UNIT 2 POWER PLANTS

Structure

2.1 INTRODUCTION

Power plant or power unit of an automobile is that component or part which produces power to drive the automobile. It is generally in the form of an internal combustion engine running on petrol or diesel. In some cases, it can be a gas turbine or steam engine. These are called external combustion engines. However, steam engines are now obsolete and therefore not used for driving any vehicle.

This unit mainly covers various aspects of internal combustion engines from concept to their principle of working. In case of an internal combustion engine (IC engines) combustion (burning) of fuel with air takes place inside the engine cylinder.

Objectives

After studying this unit, you should be able to

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- ,
- , and
- .

2.2 CLASSIFICATION OF IC ENGINES

IC engines may be classified on different bases. Some of the main classifications are given below :

According to Fuel Used

(a) Petrol engine

(b) Diesel engine

(c) LPG engine

(d) CNG (Compressed Natural Gas) engine

According to Cycle of Operation

(a) Two stroke engines

(b) Four stroke engines

According to Cycle of Combustion

(a) Otto cycle engines which work on Otto cycle.

(b) Diesel cycle engine which work on diesel cycle.

(c) Dual cycle engines which work on dual cycle.

According to Method of Ignition

Spark Ignition (*SI*) *Engines*

These engines are petrol engines in which a spark plug is used to ignite the fuel-air mixture.

Compression Ignition (*CI*) *Engines*

Diesel engines are CI engines in which air is compressed to such a high pressure and temperature so that burning of fuel takes place as soon as it is injected into the cylinder due to high temperature.

2.3 FOUR STROKE ENGINES VERSUS TWO STROKE ENGINES

Four stroke engines are those engines in which one engine cycle is completed in two revolutions of crank shaft or four piston strokes. Various piston strokes are : suction, compression, power and exhaust.

In two stroke engines, the entire cycle is completed in one revolution of crank shaft or two piston strokes.

2.4 WORKING OF FOUR STROKE PETROL ENGINE

In four stroke engines, one cycle is completed with completion of four strokes. Main features of all the strokes are discussed below and their sketch is given in Figure 2.1.

Suction or Intake Stroke

Initially the piston remains n top dead centre (TDC) position, suction valve is open and exhaust valve remains closed. The piston now moves downward and the petrol and air mixture (charge) enters into the cylinder. When piston reaches bottom dead centre (BDC). The cylinder fills with the petrol air mixture. At this moment, suction valve closes. This completes one stroke. Crank turns by 180^{o}, i.e. it completes half revolution.

Figure 2.1(a) : Suction or Charging Stroke

Compression Stroke

Both the valves (suction and exhaust) are closed. The piston moves upwards from BDC to TDC position. The charge is compressed inside the cylinder, i.e. its pressure increases and volume decreases. Along with pressure temperature also increases. The crank completes next half of revolution.

Figure 2.1(b) : Compression Stroke

Working or Expansion or Power Stroke

When the piston reaches the TDC position spark plug generates spark and the charge is ignited and combustion of mixture takes place. Because of burning of fuel temperature and pressure of gases increases tremendously., both the valves remain closed. The gases expand in the cylinder and push the piston downward and therefore, work is done by the gases on the piston. The crank revolves and completes next half revolution. The reciprocating motion of the piston is converted into rotary motion of crank-shaft by piston rod and crank. During expansion, volume of gases increases. All the power for running the engine is obtained during this stroke.

Figure 2.1(c) : Expansion or Working Stroke

Exhaust Stroke

The suction valve remains closed but exhaust valve opens. The piston moves from BDC to TDC. The burnt gases are pushed out of the cylinder due to movement of piston. The cylinder pressure falls down to little above atmospheric pressure. This completes the next half revolution of the crank. By this time, crank shaft completes two revolution and one engine cycle is completed with the completion of four strokes. After this the same process is repeated again and again.

(d) Exhaust Stroke

Figure 2.1 : Four Stroke Cycle Petrol Engine

2.5 WORKING OF FOUR STROKE DIESEL ENGINES

The main features of all the four strokes in diesel engines are given below :

Suction or Intake Stroke

Initially piston is at top dead centre (TDC), exhaust valve is closed but suction valve opens. Piston moves downwards towards bottom dead centre (BDC). As suction valve is open, air enters into the cylinder. It is important to note that only air enters the cylinder during suction in case of diesel engines. Cylinder is full of air when piston reaches BDC and suction stroke in completed. Crank shaft or crank rotates by 180^{o}, i.e. it completes half revolution.

Figure 2.2(a) : Suction or Charging Stroke

Compression Stroke

Both the valves (suction and exhaust) are closed, piston moves from BDC to TDC. Volume of air decreases and pressure and temperature increases. When the piston reaches TDC, this stroke is completed and the crank completes next half revolution. By this time crank has rotated by 360^{o}.

