Farm Power and Machinery Engineering

Unit-1 **Total Lecture: 6**

1.0 Introduction

India's total geographical area is 329 million hectares. Out of this, 195 million hectare is gross cropped area and 141 million hectare is net sown area. On the other hand, net irrigated area is only 65.3 million hectares. Rest of the land is rainfed. India has made impressive strides in the field of agriculture by enhancing agricultural production from a mere 51 million tons in 1950-51 to 292 million-tons by 2019-2020. This has been achieved through the adoption of biological, chemical and mechanical inputs and by creating/promoting required infrastructure and facilities in rural areas. Appropriate Govt. policies such as consolidation of holdings, land levelling, rural roads, and establishment of grain markets, rural electrification, adequate credit and assured minimum support price have helped in this phenomenal increase in agricultural production and productivity. Based on the size of the landholding, the farmers in India are classified as:

I. Marginal – less than 1 hectare
II. Small – 1-2 hectare
III. Semi-medium – 2-4 hectare
IV. Medium – 4-10 hectare
V. Large – 10 hectare and above

In India, More than 75 % farmers belong to marginal and small category.

2.0 Farm Mechanization

Mechanization of agriculture is an essential input in modern agriculture. It enhances productivity, besides reducing human drudgery and cost of cultivation. Mechanization also helps in improving utilization efficiency of other inputs, safety and comfort of the agricultural worker, improvements in the quality and value addition of the produce. Efficient machinery helps in increasing production and productivity, besides enabling the farmers to raise a second crop or multi crop making the Indian agriculture attractive and a way of life by becoming commercial instead of subsistence. Increased production will require more use of agricultural inputs and protection of crops from various stresses. At present the farm power availability per ha is 2.02 kW/ha (2016-17).

2.1 Benefits of Farm Mechanization:

There are various benefits of farm mechanization:

1) Timeliness of operation

2) Precision of operation

3) Improvement of work environment

4) Enhancement of safety

5) Reduction of drudgery of labour

6) Reduction of loss of crops and food products

7) Increased productivity of land

8) Increased economic return to farmers

9) Improved dignity of farmers

10) Progress and prosperity in rural areas

2.2 **Constraints in Farm Mechanization (Limiting Factors in Farm Mechanization)**

1. Small land holdings

2. Less investing capacity of farmers

3. Adequate availability of draft animals

4. Lack of suitable farm machine for different operations

5. Lack of repair and servicing facilities for machines

6. Lack of trained man power

7. Lack of coordination between research organization and manufacturer

8. High cost of machines

2.3 Present Status of Farm Mechanization:

Present status of farm mechanization is quite appreciating. We have:

(a) Improved manual tools.

(b) Improved animal drawn implements.

(c) Tractor operated implements.

(d) Custom hiring units on the farm.

(e) Other stationary equipments like threshers, irrigation pumps, sprayers, dusters etc.

3.0 Farm Power

Farm Power is an essential input in agriculture for timely field operations for increasing production and productivity of land. Farm power is used for operating different types of machinery like tillage, planting, plant protection, harvesting and threshing machinery and other stationary jobs like operating irrigation equipment, threshers/ shellers / cleaners/ graders, etc.

3.1 Sources of Farm Power

There are different sources of farm power available in India which are classified as

(i) Human power

(ii) Animal power

(iii) Mechanical power (Tractors + Power tillers + Oil engines)

(iv) Electrical power

(v) Renewable energy (Biogas + Solar energy + Wind energy)

HUMAN POWER

Human power is the main source for operating small implements and tools at the farm. Stationary work like chaff cutting, lifting, water, threshing, winnowing etc are also done by manual labour. An average man can develop maximum power of about 0.1 hp for doing farm work.

ANIMAL POWER

Power developed by an average pair of bullocks about 1 hp for usual farm work. Bullocks are employed for all types farm work in all seasons. Besides bullocks, other animals like camels, buffaloes, horses, donkeys, mules and elephants are also used at some places. The average force a draft animal can exert is nearly one-tenth of its body weight.

