INTERNAL COMBUSTION ENGINES (ICE)

2.1 Introduction

There are two types of engines; internal combustion and external combustion engines. In ICE, combustion takes place within the engine itself. All ICE aspirates (suck) air into a measured quantity of fuel for combustion to take place. Air and fuel burns inside the engine in such a way that it produces a gas containing high energy to carry out useful work through suitable mechanisms.

ICEs are employed as prime movers for stationary work and on mobile applications in agricultural operations. These engines are available in various sizes and types depending on the use they are put to. Popular designs are reciprocating, rotary and turbines. However, the reciprocating type ICEs are the most preferred designs which are available in smaller and medium power output range.

2.2 Energy Conversion

Basically, ICE is a device to release the energy available in some form of fuel like petrol, diesel and similar petroleum products. Therefore, it may also be called an energy convertor, in that it liberates the heat energy in the fuel and converts it into usable mechanical energy.

2.3 Engine Parts

To achieve the above conversion, the engine comprises several important components, some of which are listed in Figure 2.1 and Table 2.1 below

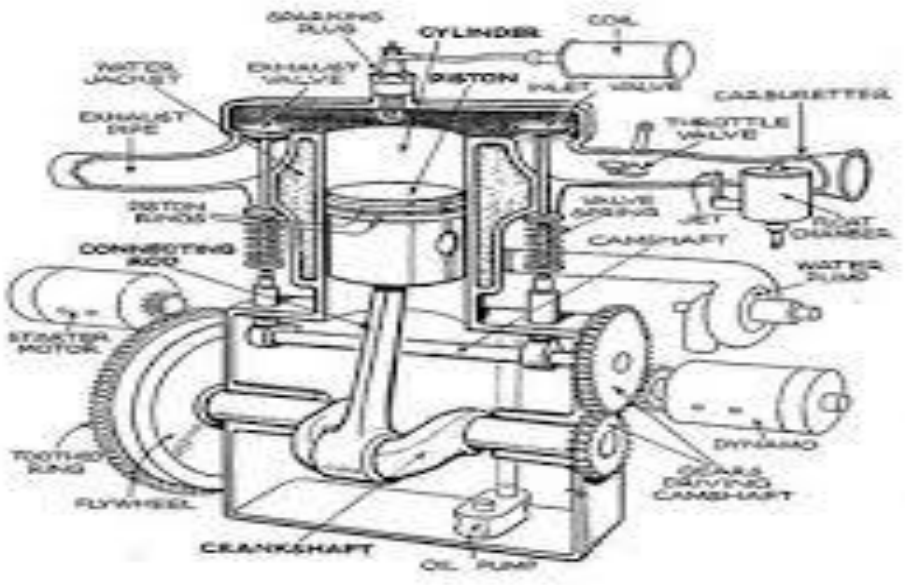

Fig 2.1 Cross section of a four cylinder combustion engine

	Component	Major function
1	Cylinder	The nucleus of all activities, but principally for receiving and burning fuel.
2	Piston	Receives power generated in the cylinder
3	Connecting rod	Transmits power to crankshaft and assists in changing to and fro motion of piston to rotary motion of crankshaft.
4	Crankshaft	Receives power from the piston through the connecting rod
5	Cylinder head	Covers the top of the cylinder (s) and houses other components, such as the valves.
6	Crankcase	Covers bottom of the cylinder and holds engine lubricating oil and other components
7	Inlet and outlet valves	Inlet valves receive fuel (petrol engines) or air (diesel engines); exhaust releases burnt gases.
8	Cam shaft	Operates the valves
9	Flywheel	Helps keep engine running, by its inertia, during idle strokes (intake, compression, exhaust).
10	Engine block	Foundation block to which all the above components are directly or indirectly attached.

Table 2.1 Internal combustion engine components and their functions

2.4 Engine Principles

An engine is a device which converts the energy in a fuel into heat and heat into mechanical energy. For field operations, the energy is made available to the implements through the tractor. Thus the tractor is the main source of engine power in agriculture.

The essential components of an engine are shown below in in Figure 2.2

For an engine to operate, energy produced from combustion of fuel is directed at the piston head. The connecting rod transmits the force into a torque on the crankshaft. The torque is transmitted through the transmission system made up of the clutch; gear, etc. to the wheels, PTO, drawbar, etc.

2.5 Definition of some important terms

1. Bottom Dead Centre (BDC): this is the lowest position of the crankshaft as it rotates in the engine. BDC also marks the lowest position of the piston.
2. Top Dead Centre (TDC): is the topmost position reached by the crankshaft and the topmost position of the piston.
3. Stroke: the distance between TDC and BDC.
4. Bore: is the diameter of the cylinder
5. Piston displacement: is the volume displaced by the piston during one stroke. It is also known as swept volume and can be computed by using Equation 1.1

   $P_d = AL$ ..... (1.1)
6. Total Piston displacement (TPD): is the volume displaced by all the pistons when each one has completed a stroke. It is also called displacement volume.

   TPD = area of cylinder * no of cylinder

7. Compression Ratio: is the ratio of combustion chamber volume at TDC. The volume remaining above the piston head is the clearance volume.

$$CR = \frac{PD + CV}{CV} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (1.2)$$

8. Displacement volume: is the total swept volume of all the pistons during power strokes occurring in a period of one minute. It is expressed as

$$V_d = ALn \ldots\ldots\ldots\ldots (1.3)$$

9. Volume of cylinder – is the sum of the clearance volume, V_c, and the swept volume, V_s

10. Piston speed – is the total travel of the piston in a cylinder during a period of one minute. It may be expressed as

$$S_p = 2Ln \ldots\ldots\ldots\ldots (1.4)$$

Where; Sp = piston seed (m/m), L = piston stroke, n = engine rpm

11. Power – is the rate of doing work i.e. how much work can be done in a given unit of time such as minute or hour.

12. Horse power – if the rate of doing work is equal to 75kg, it is said to be 1hp

13. Indicated horse power – is the total horse power developed by all the cylinders and received by the pistons, disregarding friction and losses within the engine. It may be calculated as follows

IHP = PLAN/75*60

Where;

P = indicated mean effective pressure (kg/sq. cm),

L = piston stroke (m),

A= piston area (sq cm),

n = total no of power strokes per in for all cylinders

14. Brake horse power – is the horse power available at the crankshaft and is measured by a suitable dynamometer.
15. Thermal efficiency – is the ratio of the horse power output of an engine to the fuel horse power.

Example 1

A New Holland diesel tractor has a 3 cylinder 4 stroke engine. Cylinder bore is 88.8 mm, stroke is 127 mm, compression ratio is 16.5:1, belt horse power is 32 and engine speed is 2000 rpm. Calculate (i) piston displacement, (ii) displacement volume, (iii) piston speed, (iv). Stroke ratio

Solution

Area of the piston = $\frac{\Pi D^2}{4}$ = 62 cm^2

Length of the stroke = 127 mm = 12.7 cm

No of power strokes = $\frac{2000}{2} \times 3 = 3000$

i. Piston displacement = 62 * 12.7 = 787.4 cm^3

ii. Displacement volume = $\frac{62 \times 12.7 \times 3000}{1000} = 2362$ liters

iii. Piston speed = $\frac{2 \times 12.7 \times 2000}{1000} = 50.8$ m/s

iv. Stroke bore ratio = 127/88.8 = 1.43