Figure 2.2(b) : Compression Stroke

Expansion or Power Stroke

At the end of compression stroke, both the valve remains closed. The injector fitted in the cylinder head injects diesel fuel in the high temperature air. The temperature is so high that the fuel, i.e. diesel starts burning at constant pressure. The pressure and temperature increases further due to combustion of fuel. The gases in the cylinder push the piston downwards from TDC to BDC and expansion process takes place. The volume of gases increases and work is obtained in this process. The reciprocating motion of piston is converted into rotary motion of crank shaft through piston rod and crank.

Expansion process is completed when piston reaches BDC. The crank rotates by next half revolution. This stroke is called power stroke because power of work is obtained in this stroke.

(c) Expansion or Working Stroke

Exhaust Stroke

After completion of expansion stroke, the piston starts moving upwards from BDC to TDC. Suction valve is close, exhaust valve is open. As the piston moves, it pushes the burnt gases through the exhaust vale. Thus, exhaust takes place. The cylinder becomes empty as the piston reaches TDC. The exhaust stroke is completed. Crank has now completed two revolutions and all the four strokes are now completed. This completes one engine cycle. These cycles are repeated as engine continues to run.

(d) Exhaust Stroke

Figure 2.2 : Four Stroke Cycle Diesel Engine

2.6 WORKING OF TWO STROKE PETROL ENGINES

Two stroke and four stroke engines are different in the method of filling the cylinder with fresh charge and also in the removal of burnt gases from the cylinder. In a four stroke engine these processes are performed by the movement of piston during suction and exhaust stroke. In four stroke engines these are suction and exhaust valves where as suction (inlet) and exhaust (outlet) ports are cut in the walls of cylinder.

Whole process of working of two stroke petrol engine has been shown in Figure 2.3. The Figure 2.3 shows a three channel system in which the fresh charge is compressed in the crank case of the engine. This is also called crank are compression system. Figure 2.3 shows all working of two stroke petrol engine in three stages.

Exhaust and Transference

Figure 2.3(a) shows the exhaust and transfer process. When the piston moves from TDC to BDC, i.e. downwards after expansion of gases, the piston uncovers the exhaust port. The burnt gases start going out of the cylinder. Simultaneously the slightly compressed charge in the crank case is forced into the cylinder through transfer port. The deflector on the piston crown deflects this charge and the fresh charge moves in the upward direction. This fresh charge pushes the burnt gases

out of cylinder. During this process, some fresh charge may also leave the cylinder through exhaust port.

The process of cleaning of cylinder, by pushing burnt gases by fresh charge, is known as *scavenging*.

Figure 2.3(a) : Exhaust and Transference

Compression

When the piston moves upwards from BDC to TDC, transfer port and exhaust ports are closed. Compression of charge, present in the cylinder takes place. During this motion the inlet valve open and fresh charge enters the crank case. When the piston reaches TDC, compression process is completed.

Figure 2.3(b) : Compression and Suction

Ignition and Expansion

After compression, spark plug generates spark and ignition of fuel takes place. Rapid rise in pressure and temperature takes place at constant volume. At this stage both transfer port and exhaust port are closed. Expansion of burnt gases takes place at the piston moves downward from TDC to BDC. The gases push the piston with great force and power is obtained during this process. Simultaneously, slight compression of fresh charge, present in crank case takes place.

(c) : Ignition and Expansion

Figure 2.3 : Two Stroke Cycle Petrol Engine

After this process shown in Figure 2.3(a), i.e. exhaust and transfer of charge takes place and cycle is repeated again. Thus, the cycle is completed in two strokes of piston and one revolution of crank shaft. In case of petrol engines, fresh charge consists of air petrol mixture which comes from carburetor after mixing.

2.6 WORKING OF TWO STROKE DIESEL ENGINES

Working of two stroke diesel engines is similar to that of petrol engines except the following differences :

(a) Fuel injector is provided in the cylinder head in place of spark plug.

(b) Only air enters the crank case. After slight compression, it is passed to cylinder and compressed in the cylinder.

(c) At the end of compression strokes fuel injector injects diesel into compressed air. Due to high temperature of air, diesel starts burning.

Figure 2.3 can be referred to understand the working of two stroke diesel engines also.

2.7 MAIN DIFFERENCES BETWEEN TWO AND FOUR STROKE ENGINES

(a) For the same power output the design of two stroke engine is simple where as a four stroke engine is complex in design for manufacturer.

(b) A two stroke engine gives on working stroke for each revolution of the crank shaft whereas a four stroke engine gives one power stroke per two revolutions of crank shaft.

(c) Two stroke engines have suction and exhaust ports whereas four stroke engines have suction and exhaust valves and valve mechanism.

(d) Two stroke engines lighter in weight but four stroke engines are heavier.

(e) The initial cost of two stroke engines is less than that of four stroke engines.

(f) Thermal efficiency of two stroke engines is less than that of four stroke engines.

(g) Four stroke engines are used where efficiency is important, e.g. in cars, busses, etc. Whereas two stroke engines are used where lower cost is required in two wheelers, e.g. scooters and motorcycles.