MECHANICAL POWER

Broadly speaking, mechanical power includes stationary oil engines, tractors , power tillers and self propelled combines. Internal combustion engine is a good device for converting liquid fuel into useful work(mechanical work). These engines are two types (1) Spark ignition engines (Petrol or Kerosene engine) (2) Compression ignition engines (Diesel engines)

In modern days, almost all the tractors and power tillers are operated by diesel engines. Diesel engines are used for operating irrigation pumps, flour mills, oil ghanis, cotton gins, chaff cutter, sugarcane crusher, threshers, winnowers etc

ELECTRICAL POWER

Electrical power is used mostly in the form of electrical motors on the farms. Motor is a very useful machine for farmers. It is clean, quest and smooth running. Its maintenance and operation needs less attention and care. The operating cost remains almost constant throughout its life. Electrical power is used for water pumping, diary industry, cold storage, farm product processing, fruit industry and many similar things.

RENEWABLE ENERGY

It is the energy mainly obtained from renewable sources of energy like sun, wind, biomass etc. Biogas energy, wind energy and solar energy are used in agriculture and domestic purposes with suitable devices. Renewable energy can be used for lighting, cooking, water heating, space heating, water distillation, food processing, water pumping, and electric generation. This type of energy is inexhaustible in nature.

4.0 Heat Engine

Heat engine is a machine for converting heat, developed by burning fuel into useful work. It can be said that heat engine is equipment which generates thermal energy and transforms it into mechanical energy.

4.1 Classification of Heat Engines

(i)External combustion engine

Here, the working medium, the steam, is generated in a boiler, located outside the engine and allowed in to the cylinder to operate the piston to do mechanical work.

(ii) Internal combustion engine.

In internal combustion engine, the combustion of fuel takes place inside the engine cylinder and heat is generated within the cylinder. This heat is added to the air inside the cylinder and thus the pressure of the air is increased tremendously. This high pressure air moves the piston which rotates the crank shaft and thus mechanical work is done.

There are two ways in which combustion takes place in the cylinder:

(a)Spark ignition engine (Carburetor type engines)

a mixture of air and fuel is drawn in to the engine cylinder. Ignition of fuel is done by using a spark plug. The spark plug produces a spark and ignites the air- fuel mixture. Such combustion is called constant volume combustion (C.V.C.).

(b)Compression ignition engine (injector type engines)

In compression ignition engines air is compressed in to the engine cylinder, Due to this the temperature of the compressed air rises to 700-900 C. At this stage diesel is sprayed in to the cylinder in fine particles. Due to a very high temperature, the fuel gets ignited. This type of combustion is called constant pressure combustion (CP.C.) because the pressure inside the cylinder is almost constant when combustion is taking place.

4.2 Construction of an IC Engine

I.C. engine converts the reciprocating motion of piston into rotary motion of the crankshaft by means of a connecting rod. The piston which reciprocating in the cylinder is very close fit in the cylinder. Rings are inserted in the circumferential grooves of the piston to prevent leakage of gases from sides of the piston. Usually a cylinder is bored in a cylinder block and a gasket, made of copper sheet or asbestos is inserted between the cylinder and the cylinder head to avoid ant leakage. The combustion space is provided at the top of the cylinder head where combustion takes place. The connecting rod connects the piston and the crankshaft. The end of the

connecting rod connecting the piston is called small end. A pin called gudgeon pin or wrist pin is provided for connecting the piston and the connecting rod at the small end. . The other end of the connecting rod connecting the crank shaft is called big end. When piston is moved up and down, the motion is transmitted to the crank shaft by the connecting rod and the crank shaft makes rotary motion. The crankshaft rotates in main bearings which are fitted the crankcase. A flywheel is provided at one end of the crankshaft for smoothing the uneven torque produced by the engine. There is an oil sump at the bottom of the engine which contains lubricating oil for lubricating different parts of the engine.

Mechanical cycle of internal combustion engine can be completed in two ways:

1. Four stroke cycle engine: when the cycle is completed two revolution of the crankshaft, it is called four stroke cycle engines.
2. Two stroke cycle engine: when the cycle is completed one revolution of the crankshaft, it is called tow stroke cycle engine.

