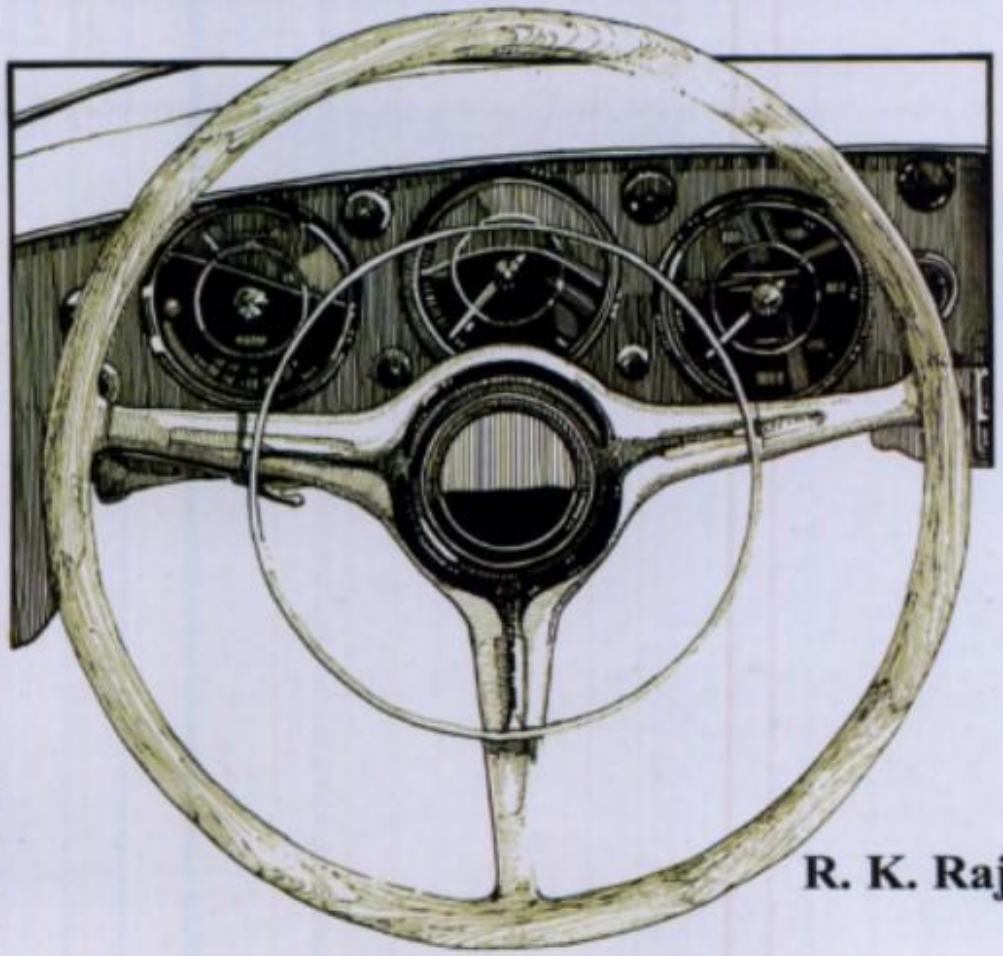
A Textbook of
AUTOMOBILE ENGINEERING



R. K. Rajput

1

Introduction

1.1. Introduction to an automobile. 1.2. Brief history of automobile. 1.3. Classification of automobiles. 1.4. Parts of an automobile—mechanical portion—chassis and transmission—the engine—electrical system—body or carriage portion. 1.5. Description of an automobile. 1.6. Performance of an automobile—Short Answer Questions—Highlights—Objective Type Questions—Theoretical Questions.

1.1. INTRODUCTION TO AN AUTOMOBILE

Automobile. *An "automobile" is a self-propelled vehicle driven by an internal combustion engine and is used for transportation of passengers and goods on ground.* ***Examples :*** Bus, car, jeep, truck, tractor, scooter, motor cycle.

