Farm Power and Machinery

5. Farm Power and Machinery (HNE 101) 2 (1+1)

Basic concepts of various forms of energy, unit and dimensions of force, energy and power, calculations with realistic examples. IC Engines: Basic principles of operation of compression, ignition and spark ignition engines, two stroke and four stroke engines, cooling and lubrication system, power transmission system, broad understanding of performance and efficiency, tractors, power tillers and their types and uses. Electric motors: types, construction and performance comparison. Tillage: objectives, method of ploughing. Primary tillage implements: construction and function of indigenous ploughs, improved indigenous ploughs, mould board ploughs, disc and rotary ploughs. Secondary tillage implements: construction and function of tillers, harrows, levelers, ridgers and bund formers. Sowing and transplanting equipment: seed drills, potato planters, seedling transplanter. Grafting, pruning and training tools and equipment. Inter-culture equipment: sweep. Junior hoe, weeders, long handle weeders. Crop harvesting equipments: potato diggers, fruit pluckers, tapioca puller and hoists.

Practical: *Calculation on force, power and energy. IC engines – showing the components of dismantled engines and motors. Primary and secondary tillage implements, hitching, adjustments and operations. Spraying equipment, calibration and operation. Plant protection equipment, calculation of dilution ratio and operation.*

FARM POWER AND MACHINERY

Chapter – 1

Energy for Agriculture

Energy is the primary and most universal measure of all kinds of work by human beings and nature. Everything what happens in the world is the expression of flow of energy in one of it's form. There are a number of different forms of energy available in nature. The different forms of energy used for agriculture (farm power) in India are Human energy (human power), Animal energy (animal power), Mechanical energy (mechanical power such as Tractors, Power tillers, Self propelled combines, Oil engines), Electrical energy (electrical power), and Renewable energy (Biomass, Solar energy and Wind energy).

Human power

Human power is the main source of energy for operating small implements and tools at the farm. Stationary work like chaff cutting, water lifting, threshing, winnowing etc. and field work like weeding, broadcasting are also done by manual labour. An average man can develop maximum power of about 0.1 hp and women labour can develop 0.05 hp power for doing farm work. But now a day the availability of human power for farm operations is depleting. The human power working in the field is shown in Plate 1.1.

The advantages of human power are; it is easily available and can be used for all types of work. The limitations of human energy are the costliest power compared to all other forms of power, very low efficiency, requires full maintenance when not in use and affected by weather condition and seasons.

Plate : 1.1 A view of human labour working in the field

Animal power

The average power developed by a pair of bullocks is about 1 hp for farm operations. Bullocks are employed for all types farm work in all seasons. Besides bullocks and buffaloes other animals like camels, horses, donkeys, mules and elephants are also used at some places. The average force a draft animal can exert for farm work is nearly $1/10^{th}$ of its body weight. A pair of bullocks working in the field is shown in Plate 1.2.

The advantages of animal power are easily available, used for all types of work, low initial investment, supplies manures to the field and fuels to farmers and lives on farm produce. The disadvantages of animal power; viz. they are not very efficient, seasons and weather affect the efficiency, cannot work continuously, requires full maintenance when not in use and very slow in doing work.

Plate : 1.2 A pair of bullocks working in the field

Mechanical power

Broadly speaking, mechanical power includes stationary oil engines, tractors and power tillers. The internal combustion engine is a good device for converting fuel energy (Chemical energy) into useful work (Mechanical energy). The internal combustion engines are of two types : Diesel engine and Petrol / Kerosene engine. The thermal efficiency of diesel engine varies from 32 to 38 per cent whereas that of petrol engine varies from 25 to 32 per cent.

In modern days, almost all the tractors and power tillers are operated by diesel engines. A tractor in field operation is shown in Plate 1.3. The diesel engines are used for stationery operations like water lifting, flour mills, oil expellers, vegetable washers, gardeners, mulberry processing equipments, threshers, winnowers, chaff cutter etc.

The advantages of mechanical power are; their efficiency is high, not affected by weather, can run at a stretch for longer period, require less space and cheaper source of power. The disadvantages of mechanical power are; initial capital investment is very high, fuel is costly and scarce, needs technical knowledge for repairs and maintenance.

Plate : 1.3 Mechanical power – Tractor in operation

Electrical power

Electrical power is the mostly used for operating electrical motors in the farms. The different types of electric motors used are shown in Plate 1.4. This is a clean and efficient source of energy. The maintenance and operation of motors needs less attention and care. The operating cost remains almost constant throughout its life. Electrical power is used for operating pump sets, high-tech nursery, diary industry, cold storage, farm product processing, fruit industry and food processing industries.

The advantages of electrical power are viz; very cheapest form of power, high efficiency, can work at a stretch continuously for longer periods, maintenance and operating cost is very low and not affected by seasons. The disadvantages are viz; initial capital investment high, requires good amount of technical knowledge and if handled carelessly, it causes great danger.

Plate : 1.4 Different types of electric motors

(Source: http://www.indiamart.com)

Renewable energy

It is the energy mainly obtained from renewable sources like sun, wind and biomass. Biomass energy (biogas, producer gas, ethanol and biodiesel), wind energy and solar energy are used in agriculture and domestic purposes with suitable devices. It can be used for lighting, cooking, water heating, space heating, water distillation, food processing, water pumping, diesel engine operation and electricity generation. This type of energy is inexhaustible in nature. The different renewable energy gadgets are depicted in Plate 1.5.

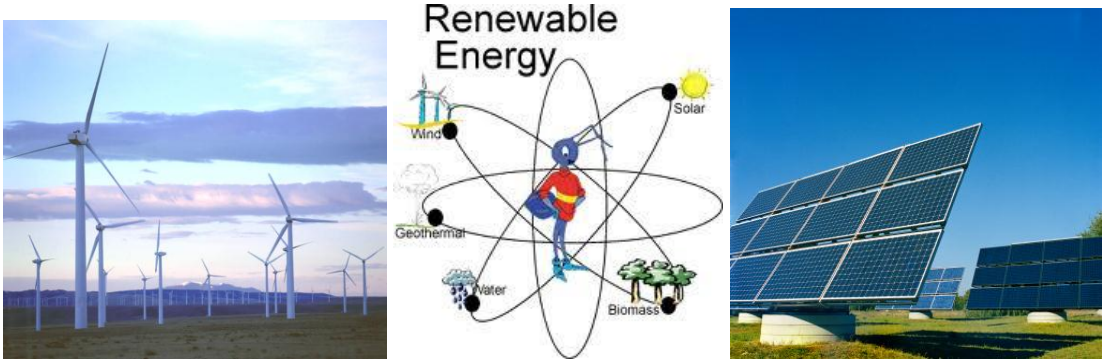

Plate : 1.5 Different renewable energy gadgets

(Source: http://www.treehugger.com , http://greenerbuyer.com & http://c1.ecopreneurist.com)

Force, work, power and energy

Force : An invisible agent which always tries to change the state of the body. The unit for force in SI system is Newton (N) and in MKS system is Kg-f

Work : When a force is applied to the body, it moves in the direction of the applied force, then work is said to be done. The unit for work is Newton- meters (N-m).

Work done = Force X Distance traveled **…….. N-m**

Power : It is the rate of doing work. The work done per unit time is called power and is expressed in N-m-Sec^{-1}.

$$\textbf{Power} = \frac{\text{Work done}}{\text{Time taken}} \quad \ldots\ldots\ldots\ldots\ldots \quad \textbf{N-m-Sec}^{-1} \textbf{ or Watt}$$

Energy: It is the capacity to do the work. The unit for energy is Joules or Calories or Kilo Watt or Horse Power.

Horse Power:- It is that amount of force which is capable or displacing 75 kg force through a distance of one meter in one second.

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Conversion factors :

One Horse power (HP) = 746 Watts or 0.746 KW.

One Watt = 1 Joule / sec.

One joule = 0.2389 Calories.

One kW = 102 Kg-m/sec.

Some of the important conversions

1 Watt = 1 Joule/sec

1 Calorie = 4.2 Joules

1 Kg = 9.8 Newton (N)

1 N-m = 1 joule

1 N-m/s = 1 joule/s = 1 Watt

1 Kg/cm^2 = 9.8 x $10^4 N/m^2$ = 9.8 x 10^4 Pascals (Pa) = 98 Pa.

1 Pa = $1N/m^2$

1 Kg-m/s = 9.8 Joules/s = 9.8 Watt

1 J/s = 0.10198 Kg-m/s

1 Calorie = 4.186 Joules

1 Joules = 0.2389 Calorie

1 kW-h = 860 k Calories

1 kW = 1000 W = 102 Kg-m/s

Chapter - 2

Internal Combustion Engines

The heat engine is a device in which heat energy of fuel after burning it properly is used to convert it into mechanical energy (mechanical work). The heat engine is an equipment which generates thermal energy and transforms it into mechanical energy. The heat energy is produced by the combustion of fuel. The heat engines are of two types :

1. **External Combustion Engine**

   In this type of engine the fuel is burnt outside the engine cylinder, in a device called boiler to produce hot gas or steam, which is used in the engine cylinder to develop the mechanical work. The line diagram of working principle of External combustion engine is shown in Fig 2.1. The best example for external combustion engine is steam engine. The thermal efficiency of external combustion engine is usually in the range of 15 to 20%, which is very low compared to the internal combustion engine.

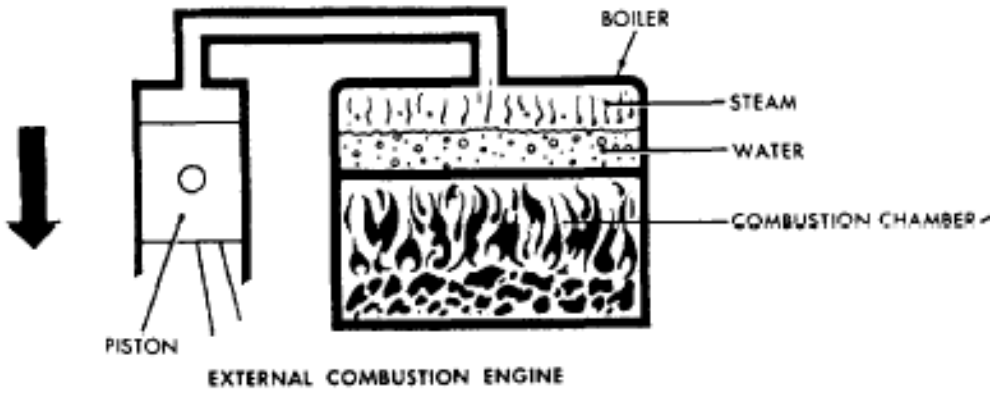

Fig 2.1. Working principle of External combustion engine.

(Source: **http://www.tpub.com**)

2. **Internal Combustion Engine** : In this type of engine the burning or combustion of the fuel takes place inside the engine cylinder. There are two ways in which combustion takes place in the cylinder:

   i) By rapid explosion of air-fuel mixture within the cylinder, when it is ignited by a spark, is called **constant volume combustion** (C.V.C.).

   ii) Combustion takes place by slow burning when the fuel is injected into highly compressed heated air contained in the cylinder. This is called **constant pressure combustion** (C.P.C.), because when the combustion takes place, the pressure in the cylinder is almost constant.

   The power is developed during the power stroke. Most of the engines used in tractors, automobiles, combine harvesters, oil engines and traction vehicles are of this type. The line diagram of working principle of Internal combustion engine is shown in Fig. 2.2. The thermal efficiency of internal combustion engine is about 40%.

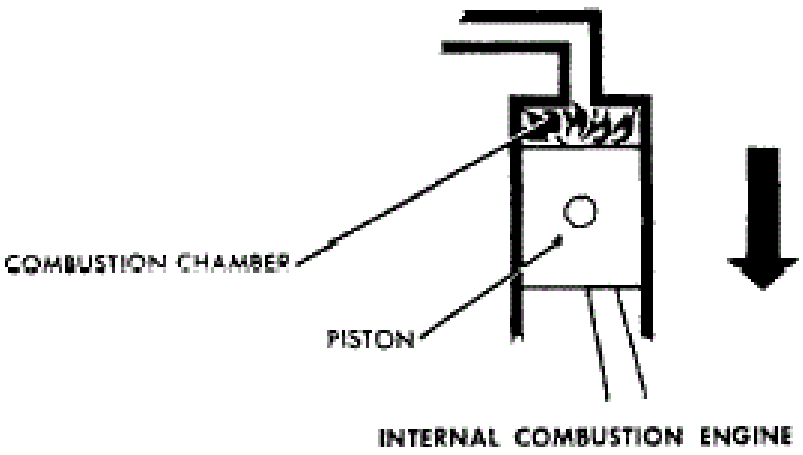

Fig. 2.2 Working principle of Internal combustion engine

(Grace: http://www.tpub.com)

Classification of Internal Combustion Engine (IC engines)

The IC engines can be classified based on number of factors as follows

I. According to Number of Strokes :

1. Four Stroke Cycle Engine : In this type of engine, one complete combustion cycle is completed in four strokes of the piston or two revolution of the crankshaft. The principle of operation of Four stroke engine is shown in Fig. 2.3. The four events that take place inside the engine cylinder are:

1. Suction of air or air – fuel mixture in to the cylinder
2. Compression of the gases
3. Ignition of the fuel mixture to produce power
4. Exhaust of burnt gases

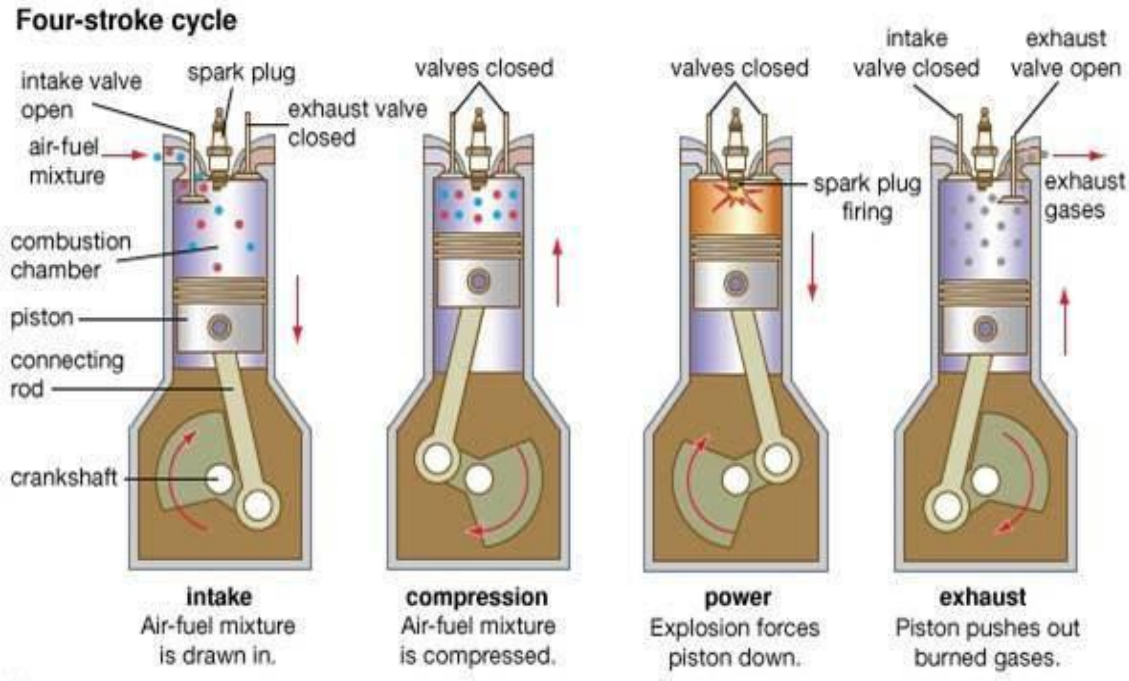

Fig. 2.3 Principle of operation of Four stroke engine

(Grace: http://www.britannica.com)

2. Two Stroke Cycle Engine: The two stroke cycle engine completes all the four events i.e. suction, compression, power or expansion and exhaust in two strokes (up stroke & down stroke) of piston or one revolution of crankshaft. During each stroke of the piston, two events takes place. The Principle of operation of Two stroke engine is shown in Fig. 2.4.

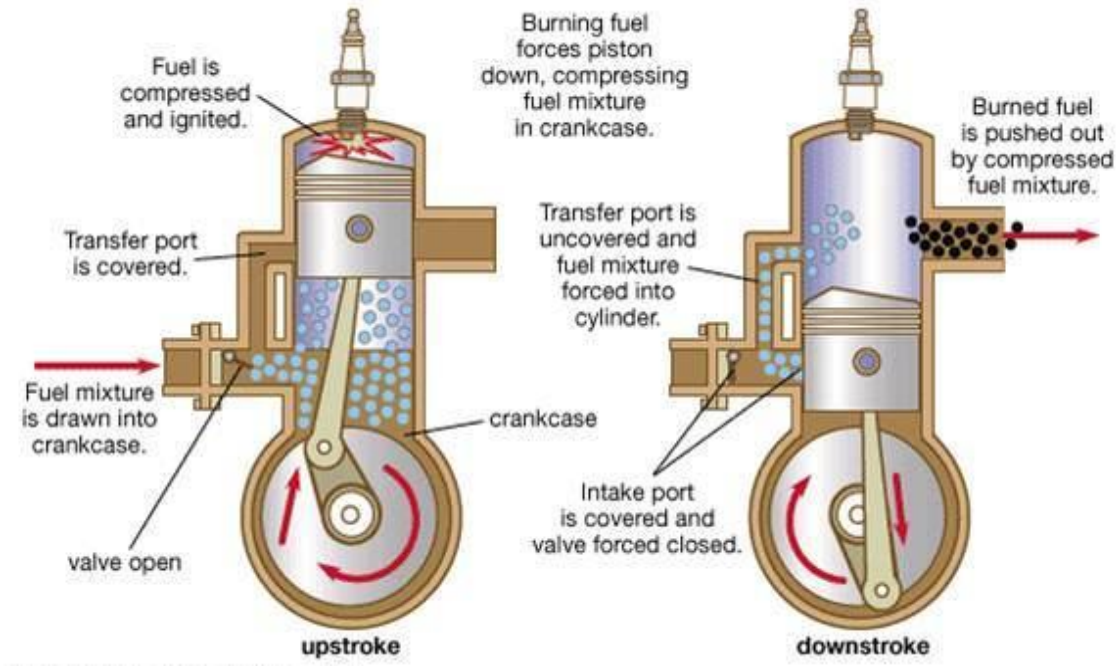

Fig. 2.4 Principle of operation of Two stroke engine

(Grace: http://tariqhafez.blogspot.com)

II. According to thermodynamic working cycle:

1. Otto-cycle engine: The heat is taken in at one constant volume and rejected at another constant volume of the cylinder. The combustion of the fuel takes place at constant volume. Petrol engine works on otto cycle.

2. Diesel cycle engine: In this cycle, the heat is taken at constant pressure and rejected at constant volume. The combustion of the fuel takes place at constant pressure. Diesel engine works on this cycle.

3. Dual cycle engine: In this type of engine, some part of the heat is taken at constant volume and the remaining part at constant pressure process. The heat is rejected at constant volume.

III. According to type of fuel used:

1. Gas engine: In this type of engine, the gaseous fuel like Compressed Natural Gas (CNG), coal gas, Bio gas, Liquid Petroleum Gas (LPG), producer gas is used

to operate the engine. The engine is equipped with a special modified manifold system.

2. Petrol engine: In this type of engine, petrol is used as a fuel. A mixture of petrol and air enters the cylinder in a proper ratio during the suction stroke. The fuel mixture in vapour form is ignited with the help of a electric spark produced in the spark plug. Their method of ignition is called spark ignition ,Most of the two stroke and small engines use this system.

3. Diesel engine: In this type of engine, diesel is used as a fuel. Here, the air is compressed in the cylinder and atomized diesel is sprayed for ignition. The method of ignition is called compression ignition. All heavy vehicle use this system.

IV. According to number of cylinders:

1. Single cylinder engine: Here only one cylinder is present as shown in Plate 2.1. The power generated in the power stroke is used for functioning of other strokes of the engine.

Plate : 2.1 Single cylinder engine

(Grace: http://www.prakashagri.com)

1. **Multi cylinder engine:** Here more than one cylinder are present as shown in Plate 2.2. As per the firing order the power suction takes place in the respective cylinders.

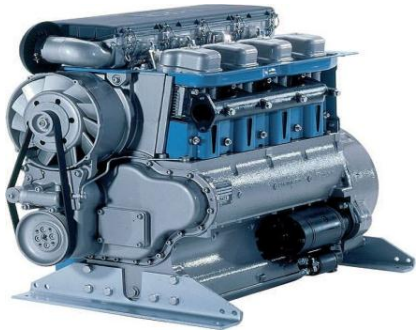

Plate : 2.2 Multi cylinder engine

(Grace: http://img.directindustry.com)

V. According to cylinder arrangement:

1. Horizontal cylinder engine: Most of the single cylinder engines are of this type of cylinder arrangement.

2. Vertical cylinder engine: Most of the present multiple cylinder engines have this type of cylinder arrangement.

VI. According to engine speed:

1. Low speed engine: The crankshaft speed of the engine is less than 100 rpm.

2. Medium speed engine: The crankshaft speed of the engine is in between 100 and 250 rpm.

3. High speed engine: Here the crankshaft speed of the engine is more than 250 rpm.

VII. According to cooling system used:

1. Air cooled engine: Here the cooling of the engine cylinder is done by air. In this case fins are provided on the cylinder as shown in Plate 2.3.