FOUR STROKE CYCLE ENGINE (DIESEL/ PETROL ENGINE)

In four stroke cycle engines the four events namely suction, compression, power and exhaust take place inside the engine cylinder. The four events are completed in four strokes of the piston (two revolutions of the crank shaft). This engine has got valves for controlling the inlet of charge and outlet of exhaust gases. The opening and closing of the valve is controlled by cams, fitted on camshaft. The camshaft is driven by crankshaft with the help of suitable gears or chains. The camshaft runs at half the speed of the crankshaft. The events taking place in I.C. engine are as follows:

1. Suction stroke
2. Compression stroke
3. Power stroke
4. Exhaust stroke

1. **Suction stroke**

During suction stroke inlet valve opens and the piston moves downward. Only air or a mixture of air and fuel are drawn inside the cylinder. The exhaust valve remains in closed position during this stroke. The pressure in the engine cylinder is less than atmospheric pressure during this stroke (Fig. 1a)

2. **Compression stroke**

During this stroke the piston moves upward. Both valves are in closed position. The charge taken in the cylinder is compressed by the upward movement of piston. If only air is compressed, as in

case of diesel engine, diesel is injected at the end of the compression stroke and ignition of fuel takes place due to high pressure and temperature of the compressed air. If a mixture of air and fuel is compressed in the cylinder, as in case of petrol engine, the mixture is ignited by a spark plug.

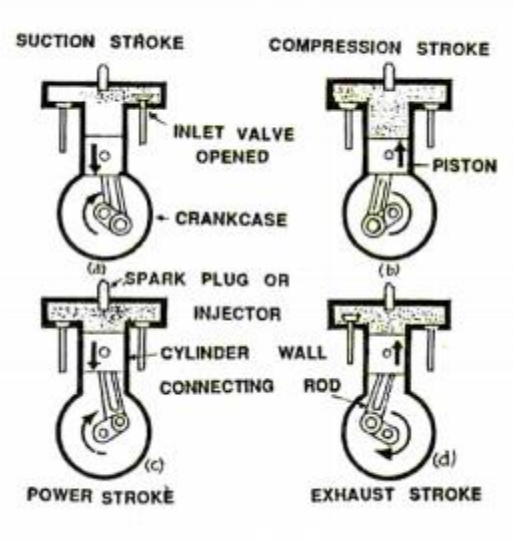


Fig.1(a,bc,d): Four stroke cycle engine

3. Power stroke

After ignition of fuel, tremendous amount of heat is generated, causing very high pressure in the cylinder which pushes the piston downward (Fig.1b). The downward movement of the piston at this instant is called power stroke. The connecting rod transmits the power from piston to the crank shaft and crank shaft rotates. Mechanical work can be taped at the rotating crank shaft. Both valves remain closed during power stroke.

4. Exhaust stroke

During this stroke piston moves upward. Exhaust valve opens and exhaust gases go out through exhaust valves opening. All the burnt gases go out of the engine and the cylinder becomes ready to receive the fresh charge. During this stroke inlet valve remains closed (Fig.1d). Thus it is found that out of four strokes, there is only one power stroke and three idle strokes in four stroke cycle engine. The power stroke supplies necessary momentum for useful work

TWO STROKE CYCLE ENGINE (PETROL ENGINE)

In two stroke cycle engines, the whole sequence of events i.e., suction, compression, power and exhaust are completed in two strokes of the piston i.e. one revolution of the crankshaft. There is

no valve in this type of engine. Gas movement takes place through holes called ports in the cylinder. The crankcase of the engine is air tight in which the crankshaft rotates.

Upward stroke of the piston (Suction + Compression)

When the piston moves upward it covers two of the ports, the exhaust port and transfer port, which are normally almost opposite to each other. This traps the charge of air- fuel mixture drawn already in to the cylinder. Further upward movement of the piston compresses the charge and also uncovers the suction port. Now fresh mixture is drawn through this port into the crankcase. Just before the end of this stroke, the mixture in the cylinder is ignited by a spark plug (Fig 2 c &d). Thus, during this stroke both suction and compression events are completed.