The modern automobile, in general, is essentially a transportation equipment unit. It consists of a *"frame"* supporting the *"body"* and certain *"power developing and transmitting units" which are further supported by "tyres and wheels" through "springs and axles".*

An *"engine"* supplies the power, which is delivered by the *"transmission system"* to the wheels through the *clutch or fluid coupling.*

Automobile engineering. *Automobile (or automotive) engineering is a branch of engineering in which we study all about the automobiles and have practice to propel them.*

— Mobile or motive means one which can move. Automobile or automotive means one *which itself can move.*

The different names for the automobile are :

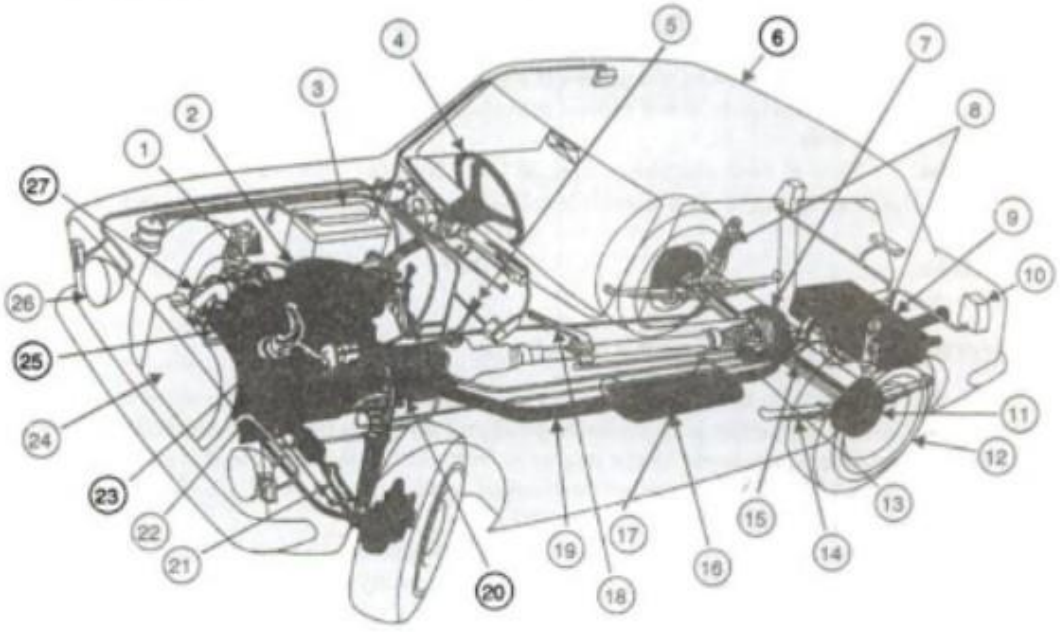
- Auto
- Automobile
- Autocar
- Autobuggy
- Car
- Motor
- Motor car
- Motor vehicle
- Motor coach
- Motor wagon
- Horseless coach.

1.2. BRIEF HISTORY OF AUTOMOBILE

The famous years in early automobile history are as follows :

Year	Event
• *1769*	French engineer Captain Nicholas Cugnot of France built the first road vehicle propelled by its own power (Attained a speed of about 2.5. m.p.h. in 15 minutes).
• *1801*	First steam carriage built by Richard Trevithick in England.
• *1804*	Oliver Evans built the finest American self-propelled steam vehicle.
• *1827*	Onesiphare Pacqueur of France invented first differential.
• *1832*	First 3-speed Transmission patented by W.H. James in England.
• *1880*	German and French efforts developed an internal combustion engine vehicle (which was used to carry fruits). The present day automobile is the development of this vehicle.

The *layout of an automobile* is shown in Fig. 1.2.



1. Engine 2. Air cleaner 3. Battery 4. Steering wheel 5. Gear lever 6. Car body 7. Differential 8. Shock obsorber 9. Fuel tank 10. Back light 11. Rear brake 12. Wheel and tyres 13. Tail pipe 14. Leaf spring 15. Rear axle 16. Silencer 17. Universal joint 18. Hand brake lever 19. Exhaust pipe 20. Clutch 21. Track rod 22. Carburettor 23. Distributor 24. Radiator 25. Fan 26. Head lamp 27. Alternator.

Fig. 1.2. Layout of an automobile.

1.5. DESCRIPTION OF AN AUTOMOBILE

The following factors should be taken into consideration while writing down the description of an automobile.

1. **Type .....** Bus, truck, car, motor cycle etc.

