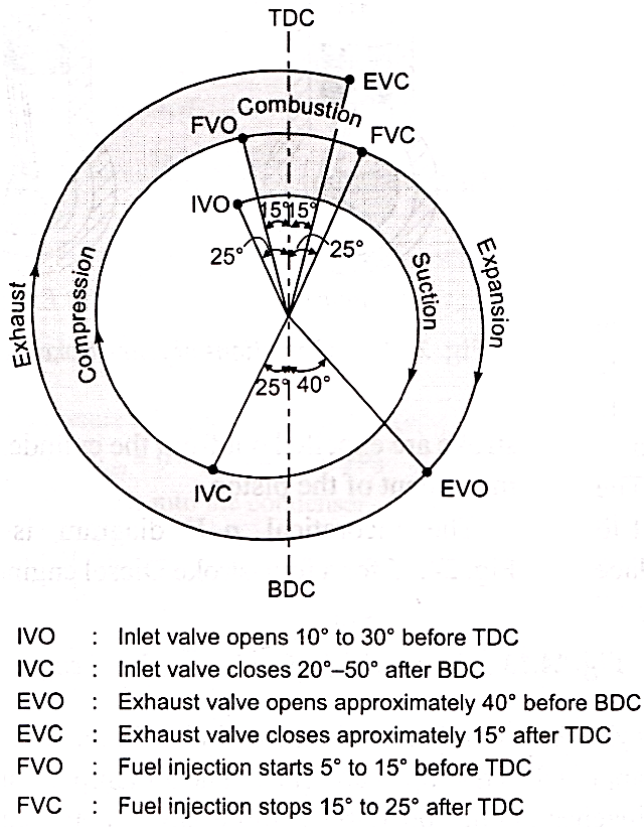


Figure 3.6 Actual Valve-Timing Diagram for Four-Stroke Diesel Engine

3.7 APPLICATIONS

These engines are mostly used in automobiles, small pumping sets for agriculture, construction machinery, air compressor and drilling jigs, tractors, jeeps, cars, taxies, buses, trucks, diesel-electric locomotives, small power plants, mobile electric generating plants, boats and ships, power saws, bulldozers, tanks, etc.

QUESTIONS FOR EXAMINATION

Q.1. Explain working of 4-Stroke Diesel/CI engines.

Ans. See Section 3.3.

Q.2. Draw and explain theoretical indicator diagram for 4-Stroke Diesel/CI engines.

Ans. See Section 3.4.

Q.3. Draw and explain actual indicator diagram for 4-Stroke Diesel/CI engines.

Ans. See Section 3.5.

Q.4. Draw theoretical valve timing diagram for 4-Stroke Diesel/CI engines.

Ans. See Section 3.6.

Q.5. Draw actual valve timing diagram for 4-Stroke Diesel/CI engines.

Ans. See Section 3.6.

Q.6. State various applications of 4-Stroke Diesel/CI engine.

Ans. See section 3.7