Plate : 2.3 Air cooled engine

2. Water cooled engine: Here cooling of the engine cylinder done by water circulated by a radiator and water pump as shown in plate 2.4.

Plate : 2.3 Water cooled engine

(Grace: http://www.indiamart.com)

Engine Components

The internal combustion engine consists of the following 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 which includes the cylinders and water jackets in case of water cooled engines. (cooling fins in the air cooled engines). Slated on engine and its components.

iii) Cylinder head : It is a detachable portion of an engine which covers the cylinder and includes the combustion chamber, spark plug/atomizer and valves.

iv) Cylinder liner or sleeve: It is a cylindrical lining either wet or dry which is inserted in the cylinder block in which the piston slides. Cylinder liner are fitted in the cylinder bore and they are easily replaceable. The overhauling and repairing of the engines, fitted with liners is easy and economical. The cylinder liners are classified as : (a) Dry liner and (b) Wet liner. The dry liner makes metal to metal contact with the cylinder block casing and do not come in contact with the cooling water. The wet liners come in contact with the cooling water.

v) Piston : It is a cylindrical part closed at one end and open at the other end, which maintain a close sliding fit in the engine cylinder. The piston is shown in Plate 2.5. The piston 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 connected rod is made of cast-iron. Cast iron is chosen due to its high compressive strength, low coefficient of expansion, resistance to high temperature, ease of casting and low cost. Aluminum and its alloys preferred mainly due to it lightness and easy dissipation of heat.

Plate : 2.5 Piston

vi) Head (Crown) of piston : It is the top portion of the piston where the grooves are provided for inserting the piston rings and oil rings..

vii) Skirt : It is that portion of the piston below the piston pin which is designed to absorb the side movements of the piston.

viii) Piston ring : It is a split expansion ring, placed in the groove of the piston. Piston rings are fitted in the grooves, made in the piston. They are usually made of cast iron or pressed steel alloy. 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 : (a) Compression ring and (b) Oil ring

a. Compression ring : Compression rings are usually plain, single piece and are always placed in the grooves, nearest to the piston head.

b. Oil ring: Oil rings are grooved or slotted and are located either in the 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. They prevent excessive oil consumption also. Oil ring is provided with small holes through which excess oil returns back to the crankcase chamber. Ring clearance is the gap at the joint of the ring, measured when the ring is inside the cylinder. The gap is usually 1 mm per 200 mm diameter of the piston. This clearance is necessary for expansion of the ring in heated condition, without which the ring can break or buckle. The piston ring and oil ring are shown in Plate 2.6.

Plate : 2.6 Piston ring and oil ring

ix) Piston Pin : It is also called as wrist pin or gudgeon pin. Piston pin is used to join the small end of the connecting rod to the piston. The piston pin is shown in Plate 2.7. It provides a flexible or hinge like connection between the piston and the connecting rod. It is usually made of case hardened alloy steel.

Plate 2.7 Piston pin

x) Connecting rod : It is special type of rod, small end of which is attached to the piston and the larger end to the crankshaft. It transmits the power of combustion to the crankshaft and makes it rotate continuously. It is usually made of drop forged steel. Its small end is fitted with bronze busing and big end is provided with split bearings. The connecting rod is shown in Plate 2.8.

Plate : 2.8 Connecting rod

xi) Crankshaft : It is the main shaft of an engine which converts the reciprocating motion of the piston into rotary motion of the flywheel. The crankshaft of a four cylinder engine is shown in Plate 2.9. Usually the crankshaft is made of drop forged steel or cast steel. Crankshaft is provided with counter weights throughout its length to have counter balance of the unit. Split shell bearings are used as main bearings of the crankshaft. Crankshaft is subjected to bending as well as twisting from the connecting rod end.

Plate : 2.9 Crankshaft of a four cylinder engine

xii) Flywheel : Flywheel is made of cast iron. The main functions of the flywheel are as follows:

a) It stores energy during power stroke and returns back the same energy during the idle strokes, providing an uniform rotary motion by virtue of its inertia.

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

Engine timing marks are usually stamped on the flywheel, which helps in adjusting the timing of the engine. Two views of the flywheel are shown in plate 2.10.

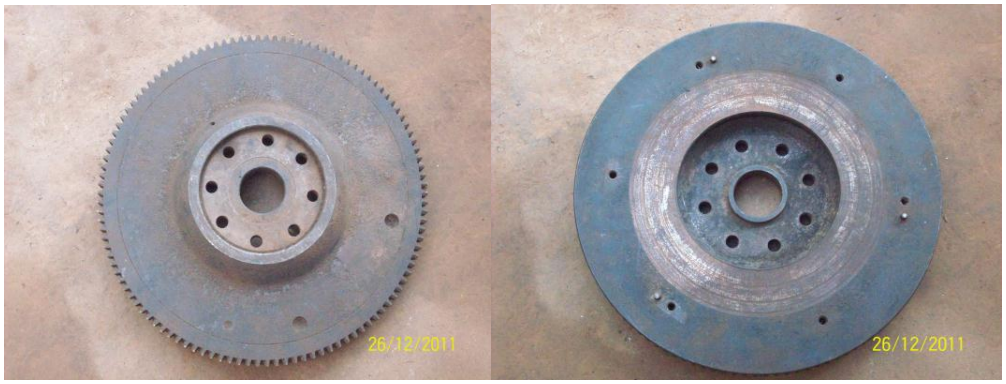

Plate : 2.10 Two views of the fly wheel

xiii) 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

of the engine. It also serves as a mounting unit for accessories as like oil pump, oil filter, dynamo, self motor and other 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. The crankcase of a four cylinder engine is shown in plate 2.11.

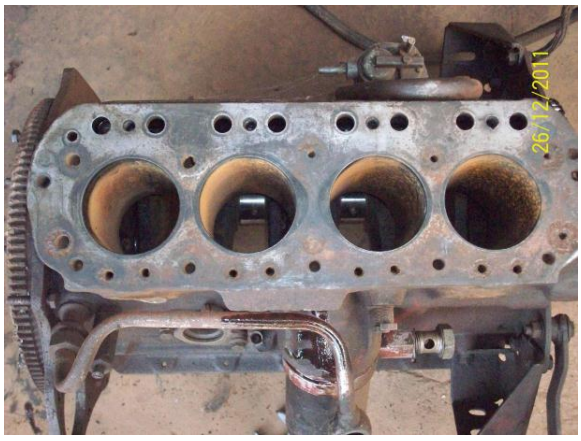

Plate : 2.11 Crankcase of four cylinder engine

xiv) Camshaft : It is a shaft which raises and lowers the inlet and exhaust valves at proper time. Camshaft is driven by crankshaft by means of gears, chains or sprockets. The camshaft of a four cylinder, four stroke engine is shown in Plate 2.12. 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.

Plate : 2.12 Cam shaft of a four cylinder engine

xv) 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 end of the crankshaft. Camshaft gear 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. Plate 2.13 shows the timing gear and chain drive of an engine.

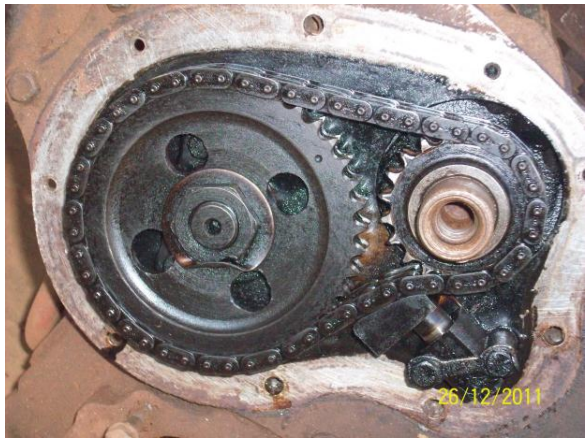

Plate : 2.13 A view of timing gear and chain arrangement

xvi) 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.

xvii) 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.

The different parts of piston and engine parts along with their position in the engine are shown in Plates 14 and 15.

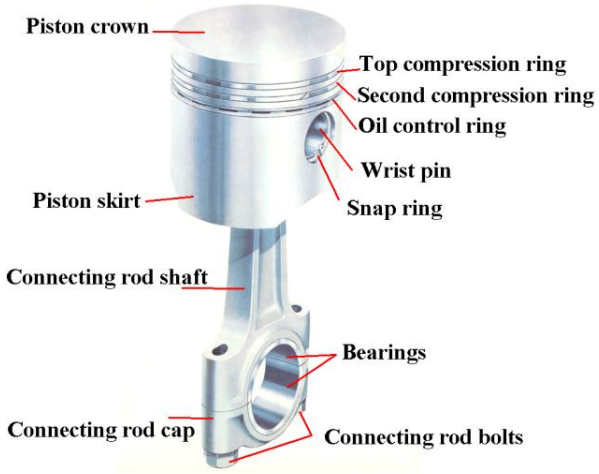

Plate : 3.14 Different parts of the piston

(Grace: http://www.motorera.com)

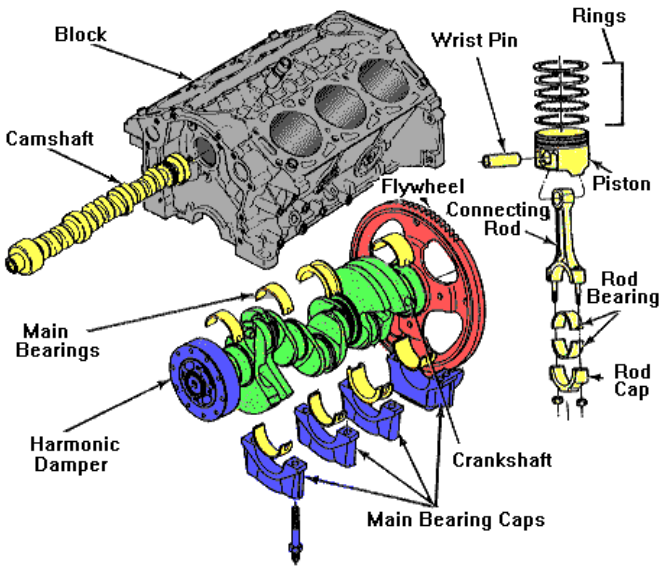

Plate : 2.15 Different parts of the engine
(Source: http://www.aa1car.com)

Chapter – 3

Four stroke and two stroke engine

Principle of I.C. Engine

A mixture of fuel with correct amount of air is exploded or burnt inside the engine cylinder which is closed at one end. As a result of the explosion, heat is released and this causes the pressure of the burning gases to increase, regulating the piston to move down in the cylinder. The movement of piston is transmitted to a crankshaft by a connecting rod, so that the crankshaft rotates the flywheel. To obtain continuous rotation of the crankshaft explosion has to be repeated. In addition to this, the burnt gases has to be expelled from the cylinder, fresh charges of fuel and air must be admitted and the piston must be moved back to its original position.

Working of I.C. Engine

In IC engine the piston which is reciprocating in the cylinder is tight 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. The combustion space is provided at the top of the cylinder head where combustion takes place. There is a rod called connecting rod for connecting the piston and the crankshaft. A pin called gudgeon pin or wrist pin is provided for connecting the piston and the connecting rod of the engine. The end of the connecting rod which fits over the gudgeon pin is called small end of the connecting rod. The other end which fits over the crank pin is called big end of the connecting rod. The crankshaft rotates in main bearings which are fitted in the crankcase. A flywheel is provided at one end of the crankshaft for smoothening the uneven torque, produced by the engine. In I.C. engine the connecting rod converts the reciprocating motion of piston into rotary motion of the crankshaft. There is an oil sump at the bottom of the engine which contains lubricating oil for lubricating different parts of the engine. The cycle of internal combustion engine can be completed in two ways:

a. When the cycle is completed in two revolutions of the crankshaft or four strokes of the piston, it is called **four stroke cycle engine**.

b. When the cycle is completed in one revolution of the crankshaft or two strokes of the piston, it is called **two stroke cycle engine**.

1. **Four Stroke Cycle Engine**

In four stroke cycle engine, all the events taking place inside the engine cylinder are completed in four strokes of the piston. This engine has got valves for controlling the charges and 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 :

I. Air or air-fuel mixture (charge) is taken in the cylinder.
II. The charge is compressed in the cylinder by the piston.
III. If charge is only air, the fuel is injected at the end of compression.
IV. The charge is ignited at a predetermined time under specified pressure inside the engine cylinder.
V. The power developed due to expansive forces of gases inside the cylinder is transferred to the crankshaft through the connecting rod.
VI. Exhaust gases go out of the cylinder at regular interval of time.

The complete cycle covers all these events in systematic manner. Four stroke cycle engines complete all these events in four strokes of the piston, whereas the two stroke cycle engine covers all these events in two strokes of the piston. The four strokes of the piston are:

I. Suction stroke
II. Compression stroke
III. Power stroke or expansion stroke
IV. Exhaust stroke

i. Suction /Induction stroke

During suction stroke (Fig. 3.1), only air or mixture of air and fuel are drawn inside the cylinder. The charge enters the engine through the inlet valve which remains open during admission of the charge. The exhaust valve remains closed during this stroke. The pressure in the engine cylinder is less than atmospheric pressure during this stroke due to which the charge is sucked in to the engine cylinder.

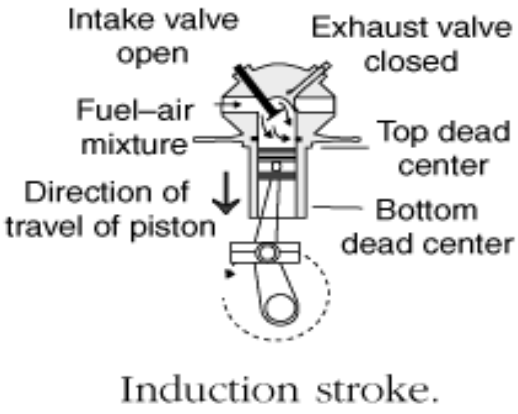

Fig. 3.1 Suction stroke

(Source: http://content.answcdn.com)

ii. Compression stroke

The charge taken in the cylinder is compressed by the piston during this stroke (Fig. 3.2). The entire charge of the cylinder is compressed to a small volume contained in the clearance volume of the cylinder. If only air is compressed in the cylinder (as in case of compression ignition engine), the fuel is injected at the end of the compression stroke. The ignition takes place due to high pressure and temperature. If the mixture of air and fuel is compressed in the cylinder (as in case of spark ignition engine) the mixture is ignited by spark plug. After ignition, tremendous amount of heat is generated, causing very high pressure in the cylinder which pushes the piston backward for useful work. Both valves are closed during this stroke.

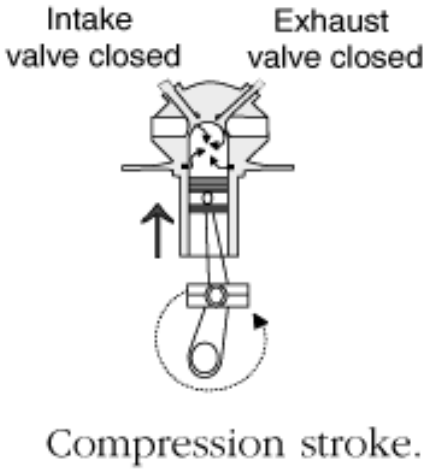

Fig. 3.2. Compression stroke

(Source: http://content.answcdn.com)

iii. Power Stroke

During power stroke (Fig. 3.3), the high pressure developed due to combustion of fuel causes the piston to be forced downward at regular intervals. The connecting rod with the help of crankshaft transmits the power to the transmission system for useful work. Both valves are closed during this stroke.

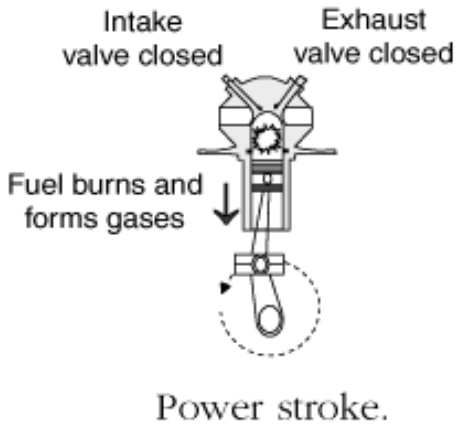

Fig. 3.3 Power stroke

(Source: http://content.answcdn.com)

iv. Exhaust stroke

Exhaust gases go out through exhaust valves during this stroke. All the burnt gases go out of the engine and the cylinder becomes ready to receive the fresh charge.

The inlet valve is closed and exhaust valve remains open during this stroke as shown in Fig. 3.4.

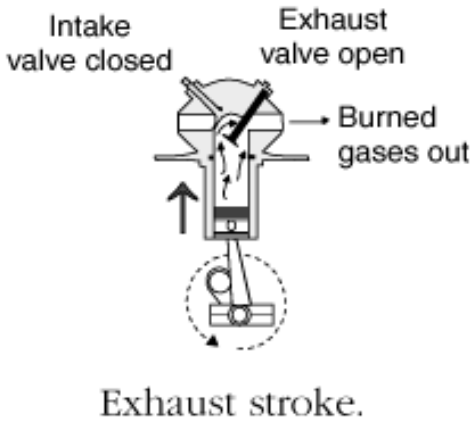

Fig. 3.4 Exhaust stroke

(Source: http://content.answcdn.com)

Thus it is found that out of four strokes, there is only one power stroke and three idle strokes. The power stroke supplies necessary momentum for remaining three stroke. The working of four stroke engine and the position of different parts are shown in Plate 3.1.

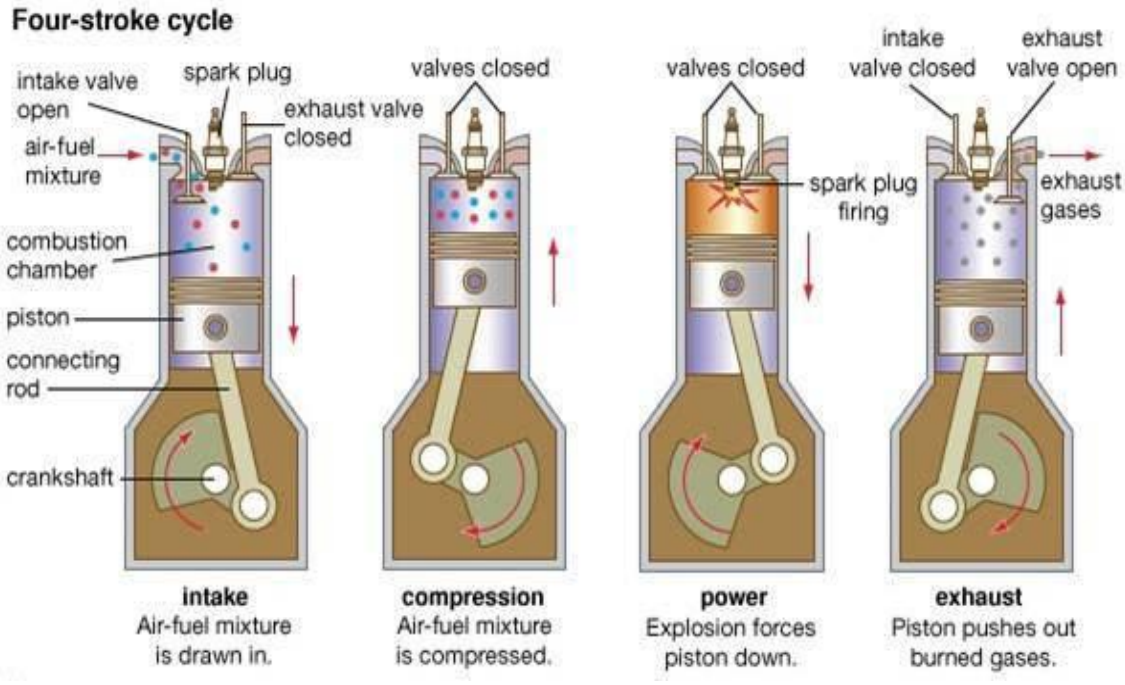

Plate : 3.1 Principle of operation of Four stroke engine

(Grace: http://www.britannica.com)

b. Two stroke cycle engine

In such engines, the whole sequence of events i.e., suctions, compression, power and exhaust are completed in two strokes of the piston or one complete revolution of the crankshaft. There is no valve in this type of engine. Gas movement takes place through ports in the cylinder. The crankcase of the engine is gas tight in which the crankshaft rotates.

i. First stroke (Suction and Compression)

When the piston moves up in the cylinder it covers two of the ports, the exhaust port and transfer port, which are normally almost opposite to each other. This traps a charge of fresh mixture in the cylinder and further upward movement of the piston compresses this charge. Further movement of the piston also uncovers a third port in the cylinder called transfer port and the charge is compressed. More fresh mixture is drawn through this port into the crankcase. Just before the end of this stroke, the mixture in the cylinder is ignited in the two stroke cycle. The first stroke is depicted in Plate 3.2.