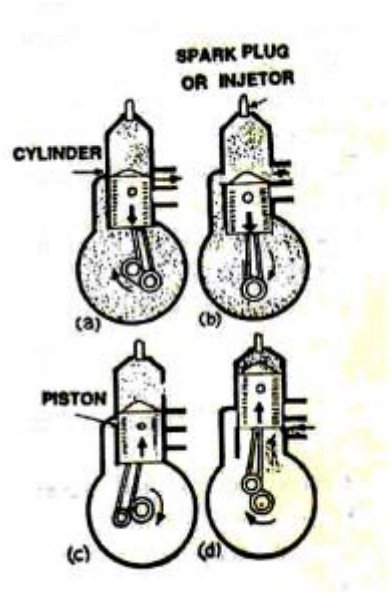


Fig.2; Two Stroke Cycle Engine

Downward stroke (Power + Exhaust)

Burning of the fuel rises the temperature and pressure of the gases which forces the piston to move down the cylinder. When the piston moves down, it closes the suction port, trapping the fresh charge drawn into the crankcase during the previous upward stroke. Further downward movement of the piston uncovers first the exhaust port and then the transfer port. Now fresh charge in the crankcase moves in to the cylinder through the transfer port driving out the burnt gases through the exhaust port. Special shaped piston crown deflect the incoming mixture up around the cylinder so that it can help in driving out the exhaust gases . During the downward stroke of the piston power and exhaust events are completed.

4.3 Working Principle of Diesel Engine

The basic components of diesel engine are cylinder, piston, injector, valves, connecting rod and crankshaft. In diesel engines only air is drawn into the cylinder. The engine has high compression ratio hence the air in the cylinder attains very high temperature and pressure at the end of the compression stroke. At the end of the compression stroke, the fuel is sprayed into the cylinder in atomized form using injectors. Due to high temperature, the fuel gets ignited, begins to burn and produce lot of heat. Due to the heat the gases expand, move the piston downward and rotate the crank shaft. The torque available at the rotating crank shaft is used to do any mechanical work.

Special features of diesel engine

1) Engine has high compression ratio ranging from 14:1 to 22:1.

2) During compression stroke, the engine attains high pressure ranging from 30 to 45 kg/cm2 and high temperature of about 500°C.

3) At the end of the compression stroke, fuel is injected into the cylinder through injectors (atomizers) at a very high pressure ranging from 120 to 200 kg/cm2 .

4) Ignition takes place due to heat of compression only.

5) There is no external spark in diesel engine.

6) Diesel engine has better slogging or lugging ability i.e. it maintains higher torque for a longer duration of time at a lower speed.

4.4 Comparison of Diesel Engine with Petrol Engine

SN	Diesel Engine	**Petrol Engine**
1.	It has got no carburetor, ignition coil and spark plug.	It has got carburetor, ignition coil & spark plug.
2.	Its compression ratio varies from 14:1 to 22:1	Its compression ratio varies from 5:1 to 8:1.
3.	It uses diesel oil as fuel	It uses petrol (gasoline) or power kerosine as fuel.
4.	Only air is sucked in cylinder in suction stroke.	Mixture of fuel and air is sucked in the cylinder in suction stroke.
5.	Fuel is injected in combustion chamber where burning of fuel takes places due to heat of compression.	Air fuel mixture is compressed in the combustion chamber when it is ignited by an electric spark.
6.	Thermal efficiency varies from 32 to 38%	Thermal efficiency varies from 25 to 32%
7.	Compression pressure inside the cylinder varies from 35 to 45 kg/cm2 and temperature is about 500°C.	Compression pressure varies from 6 to 10 kg/cm2 and temperature is above 260°C.