2. **Capacity .....**Carriage capacity— 5 ton, 3 ton etc. ; 4 seater, 6 seater, 30 seater, 45 seater etc.

3. **Make.** It is the actual name allotted by the manufacturer. In most cases, the make also indicates capacity/H.P. of the engine fitted in the vehicle, such as *Maruti 800*. This means that in Maruti make of car 800 c.c. engine, the total piston displacement is about 800 c.c.

4. **Drive.** The description of an automobile with regard to drive may be given as follows:

(*i*) *Right hand or left hand drive*. It means whether the steering is fitted on the right side or left side.

(*ii*) *Two wheel drive ; 4 wheel drive ; 6 wheel drive*. This means as to how many wheels the engine power flows or how many wheels are directly connected with the engine.

- In *majority of the cars the engine power flows to the rear wheel only and the front wheels are filled on the dead axle*. These types of cars are known as *"two wheel drive vehicles."*
- In certain vehicles, like jeep, all the vehicles are directly in contact with engine and the engine *power could be transmitted to all the four wheels.*

- Drive is usually indicated as under :

Left hand drive ; 4 × 4 (4 wheel drive)

Or

Left hand, Four wheel drive ; **4 × 4** means the vehicle contains 4 wheels and the engine power could flow towards all the 4 wheels, **6 × 4** means that there are 6 wheels but the engine power could flow towards 4 wheels only.

5. **Model.** .....Year of manufacture or special Code Number allotted by the manufacturer.

Thus for the description of an automobile following *information* will be required :

(*i*) Type (*ii*) Capacity
(*iii*) Make (*iv*) Drive
(*v*) Model.

1.6. PERFORMANCE OF AN AUTOMOBILE

When the fuel burns in the cylinder, *pressures* are developed. These pressures are transmitted to the crankshaft by the piston and connecting rod and torque is produced which sets the crankshaft in motion. *The torque produced by the engine is transmitted through the drive line to the road wheels to propel the vehicle* (The crankshaft is *coupled to the driving road wheels through clutch, gearbox, propeller shaft, differential and axle shafts*).

The torque is measured in Nm (SI units) ; the actual power delivered by the engine is known as Brake Power (B.P.) and is measured by dynamometer or prony brake.

$$\text{B.P.} = \frac{2\pi NT}{60 \times 1000} \text{ kW} \qquad ...(1.1)$$

where, T = Torque, Nm, and

N = Speed in r.p.m. (revolutions per minute).

— The torque increases with the increase in engine speed upto a certain point after which it starts to fall down even though the engine speed continues to increase. The number of r.p.m. at which the torque begins to decrease, depends upon *engine design*. At higher speeds, engine vacuum falls down and less fuel enters the cylinders resulting in lesser force available at the piston and hence the fall in torque as shown in Fig. 1.3.

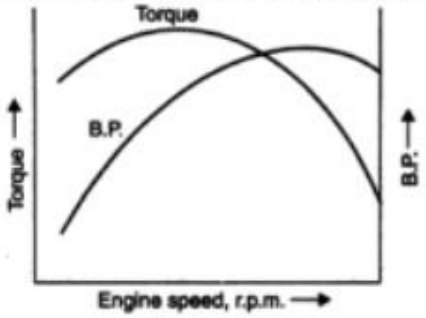


Fig. 1.3. Typical curves of torque and B.P. with speed of an engine.

The torque available at the contact between driving wheels and road is referred to as *tractive effort. Gear box and final drive at differential act as leverage to multiply torque which is inversely proportional to speed.* If the gear speed is lowered, the torque shall be increased in the same ratio and vice versa.

Let, T_w = Torque at driving wheels,

G = Gear box ratio,

η_t = Overall transmission efficiency,

T_E = Engine torque (Nm), and

N = r.p.m. of the crankshaft.

Then, $$T_w = G \times \eta_t \times T_E \qquad ...(1.2)$$

Engine torque, $$T_E = \frac{B.P. \times 60 \times 1000}{2\pi N} \text{ Nm}, \qquad ...(1.3)$$

where B.P. is in kW.

gases and air, known as *gas engines*, those *using lighter liquid fuel* or *spirit* known as *petrol engines* and those using heavier liquid fuels, known as *oil compression ignition* or *diesel engines*.