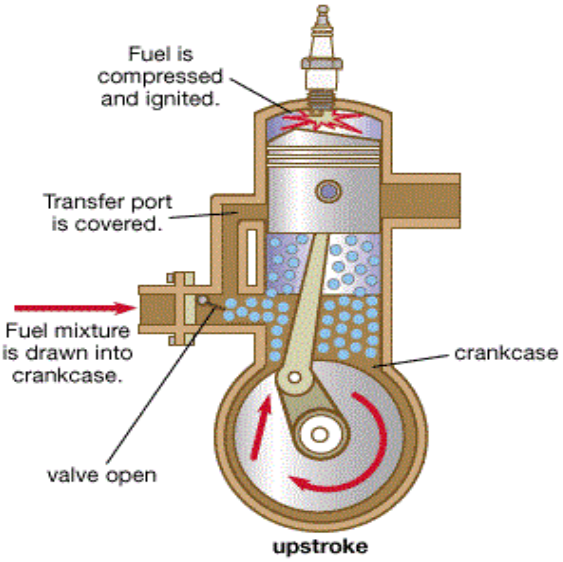

Plate : 3.2 First stroke in two stroke engine

(Source: http://3.bp.blogspot.com)

ii. Second stroke (Power and Exhaust)

The rise in pressure in the cylinder caused by the burning gases forces the piston to move down in the cylinder. When the piston goes down, it covers and closes the suction port, trapping the mixture drawn into the crankcase during the previous stroke then compressing it. Further downward movement of the piston uncovers first the exhaust port and then transfer port. This allows the burnt gases to flow out through exhaust port. Also the fresh mixture under pressure in the crankcase is transferred into the cylinder through transfer port during this stroke. Special shaped piston crown deflect the incoming mixture up around the cylinder so that it can help in driving out the exhaust gases. The Second stroke is depicted in Plate 3.3.

When the piston is at the top of its stroke, it is said to be at the *top dead centre* (TDC), 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 in the case of four stroke cycle engine.

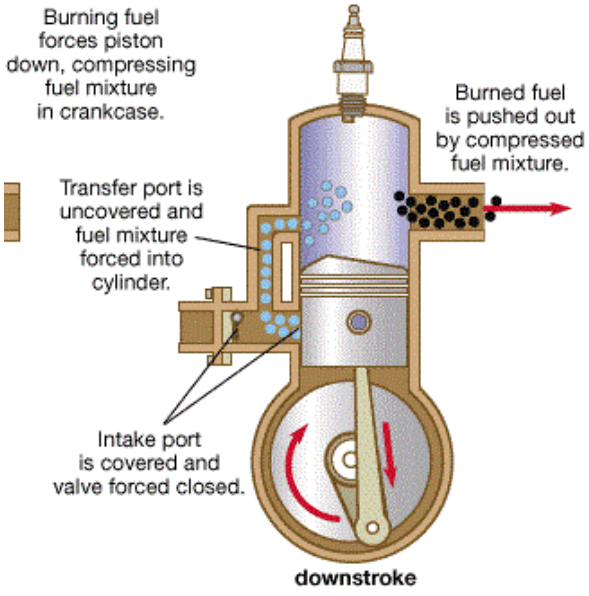

Plate : 3.3 Second stroke in two stroke engine

(Source: http://3.bp.blogspot.com)

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.

Comparison between two stroke and four stroke engine

Four stroke engine	Two stroke engine
One power stroke for every two revolutions of the crankshaft.	One power stroke for each revolution of the crankshaft.
There are inlet and exhaust valves in the engine.	There are inlet and exhaust ports instead of valves.
Crankcase is not fully closed and air tight.	Crankcase is fully closed and air tight.
Top of the piston compresses the charge.	Both sides of the piston compress the charge.
Size of the flywheel is comparatively larger.	Size of the flywheel is comparatively smaller.
Fuel is fully burnt.	Fuel is partially burnt.
Weight of engine per hp is high.	Weight of engine per hp is comparatively low.
Thermal efficiency is high.	Thermal efficiency is comparatively low.
Removal of exhaust gases easy.	Removal of exhaust gases comparatively difficult.
Torque produced is even.	Torque produced is less even.
All types of speed are possible (high and low).	Mostly high speed engines are there.
It can be operated in one direction only.	It can be operated in both directions (clockwise and counter clockwise).

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Chapter - 4

Spark and compression ignition engines

The internal combustion engines are classified based on Spark ignition engine (petrol engine) and Compression ignition engine (diesel engine) method of ignition of the fuel in the engine cylinder.

Spark ignition engine (Petrol engine)

In this type of engine, a device called carburetor, which atomizes and mixes fuel with air in correct proportion and send the mixture to the engine cylinder during the suction stroke. Some times these engines are also regarded as carburetor type engine.

It is an engine designed to convert chemical energy of heavier fuel into mechanical energy. The injected fuel is ignited by the heat of the air which is compressed by the piston within the cylinder. In this engine only, air is sucked into the engine cylinder during suction stroke.

Compression ignition engine (Diesel engine)

In compression ignition engines only air is drawn into the cylinder instead of mixture of air and fuel as in carburetor type engine. Compression of the air during the compression stroke makes the charge very hot, and increasing pressure and temperature. At the end of the compression stroke, diesel fuel is injected into the cylinder in atomised form through an injector, which ignites in the engine cylinder, causing rise in pressure which forces the piston to move downwards.

The basic elements of CI engine are same as that of spark ignition engine but the method of fuel introduction and ignition are different to a great extent. The engine has high compression ratio hence the air in the cylinder attains a 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 through an atomizer (injectors). The cylinder contains air at high pressure and temperature; hence the fuel begins to burn as soon as the fuel reaches the cylinder in atomised form. Such engines are called **compression ignition engines** because the ignition of fuel takes place due to heat of compression. CI engine is equipped with fuel injection pump and injectors. The injectors protrude into the combustion space of the engine.

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/cm^2 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/cm^2.
4) Ignition takes place due to heat of compression.
5) Diesel engine has better slogging or lugging ability i.e. it maintains higher torque for a longer duration of time at a lower speed.

Comparison between Compression ignition engine and Petrol ignition engine

Compression ignition engine	Petrol ignition engine
It has got fuel injection pump and injector.	It has got carburetor, ignition coil and spark plug.
The compression ratio varies from 14:1 to 22:1	The compression ratio varies from 5:1 to 8:1.
It uses diesel oil as fuel.	It uses petrol (gasoline) or power kerosene as fuel.
Only air is sucked in cylinder in suction stroke.	Mixture of fuel and air is sucked in the cylinder in suction stroke.
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.
Thermal efficiency varies from 32 to 38%	Thermal efficiency varies from 25 to 32%
Engine weight per horse-power is high.	Engine weight per horsepower is comparatively low.
Operating cost is low.	Operating cost is high.
Compression pressure inside the cylinder varies from 35 to 45 kg/cm^2 and temperature is about 500°C.	Compression pressure varies from 6 to 10 kg/cm^2 and temperature is above 260°C.

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Chapter - 5

Cooling System

Fuel is burnt inside the cylinder of an internal combustion engine to produce power and hence large amount of heat is produced inside the engine cylinder. This raises the temperature of the cylinder, piston and valves. The temperature may reach 1600 ^{o}C, which is above the melting point of the engine parts in contact. The material strength is reduced even at 150 ^{o}C. Because of heat the lubricating oil is also gets oxidized. So the cooling system is necessary for the engine to remove the excess heat from the engine block and to maintain the temperature of the components within the limit. The cooling system keeps the engine running efficiently. It is estimated that about 40% of the total heat produced in the engine cylinder is passed to the atmosphere by the exhaust gases, 30% is removed by cooling system and only about 30% is used to produce useful power.

Effect of high temperature in the engine

- Cylinder and piston may expand to such an extent that the piston would seize in the cylinder and stop the engine.
- Lubricating quality of the oil inside the cylinder would be reduced due to high temperature and resulting poor sucking of air in the cylinder
- Preignition of fuel mixture would take place and cause engine knocking as well as loss of power.

For satisfactory performance of the engine, neither overheating nor over-cooling is desirable. Experiments have shown that best operating temperature of Internal combustion engine lies between 60°C to 93°C, depending upon types of engines and load conditions.

Purpose of cooling

The main purpose of cooling are :

- To maintain optimum temperature of engine for efficient operation under all conditions.
- To dissipate surplus heat for protection of engine components like cylinder, cylinder head, piston, piston rings and valves.

- To maintain the lubricating property of the oil inside the engine cylinder for normal functioning of the engine.

Methods of cooling the engine

There are two methods of cooling systems used in IC engines namely Air cooling system and Water cooling system.

1. Air cooling system

In this type of cooling system, air is used as a medium for removing heat from engine to atmosphere. Air cooled engines are those engines, in which heat is conducted from the working components of the engine to the atmosphere directly. In such engines, cylinders are generally not grouped in a block. Air cooling is usually employed for light vehicles.

Radial ribs or fins (Plate 5.1) are used to increase the external surface area of the cylinder. The length of these fins will be the greatest where the cylinder is the hottest, particularly near the cylinder head and will progressively reduce towards the crank case. Air-cooled engines are mounted on motorcycle frame. They are usually exposed to the surrounding atmosphere. They relay on natural air stream. Air circulates around the cylinders, head and crank case during forward movement of the vehicle.

Plate : 5.1 A view of fins provided on the cylinder

In some engines, the cylinder of an air cooled engine has fins to increase the area of contact with air for speedy cooling. The cylinder is normally enclosed in a sheet metal casing called Cowling. The flywheel has blades projecting from its face, so that it acts

like a fan drawing air through a hole in the cowling and directing it around the cylinder fins. For maintenance of air cooling system, passage of air is kept clean. This is done by removing the cowling and cleaning out the dirt etc, by a stiff brush or compressed air. When separate fan is provided, the belt tension is to be checked and adjusted if necessary.

Advantages of air cooled engine

- It is simpler in design and construction.
- Water jackets, radiators, water pump, thermostat, pipes, hoses etc. are eliminated.
- It is more compact.
- Air-cooled engines operate well in both hot and cold climates.
- Air-cooled engines, rapidly reach their working temperature from cold.
- Air cooling is natural cooling and it is free from corrosive products.
- This system is more reliable and less maintenance is required.
- Air-cooled engines can operate at higher working temperatures than equivalent liquid cooled.
- Air cooled engines have no coolant leakage (or) problems
- It is comparatively lighter in weight.

Disadvantages of air cooled engine

- There is uneven cooling of the engine parts.
- Each cylinder has to be cast individually. Fin design and casting is difficult.
- Used only in small engines provided in brush cutter and weeder engines, portable engines, lawn mower engines, etc.,

2. Water cooling system

In this type of engine water or coolant (heavy water) is used as a cooling medium. These engines are called “water cooled engines”. The liquid is circulated around the cylinders by means of jacket provided, to absorb heat from the cylinder walls and further the heated water is conducted through a radiator which helps in cooling the water as shown in Fig. 5.1.

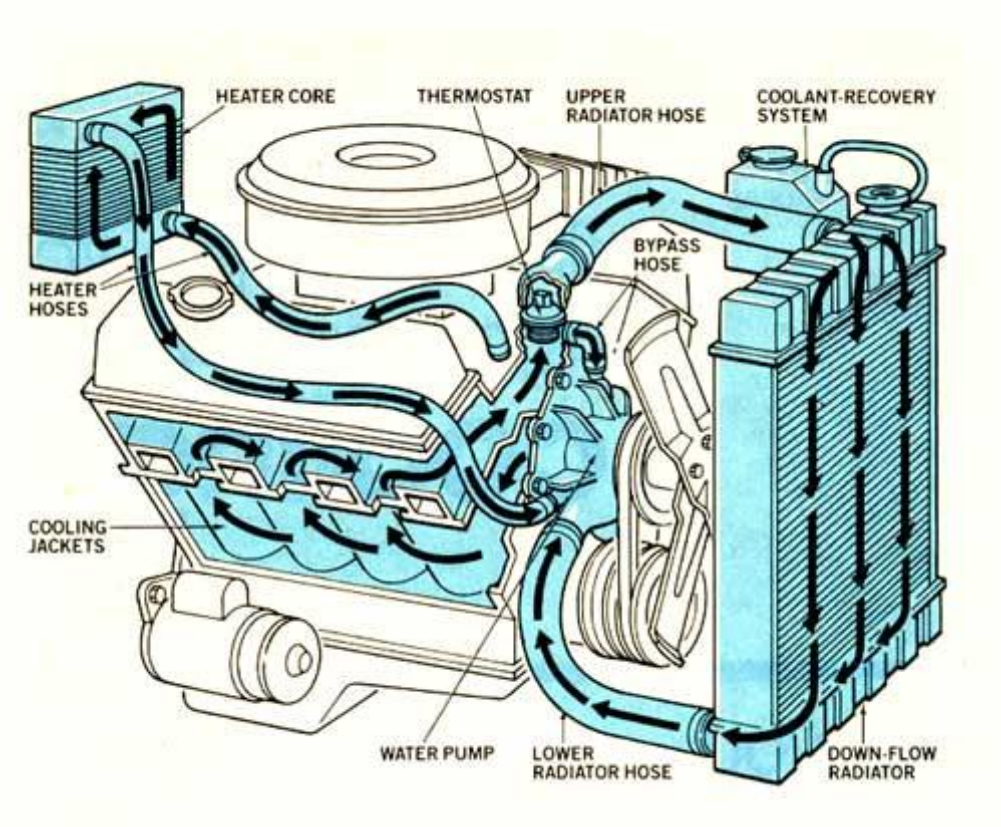

Fig. 5.1 Flow diagram of cooling liquid in the engine cooling system

(Courtesy: http://coolingtower-design.com)

There are four common methods of water cooling:

i. Open jacket or hopper method
ii. Thermo syphon method
iii. Forced circulation method
iv. Pressurized cooling

i. Open jacket or hopper method

In this method a hopper or a jacket is provided around the engine cylinder in which the cooling water or coolant is flowing. As long as the hopper contains water, the engine continues to operate satisfactorily. The hopper is large enough to run for several hours without refilling. A drain plug is provided for draining water. This system is not common in present days.

ii. Thermo syphon method

It consists of a radiator, water jacket, fan, temperature gauge and hose connections as shown in fig. 5.2. The system is based on the principle that heated water which surrounds the cylinder becomes lighter in weight and it rises up wards in liquid column. Hot water goes to the radiator, where it passes through tubes surrounded by air. Circulation of water takes place due to the density difference between the hot water in the engine jacket and cold water in the radiator. These two are connected at both sides i.e. at the top and the bottom by using the hose pipe. A fan is driven with the help of a V-belt connected to the crankshaft to suck air through cells of the radiator unit resulting in cooling. The disadvantage of the system is that circulation of water is greatly reduced by accumulation of scale or foreign matter in the passage and consequently it causes overheating of the engine.

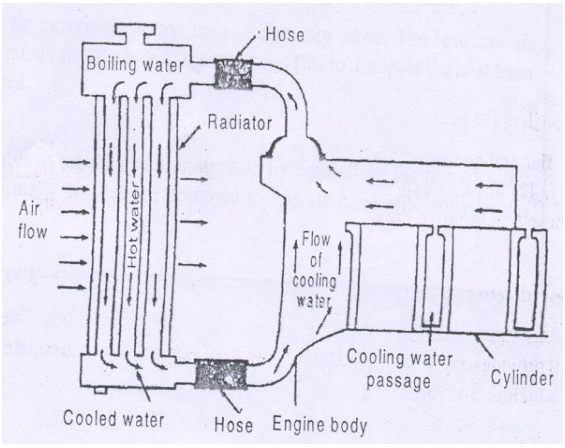

Fig. 5.2 Thermo syphon water cooling method

iii. Forced Circulation method

In this method, a water pump is used to force water from the radiator to the water jacket of the engine (Fig. 5.3). After circulating the entire run of water in jacket, water comes back to the radiator where it loses its heat by the process of conduction. To maintain the correct engine temperature, a thermostat valve is placed at the outer end of cylinder head. Cooling liquid is by-passed through the water jacket of the engine until the engine attains the desired temperature. Then thermostat valve opens and by-pass is closed, allowing the water to go to the radiator.

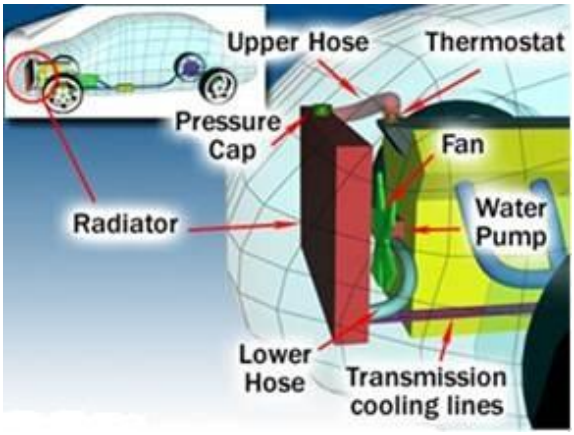

Fig. 5.3 Forced circulation system

(Courtesy: http://static.howstuffworks.com)

iv. Pressurized cooling:

In this type of cooling, the system is made tight enough to bear the additional pressure (Fig. 5.4). A special spring loaded cap for the radiator is provided to withstand the pressure. An overflow pipe is fitted above the spring loaded part of the cap. There is a vacuum relief disc, a spring and the pressure cap. When the engine cools, the water level in the radiator goes down and a vacuum is created. The vacuum operates the disc which is pushed down to save the radiator tubes from collapsing. With the increase in pressure, the boiling temperature of water increases from 100^{o}C to 172^{o}C. The higher water temperature gives more efficient engine performance and is useful at high altitudes.

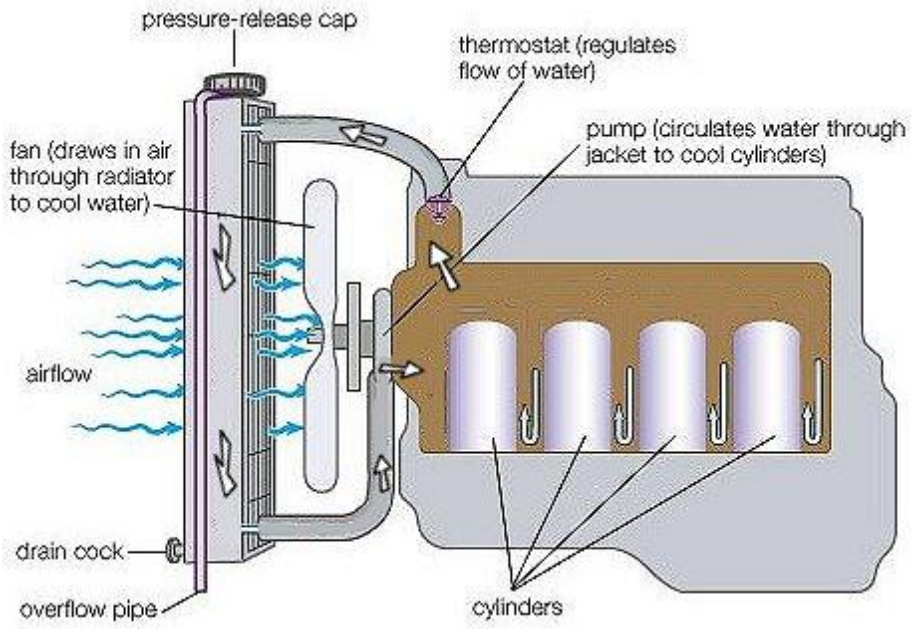

Fig. 5.4 Pressurized cooling system

(Courtesy: http://www.2carpros.com)

The different parts of the forced circulation method are explained below:

a. Radiator

The radiator transfers the heat absorbed by the water to the surrounding air. The radiator is flat and rectangular in shape as shown in plate 5.2. It consists of tubes which are made of copper or aluminum alloy. These tubes expose large surface area to the air stream. Fins are attached to these tubes. These fins improve the effectiveness of air convection heat dissipation.

Plate : 5.2 Radiator

b. Cooling fan

A fan (Plate 5.3) is positioned between the radiator and the engine and is driven by engine crankshaft. Fan is to increase the normal air movement across the radiator core tubes. The resultant air movement will provide a continuous air stream over the tubes and fins to dissipate the heat from the hot water which is circulated.