4.5 ENGINE COMPONENTS

Internal combustion engine consists of a number of parts which are given below :

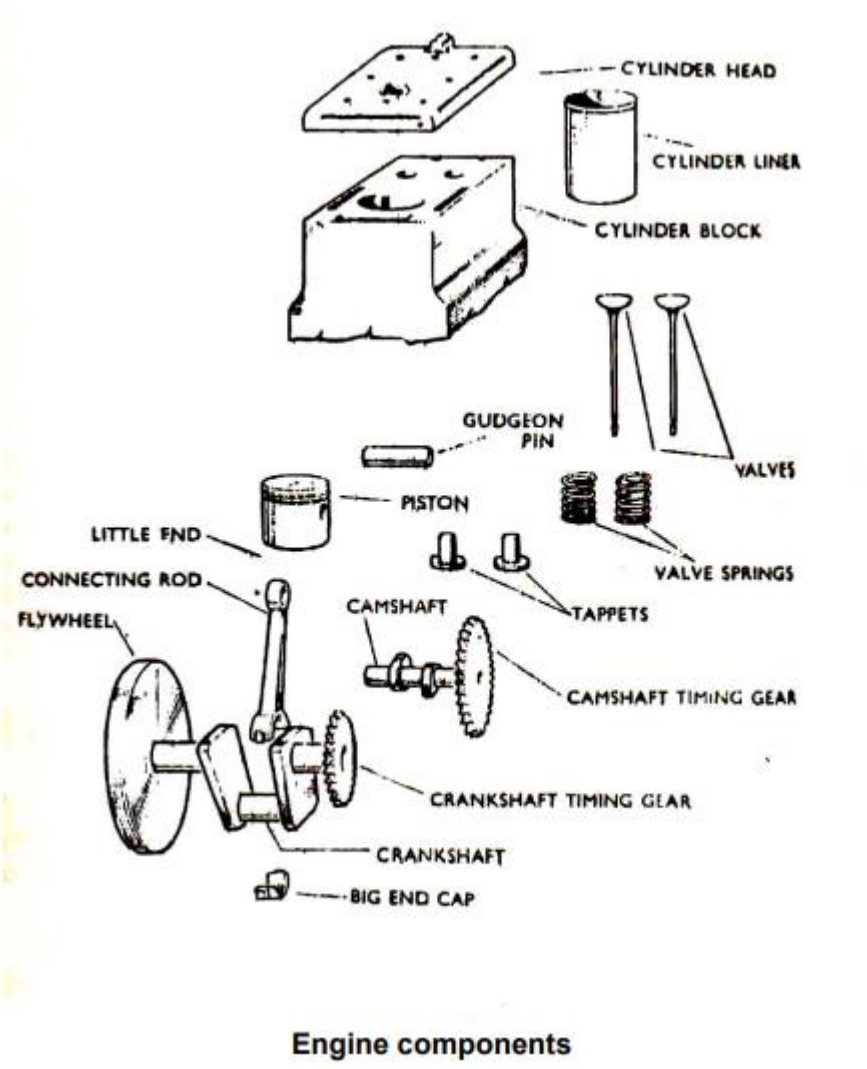


Fig.3: Engine Components

(i) Cylinder: It is a part of the engine which confines the expanding gases and forms the combustion space. It is the basic part of the engine. It provides space in which piston operates to suck the air or air-fuel mixture. The piston compresses the charge and the gas is allowed to expand in the cylinder, transmitting power for useful work. Cylinders are usually made of high grade cast iron.

(ii) Cylinder block: It is the solid casting body which includes the cylinder and water jackets (cooling fins in the air cooled engines).

(iii) Cylinder head: It is a detachable portion of an engine which covers the cylinder and includes the combustion chamber, spark plugs or injector and valves.

(iv) Cylinder liner or sleeve: It is a cylindrical lining either wet or dry type which is inserted in the cylinder block in which the piston slides. Liners are classified as : (1) Dry liner and (2) Wet liner. Dry liner makes metal to metal contact with the cylinder block casing. wet liners come in contact with the cooling water, whereas dry liners do not come in contact with the cooling water.