- Now a days, **I.C. engines** *are most-commonly used in* **automobiles.**

The detailed classification of heat engines is given in Fig. 2.1.

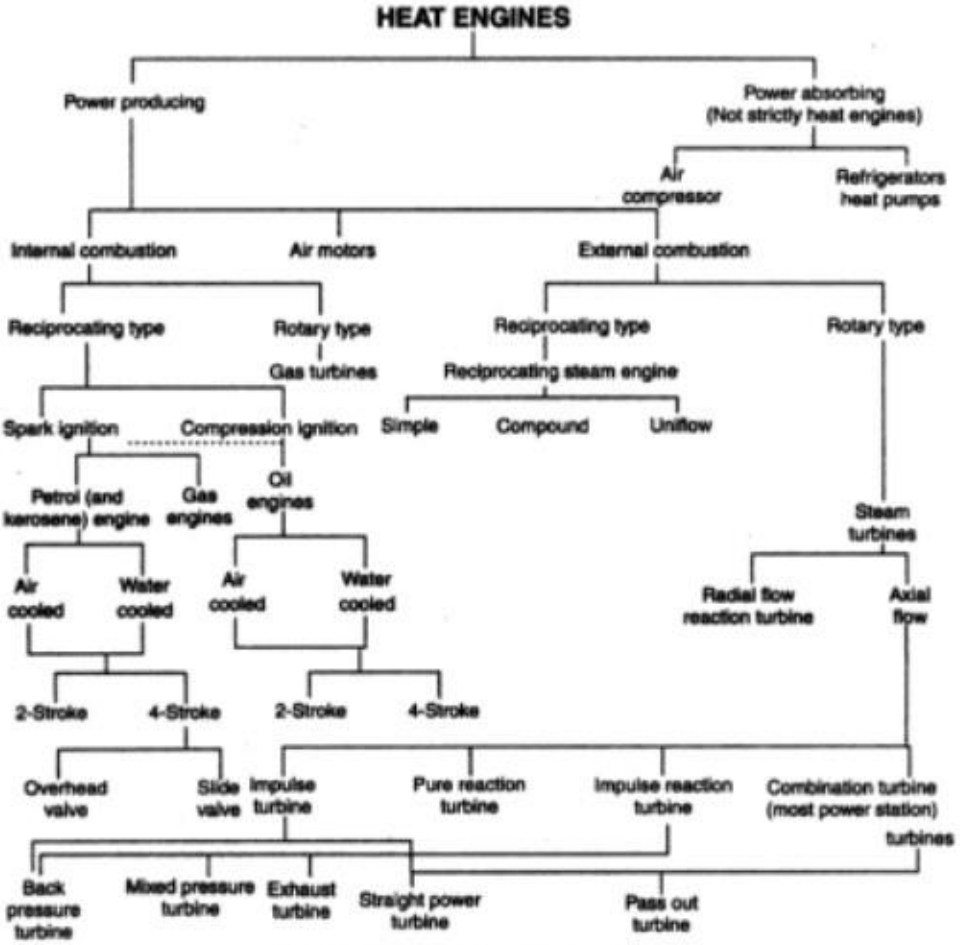


Fig. 2.1. Classification of heat engines.

Advantages of reciprocating internal combustion engines over external combustion engines :

Reciprocating internal combustion engines offer the following *advantages* over external combustion engines :

1. Overall efficiency is high.
2. Greater mechanical simplicity.
3. Weight-to-power ratio is generally low.
4. Generally lower initial cost.
5. Easy starting from cold conditions.
6. These units are compact and thus require less space.