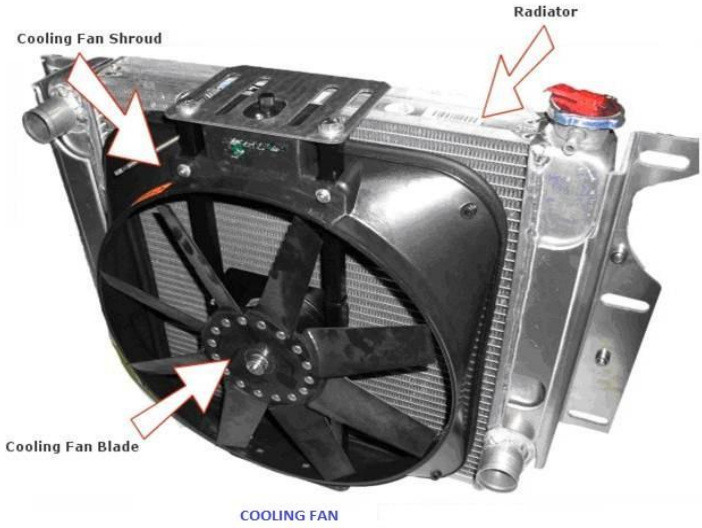

Plate : 5.3 Cooling fan

(Courtesy: http://www.2carpros.com)

C. Thermostat

The function of the thermostat is to regulate heat dissipation by controlling the rate of water flow through the radiator. Normally engines are designed to operate most efficiently over a temperature range between 80º C and 100ºC. Thermostat (Plate 5.4) is placed in the outlet of cooling water from the engine. The thermostat has a valve, which opens only when the normal operating temperature of about 60ºC is reaches by the water. The water flows from engine to upper part of the radiator through thermostat.

Plate : 5.4 Thermostat

(Courtesy: http://blog.autowarranties.com)

4. Water Pump

A centrifugal pump is used to speed up the rate of water circulation in the cooling system.

Cooling system troubles

In the engines, due to defective cooling system, several adverse effects are noticed, such as:

1. Overheating
2. Slow warm-up of the engine.

Over heating is mostly due to:

a. **Accumulation of rust and scale in the radiator and water jacket :** Rust and scale accumulate in the radiator and water jacket. They restrict the circulation of water in the passage. Due to such restriction engine is overheated. Rust is caused by the oxidation of ferrous parts of the cooling system. It has got tendency to clog water passage and to insulate the iron part from the cooling liquid. Rust can be prevented by the use of suitable protective.

Scale is a hard deposit inside the water passage. It acts as a barrier to the flow of heat from the cylinder to the water.

b. Defective hose pipe : Sometimes, there is leakage in the hose pipe and consequently the water in the radiator is drained very quickly.

c. Defective thermostat : If the thermostat is stuck up in its seat due to some

distortion and resulting in Slow warm-up of the engine.

d. Defective water pump : Defective water pump disturbs the circulation of water in the system.

e. Loose fan belt : Loose fan belt causes slippage on the pulley and reduces effectiveness of cooling.

Care and maintenance of cooling system

- Clean and fresh water should be filled in the radiator.
- Salt free water should be used in the radiator as far as possible for prevention of scale formation.
- In some cold countries, the water in the radiator gets converted into ice and creates problems in initial starting of the engine. Hence ethyl alcohol is mixed with water to avoid ice formation.
- Rotten or soft hose pipe should not be used in the system.
- The tension of the fan belt should be checked very frequently. A loose belt will cause overheating, reduce charging current and high wear of the belt. If the belt is very tight, it will cause wear on the pulley of pump and dynamo. The maximum permissible V-belt sag when applying average finger pressure is 15 mm. If it is more than this limit, the belt should be adjusted.
- Oil and grease should always be kept away from the belt. Greasy belts should be wiped clean.
- The bearing of the water pump should be lubricated regularly.
- Very hot engines should never be filled with cold water, to avoid fracture in the cylinder wall and the cylinder head.
- Radiator and water jackets should be flushed out with special air pressure guns. Radiator can be cleaned by blowing air with compressor. This process will remove bugs, leaves and dirt from the radiator.
- The cooling system should be cleaned at periodically to remove rust and scale.
- The radiator cap should not be opened when the engine is hot.

The following suitable procedure may be followed to remove scale from the system. One kg of washing soda and 0.5 kg of kerosene oil should be filled with fresh water and allowed to remain in the radiator for 8 to 10 hours. After this, the engine

should be started and run on medium speed. When the engine has run for 15 to 20 minutes, the solution should be drained out and radiator should be flushed with clean water.

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Chapter – 6

Lubrication system

Internal combustion engines are made up of many moving parts. Due to continuous movement of two metallic surfaces over each other, there is continuous wearing of moving parts, generation of heat and loss of power in the engine. To prevent all these harmful effects the lubrication system is essential.

Purpose of lubrication system

Reducing the friction: The primary function of the lubrication is to reduce the friction and wear and tear of the two rubbing parts. Two rubbing parts always produce friction and continuous friction produces heat, which causes wearing of the different parts of the engine and power loss. This friction can be reduced by proper lubrication. The lubricating oil forms a thin oil film between moving surface and avoids direct contact. This also reduces noise produced by the movement of two metal surfaces.

Cooling effect: The heat is generated by piston, cylinder and bearings is removed by lubricant to a great extent. Lubrication creates cooling effect on the engine parts and acts as coolant.

Sealing effect: The lubricant enters into the gap between the cylinder liner, piston and piston rings. Thus it acts as a seal preventing the leakage of the gas.

Cleaning effect: Lubrication keeps the engine parts clean by removing dirt or carbon from inside the engine.

Types of Lubricants

The lubricants are the different types of oils used for lubrication. Lubricants are obtained from animal fat, vegetables and minerals. The lubricants made of animal fat does not withstand much heat, it becomes gummy and waxy and hence not suitable for machines. Vegetable lubricants are obtained from seeds and plants such as cotton seed, olive oil, linseed oil and castor oil are used as lubricant in small machines. Mineral lubricants are most popular for engines and machines. It is obtained from crude petroleum, which is a natural resource. Mineral lubricants are less expensive and very much suited for internal combustion engine. Now days synthetic oil, which are produced from sand and coal such as poly alkaline and glycol are also used as lubricants.

There are different types of lubricants such as **Solid lubricants** (Graphite, Mica, Talc powder), **Liquid lubricants** (animal fat oil, vegetable oil, mineral oil) and **Semi solid** (Grease).

Properties of lubricating oil

The different properties of the lubricating oil :

Viscosity

It is the property of a lubricant by virtue of which it offers resistance to flow. The oil should be viscous enough to maintain a fluid film between the two mating surfaces. The viscosity is measured by an instrument called viscometer and expressed in terms of viscosity number. The unit of viscosity in SI system is Newton-second per square meter ($N\text{-}s/m^2$) or Pascal seconds (Pas). Viscosity is inversely proportional to temperature i.e., as the temperature increases the viscosity decreases and vice versa.

Flash point and Fire point

When the oil is heated, vapors are released. Flash point is the lowest temperature at which oil is to be heated until sufficient inflammable vapour come off which produces a momentary flash when brought to flame. When the vapours are released continuously and the flame persists for longer period, then that temperature is called fire point. A good lubricant has its flash and fire point above the temperature at which engine work, so that fire hazards are reduced.

Cloud point and Pour point

When lubricating oil is cooled, the temperature at which wax and other substance in the oil crystallize and separate out from oil is called Cloud point. The lowest temperature at which the oil ceases to flow when cooled is called Cloud point. Cloud point and Pour point indicates the suitability of lubricant for use in cold conditions. A good lubricant required to give service at low temperature should possess low pour point and cloud point.

Oiliness and Wettability

The ability of the lubricating oil to adhere to the surface is known as oiliness which depends upon on its wettability and surface tension. A good lubricant should have oiliness enough to adhere to the surface even at very high pressure.

Volatility: A good lubricant should have low volatility at working temperature.

Carbon residue: Lubricating oil has higher percentage of carbon in the combined form. A good lubricant should not deposit carbon when used at high temperature.

Engine lubrication system

The lubricating system of an engine is an arrangement of mechanism which maintains supply of lubricating oil to the rubbing surfaces of the engine at correct pressure and temperature. The engine parts which are to be lubricated are internal surfaces of cylinder walls, piston pin, piston rings, crankshaft, big and small end of the connecting rod, crankpin, valve operating mechanism, camshaft bearings, cooling fan, water pump and ignition mechanism.

There are three method of lubrication systems used in engines are:

- Petro-oil lubrication system.
- Splash lubrication system
- Forced feed or pressure lubrication system
- Combination Of splash and forced feed system

Petro-oil lubrication system

In this method of lubrication system, the lubricating oil is mixed with the petrol and fed in to the engine cylinder during the suction stroke. The droplets of the partials cause the lubricating effect in the engine cylinder. This method of lubrication is used in small engines like motorcycles and scooters. This method is not much effective in large engines.

The system of lubrication is used in scooters and motor cycles, particularly for two stroke engines about 3 to 6% of lubrication oil is added with petrol is the petrol tank. The petrol evaporates when the engine is working. The lubricating oil is left behind in the form of mist. The parts of the engine such as piston, cylinder walls and connecting rod are lubricated by being waited with the oil mist left behind.

When the added oil is less, there will be insufficient lubrication and even result in seizure of the engine. If the added oil is more, it will lead to excess exhaust smoke and carbon deposits in the cylinder exhaust port and spark plugs.

Splash lubrication system

In this system, the lubricating oil is filled in the sump or trough at the bottom of the crank case. Scoops (it is like a spoon) are attached to the big end of the connecting rod (Fig. 6.1). This pan receives its oil supply from the oil sump either by means of a gear pump or by gravity. A dipper is provided at the lower end of the connecting rod. This dipper dips into the oil trough and splashes oil out of the pan. The splashing action of oil maintains a fog or mist of oil that drenches the inner parts of the engine such as bearings, cylinder walls, pistons, piston pins, timing gears etc. The splash oil then drips back into the sump.

This system is commonly used in single cylinder engine with closed crankcase. For effective functioning of the engine, proper level of oil is maintained in the oil pan. Lubrication depends largely upon the size of oil holes and clearances. This system is very effective if the oil is clean and undiluted. Its disadvantages are that lubrication is not very uniform and when the rings are worn, the oil passes the piston into combustion chamber, causing carbon deposition, blur smoke and spoiling the plugs. There is every possibility that oil may become very thin through crankcase dilution. The worn metal, dust and carbon may be collected in the oil chamber and be carried to different parts of the engine, causing wear and tear.

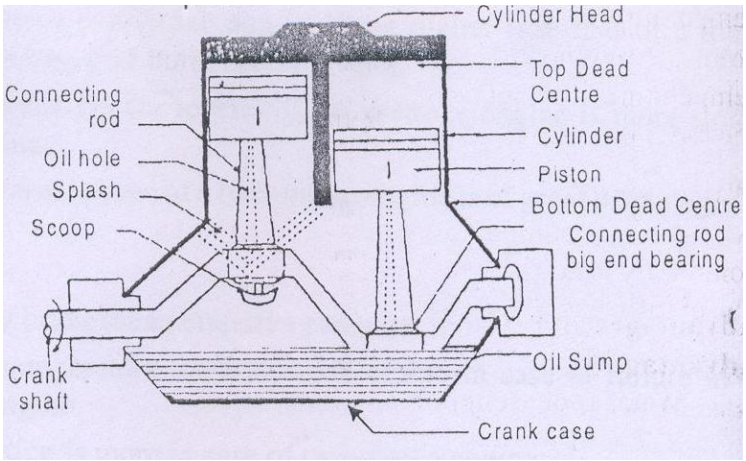

Fig. 6.1 Splash lubrication system

Forced feed or pressure lubrication system

In this system, the oil is pumped directly to the crankshaft, connecting rod, piston pin, timing gears and camshaft of the engine through suitable paths of oil as shown in fig. 6.2. Usually the oil first enters the main gallery, which may be a pipe or a channel in the crankcase casting. From this pipe, it goes to each of the main bearings through holes. From main bearings, it goes to big end bearings of connecting rod through drilled holes in the crankshaft. From there, it goes to lubricate the walls, pistons and rings. There is separate oil gallery to lubricate timing gears. Lubricating oil pump is a positive displacement pump, usually gear type or vane type. The oil also goes to valve stem and rocker arm shaft under pressure through an oil gallery. The excess oil comes back from the cylinder head to the crankcase. The pump discharges oil into oil pipes, oil galleries or ducts, leading to different parts of the engine. This system is commonly used on high speed multi cylinder engine in tractors, trucks and automobiles.

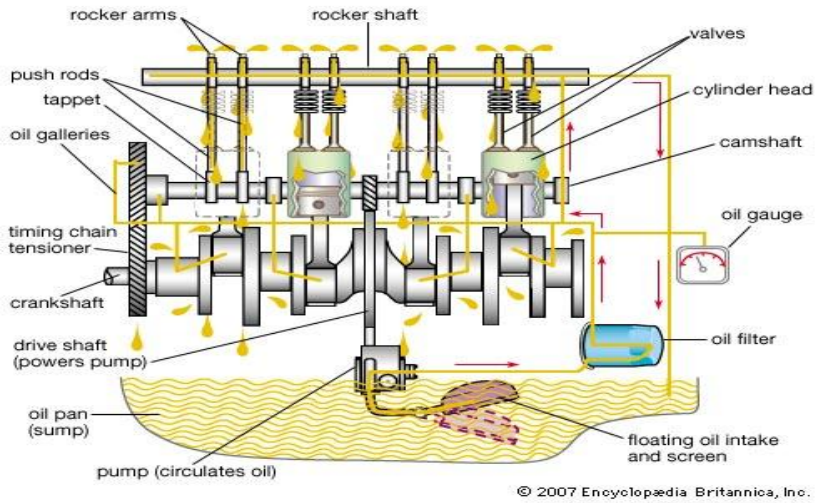

Fig. 6.2 Forced feed or pressure lubrication system

Combination of splash and forced feed system

In this system, the engine component, which are subjected to very heavy load are lubricated under forced pressure, such as main bearing, connecting rod bearing and camshaft bearing. The rest of the parts like cylinder liners, cams, tappets etc. are lubricated by splashed oil.

Parts of lubrication system

Oil pump

Oil pump is usually a gear type pump, used to force oil into the oil pipe. The pump is driven by the camshaft of the engine. The lower end of the pump extends down into the crankcase which is covered with a screen to check foreign particles. A portion of the oil is forced to particles. A portion of the oil is forced to the oil filter and the remaining oil goes to lubricate various parts of the engine. An oil pressure gauge fitted in the line, indicates the oil pressure in the lubricating system. About 3 kg / cm^2 pressure is developed in the lubrication system of a tractor engine. If the oil pressure gauge indicates low pressure in the line, there is some defect in the system which must be checked immediately. Lubricating oil pump is a positive displacement pump.

Troubles in lubrication system

There are some problems which are commonly faced in lubrication system such as: Excessive oil goes to combustion, low oil pressure and excessive oil pressure.

1. **Excessive oil consumption:** The reasons for excessive oil consumption are :

(a) More oil goes to combustion chamber and gets burnt

(b) Some leakage occurs in some part of the line and

(c) Loss of oil in form of vapour through ventilating system.

Oil can enter the combustion chamber through rings and cylinder walls, worn piston rings and worn bearings.

2. **Low oil pressure :** Low oil pressure can result due to :

(a) Weak relief valve spring

(b) Worn oil pump

(c) Cracked oil line

(d) Obstruction in the oil lines

(e) Very thin oil and

(f) Worn out bearings

Care should be taken to remove these defects as far as possible to increase the oil pressure in the lubricating system. Sometimes defective oil pressure indicator shows low oil pressure. This should be checked.

3. **Excessive oil pressure** : Excessive oil pressure may result due to:

(a) stuck relief valve

(b) strong valve spring

(c) clogged oil line and

(d) very heavy oil

These defects should be removed to reduce the excessive oil pressure in the lubricating system. Sometimes defective oil pressure indicator records high oil pressure. Care should be taken to check this defect.

Care and maintenance of lubrication system

The following care and maintenance should be taken to work lubrication system properly

1. A good design of oil circulation system should be chosen.
2. Correct grade of lubricant ensures long and trouble free service.
3. Oil should be maintained at desired level in the oil chamber.
4. Oil should be cleaned regularly and after specified period of use, old filters should be replaced by new filters.
5. Connections, peeping, valves and pressure gauge should be checked regularly.
6. Oil should be changed regularly after specified interval of time. Before putting the new oil, the crankcase should be cleaned and flushed well with a flushing oil.
7. Precautions should be taken to keep the oil free from dust and water.

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Chapter – 7

Power transmission system

Transmission is a speed varying mechanism, equipped with several gears. It may be called a sequence of gears and shafts, through which the engine power is transmitted to the tractor wheels. The system consists of various devices, which cause forward and backward movement of tractor to suit different field condition. The complete path of power from the engine to the wheels is called Power train.

Functions of power transmission system

The main functions of the power transmission system are:

- To transmit power from the engine to the rear wheels of the tractor.
- To make reduced speed available, to rear wheels of the tractor.
- To alter the ratio of wheel speed and engine speed in order to suit the field conditions.
- To transmit power through right angle drive, because the crankshaft and rear axle are normally at right angles to each other.

The power transmission system consists of clutch, transmission gears, differential, final drive, rear axle and rear wheels as shown in Fig. 7.1. Combination of all these components are responsible for transmission of power from crankshaft to the rear wheels. These components are explained in the following sections.

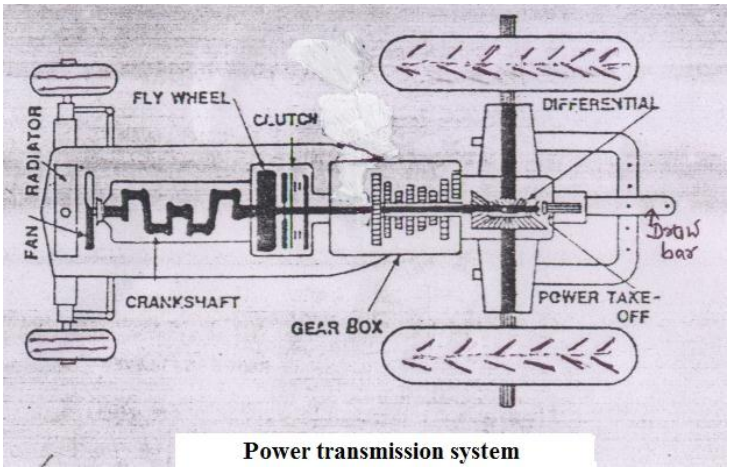

Fig. 7.1 Power transmission system

Clutch

Clutch is a device, used to connect and disconnect the tractor engine from the transmission gears and drive wheels. Clutch transmits power by means of friction between driving members and driven members.

Why clutch in a tractor is essential?

- Engine needs cranking by any suitable device. For easy cranking, the engine is disconnected from the rest of the transmission unit by a suitable clutch. After starting the engine, the clutch is engaged to transmit power from the engine to the gear box.
- In order to change the gears, the gear box must be kept free from the engine power, otherwise the gear teeth will be damaged and engagement of gear will not be perfect. This work is done by a clutch.
- When the belt pulley of the tractor works in the field it needs to be stopped without stopping the engine. This is done by a clutch.

The important essential features of a good clutch are:

- It should have good ability of taking load.
- It should have higher capacity to transmit maximum power without slipping.
- Friction surface should be highly resistant to heat effect.
- The control by hand lever or pedal lever should be easy.

Types of clutch:

The clutches used in engines are of three types namely, Friction clutch, Dog clutch and Fluid coupling. Friction clutch is most popular in four wheel tractors. Dog clutch is mostly used in power tillers. Fluid clutch is used in some type of tractors in these days.

Gear and gear box

A tractor engine runs at high speed, but the rear wheel of the tractor requires power at low speed with high torque. Hence it is very much essential to reduce the engine speed and increase the torque available at the rear wheels of the tractor.

The power available is given by

$$\text{Power} = \frac{2\pi NT}{60 \times 1000} \quad \text{.....Watt}$$

where,

T - Torque in Newton-metre (N-m)
N - Speed in rpm

If the engine power is constant, it is obvious that for higher torque at wheels, low speed is required and vice versa. So the gear box (Plate 7.1) is fitted between engine and rear wheel for variable torque and speed. This is done by suitable design of gear and shafts. Speed varies according to the field requirements and hence a number of gear ratios are provided to suit the varying conditions. Gears are usually made of alloy steel.

Plate : 7.1 Gear box of a tractor

There are different types of gear box used in tractors such as Sliding mesh, Constant mesh and Synchromesh

Differential unit and final drive:

Differential unit is a special arrangement of gears to permit one of the rear wheels of the tractor to rotate slower or faster than the other. While turning the tractor on a curved path, the inner wheel has to travel lesser distance than the outer wheel. The inner wheel requires lesser power than the outer wheel. This condition is fulfilled by differential unit, which permits one of the rear wheel of the tractor to move faster than the other at the turning point. The output shaft coming from the gear box is provided with a bevel pinion at the end of the shaft. The bevel pinion is in mesh with a large bevel wheel known as Crown wheel.

The main functions of Crown wheel assembly are to transmit power through right angle drive to suit the tractor wheels and to reduce the speed of rotation.

The Differential unit consists of different parts like differential casing, differential pinion, crown wheel, half shaft and bevel gear as shown in Fig. 7.2 The differential casing is rigidly attached with the crown wheel and moves like one unit. Two pinions are provided inside the differential casing, such that they are carried round by the crown wheel but they are free to rotate also on their own shaft or stud. There are two or more bevel gears in mesh with differential pinion. One bevel are two or more bevel gears in mesh with differential pinion. One bevel pinion is at the end of each half shaft, which goes to the tractor rear wheel. Thus instead of crown wheel being keyed directly to a solid shaft between the tractor wheels, the drive is taken back from the indirect route through differential casing, differential pinion and half shaft of the tractor. When the tractor is moving in a straight line, the differential pinion do not rotate on the stub shaft but are solid with the differential casing. They drive the two bevel gears at the same speed and in the same direction as the casing and the crown wheel.