2.8 APPLICATION OF TWO STROKE AND FOUR STROKE ENGINES

Two stroke petrol engines are preferred in applications where low cost, compactness and light-weightness are important considerations.

Example : Scooter, mopeds and motorcycle, etc.

Two stroke diesel engines are used in marine applications such as in ships where engine space is small.

Four stroke petrol engines are now-a-days popular in motorcycle also due to their high fuel efficiency.

Four stroke petrol engines are generally used in light vehicles such as car and jeep, etc. where fuel efficiency is an important criteria and cost is not a limiting factor.

Four stroke diesel engines are used in heavy motor vehicles such as bus, truck and big size carries and tractors, etc.

2.9 IMPORTANT TERMS

Figure 2.4 shows the cross-section of a single cylinder spark ignition internal combustion engine. Description of different components of this engine is given below.

Figure 2.4 : Different Parts of an Internal Combustion Engine

Cylinder

The cylinder is that part in which air-fuel mixture is sucked, compressed, ignited and expanded.

Cylinder Block

Cylinder block is made by casting and is used to support the cylinder in position.

Piston

Piston reciprocates inside the cylinder.

Combustion Chamber

The space enclosed between cylinder and upper part of the cylinder forms the combustion chamber where fuel-air mixture burns.

Piston Rings

Piston rings are provided on the piston. These are used to seal the high pressure side (cylinder) and low pressure side (crank case), i.e. to prevent leakage of gases. There is one oil ring also which is used to scrap the lubricating oil at the cylinder surface so that it returns to crank case.

Spark Plug

A spark plug is put near the top of the cylinder or in the cylinder head. It is used to ignite the fuel-air mixture by generating a spark in petrol engines.

Fuel Injector

Fuel injector is used in diesel engines in place of spark plug.

Piston Rod

Piston rod or connecting rod connects the piston and crank.

Gudgeon Pin

It is provided on the piston. It joins the piston and connecting rod.

Crank Pin

Crank pin joins the crank and piston rod.

Crank

Crank and the piston rod convert the reciprocating motion of piston into rotary motion of the crank shaft.

Crank Shaft

It is supported on bearings attached to the crank case.

Crank Case

It is the main body of the engine to which cylinder is connected.

Valve Mechanism

A mechanism to open and close the suction and exhaust valves is also provided in four stroke engines. This is not shown in Figure 2.4.

Top Dead Centre (TDC)

Top dead center is the upper most position upto which piston moves.

Bottom Dead Centre (BDC)

Bottom dead centre is the lower most position upto which piston comes down.

Bore (D)

Bore is the diameter of piston on cylinder.

Stroke (L)

The nominal distance through which the piston moves from one extreme position (say TDC) to other extreme position (say BDC).

Suction Manifold

Suction or intake manifold is the pipe through which air and petrol mixture enters the cylinder (through suction valve).

Exhaust Manifold

Exhaust manifold is the pipe through which burnt gases pass from cylinder (through exhaust valve) to the silencer of the engine.

Stroke Volume

The volume of the cylinder between TDC and BDC is known as stroke volume.

Clearance Volume

It is the volume of cylinder left above TDC, i.e. between TDC and top of cylinder.

2.10 SPECIFICATIONS OF AUTOMOBILE ENGINE

Engine specifications may include following details :

(a) **Model Designation :** Model designation as specified by manufacturer.

(b) **Engine Configuration :** Number of cylinders and their arrangement.

(c) **Fuel System :** Fuel system with carburetor or with multi-point fuel injection (MPFI).

(d) **Displacement Volume :** Stroke volume of all cylinders.

(e) Ignition System

(f) Maximum Horse Power

(g) Maximum Torque

Example : Engine Specification of Santro Car.

Model Designation : Hydraulic epsilon engine.

Configuration : In-line-4 cylinder.

Fuel System : Multi-point fuel injection (MPFI).

Displacement : 1086 cc.

Ignition System : Distributorless.

Maximum Horse Power (*BHP/rpm*) : 63 at 5500 rpm.

Maximum Torque (*kgm/rpm*) : 9.8 kg at 3000 rpm.

SAQ 1

(a) What do you understand about power plant? Explain.

(b) How do you classify internal combustion (IC) engines? Explain.

(c) Describe the working of two stroke petrol engine with neat diagrams.

(d) Describe the working of four stroke petrol engine with net diagram.

(e) Describe the working of two stroke diesel engine with neat diagram.

2.11 SUMMARY

In this unit, we have learnt the concept of power plant, its applications and types. It is also called as power unit, used in the automobiles to develop the power. It is also called as IC engine. This unit also explains the various types of IC engines. The construction and working of petrol and diesel engines also explained very well. Finally, the unit concluded with explaining the various terms used n the spark ignition petrol engine.

1.8 KEY WORDS

1.9 ANSWERS TO SAQs

Refer the preceding text for all the Answers to SAQs.