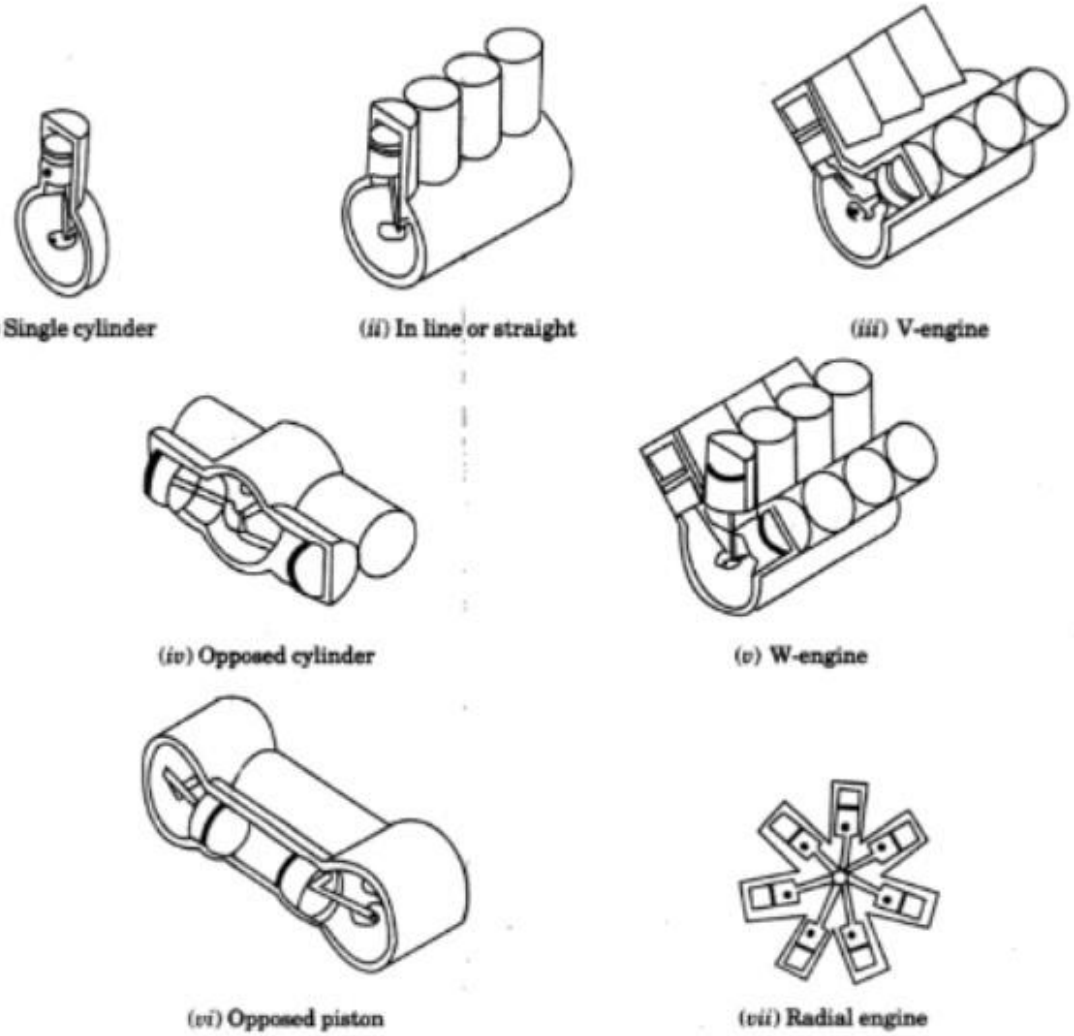
2. **According to cycle of combustion :**

(*i*) Otto cycle engine (combustion at constant volume)

(*ii*) Diesel cycle engine (combustion at constant pressure)

(*iii*) Dual-combustion or Semi-Diesel cycle engine (combustion partly at constant volume and partly at constant pressure).

3. **According to arrangement of cylinder :** Refer Fig. 2.2.