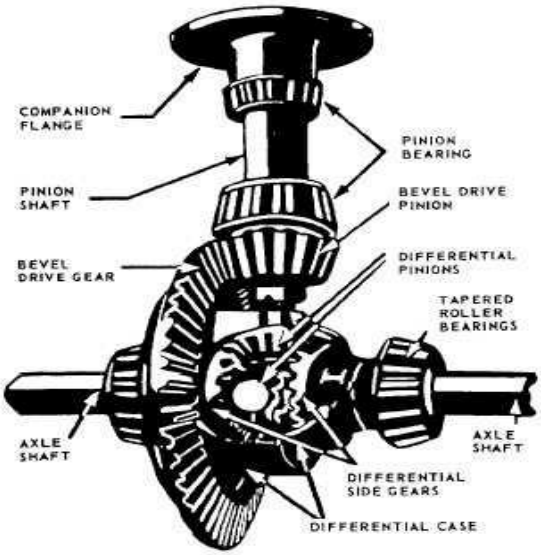

Fig. 7.2 Differential unit

Differential lock

Differential lock is a device to join both half axles of the tractor so that even if one wheel is under less resistance, the tractor comes out from the mud etc. as both wheels move with the same speed and apply equal traction.

Final drive

Final drive is a gear reduction unit in the power trains between the Differential and the Drive wheels. Final drive transmits the power finally to the rear axle and the wheels. The tractor rear wheels are not directly attached to the half shafts but the drive is taken through a pair of spur gears. Each half shaft terminates in a small gear which meshes with a large gear called Bull gear. The Bull gear is mounted on the shaft carrying the tractor rear wheel. The device for final speed reduction, suitable for tractor rear wheel is known as Final drive mechanism.

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Chapter - 8

Engine performance

The different terms used in the engine system are :

Bore: Bore is the diameter of the engine cylinder expressed in cm or metre.

Stroke: It is the linear distance traveled by the piston from Top dead centre (TDC) to Bottom dead centre (BDC) and the distance travelled is called stroke length, expressed in cm or metre.

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 from 1 to 1.45 and for tractor engines, this ratio is about 1.25.

Swept volume: It is the volume displaced by one stroke of the piston.

Swept volume = A x L …… m^3

Where,

A - Cross sectional area of piston in m^2

L - Stroke length in m.

Compression ratio: It is the ratio of the volume of the charge at the beginning of the compression stroke to the volume of the charge 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 spark ignition engine (carburetor type engine) varies from 4:1 to 8:1.

Indicated power (ip)

It is the total power generated in the engine cylinder by the combustion of the fuel and received by the piston. It is the power developed in a cylinder without friction or auxiliary unit. In SI system, the indicated power is expressed in terms of Kilowatts (kW) and the formula for determining is given by

$$ip = \frac{PLAN}{60 \times 10^{12}} \times \frac{n}{2} \quad \text{…… for four stroke engine}$$

$$ip = \frac{PLAN \times n}{60 \times 10^{12}} \quad \text{…… for two stroke engine}$$

Where, P = mean effective pressure, Pa or N/m^2
L = stroke length, mm
A = cross sectional area of piston, mm^2
N = engine speed, rpm
n = number of cylinders

Brake power (bp): It is the power delivered by the engine and is available at the end of the crankshaft. It is measured by using a suitable dynamometer.

Mechanical efficiency (η_{mech}) : It is the ratio of brake power to indicated power expressed in percentage.

Belt power: It is the power of the engine, measured at the end of a suitable belt, receiving drive from the PTO shaft of the tractor.

Power take-off horse power (Pto power) : 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.

Drawbar power (db): It is the power of a tractor measured at the end of the drawbar. It is that power which is available for pulling loads at the draw bar.

Frictional power (fp) : 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. It is the power lost due to the friction between the rubbing parts of the engine.

$$\mathbf{ip = bp + fp}$$

Mean effective pressure (mep): It is the average pressure during the power stroke minus the average pressure during other strokes. This pressure actually forces the piston down during the power stroke.

Volumetric efficiency: It is the ratio of actual weight of air introduced by the engine on the suction stroke to the theoretical weight of air that should have been introduced by filling the piston displacement volume with air at atmospheric pressure and temperature.

Torque : A turning effect due to force applied on some point is called torque (T).

T = F x r …… Kg-m or N-m

Where,

F = force in Kg or N
r = distance of the force from the centre of the shaft in meters.

Piston displacement: It is the volume displaced by one stroke (L) of the piston. It is also known as swept volume.

Piston displacement = A x L …….. m^3

Where,

A = cross sectional area in m^2
L = length of stroke in meters.

Displacement volume: It is the total swept volume of all pistons during power strokes occurring in one minute.

Displacement volume = A x L x N x n/2 (for 4 stroke engine)
Displacement volume = A x L x N X n/1 (for 2 stroke engine)

Where,

A = cross sectional area of piston in m^2
L = stroke length in meters
N = speed in rpm
n = number of cylinders

Piston speed (Sp): It is the total length of travel of the piston in a cylinder in one minute.

Sp = 2 x Lx N

Specific fuel consumption: It is the quantity of fuel consumed per kW– hr. in an engine. The unit of specific fuel consumption is Kg/ kW-hr.

Brake dynamometer

The brake dynamometer is used to measure the brake power of the tractor engine. Different types of dynamometer are used to measure the power.

Problem 1 : Calculate the brake power and mechanical efficiency of a 4 stroke 4 cylinder internal combustion engine, having following dimensions: Cylinder bore, D = 125 mm, Stroke length, L = 150mm, Crankshaft speed, N = 1000 mm rev /min, Friction power = 20 kW, Mean effective pressure, P = 700 kPa, No. of cylinder, x = 4.

Solution:

PLAN n

$$\text{Indicated power (ip)} = \frac{PLAN}{60 \times 10^{12}} \times \frac{n}{2} \quad \text{..... kW}$$

Where,
Pressure P = Pascal = N/m2
L = Length of stroke, mm
A = Cross sectional area, mm^2
N = Speed, rpm.
n = Number of cylinder

$$\text{Indicated power (ip)} = \frac{700 \times 1000 \times 150 \times \prod \times 125 \times 125 \times 1000 \times 4}{60 \times 10^{12} \times 4 \times 2}$$

Indicated power (ip) = 42. 95 kW

Brake power = Indicated power – friction power

= 42.95 – 20

Brake power = 22. 95 kW

Mechanical efficiency, η_{mech} = BP/IP= 22.55 x 100 /42.55 =52.99%

Mechanical efficiency, η_{mech} = 52.99%

Problem 2 : Calculate the brake power of a 2 cylinder 4 stroke cycle I.C. engine 12 X 15 cm. The mean effective pressure is 700 k Pa and speed of crankshaft is 1200 revolutions per minute. The mechanical efficiency is 75%.

Solution:

Bore diameter, D = 120 mm

Stroke length, L = 150 mm

Mep, P = 700 k Pa

Speed, N = 1200 rpm.

No. of cylinder, n = 2

We know that,

$$\text{Indicated power (ip)} = \frac{PLAN}{60 \times 10^{12}} \times \frac{n}{2} \quad \text{..... kW}$$

Where,
P - Pressure, Pascal
L - Length of stroke, mm

A - Cross sectional area, mm^2
N - Speed, rpm.
n - Number of cylinder

$$\text{Indicated power (ip)} = \frac{700 \times 1000 \times 150}{60 \times 10^{12}} \times \frac{\prod}{4} \times \frac{120 \times 120 \times 1200 \times 2}{2}$$

Indicated power (ip) = 23.75 kW

Brake power = Indicated x mechanical efficiency

Brake power = 23.75 X 75/100

Brake power = 17.81 kW

Problem 3 : A four cylinder four stroke engine having cylinder bore 7.5 cm and stroke length 10 cm develops 15 kW at 1650 rev / min. Assuring a mechanical efficiency of 85%, find indicated power and mean effective pressure.

Solution :

Given,

Bore diameter, D = 7.5 cm = 75 mm

Stroke length, L = 10 cm = 100 mm

Brake power, bp = 15 kW

Speed. N = 1650 rpm .

η_{mech} = 85 %

Number of cylinder, n = 4

$$\text{Indicated power (ip)} = \frac{\text{Brake power}}{\eta_{mech}} = \frac{15}{0.85} = 17.64 \text{ kW}$$

$$\text{Indicated power (ip)} = \frac{\text{PLAN}}{60 \times 10^{12}} \times \frac{X}{2} \quad \text{……..} \text{ kW}$$

$$17.64 = \frac{P \times 100}{60 \times 10^{12}} \times \frac{\prod}{4} \times \frac{75 \times 75 \times 1650 \times 4}{2}$$

Mean effective pressure, P = 725. 97 kPa

Problem 4 : Determine the power and compression ratio of the engine, working on four stroke cycle principle. When it runs at 400 rev / min, the volume at the beginning of the compression is 0.032 m^3 and at the end of compression is 0.005 m^3. The work done per cycle is 650 kg-m.

Solution :

$$\text{Compression ratio} = \frac{0.032}{0.005} = 6.4$$

Compression ratio = 6.4 : 1

$$\text{Total cycles /sec.} = \frac{400}{2 \times 60} = \frac{10}{3}$$

Work done in 10/3 cycles / sec. $= \frac{10}{3} \times 650$ kg- m / s

$= 2166.66$ kg-m /s

$= 2199.66 \times 9.8$ N-m /s

$= 21233.26$ watts.

Power of engine = 21.23 kW

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Chapter – 9

Tractors and power tillers

Tractor

Tractor is a self propelled machine used either for pulling or pushing and stationary work. The word tractor is derived from two words traction and motor. Tractor is a machine which is used for traction purpose. Tractor can be used for different job by attaching implements, tools, as single unit. The tractor is farmer's movable power house. Tractor is a self propelled power unit having wheels or tracks for operating agricultural implements and machines including trailers. Tractor engine is used as a prime mover for active tools and stationary farm operations through power take-off shaft or belt pulley.

Tractor Development

The present tractor is a result of gradual development of machines in different stages.

1890	Tractor engine invented by George Harris of Chicago, and used the world first tractor
1906	First gasoline tractor developed by Charles Hart from IOWA
1915-19	PTO – Power take off was introduced in tractor
1920-24	All purpose tractor developed
1936-37	Diesel engine and pneumatic tyres were used for tractors
1950-60	Large scale manufacturing of diesel tractors
1937-41	Hydraulic system and three point linkage developed
1960-61	Tractor manufacturing started in India by first manufacturer M/s. Eicher Good Earth.
1962-70	Manufacturers like Tractor and Farm equipment, Hindustan tractors, Escorts tractors, and International harvesters started work during this period
1971	Escort tractor limited started producing Ford Tractor
1973	Manufacturing of HMT tractors started
1974	Pitti & Kirlosker tractors were started
1975	Harsha tractors were started
1981	Auto tractors were developed
1982	Universal tractors were established
1983-08	GTCL tractors, Bajaj, Mahindra, Swaraja, Hindustan, Sonalika, Johndeer,

	PTL, VST and many other companies started manufacturing tractor in India.

Classification of tractor

The tractors are classified into three classes on the basis of type of construction, type of drive and purpose**.**

Based on type of construction, they are classified as

(a) Riding type tractors – Tractors in which a driver can sit and drive e.g., General purpose four wheel tractors.

(b) Walking type tractors – Tractors with which the operator walks along e.g., garden tractors, power tillers.

Based on type of drive :

(a) Track type tractors – In this type of tractors, instead of wheels; one track is fitted on either side. This track gets drive from the sprocket run by rear axle shaft. To steer the tractor, there is not steering gear fitted. The tractor is steered by applying brakes to one side of the track with the other track moving. These are used for bulldozing or land clearing work.

(b) Wheel type of tractors – These are most commonly used agricultural tractors. They can run fast and wheel tyres absorb a certain amount of field shocks also. These can be further divided as :

1) Two-wheel tractors – These tractors are used for small farms, hilly area and gardening purposes and are called power tillers.

2) Three-wheel tractors – These tractors were very popular 15 years back but now its place has been taken by four wheel tractors. These tractors had single or dual wheel fitted at the front end in the centre and were considered good for negotiable shorter turns.

3) Four-wheel tractors – These are most commonly used tractors in the country. These are also known as all purpose tractors. On the basis of available power, these have been classified as

(1) Small tractors – 15 to 25 hp.

(2) Medium tractors – 25 to 45 hp.

(3) Large tractors – more than 45 hp.

Based on purpose :

(a) Utility tractors – It is a specific purpose field tractor and is designed for ploughing driving any other equipment through its P.T.O. drive. It is not being manufactured at present in the country.

(b) All purpose tractor – It is designed in such a way that it can meet practically all the demands for agricultural purposes such as ploughing, harrowing, leveling, pulling, seed drill, operating threshers, and pumps through its P.T.O. These are provided with three point linkages.

(c) Orchard type tractors - These are special types of tractors used in orchards. These are made very high in height so that driver while sitting on the seat, the operations on the trees could be performed. No part of the tractor is protruded outside so that tractor can go easily in between trees safely.

(d) Garden tractors - These tractors are in the range of 1 to 10 hp and are very small in construction. These are mostly used for kitchen or vegetable gardens.

(e) Rotary Tillers - These are walking type of tractors and are used in small fields or on hills where fields are very small and are at different levels where ordinary tractors cannot work efficiently. Tined blades are fitted to the tillers to prepare the seedbeds quite effectively by pulvlerizing the soil. These are also used in rice fields for puddling and other operations.

(f) Earth Moving tractors - These tractors are heavy in weight and strongly built available both is tract and tyre type. These are used for earth moving work on dams, quarries and other constructional works.

Characteristics of a good tractor –

The most important requirements of a good tractor are :

1. Greater clearance, both vertical and horizontal.
2. Adaptation to the usual row-widths.
3. Quick – short turning ability.
4. Convenient and easy handling.
5. Quick and easy attachment.
6. Essential accessories such as hydraulic controls. Three point linkage and PTO.

Components of a tractor

A tractor consists of the following main parts:

- Internal combustion engine
- Clutch
- Transmission gears
- Differential unit
- Final drive
- Rear wheels
- Front wheels
- Steering system
- Hydraulic control and hitch system
- Brakes
- Power take off unit
- Tractor pulley
- Control panel

Selection of Tractor

The tractor should be selected based on the following factors :

1. **Land holding:** Under a single cropping pattern, it is normally recommended to consider 1 hp for every 2 hectares of land. In other words, one tractor 20-25 hp is suitable for 40 hectares farm.
2. **Cropping pattern:** Generally 1.5 hectare/hp been recommended where adequate irrigation facilities are available and more than one crop is taken. So a 30-35 hp tractor is suitable for 40 hectares farm.
3. **Soil conditions:** A tractor with less wheel base, higher ground clearance and low overall weight may work successfully in lighter soil but it will not be able to give sufficient depth in black cotton soil.
4. **Climatic conditions:** For very hot zone and desert area, air cooled engines are preferred over water cooled engines. Similarly for higher altitude, air cooled engines are preferred because water is liable to be frozen at higher altitude.
5. **Repairing facilities:** It should be ensured that the tractor to be purchased has a dealer at near by place with all the technical skills for repair and maintenance of machine.

6. **Running cost:** Tractors with less specific fuel consumption should be preferred over others so that running cost may be less.
7. **Initial cost and resale value:** While keeping the resale value in mind, the initial cost should not be very high, otherwise higher amount of interest will have to be paid.

Control Board or Dash Board of a Tractor: The control board of a tractor generally consists of the following:

- **Ignition switch**: When the ignition switch is on, the electric current flows in the electrical circuit.
- **Throttle lever**: This lever is for increasing or decreasing the speed of the engine.
- **Decompression lever**: This lever releases compression pressure from the combustion chamber of the engine and helps to stop the engine.
- **Hour meter:** This meter indicates the engine hour as well as engine revolution per minute.
- **Light switch:** Light switch is for light points only.
- **Horn button:** This is for horn of the tractor.
- **Battery charging indicator:** This indicates the charge and discharge of the battery.
- **Oil pressure indicator:** This indicates the lubricating oil pressure in the system.
- **Water temperature gauge:** This indicates the temperature of water of the cooling system.

Precautions to be taken before starting of a tractor

1) Fuel oil should be checked in the fuel tank. If it is not adequate, fuel oil should be added to the tank.
2) Lubricating oil should be checked by a dipstick and if necessary it should be topped up.
3) Water in the radiator should be checked, if necessary it should be topped up.
4) Air cleaner should be checked to see whether it is clean or blocked. If blocked, it should be cleaned.

5) Transmission oil should be checked by a dipstick, if necessary it should be topped up.
6) Air pressure in the tyres should be checked and if necessary the tyres should be inflated as recommended by the manufacturers.
7) Fan belt should be checked by hand; if necessary it may be tightened or loosened.
8) Grease points should be checked, to see whether they have been greased or not.
9) Important nuts and bolts should be checked. If any of them are loose, it should be tightened.
10) The water level of the battery should be checked. If it is below the partition wall, it should be filled up with distilled water.

Method of starting a diesel tractor

In order to start a tractor, the following sequence should be followed:

1) Open the fuel cock.
2) Put the gear shift lever and PTO lever into neutral position.
3) Put the throttle lever in about $3/4^{th}$ position.
4) Put the hydraulic control level to the lowered position.
5) Press the clutch pedal and turn the ignition key to the on position. Thus the tractor will be started.

Method to stop a tractor

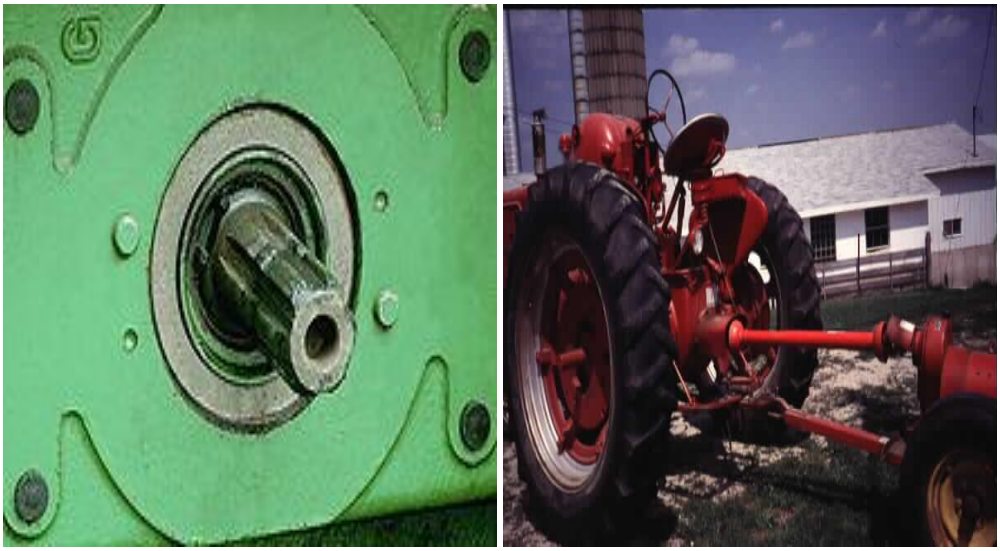
Tractor is a heavy machine and it can cause serious accident if it is not stopped in time. The following procedure should be followed for stopping the movement of the tractor.

1) Move the throttle lever down and reduce the engine speed to the lowest possible limit.
2) Press the clutch pedal and press the brake pedal of the tractor to stop the motion of the tractor.
3) Put the gear shift lever into neutral position.
4) If an implement is attached to the tractor, hydraulic control lever should be moved slowly to the lower position.
5) Pull the stock lever.
6) Apply the parking brakes, if necessary.

Outlets of a tractor : There are four power outlets of tractor :

- **Power take-off unit (PTO)**

It is a part of tractor transmission system. It consists of a shaft, a shield and a cover. The shaft is externally splined to transmit torsional power to another machine as shown in Plate : 9.1. A rigid guard fitted on a tractor covers the power take-off shaft as a safety device. This guard is called power take-off shield. Agricultural machines are coupled with this shaft at the rear part of the tractor. As per ASABE standard pto speed is 540±10 rpm when operating under load. In order to operate 1000 rpm drive machine, a new standard has been developed. Modern tractors are provided with pto speed of 1000±10 rpm.