(v) Piston: It is a cylindrical part closed at one end which maintains a close sliding fit in the engine cylinder. It is connected to the connecting rod by a piston pin. The force of the expanding gases against the closed end of the piston, forces the piston down in the cylinder. This causes the connecting rod to rotate the crankshaft (Fig 3). Cast iron is chosen due to its high compressive strength. Aluminum and its alloys preferred mainly due to it lightness.

Head (Crown) of piston: It is the top of the piston.

Skirt: It is that portion of the piston below the piston pin which is designed to

adsorb the side movements of the piston.

(vi) Piston ring: It is a split expansion ring, placed in the groove of the piston. They are usually made of cast iron or pressed steel alloy (Fig.3). The function of the ring are as follows :

a) It forms a gas tight combustion chamber for all positions of piston.

b) It reduces contact area between cylinder wall and piston wall preventing friction losses and excessive wear.

c) It controls the cylinder lubrication.

d) It transmits the heat away from the piston to the cylinder walls.

Piston rings are of two types: (1) Compression ring and (2) Oil ring

(vii) Compression ring: Compression rings are usually plain, single piece and are always placed in the grooves of the piston nearest to the piston head. They prevent leakage of gases from the cylinder and helps increasing compression pressure inside the cylinder.

Oil ring: Oil rings are grooved or slotted and are located either in lowest groove above the piston pin or in a groove above the piston skirt. They control the distribution of lubrication oil in the cylinder and the piston.

Piston Pin: It is also called wrist pin or gudgeon pin. Piston pin is used to join the connecting rod to the piston.

(viii) Connecting rod: It is special type of rod, one end of which is attached to the piston and the other end to the crankshaft (Fig.3). It transmits the power of combustion to the crankshaft and makes it rotate continuously. It is usually made of drop forged steel.

(ix) Crankshaft: It is the main shaft of an engine which converts the reciprocating motion of the piston into rotary motion of the flywheel (Fig.3). Usually the crankshaft is made of drop forged steel or cast steel. The space that supports the crankshaft in the cylinder block is called main journal, whereas the part to which connecting rod is attached is known as crank journal. Crankshaft is provided with counter weights throughout its length to have counter balance of the unit.

(x) Flywheel: Flywheel is made of cast iron. Its main functions are as follows :

a) It stores energy during power stroke and returns back the energy during the idle strokes, providing a uniform rotary motion of flywheel.

b) The rear surface of the flywheel serves as one of the pressure surfaces for the clutch plate.

c) Engine timing marks are usually stamped on the flywheel, which helps in adjusting the timing of the engine.

d) Sometime the flywheel serves the purpose of a pulley for transmitting power.

(xi) Crankcase: The crankcase is that part of the engine which supports and encloses the crankshaft and camshaft. It provides a reservoir for the lubricating oil. It also serves as a mounting unit for such accessories as the oil pump, oil filter,, starting motor and ignition components. The upper portion of the crankcase is usually integral with cylinder block. The lower part of the crankcase is commonly called oil pan and is usually made of cast iron or cast aluminum

(xii) Camshaft: It is a shaft which raises and lowers the inlet and exhaust valves at proper times. Camshaft is driven by crankshaft by means of gears, chains or sprockets (Fig3). The speed of the camshaft is exactly half the speed of the crankshaft in four stroke engine. Camshaft operates the ignition timing mechanism, lubricating oil pump and fuel pump. It is mounted in the crankcase, parallel to the crankshaft.

(xiii) Timing gear: Timing gear is a combination of gears, one gear of which is mounted at one end of the camshaft and the other gear at the crankshaft. Camshaft gear (fig.3) is bigger in size than that of the crankshaft gear and it has twice as many teeth as that of the crankshaft gear. For this reason, this gear is commonly called half time gear. Timing gear controls the timing of ignition, timing of opening and closing of valve as well as fuel injection timing.

(xiv) Inlet manifold: It is that part of the engine through which air or air-fuel mixture enters into the engine cylinder. It is fitted by the side of the cylinder head.

(xv) Exhaust manifold: It is that part of the engine through which exhaust gases go out of the engine cylinder. It is capable of withstanding high temperature of burnt gases. It is fitted by the side of the cylinder head.