(*i*) Single cylinder (*ii*) In line or straight (*iii*) V-engine

(*iv*) Opposed cylinder (*v*) W-engine

(*vi*) Opposed piston (*vii*) Radial engine

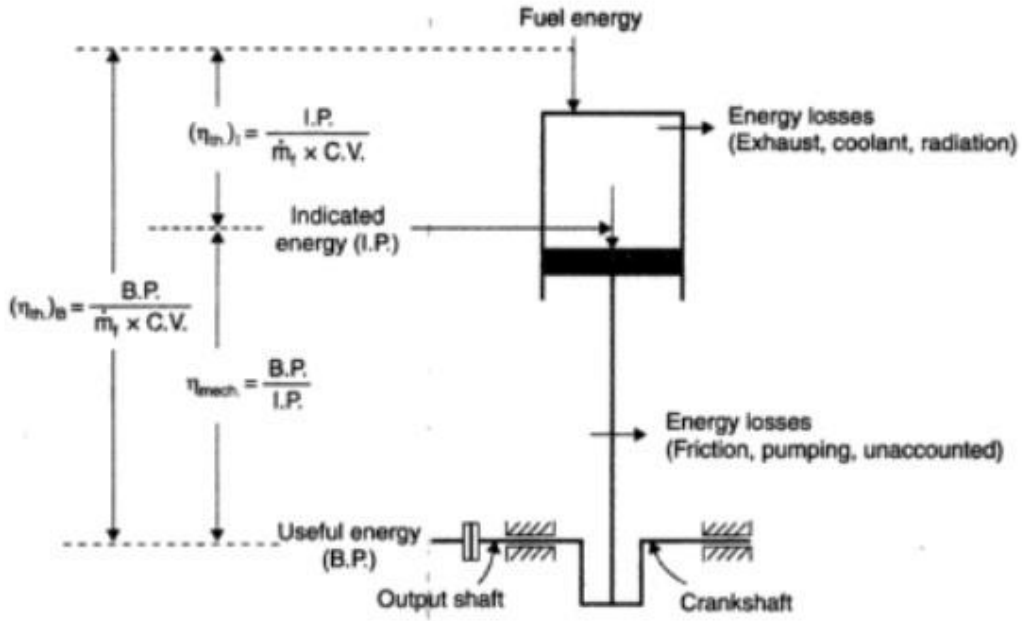
Fig. 2.2. Engine classification by cylinder arrangement.

(*i*) **Single cylinder engine.** Engine has one cylinder and piston connected to the crankshaft.

(*ii*) **In-line or straight engines.** Cylinders are positioned in a straight line one behind the other along the length of the crankshaft.

(*iii*) **V-engine :**

- An engine with two cylinder banks (*i.e.*, two-in-line engines) inclined at an angle to each other and with one crankshaft.



I.P. = Indicated power

B.P. = Brake power

$(\eta_{th.})_i$ = Indicated thermal efficiency = $\frac{I.P.}{\dot{m}_f \times C.V.}$

(where $\dot{m}_f$ = mass of fuel in kg/s and C.V. = calorific value)

$(\eta_{th.})_B$ = Brake thermal efficiency.

Fig. 2.3. The energy flow through the reciprocating engine.

- The energy available at the piston passes through the connecting rod to the crankshaft. In this transmission of energy/power there are losses due to friction, pumping, etc. The sum of all these losses, converted to power, is termed as **Friction Power (F.P.).** The remaining energy is the *useful mechanical energy and is termed as* **shaft energy** or **Brake Power (B.P.).** The *ratio of energy at shaft to fuel input energy is called* **brake thermal efficiency** $[\eta_{th.(B)}]$.
- The *ratio of shaft energy to the energy available at the piston is called* **mechanical efficiency** ($\eta_{mech.}$).

2.6. BASIC IDEA OF I.C. ENGINES

The basic idea of internal combustion engine is shown in Fig. 2.4. The cylinder which is closed at one end is filled with a mixture of fuel and air. As the crankshaft turns it pushes piston. The piston is forced up and compresses the mixture in the top of the cylinder. The mixture is set alight and, as it burns, it creates a gas pressure on the piston, forcing it down the cylinder. This motion is shown by arrow '1'. The piston pushes on the rod which pushes on the crank. The crank is given rotary (turning) motion as shown by the arrow '2'. The fly wheel fitted on the end of the crankshaft stores energy and keeps the crank turning steadily.