(Courtesy: http://web.extension.illinois.edu & http://en.wikipedia.org **)**

Plate : 9.1 Tractor operator PTO shaft and it's operation

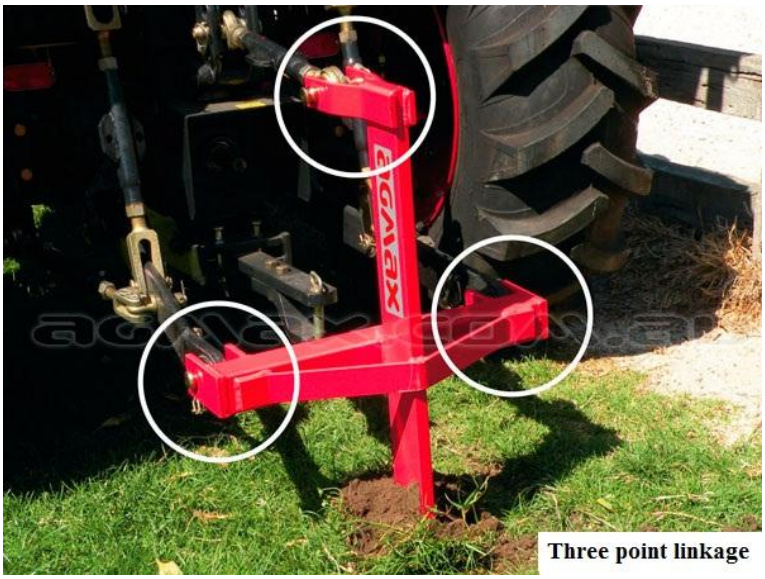
- **Hook**

A hook (Plate : 9.2) is provided for hitching of trailers, and other stationery machines operated by tractor like thresher, winnower etc. It is provided at the back of the tractor.

(Courtesy: http://daimlersteelforge.com)

Plate : 9.2 Tractor hook

- **Three point linkage**
- It is a combination of three links, one is upper link and two are lower links, the links articulated to the tractor and the implements at their ends in order to connect the implement to the tractor. All the tractor drawn implement are attached to this and hydraulic control is also provided for three point linkage. The Three point linkage is shown in Plate : 9.3.



(Courtesy: http://www.agmax.com.au)

Plate : 9.3 There point linkage of tractor

- **Belt pulley**

A pulley is provided with pto shaft for some of the tractors through which rotary power output can be tapped for operating stationery machines.

Power tiller

The power tiller (Plate : 9.4) is a walking type tractor in which the direction of travel and its control for field operation is performed by the operator walking behind it. It is also known as Hand tractor or Walking type tractor. The concept of also known as Hand tractor or walking tractor. The operator walks behind the power tiller, holding the two handles of power tiller in his hands. Power tiller may be called a single axle walking type tractor, though a riding seat is provided in certain designs. The concept of power tiller came in the world in the year 1920. Japan is the first country to use power tiller was designed in the year 1947. Production of power tiller rapidly increased during the year 1950 to 1965. Power tiller was first introduced in India in the year 1963. Manufacturing of several makes of power tillers like Iseki, Sato, Krishi, Kubota, Yanmar and Mitsubishi were started in India after 1962.

(Courtesy: http://www.china-tractors.com)

Plate : 9.4 Power tiller

Components of power tiller

A power tiller consists of the following main parts:

1. Engine
2. Transmission gears
3. Clutch
4. Brakes
5. Rotary unit

All the power tillers are fitted with an I.C. engine. At present, most of the power tillers are fitted with diesel engine. Only Iseki make have used kerosene engine. Other makes like Kamco, Mitsubishi, Krishi, Yanmar and Satoh have used diesel engine in India.

Operation

The main clutch is a lever on the handle. The lever can be shifted to on or off position while operating in the field. When the lever is shifted to on position, the power from the engine is transmitted through the main clutch to the various parts of power tiller. When the lever is shifted to off position, the power from the engine is cut-off from the rest of the transmission.

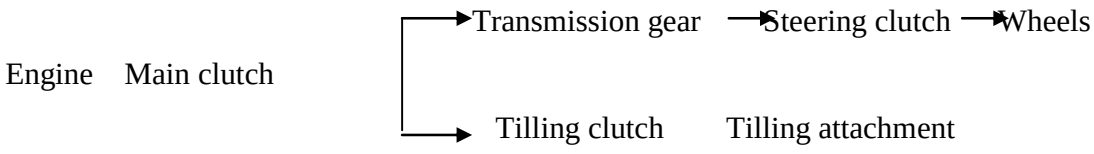
Power transmission in power tiller

For operation of power tiller, the power is obtained from the I.C. engine, fitted on the power tiller. The engine power goes to the main clutch with the help of belt or chain. From main clutch, the power is divided in two routes, one goes to transmission gears, steering clutch and then to the wheel. The other component goes to the tilling clutch and then to the tilling attachment.

Components of a power tiller

No.	Name of Parts	No.	Name of Parts
1.	Handle grip	21.	V – belt
2.	Throttle lever	22.	Tension pulley
3.	Auxiliary handle	23.	Main clutch pulley
4.	Main gearshift lever	24.	Belt cover
5.	Hanger	25.	Handle cover
6.	Front stand operating lever	26.	Handle cover grip
7.	Auxiliary chain case set screw	27.	Tine speed change lever
8.	Auxiliary chain case	28.	Main gear shift lever
9.	Steering clutch lever (right)	29.	Hand light
10.	Rear wheel height adjusting lever	30.	Lamp switch
11.	Rear wheel pipe attaching handle	31.	Steering clutch lever (left)
12.	Ridger set screw	32.	Steering clutch wire
13.	Mud – guard (right)	33.	Rubber guard
14.	Side cover (right)	34.	Protector
15.	Tilling tines	35.	Fender left
16.	“Magic Bar”	36.	Rubber tire
17.	Front frame	37.	Hexagon wheel the
18.	Protector	38.	Side Frame
19.	Front lights	39.	Tilling tines
20.	Engine pulley	40.	Rear wheel

The flow diagram for transmission of power is given below:



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V-belt is usually used to transmit power from the engine to the main clutch, because V – belt has very high efficiency and it works as a shock absorber also.

Engine : Single cylinder, diesel, air/water cooled, 8-15HP.

Main clutch

Power goes from the engine to the main clutch. Clutch may be:

(a) Friction clutch or

(b) V – belt tension clutch

Friction clutch is generally used for bigger power tiller. Usually it is a dry type multiple disc clutch. V – belt tension clutch is used for small power tillers. The main function of clutch in a power tiller are:

(i) To transmit engine power to transmission gears and

(ii) To make power transmission gradually and smooth

Trouble :

The clutch slips continuously, the causes and remedies are :

S.No	Causes	Remedy
1	Oil inside the clutch	Clean with gasoline and dry it
2	Worn lining	Replace the lining
3	Spring tension not sufficient	Replace the spring
4	Water inside the clutch	Dry it with heater etc.
5	Poor adjustment of clutch	Adjust the clutch
6	Poor contact of friction surface	Grind the surface

Transmission gears : Transmission box consists of gears, shafts and bearings. The speed change device may be either Gear type or belt type.

Brakes : All power tillers have some braking arrangement for stopping the movement. Most of the power tillers use inner side expansion type brake.

Wheels : Usually 2 pneumatic tyres are used in power tillers. The pressure of the type ranges from 1.1 to 1.4 kg/cm^2**.**

Rotary unit : Power tiller has a rotary unit for field operation which may be centre drive type or side drive type. The power tiller operated rotary tiller is shown in Plate : 9.5. The centre drive type has got transmission at the centre and the side drive type the transmission at one side.

(Courtesy: http://web.tradekorea.com)

Plate : 9.5 Power tiller operated tiller

The centre drive type has the following characteristics:

(a) Tilling width can be widened

(b) Rotary unit is light in weight

(c) Fixing of attachment is easy

(d) The tine shaft can be detached easily

(e) Mounting and dismounting of rotary unit is very easy

(f) It may leave some portion of the field untilled

(g) It has one point support on the ground

The side drive type has the following characteristics:

(a) Deeper tilling is possible

(b) The arrangement is useful for hard soil

(c) It has two point support on the ground

Rotary tines: Rotary tines are used in rotary unit for soil cutting and pulverization purpose. Rotary tines are of three types namely, straight tines, curved tines and sliding tines.

Steering clutch lever: Steering clutch is provided on the grip of the right and left handles. When the left side is gripped, power is cut-off on left side of the wheel and the

power tiller turns to the left. Similarly when the right side is gripped, the power tiller turns to the right.

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Chapter – 10

Electric motors

Electric motor is a machine which converts electrical energy in to mechanical energy at much higher efficiencies than I.C. engines. Electrical motors operate at efficiencies ranging from 50 to 90 % as against I.C. engines having thermal efficiencies between 28 to 38 %. The most important feature are the low initial cost, low operating cost, easy to start even at loads etc. besides, the motors are designed to take up temporary over loads. These motors have long life, compact construction, low noise levels, nothing like exhaust smokes, operational simplicity and minimum safety hazards.

A motor has primarily consists of armature coil and a field coil. When armature coil are supplied with electric current from the supply and the field magnets are excited and they experience a force tending to rotate the armature. Each conductor experiences a force which tends to rotate the armature in either clockwise or anticlockwise direction. These forces collectively produce a twisting effect or a torque. This causes the armature to rotate in one of the direction.

The electric motors are classified as Direct current motor (D.C.Motor) and Alternating current motor (A.C.Motor). Electric motors are also classified on the basis of armature designs, rotor design and kilo watt power output.

D.C.Motor

An electric motor is a machine which when supplied with electric current, can be used for some mechanical work. Direct current motors are widely used in applications that require control of speed e.g., electric trams, engine starters and elevators etc. They are made in sizes from 1/100 hp to thousands of hp. D.C. motors are similar to D.C. generators in appearance and construction. They have a similar armature, field poles and other motors, current is conducted to the armature winding. This is accomplished by connecting leads from the armature winding to the commutator, and then feeding the commutator with current. The commutator is supplied with current by means of carbon brushes. There are three main types of D.C. motors: the series motor, the shunt motor and the compound motor. These motors differ in the construction of their field coils and in the connections between the field coils and armature.

Small D.C. motors of less than 1/2 kW size consume very little current and therefore, can be started by placing full voltage across the motor terminals. But in large D.C. motors, if full

voltage is applied, excessive current will flow which damages the motor. To start a large motor, it is necessary to connect a resistance unit in series with the armature, so that the starting current is reduced to a safe value. As the motor starts, the resistance is completely cut off after the motor has reached the desired speed. At high speed the counter emf produced in the armature prevents an excessive current flow. Rotation of D.C. motors can be changed by reversing the direction of the current flow in either the armature or field circuit, but not both. Generally, it is reversed by changing the direction of current flow in the armature circuit.

D.C.Motor Starter : The operation of the starter of a D.C. motor is usually done manually. When the handle is brought to make the current with the first point, the shunt field is immediately connected directly across the supply line. The contact with the point first the shunt field is immediately connected directly across the supply line. The contact with the point also connects the entire resistance in series with the armature which begins to rotate and the initial current is limited to a safe value. As the handle is moved current up, the resistance is gradually removed from the armature circuit. When all the resistance is finally removed, the operating handle rests against a holding magnet mounted along side the last point. The holding magnet is connected in series with the main-shunt field of the motor. The operating handle is provided with a heavy spring which will instantly return it to the off position if the holding magnet is demagnetized due to failure of the power supply or break in the motor field circuit. In such a case the handle automatically returns to the of position and the motor stops. It will remain so until started again by hand.

A.C. Motors

For most farm work where electric motors can be used, induction motors are generally preferred. Induction motors may be classified as :

1. Single phase motors : This type of motors are further classified as (a) split phase type, (b) Capacitor start type, (c) Shaded pole type, (d) Wound rotor type, (e) Synchronous type (f) Universal type.
2. Poly phase motors: two types : (a) Two phase motors and (b) Three phase motors.

Among the single phase motors, the first two types are very much in use and they are described in detail here.

Split-Phase Motor: This motor has four main parts, namely rotor, stator, end plates, and centrifugal switch. It is generally operated from a single phase lighting or power circuit. The

rotor consists of three parts, the laminated core, the shaft and the squirrel cage winding. The third part consists of heavy copper bars which are placed in slots in iron core and which connected to each other by means of heavy copper rings placed on both ends of the core.

The stator is composed of a laminated iron core with semi closed slots, a heavy cast iron frame, and two windings of insulated copper wires that are wound into the slots and are called the running and starting windings. Both the winding are connected to the power line when the motor is started. As the current starts flowing through both the windings, it causes a magnetic field to be formed inside the motor. This magnetic field rotates and induces a current in the rotor winding which in term causes another magnetic field. These combine in such a manner as to causes rotation of the rotor. No sooner does the motor reach approximately 75 per cent of the full speed and then the starting windings is cut out of the circuit by means of centrifugal switch.

The end plates are fastened to the stator frame and mainly keep the rotor in position. End plates are fitted with either ball bearings or sleeve bearings in which the rotor shaft rotates.

Capacitor Motor: The construction of the capacitor motor is similar to that of the split phase motor. But an additional part known as the 'Capacitor' is also provided with these machines. The capacitor is usually mounted on the top of the motor. It is connected in series with the starting winding and, therefore, higher starting torque with lower starting current is developed. A capacitor has capacity to store electricity. It is formed when two conductors are separated by an insulator, such as waxed paper. Capacitors are rolled and placed in a metal container. They are rated in microfarads. Depending upon the size of the motor, its capacity may vary from 10 to 150 microfarads.

To produce a starting torque in a capacitor motor, a revolving magnetic field must be established inside the motor. This is accomplished by placing the starting winding 90 electrical degrees out of phase with the running winding. The capacitor helps the current in the starting winding to reach the maximum value before the current in the running winding becomes a maximum. This condition produces a revolving magnetic field in the stator which in turn induces current in the rotor winding. As a result the magnetic field acts in such a manner as to produce rotation of the motor.

Three Phase Induction Motor: Three Phase Induction Motor has three main parts: stator, rotor and end plates. Its construction is very similar to that of the split phase motor, but it is not provided with centrifugal switch. The stator consists of cast iron frame and laminated iron core.

The coils in the slots of the iron core are connected to form three separate windings called phases. These windings are connected so that a magnetic field is foamed inside the stator and that causes the rotor to turn at a constant speed. The squirrel cage type rotor is mostly used. The end plates are meant for supporting the rotor shaft.

A.C.Motor Starters: If an A.C. motor is started on full line voltage, it will draw about four times its normal running current. On very large motors, it is always desirable to reduce the starting current, otherwise damage may be done to the motor and line disturbances may be created affecting operation of other motors, on the same line. For single phase small motors (below 1 kW), a hand operated switch is used to control the motor. In the case of medium size motors (2hp or more), it is necessary to insert in the line some device which will reduce the starting current. Push button type starters or direct on line starters and star-delta-starters are widely used for three phase up to 7.5 kW motors above 7.5 kW only star-delta starter is used.

Push Button Starter : This consists of two push buttons, one for starting (usually green) and other for stopping (usually red) the motor. Pressing the green button causes the contacts inside the switch to make and connect the motor across the line. Pressing the red or stop button causes the contacts to break apart and open the circuit to the motor. Generally the push button starter is equipped with an overload safety device. It opens the circuit to the motor if an over load current flows for a short period of time.

Star-delta-Starters : This starter uses the reduced voltage starting principle only to three phase-delta connected motors. While starting, the motor is connected to star and thus the line voltage is reduced to $1/\sqrt{3}$ value which each phase of the motor received then (400 line voltage reduces to 230 volts). The reduced phase voltage thus reduces the phase current in the same proportion. To make use of this type of starter, it is necessary to bring 6 leads out of the motor so that they can be changed from star at starting time in delta in the running condition. In starting, as the starting lever is pressed down, the motor starts rotating as a star connected motor. After the motor accelerates the starting lever is raised up, thus the switch is closed in the running position. The motor now runs on full voltage.

Selection of Electric Motors

The starting requirements of equipment and the maximum current that may be drawn from the single phase power service are the two most important requirements for selecting an

appropriate motor. However, choosing a motor that will meet load requirements without exceeding temperature and torque limits are also equally important considerations. Hence, the first step in motor selection is to determine the load characteristic such as power or torque requirements, speed and duty cycle.

To select the right type of motor for any particular job, the following factors should be considered:

1. The characteristic of the power supply whether A.C or D.C. ; single or three phase, 50 or 60 cycles supply is available.
2. Horse Power requirement - to avoid over loading, slightly higher size should be preferred.
3. Duty requirement - continuous or intermittent duty.
4. Speed of operation - should be selected with the consideration of the machine to be driven.
5. Starting current requirement should be known before selecting the motor for a particular use.
6. Atmospheric and environmental conditions-humidity, splashing of liquids, excess dust etc. should be kept in view.
7. Over load protection device-this always desirable if the motor is equipped with such a device.
8. Price-it is quite logical to select the lowest price motor that will do the job satisfactorily.
9. However, the price should not be the first consideration.

By measuring the mechanical output of a motor and the electrical input to the motor under different load conditions with the help of 'Prony Brake' dynamometer, the torque-speed characteristic curves can be developed.

Care of Electric Motors

1. Keep the motor bearings properly lubricated.
2. Keep the motor clean and well ventilated.
3. Never overload the motor and thus avoid damage to the motor due to burning of the windings.
4. Keep the belt moderately tight between motor and driven machine.
5. Never connect the motor to too low or high supply voltage. Both conditions are harmful.

6. Keep the motor grounded.
7. Keep the motor away from moisture, dust and saw dust.

How to Clean a Motor

Electric motors must be kept clean and lubricated if they are expected to work efficiently for a longer period. The following procedure should be observed to keep a motor clean :

1. After having disconnected the motor from the power, it is necessary to disassemble it by removing the rotor, shaft and fan assembly. All possible care should be taken not the break any wire connection or centrifugal switch mounted on the rotor shaft or elsewhere.
2. The second step is to blow out the loose dirt from the motor windings and from inside the end plates by using pressurized air from a blower or from a cycle pump. If necessary, a dry paint brush or cloth can be used to carefully wipe off dirt that might remain even after using pressurized air.
3. All dirt from the air passages in the frame and in the rotor should be removed. Metal parts may be washed with non- inflammable fluid.
4. All the accessories like the starting switch, the commutator and brushes should be checked and repaired before the parts are reassembled.
5. Lastly the motor bearings are lubricated with the recommended type of lubricant before the connection is provided to check its operation.

Fuse: Fuse generally means a fuse wire, placed in a fuse holder. It is a safety device, which protects electrical/electronic circuits against over loads, short circuits and earth faults. The fuse is connected in the phase of the supply. When the current taken by the circuit exceeds the rated current of the fuse wire, the fuse wire melts and cuts. This disconnects the supply from the circuit and thus protects the circuit and the components connected in the circuit. Rating of the fuse: The maximum current that a fuse can carry, without being burnt, is called the rating of the fuse wire. It is expressed in Amperes. Ex. 5 A fuse, 10 A fuse, 16A fuse, 60A fuse, 100 A fuse, etc. Current rating of the fuse, selected for a circuit, should be equal to the maximum current rating of the machinery, appliance or component connected in the circuit.

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Chapter 11

Tillage

Tillage

It is a mechanical manipulation of soil to provide favorable condition for crop production. Soil tillage consists of breaking the compact surface of earth to a certain depth and to loosen the soil mass, so as to enable the roots of the crops to penetrate and spread into the soil.

Objective of Tillage

- To obtain seed bed, suitable for different type of crops.
- To add more humus and fertility to soil by covering the vegetation.
- To destroy and prevent weeds.
- To aerate the soil for proper growth of crops.
- To increase water absorbing capacity of the soil.
- To destroy the insects, pests and their breeding places and
- To reduce the soil erosion.

Classification of Tillage

Tillage is divided into two classes: i) Primary tillage, ii) Secondary tillage.

Primary tillage

It constitutes the initial major soil working operation. It is normally designed to reduce soil strength, cover plant materials and rearrange aggregates. The operations performed to open up any cultivable land with a view to prepare a seed bed for growing crops is known as primary tillage. Implements may be tractor drawn or animal drawn implements. Animal drawn implements mostly include indigenous plough and mould-board plough. Tractor drawn implements include mould-board plough, disc plough, subsoil plough, chisel plough and other similar implements.

Secondary tillage

Tillage operations following primary tillage which are performed to create proper soil tilth for seeding and planting are secondary tillage.

These are lighter and finer operations, performed on the soil after primary tillage operations. Secondary tillage consists of conditioning the soil to meet the different tillage

objectives of the farm. The implements used for secondary tillage operations are called secondary tillage implements. They include different types of harrow, cultivators, levellers, clod crushers and similar implements. These operations are generally done on the surface soil of the farm. Secondary tillage operations do not cause much soil inversion and shifting of soil from one place to other. These operations consume less power per unit area compared to primary tillage operations.

- To break the big clods and to make the field surface uniform and levelled.
- To cut crop residues and mix them with top soil of the field.

Secondary tillage implements may be tractor drawn or bullock drawn implements. Bullock drawn implements include harrows, cultivators, hoes etc.

Terms Used in tillage :

Tool - It is an individual working element such as disc or shovel.

Implement - It is an equipment generally having no driven moving parts, such as harrow or having only simple mechanism such as plough.

Machine -It is a combination of rigid or resistant bodies having definite motions and capable of performing useful work.

Plough

The main implement for primary tillage is plough, which is used for ploughing operations. Ploughing is the primary tillage operations, which is performed to cut, break and invert the soil partially or completely. Ploughing essentially means opening the upper crust of the soil, breaking the clods and making the soil suitable for sowing seeds. The purpose of ploughing is to achieve the objectives of the tillage.

Types of ploughing :

Normal Ploughing : It is the ploughing up to a depth of about 15 cm.