(xiv) Top dead centre - When the piston is at the top of its stroke, it is said to be at the top dead centre (TDC),

(xv) Bottom dead centre - when the piston is at the bottom of its stroke, it is said to be at its bottom dead centre (BDC).

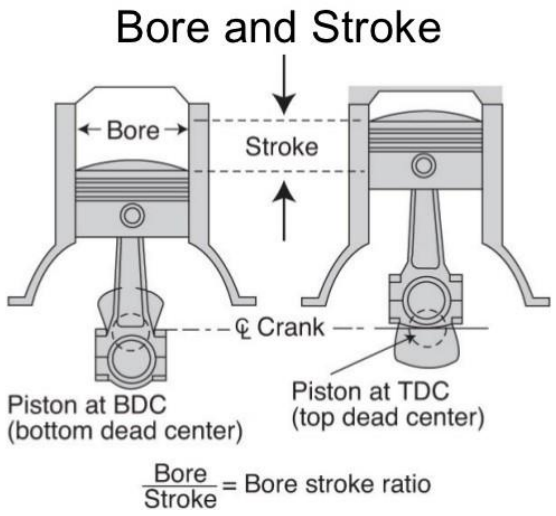
In two stroke cycle engine both the sides of the piston are effective which is not the case in four stroke cycle engine.

(xvi) Scavenging The process of removal of burnt or exhaust gases from the engine cylinder is known as scavenging. Entire burnt gases do not go out in normal stroke, hence some type of blower or compressor is used to remove the exhaust gases in two stroke cycle engine.

Terminology related to IC Engine

Bore- Bore is the diameter of the engine cylinder.

Stroke - It is the linear distance traveled by the piston from Top dead centre (TDC) to Bottom dead centre (BDC).



Stroke-bore ratio -The ratio of length of stroke (L) and diameter of bore (D) of the cylinder is called stroke-bore ratio (L/D). In general, this ratio varies between 1 to 1.45 and for tractor engines, this ratio is about 1.25.

Swept volume - It is the volume (A x L) displaced by one stroke of the piston where A is the cross sectional area of piston and L is the length of stroke.

Compression ratio - It is the ratio of the volume of the cylinder at the beginning of the compression stroke to that at the end of compression stroke, i.e. ratio of total cylinder volume to clearance volume. The Compression ratio of diesel engine varies from 14:1 to 22:1 and that of carburetor type engine (spark ignition engine) varies from 4:1 to 8:1.

Indicated horse power (IHP) - It is the power generated in the engine cylinder and received by the piston. It is the power developed in a cylinder without accounting frictional losses.

$$IHP = \frac{PLAN}{4500} X \frac{x}{2} \qquad for\ 4\ stroke$$

$$IHP = \frac{PLAN}{4500} X \frac{x}{1} \qquad for\ 2\ stroke$$

Where,

P= mean effective pressure, kg/cm^2

L= length of stroke, m

A= cross sectional area of piston, cm^2

N=engine speed, rev/min.

x=number of cylinder

Brake horse power (BHP) - It is the power delivered by the engine at the end of the crankshaft. It is measured by a dynamometer.

Belt horse power - It is the power of the engine measured at a pulley receiving drive from the PTO shaft of the tractor.

Power take-off horse power (PTO HP) - It is the power delivered by a tractor through its PTO shaft. In general, the belt and PTO horse power of a tractor will approximately be the same. The PTO hp is around 80-85% 0f tractor engine power

Drawbar horse power (DBHP) - It is the power of a tractor measured at the drawbar of a tractor. It is that power which is available for pulling loads. It is around 50-55 % of engine power

Frictional horse power (FHP) - It is the power required to run the engine at a given speed without producing any useful work. It represents the friction and pumping losses of an engine.

IHP = BHP + FHP

Mechanical Efficiency- it is ratio of the brake power to indicated power and expressed as:

$$\text{Mechanical efficiency} = \frac{\text{Brake horse power(BHP)}}{\text{Indicated horse power(IHP)}} \text{x}100$$

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