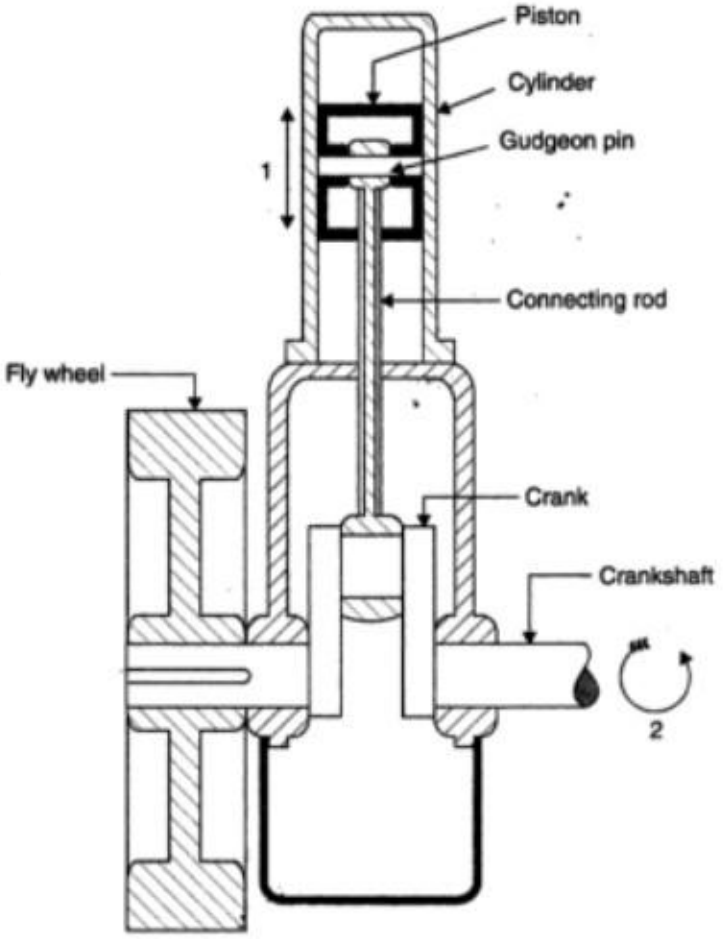


Fig. 2.4. Basic idea of I.C. engine.

2.7. DIFFERENT PARTS OF I.C. ENGINES

Here follows the detail of the various parts of an internal combustion engine.

A cross-section of an air-cooled I.C. engine with principal parts is shown in Fig. 2.5.

A. Parts common to both petrol and diesel engine :

1. Cylinder
2. Cylinder head
3. Piston
4. Piston rings
5. Gudgeon pin
6. Connecting rod
7. Crankshaft
8. Crank
9. Engine bearing
10. Crankcase
11. Flywheel
12. Governor
13. Valves and valve operating mechanisms.

B. Parts for petrol engines only :

1. Spark plugs
2. Carburettor
3. Fuel pump.

C. Parts for Diesel engine only :

1. Fuel pump. 2. Injector.

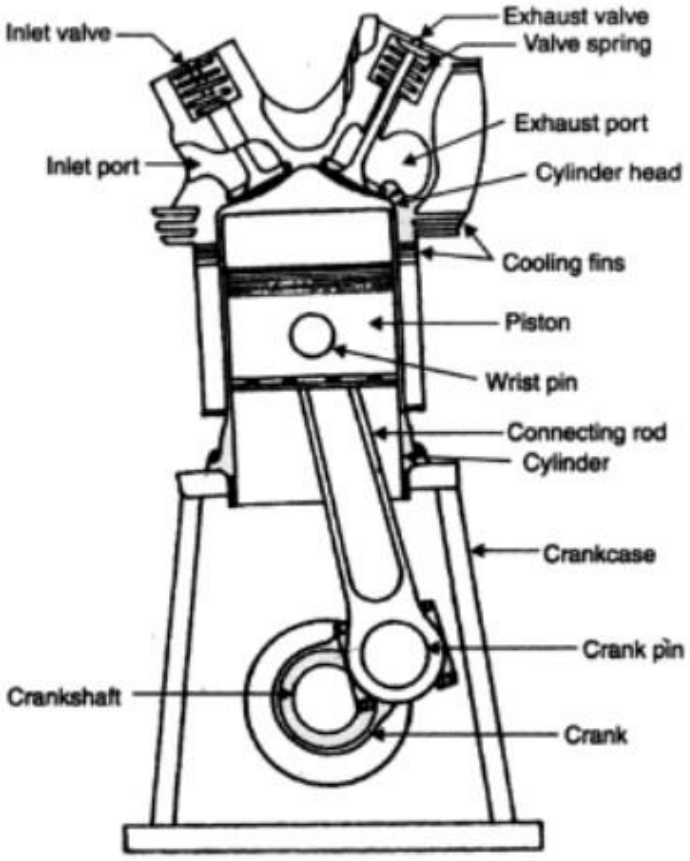


Fig. 2.5. Air-cooled I.C. engine.