Contour Ploughing: It is the method of ploughing in which the soil is broken and turned along the contours.

Ploughing of Land

The ploughing of land is to separate the top layer of soil into furrow slices. The furrows are turned sideways and inverted to a varying degree, depending upon the type of plough being used. It is a primary tillage operation, which is performed to shatter soil

uniformly with partial or complete soil inversion. There are a few important terms frequently used in connection with ploughing of land.

(i) Furrow - It is a trench formed by an implement in the soil during the field operation.

(ii) Furrow slice- The mass of soil cut, lifted and thrown to one side is called furrow slice.

(iii) Furrow wall - It is an undisturbed soil surface by the side of a furrow.

(iv) Crown- The top portion of the turned furrow slice is called crown.

(v) Back furrow - A raised ridge left at the centre of the strip of land when ploughing is started from centre to side is called back furrow. When the ploughing is started in the middle of a field**,** furrow is collected across the field and while returning trip another furrow slice is lapped over the first furrow. This is the raised ridge which is named as back furrow.

(vi) Dead furrow - An open trench left in between two adjacent strips of land after finishing the ploughing is called dead furrow.

(vii) Head land - While ploughing with a tractor to turn, a strip of unploughed land is left at each end of the field for the tractor to turn, that is called head land. At the end of each trop, the plough is lifted until the tractor and the plough have turned and are in position to start the return trip. The head land is about 6 metres for two or three bottom tractor plough and one metre more for each additional furrow. The Line diagram of different terminology used in ploughing is shown in Fig.11.1.

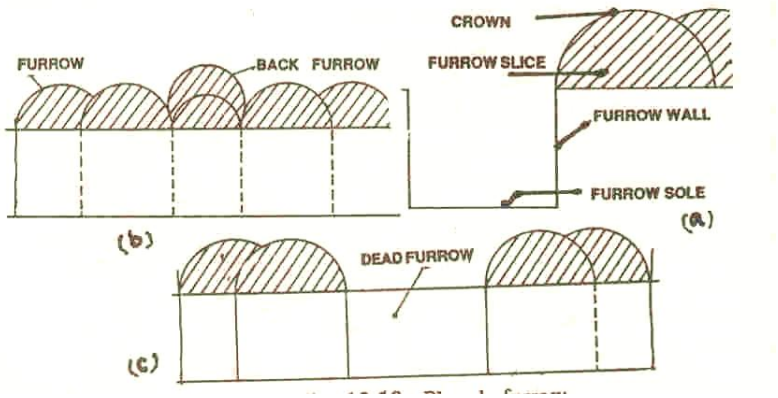

Fig. 11.1 Line diagram of different terminology used in ploughing

Methods of ploughing

In order to provide furrows at all times on the right hand side of the plough, two method of working are used called Gathering and Castering (Fig.11.2).

Gathering - Whenever a plough works round a strip of ploughed land, it is said to be gathering.

Casting- Whenever a plough works round a strip of unploughed land, it is said to be casting. Ploughing of a field by casting or gathering alone is normally uneconomical. The following are a few important methods used in tractor ploughing.

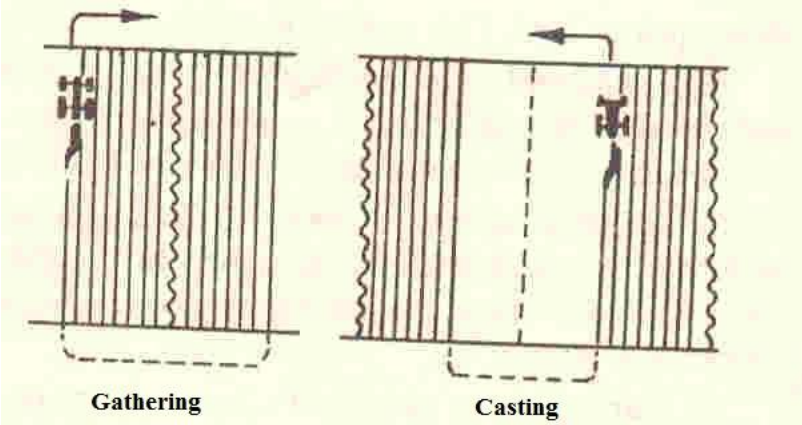

Fig.9.2 Line diagram if plouging methods

Continuous ploughing method

In normal conditions, the continuous ploughing method (Fig. 11.3) is considered very convenient and economical. This is a method usually used in which the tractor and plough never run idle for more than three quarter land width along the headland and never turn in a space narrower than a quarter land width. In this method, first the headland is marked and the first ridge is set up at three quarter of a land width from the side. The other ridges are set at full width over the field. The operator starts ploughing between the first ridge and the side land. The operator continues to turn left and cast in the three quarter land until a quarter land width of ploughing is completer on each side. At this stage, it is important to lift the plough to half depth for last trip down the side land of the field. This leaves a shallow furrow where the finish comes.

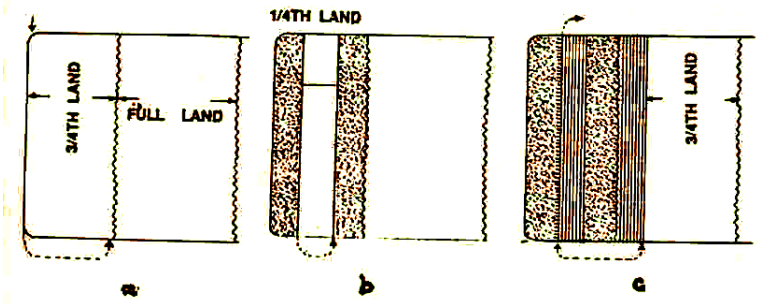

Fig. 11.3 Line diagram of Continuous ploughing method

After this, the driver turns right and gathers round the land already ploughed on the first ridge. Gathering is continued till the unploughed strip in first three-quarter land has been ploughed and completed. This gathering reduces the first full land by a quarter. The remaining three quarter land can be treated in exactly the same manner as the original three quarter land. This process is repeated for all other lands in the field.

Round and round ploughing

In this method, the plough moves round and round a field. This system is adopted under conditions where ridges and furrows interfere with cultivation work. The field can be started in two ways.

a) Starting at the centre

A small plot of land is marked in the middle of the field and it is ploughed first. After that, the plough works round this small plot and the entire plot is completed. This is not a very economical method.

b) Starting at the outer end

Tractor starts ploughing at one end of the field and then moves on all the sides of the plot and comes gradually from the sides to the centre of the field. Wide diagonals are left unploughed to avoid turning with the plough. There are no back furrows in this method. Conventional ploughing is usually done by this method.

One way ploughing

This system requires the use of a special type of plough known as reversible plough or one way plough. Such a plough turns furrows to the left or right. After the headland has been marked, the operator plough along a straight side land mark. At the end of the first trip, he turns his tractor in a loop and returns down the same furrow. No

dead and back furrows are left in the field. In gently sloping fields, this method is suitable.

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Chapter 12

Primary tillage implements

Indigenous plough

Indigenous plough is most commonly used in this country as a primary tillage implement. The shape and size of the plough varies with places and regions due to variation in soil types and tillage requirements. The bullock drawn indigenous plough is shown in Plate : 12.1. The main parts of the plough are: body, share, shoe, beam and handle. The body is the main frame to which the shoe, beam and handle are attached. The share is a narrow steel bar attached to the upper surface of the *shoe* longitudinally along the centre line and the handle is generally attached to the body of the plough. The share is attached to the shoe which penetrates into the soil and breaks it open. The shoe also helps in stabilizing and balancing the plough while in operation. The plough is provided with a wooden beam and a handle. The indigenous plough is made of wood except the share which is made of steel bar.

Plate : 12.1 Bullock drawn indigenous plough

Mould board plough

A mould board plough is very common implement used for primary tillage operations and is shown in plate : 12.2.

Plate : 12.2 Two bottom fixed Mould board plough

The main functions of mould board plough are:

- Cutting the furrow slice
- Lifting the soil
- Turning the furrow slice
- Pulverizing the soil.

Components of mould board plough

A mould board plough consists of the different parts like Share, Mould board, Land side, Frog and Tail piece. The different parts of mould board plough are shown in Fig. 12.1

1. Share: It is that part of the plough bottom which penetrates into the soil and makes a horizontal cut below the surface.

2. Mould board - It is the curved part which lifts and turns the furrow slice.

3. Land side - It is the flat plate which bears against and transmits the rear side lateral thrust of the plough bottom to the furrow wall.

4. Frog - It is the part to which other components of the plough bottom are attached.

5. Tail piece - It is an adjustable extension, which can be fastened to the rear of a mould board to help in turning a furrow slice.

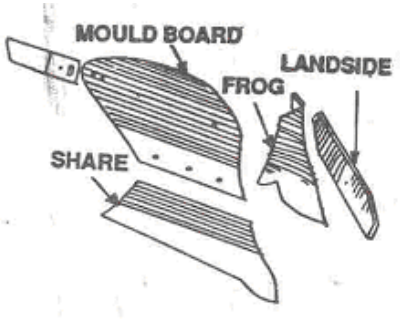

Fig. 12.1. Components of Mould Board plough

The share is one of the important part of the plough, which penetrates into the soil and makes a horizontal cut below the soil surface. It is a sharp, well polished and pointed component. The different parts of the share are shown in Fig. 12.2.

1. **Share point :** It is the forward end of the cutting edge which actually penetrates into the soil .
2. **Cutting edge:** It is the front edge of the share which makes horizontal cut in the soil.
3. **Wing of share:** It is the outer end of the cutting edge of the share. It supports the plough bottom .
4. **Gunnel:** It is the vertical face of the share which slides along the furrow wall. It takes the side thrust of the soil and supports the plough bottom against the furrow wall.
5. **Cleavage edge:** It is the edge of the share which forms joint between mould board and share on the frog.
6. **Wing bearing:** It is the level portion of the wing of the share, providing a bearing for the outer corner of the plough bottom.

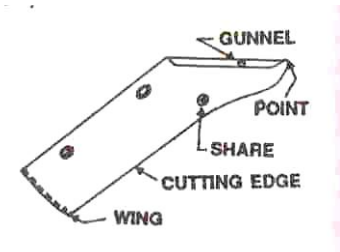

Fig. 12.2 Different parts of the share

Material of share

The shares are made of chilled cast iron or steel. The steel mainly contains about 0.70 to 0.80% carbon and about 0.50 to 0.80% manganese besides other minor elements.

Type of Share

There are four different types of shares used for the mould board plough such as Slip share, Slip nose share, Shin share and Bar point share and are shown in Fig.12.3.

i) Slip share

It is one piece share with curved cutting edge, having no additional part. It is a common type of share, mostly used by the farmers. It is simple in design, but it has got the disadvantage that the entire share has to be replaced if it is worn out due to constant use.

ii) Slip nose share

It is a share in which the point of share is provided by a small detachable piece. It has the advantage that share point can be replaced as and when required. If the point is worn out, it can be changed without replacing the entire share, effecting considerable economy.

iii) Shin share

It is the share having a shin as an additional part. It is similar to the slip share with the difference that an extension is provided to it by the side of the mould board.

iv) Bar point share

It is the share in which the point of the share is provided by an adjustable and replaceable bar. This bar serves the purpose of point of the share and land side of the plough.

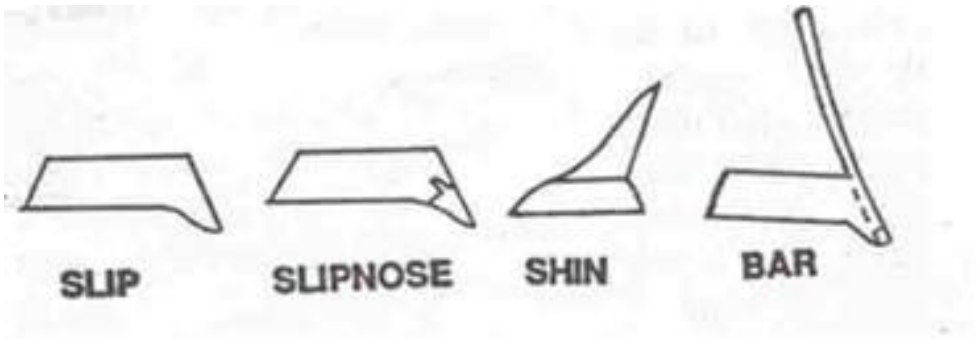

Fig. 12.3 Different types of share

2. Mould board

The mould board is that part of the plough which receives the furrow slice from the share. If lifts, turns and breaks the furrow slice. To suit different soil conditions and crop requirements, mould board has been designed in different shapes. There are four types of mould board used such as : General purpose, Stubble, Sod or Breaker and Slat.

General purpose

It is a mould board having medium curvature lying between stubble and sod. The sloping of the surface is gradual. It turns the well defined furrow slice and pulverizes the soil thoroughly. It has a fairly long mould board with a gradual twist, the surface being slightly convex. The general purpose mould board is shown in Fig.12.4

Fig. 12.4 General purpose mould board

Stubble type

It is short but broader mould board with a relatively abrupt curvature which lifts breaks and turns the furrow slice used in stubble soils. Its curvature is not gradual but it is abrupt along the top edge. This causes the furrow slice to be thrown off quickly, pulverizing it much better than other types of mould board. This is best suited to work in stubble soil that is under cultivation for years together. Stubble soil is that soil in which stubble of the plants from the previous crop is still left on the land at the time of ploughing. This type of mould board is not suitable for lands full of grasses and is shown in Fig. 12.5.

Fig. 12.5 Stubble mould board

Sod or Breaker type

It is a long mould board with gentle curvature which lifts and inverts the unbroken furrow slice. It is used in tough soil of grasses. It turns over thickly covered vegetable of the soil. This is very useful where complete inversion of soil is required by the farmer. This type has been designed for used in sod soils. The sod or breaker type mould board is shown in Fig. 12.6.

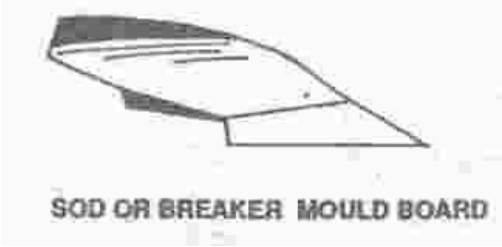

Fig. 12.6 General purpose mould board

Slat type

It is a mould board whose surface is made of slats placed along the length of the mould board, so that there are gaps between the slats. This type of mould board is often used, where the soil is sticky, because the solid mould board does not scour well in sticky soils and is shown in Fig.12.7.

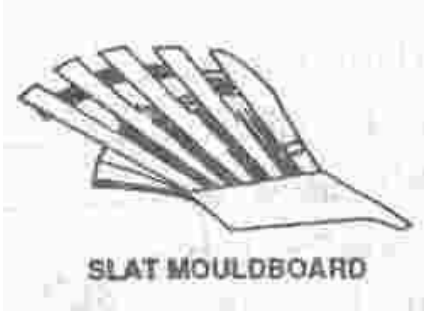

Fig. 12.7 Slat mould board

3. Land side

It is the flat plate which bears against and transmits lateral thrust of the plough bottom to the furrow wall. It helps to resist the side pressure exerted by the furrow slice on the mould board. It also helps in stabilizing the plough while it is in operation. Land

side is fastened to the frog with the help of plough bolts. The rear bottom end of the land side is known as heel which rubs against the furrow sole.

4. Frog

Frog is that part of the plough bottom to which the other components of the plough bottom are attached (Fig.6). It is an irregular piece of metal. It may be made of cast iron for cast iron ploughs or it may be welded steel for steel ploughs.

5. Tail piece

It is an important extension of mould board which helps in turning a furrow slice.

Plough accessories

There are a few accessories, which are used to increase the efficiency of ploughing. The different accessories used are Jointer, Coulter, Gauge wheel, Land wheel and Furrow wheel.

1. Jointer

It is a small irregular piece of metal having a shape similar to an ordinary plough bottom. It looks like a miniature plough. Its purpose is to turn over a small ribbon like furrow slice directly in front of the main plough bottom. This small furrow slice is cut from the left and upper side of the main furrow slice and is inverted so that all trashes on the top of the soil are completely turned down and buried under the right hand corner of the furrow.

2. Coulter

It is a device used to cut the furrow slice vertically from the land ahead of the plough bottom. It cuts the furrow slice from the land and leaves a clear wall. It also cuts trashes which are covered under the soil by the plough. The coulter may be (a) Rolling type disc coulter and (b) Sliding type knife coulter.

a. Rolling type disc coulter

It is a round steel disk which has been sharpened on the edge and suspended on a shank and yoke from the beam. The edge of the coulter may be either smooth or notched. It is so fitted that it can be adjusted up-down and side ways. The up-down adjustment takes care of depth and sideways adjustment is meant for taking care of width of cut.

b. Sliding type knife coulter

It is a stationary knife fixed downward in a vertical position on the beam. The knife does not roll over the ground but slides on the ground. The knife may be of different shapes and sizes.

3. Gauge wheel

It is an auxiliary wheel of an implement to maintain an uniform depth of working. Gauge wheel helps to maintain uniformity in respect of depth of ploughing in different soil conditions. It is usually placed in hanging position.

4. Land wheel - It is the wheel of the plough which runs on the unploughed land.

5. **Furrow wheel –** There are two types of furrow wheel.

Front furrow wheel - It is the front wheel of the plough which runs in the furrow.

Rear furrow wheel - It is the rear wheel of the plough which runs in the furrow.

Adjustment of mould board plough

For proper penetration and efficient work by the mould board plough, some clearance is provided in the plough. This clearance is called suction of the plough. Suction in mould board plough is of two types (i) Vertical suction and (ii) Horizontal suction.

Vertical suction (Vertical clearance)

It is the maximum clearance under the land side and the horizontal surface when the plough is resting on a horizontal surface in the working position. It is the vertical distance from the ground, measured at the joining point of share and land side. It helps the plough to penetrate into the soil to a proper depth. This clearance varies according to the size of the plough. The vertical clearance is shown in Fig.12.8.

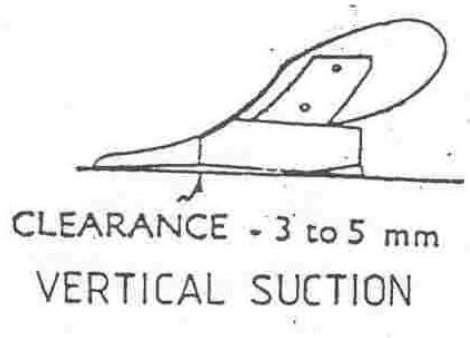

Fig. 12.8 Vertical suction of mould board

Horizontal suction (Horizontal clearance)

It is the maximum clearance between the land side and a horizontal plant touching point of share at its gunnel side and heal of land side. This suction helps the plough to cut the proper width of furrow slice. This clearance varies according to the size of the plough. It is also known as side clearance and is shown in Fig.12.9.

Fig. 12.9 Horizontal suction of mould board

Throat clearance

It is the perpendicular distance between point of share and lower position of the beam of the plough. The throat clearance of mould board plough is shown in Fig. 12.10.

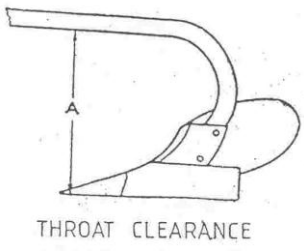

Fig. 12.10 Throat clearance of plough

Vertical clevis

It is a vertical plate with a number of holes at the end of the beam to control the depth of operation and to adjust the line of pull. The vertical clevis and line of pull is shown in Fig.12.11.

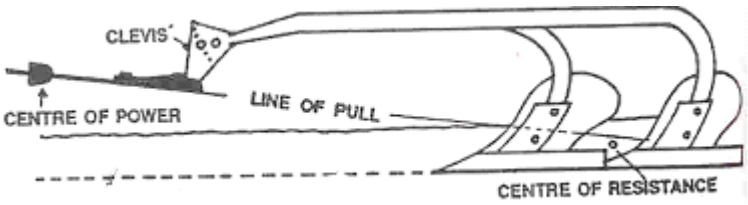

Fig. 12.11. Vertical Clevis and line of pull

Horizontal clevis

It is a device to make lateral adjustment of the plough relative to the line of pull.

Plough size

The perpendicular distance from wing of the share to the line jointing the point of the share and heel of land side is called size of plough. The size of the mould board plough is expressed by width of cut of the soil.

Tractor Drawn Implements

Tractor drawn implements possess higher working capacity and are operated at higher speeds. These implements need more technical knowledge for operations and maintenance work. Tractor drawn implements may be either trailed type or semi-mounted type or mounted type.

Trailed type implement

It is one that is pulled and guided from single hitch point but its weight is not supported by the tractor.

Semi-mounted type implement

This type of implement is one which is attached to the tractor only to the lower link of the hydraulic system. It is controlled directly by tractor steering unit but its weight is partly supported by the tractor.

Mounted type implement

A mounted implement is one which is attached to the three point linkage of hydraulic system, which can be controlled directly by the tractor steering unit. The implement is carried fully by the tractor. It can be raised, lowered and hold in any position.

Terms used in ploughing

Centre of power: It is the true point of hitch of a tractor.