A. Parts Common to Both Petrol and Diesel Engines :

1. Cylinder :

The cylinder contains gas under pressure and guides the piston. It is in direct contact with the products of combustion and it must be cooled. The ideal form consists of a plain cylindrical barrel in which the piston slides. The movement of the piston or stroke being in most cases, longer than the bore. This is known as the *"stroke-bore ratio"*. The upper end consists of a combustion or clearance space in which the ignition and combustion of the charge takes place. In practice, it is necessary to depart from the ideal hemispherical slope in order to accommodate the valves, sparking plugs etc. and to control the combustion. Sections of an air-cooled cylinder and a water-cooled cylinder are shown in Figs. 2.6 and 2.7, respectively. *The cylinder is made of hard grade cast-iron and is usually, cast in one piece.*

2. Cylinder head :

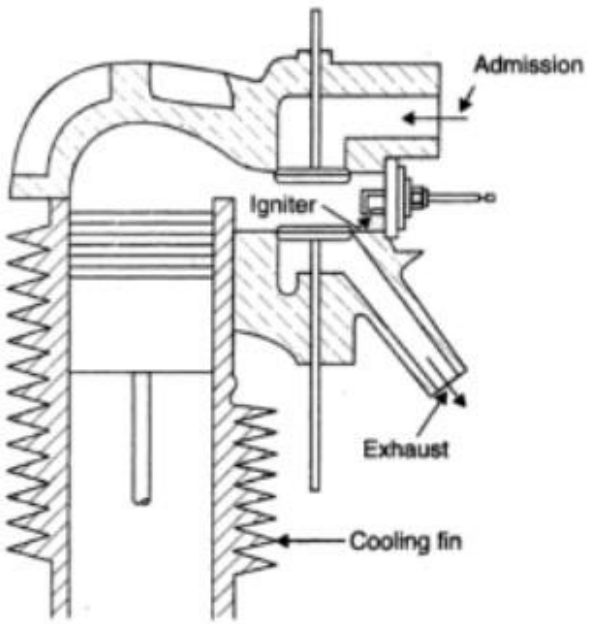


Fig. 2.6. Air-cooled cylinder.

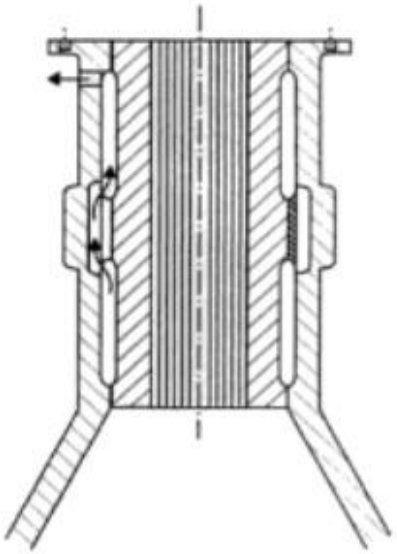


Fig. 2.7. Water-cooled cylinder.

One end of the cylinder is closed by means of a *removable cylinder head* (Fig. 2.6) which usually contains the inlet or admission valve [Fig. 2.8 (*a*)] for admitting the mixture of air and

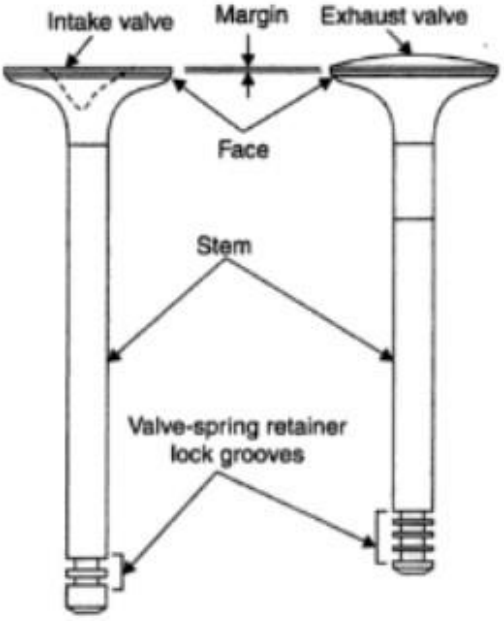


Fig. 2.8