Centre of resistance: It is the point at which the resultant of all the horizontal and vertical forces act. The centre lies at a distance equal to $3/4^{th}$ size of the plough from the share wing.

Line of pull: It is an imaginary straight line passing from the centre of resistance through the clevis to the centre of pull.

Pull : It is the total force required to pull an implement.

1) Fixed type (one way) mould board plough

One way plough throws the furrow slice to one side of the direction of motion and is commonly used everywhere. It may be long beam type or short beam type. There are single bottom, two bottom, three bottom, four bottom and five bottom fixed mould board ploughs are available which are based on the power source horse power.

Plate : 12.3 Two bottom fixed mould board plough

2) Two-way or Reversible plough

It is a mould board plough which turns furrow slice to the right or left side of direction of travel as require. Such ploughs have two sets of opposed bottoms. In such plough, all the furrow can be turned towards the same side of the field by using one bottom for one direction of travel and the other bottom on the return trip. Two sets of bottom are so mounted that they can be raised or lowered independently or rotated along an axis. Two way ploughs have the advantages that they neither upset the slope of the land nor leave dead furrows or back furrows in the middle of the field.

Plate : 12.4 Single bottom reversible mould board plough

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Chapter 13

Disc plough

Disc Plough

It is a plough which cuts, turns and in some cases breaks furrow slices by means of separately mounted large steel discs. A disc plough is designed with a view of reduce friction by making a rolling plough bottom instead of sliding plough bottom. A disc plough is shown in Plate 13.1. A disc plough works well in the conditions where mould board plough does not work satisfactorily.

Plate : 13.1 Disc plough

Advantages of disc plough

- A disc plough can be forced to penetrate into the soil which is too hard and dry for working with a mould board plough.
- It works well in sticky soil in which a mould board plough does not scour.
- It is more useful for deep ploughing.
- It can be used safely in stony and stumpy soil without much danger of breakage.
- A disc plough works well even after a considerable part of the disc is worn off in abrasive soil.
- It works in loose soil also (such as peat) without much clogging.

Disadvantages of disc plough

- It is not suitable for covering surface trash and weeds as effectively as mould board plough does.
- Comparatively, the disc plough leaves the soil in rough and more clody condition than that of mould board plough.

♦ Disc plough is much heavier than mould board plough for equal capacities because penetration of this plough is affected largely by its weight rather than suction. There is one significant difference between mould board plough and disc plough i.e. mould board plough is forced into the ground by the suction of the plough, while the disc plough is forced into the ground by its own weight.

Types of Disc Plough

Disc ploughs are of two types' *viz*., Standard disc plough and Vertical disc plough.

(i) Standard disc plough

It consists of steel disc of 60 to 90 cm diameter, set at a certain angle to the direction of travel. Each disc revolves on a stub axle in a thrust bearing, carried at the lower end of a strong stand which is bolted to the plough beam Fig.13.1.

The angle of the disc to the vertical and to the furrow wall is adjustable. In action, the disc cuts the soil, breaks it and pushes it sideways. There is a little inversion of furrow slice as well as little burying of weeds and trashes. The disc plough may be mounted type or trailed type. In mounted disc plough, the side thrust is taken by the wheels of the tractor. Sometimes a rear wheel is fitted to take side thrust of the plough to some extent. In trailed type, side thrust is taken by the furrow wheel of the plough. Disc is made of heat treated steel of 5 mm to 10 mm thickness. The edge of the disc is well sharpened to cut the soil. The amount of concavity varies with the diameter of the disc. The approximate values being 8 cm for 60 cm diameter disc and 16 cm for 95 cm diameter. A few important terms connected with disc plough is explained below.

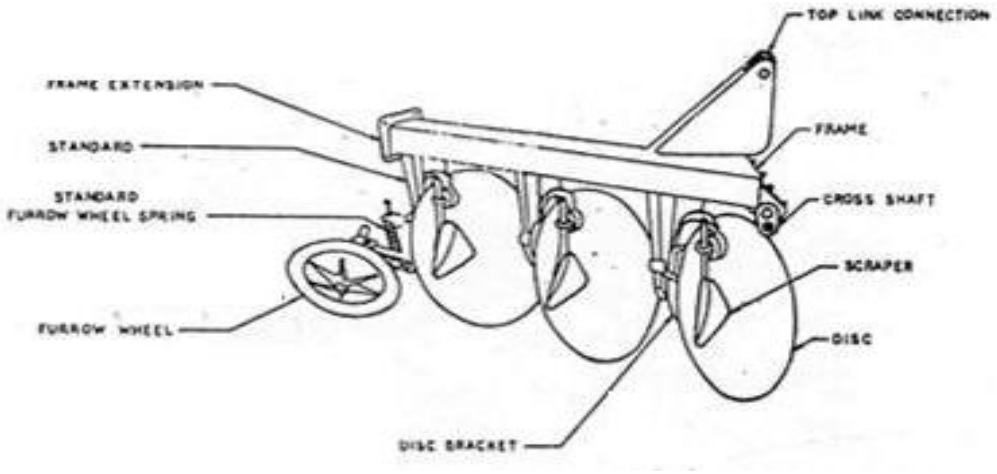

Fig. 13.1 Standard disc plough

Disc - It is a circular, concave revolving steel plate used for cutting and inverting the soil.

Disc angle - It is the angle at which the plane of the cutting edge of the disc is inclined to the direction of travel.. Usually the disc angle of good plough varies between 42° to 45°.

Tilt angle - It is the angle at which the plane of the cutting edge of the disc is inclined to a vertical line. The tilt angle varies from 15° to 25° for a good plough. The disc and tilt angles of disc plough are shown in Fig. 13.2.

Scraper – It is a device to remove soil that tends to stick to the working surface of a disc.

Concavity - It is the depth measured at the centre of the disc by placing its concave side on a flat surface.

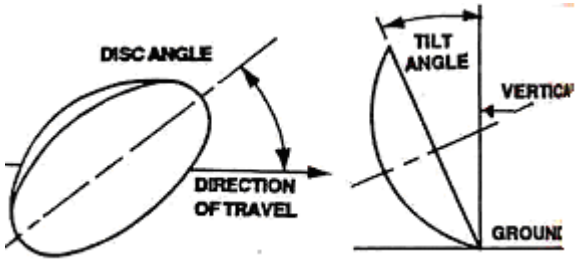

Fig. 13.2 Angles of disc plough

Draft of disc plough

The disc plough is lighter in draft than the mould board plough, turning same volume of soil in similar conditions. In very hard soil, some extra weight is added to the wheel which increases the draft. The bearings and scrapers of the disc plough also affect the draft.

Special purpose ploughs

1. Rotary tiller (Rotovator)

The rotary cultivator is widely considered to be the most important tool as it provides fine degree of pulverization enabling the necessary rapid and intimate mixing of soil besides reduction in traction demanded by the tractor driving wheels due to the ability of the soil working blades to provide some forward thrust to the cultivating outfit.

Plate : 13.2 Rotavator

The functional components include tynes, rotor, transmission system, universal joint, leveling board, shield, depth control arrangement, clutch and three point linkage connection. Rotary tiller is directly mounted to the tractor with the help of three point linkage. The power is transmitted from the tractor PTO (Power Take Off) shaft to a bevel gear box mounted on the top of the unit, through telescopic shaft and universal joint. From the bevel gear box the drive is further transmitted to a power shaft, chain and sprocket transmission system to the rotor. The tynes are fixed to the rotor and the rotor with tynes revolves in the same direction as the tractor wheels. The number of tynes varies from 28 - 54. A leveling board is attached to the rear side of the unit for leveling the tilled soil. A depth control lever with depth wheel provided on either side of the unit ensures proper depth control.

The following types of blades are used with the rotovator.

i. 'L' type blade - Works well in trashy conditions, they are more effective in cutting weeds and they do not pulverize the soil much.

ii. Twisted blade - Suitable for deep tillage in relatively clean ground, but clogging and wrapping of trashes on the tynes and shafts.

iii. Straight blade - Employed on mulches designed mainly for secondary tillage.

The benefits of the rotary tiller are effective pulverization of soil ensures good plant growth, stubble and roots are completely cut and mixed with the soil and proper ground levelling after the operation.

2. Chisel plough

Chisel ploughs are used to break through and shatter compacted or otherwise impermeable soil layers. Deep tillage shatters compacted sub soil layers and aids in better infiltration and storage of rainwater in the crop root zone. The improved soil structure also results in better development of root system and the yield of crops and their drought

tolerance is also improved. The functional component of the unit include reversible share, skids, beam, cross shaft and top link connection.

Chisel plough consists of heavy chisel type tyne which is pulled through the soil normally at a depth greater than that at which conventional ploughing would be done and bursting up the underlying layers of soil without bringing the sub-soil to the surface. The tynes of the implement are sturdy and strong enough to withstand the stresses applied when they are working at depth where the soil conditions are hardened. The implement frame is also strongly constructed usually of box section steel to withstand the stresses applied. The chisel plough has a sturdy but light structure made of 3 mm thick hollow rectangular tubular mild steel sections. The share has a lift angle of 20 degree, width of 25 mm and a length of 150 mm. The implement is protected by a shear pin, which prevents damage from over loading. The implement could be used for deep tillage upto a depth of 40 cm. The coverage is 0.42 ha/hr when operated at a spacing of 1.5 m between rows. The salient features of the unit are:

- The implement could be used for deep tillage upto a depth of 40 cm for bursting of the sub-soil hard pan, improving the drainage and aerating the soil.
- Reduces the bulk density of soil
- Two fold increase in hydraulic conductivity of sub-soil
- Conserves around 30 to 40% more soil moisture
- Roots proliferation is improved from 40 to 45%
- Easily operated by any 35 to 45 hp tractor

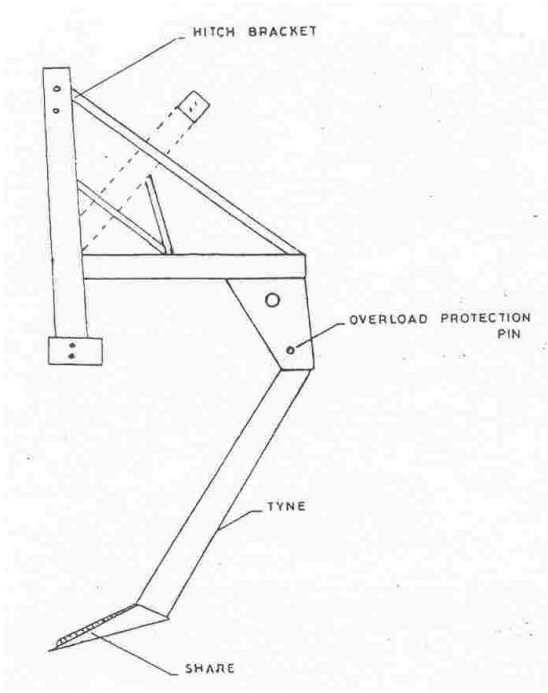

Fig. 13.3 Line diagram of chisel plough

3. Sub-Soil plough

The function of the sub-soil plough also called sub soiler is to penetrate deeper than the conventional cultivation machinery and break up the layers of the soil, which have become compacted due to the movement of heavy machinery or as a result of continuous ploughing at a constant depth. These compacted areas prevent the natural drainage of the soil and also inhibit the passage of air and nutrients through the soil structure. The sub-soiler consists of heavier tyne than the chisel plough to break through impervious layer shattering the sub-soil to a depth of 45 to 75 cm and requires 60 to 100 hp to operate it. The line diagram of sub soiler is shown in Fig. 13.4. The advantages are same as that of chisel plough.

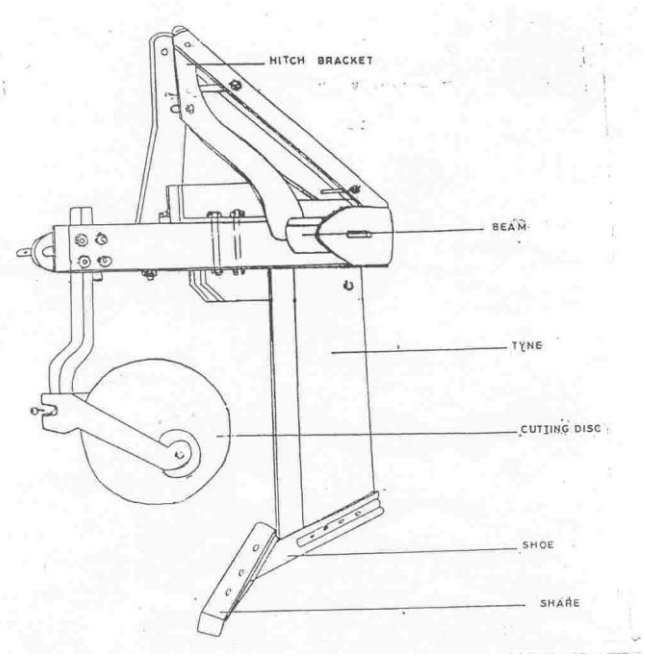

Fig. 13.4 Line diagram of Sub soiler

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Chapter 14

Secondary tillage implements

Secondary tillage

Tillage operations following primary tillage which are performed to create proper soil tilth for seeding and planting are called secondary tillage.

These are lighter and finer operations, performed on the soil after primary tillage operations. Secondary tillage consists of conditioning the soil to meet the different tillage objectives. The implements used for secondary tillage operations are called secondary tillage implements. They include different types of harrow, cultivators, levelers, clod crushers and similar implements. These operations are generally done on the surface soil of the farm. Secondary tillage operations do not cause much soil inversion and shifting of soil from one place to other. These operations consume less power per unit area compared to primary tillage operations. The main objectives of secondary tillage operations are :

1. To break the big clods and to make the field surface uniform and leveled for sowing.
2. To cut crop residues and mix them with top soil of the field.

Secondary tillage implements may be tractor drawn or bullock drawn implements. Bullock drawn implements include harrows, cultivators, hoes etc.

1. Harrow

Harrow is a secondary tillage implement that cuts the soil to a shallow depth for smoothening and pulverizing the soil as well as to cut the weeds and to mix the materials with the soil. There are several types of harrow used in India such as disc harrow, spike tooth harrow, spring tooth harrow, acme harrow, patela, triangular harrow, blade harrow,

2. Disc harrow

It is a harrow, which performs the harrowing operation by means of a set, or a number of sets of rotating slat discs, each set being mounted on a common shaft. Disc harrow is found very suitable for hard ground, full of stalks and grass fields. It cuts the lumps of soil, clods and roots. Discs are mounted on one, two or more axles which may

be set at a variable angle to the line of motion. As the harrow is pulled ahead, the discs rotate on the ground. The disc harrow in field operation is shown in Plate 14.1.

(Courtesy: http://www.woodsequipment.com)

Plate : 14.1 Disc harrow in operation

Classification of disc harrow :

The disc harrows are classified based on disc arrangement as Single action, Double action disc harrows, tandom disc harrows and Off-set disc harrows. Based on power source, they are classified as Tractor drawn and bullock drawn disc harrows.

a) Single action disc harrow

It is a harrow with two gangs placed end to end, which throw the soil in opposite directions. The discs are arranged in such a way that right side gang throws the soil towards right, and left side gang throws the soil towards left as shown in Fig. 14.1.

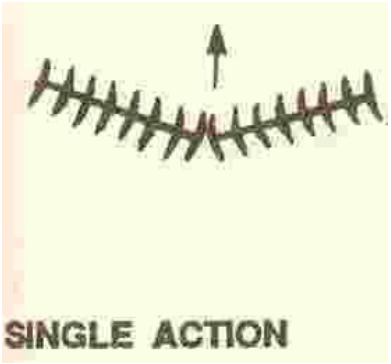

Fig. 14.1 line diagram of disc arrangement in single action disc harrow

b) Double action disc harrow

A disc harrow consisting of two or more gangs, in which a set of one or two gangs follow behind the set of the other one or two, arranged in such a way that the front and rear gangs throw the soil in opposite directions (Fig. 14.2). Thus the entire field is worked twice in each trip. It may be of two types i) Tandem and ii) Off-set type.

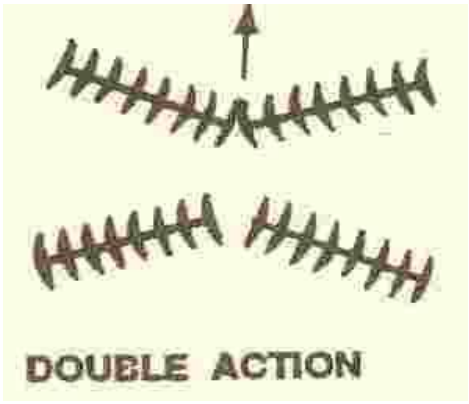

Fig. 14.2 line diagram of disc arrangement in double action disc harrow

c) Tandom disc harrow

It is a disc harrow comprising of four gangs in which each gang can be angled in opposite direction as shown in Fig.14.3.

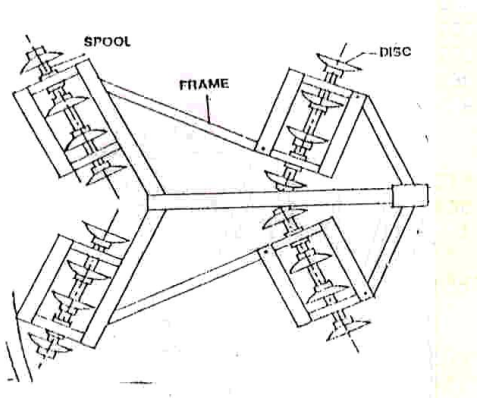

Fig. 14.3 line diagram of disc arrangement in tandom disc harrow

d) Off-set disc harrow

It is a disc harrow with two gangs in tandem, capable of being off-set to either side of the centre line of pull. Two gangs are fitted one behind the other. The soil is thrown in both directions because discs of both gangs face in opposite directions. It is very useful for orchards and gardens. It travels left or right of the tractor. The line of pull

is not in the middle, that's why it is called off-set disc harrow. Off-set disc harrow is based on the basic principle that side thrust against the front gang is opposed by the side thrust of the rear gang. Hence the gangs are arranged at suitable angles so that both thrusts are counter balanced with each other.

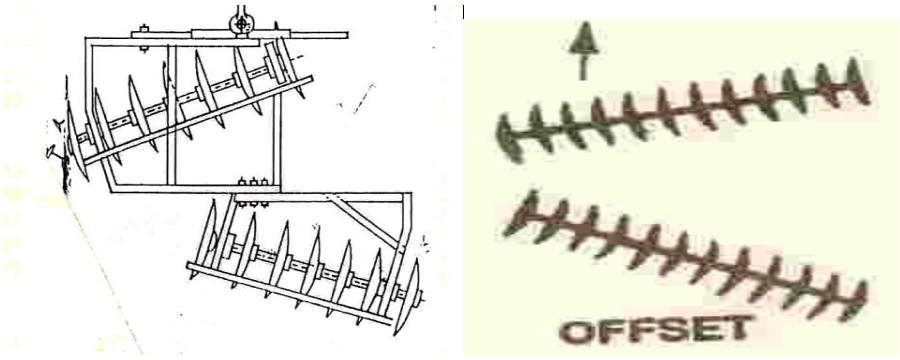

Fig. 14.4 line diagram of disc arrangement in offset disc harrow

Components of a Disc harrow

A disc harrow mainly consists of disc, gang, gang bolt, gang central lever, spool or spacer arbor bolt, bearings, transport wheels, scraper and weight box.

Disc: It is a circular concave revolving steel plate used for cutting a inverting the soil (Plate : 14.2). Disc is made of high glass heat-treated hardened steel. Tractor drawn disc harrows have concave discs of size varying from 35-70 cm diameter. Concavity of the disc affects penetration and pulverization of soil. Usually two types of disc are used in disc harrows, plain disc and cut away disc. Plain discs have plain edges and they are used for all normal works. Most of the harrows are fitted with plain discs only. Cut away discs have serrated edges and they cut stalks, grass and other vegetation. They are not effective for pulverization of soil but it is very useful for puddling the field especially for paddy cultivation.

(Courtesy: http://www.sumoindia.com)

Plate : 14.2 Different types of disc used in disc harrow

Gang: Each set of discs that are mounted on a common shaft is called the gang.

Gang bolt or arbor bolt: It is a long heavy of square headed bolt from the other end, a set of discs are mounted on the gang bolt. The spacing between the discs on the gang bolt ranges from 15 to 25 cm for light duty and 25 to 30 cm for heavy duty harrows. The angle between the axis of the gang bolt and the direction of travel is called the gang angle.

Gang control lever: A lever, which operates the gang mechanisms of the disc harrow, is called the gang control lever.

Spool or spacer: The flanked tube, mounted on the gang bolt between every two discs to prevent the lateral movement of the disc on the shaft is called the `spool' or `spacer'. It is just a device for keeping the discs at equal spacing on the gang bolt. It is usually cast in special shapes and sizes and is generally made of iron.

Bearing: Bearing is essential to counter act the end thrust of the gang due to soil thrust. The harrow bearings are subjected to heavy radial and thrust loads Chilled cast iron bearings are used for heavy radial and thrust loads and they are also used due to their durability.

Transport wheel: In trailing type disc harrow, the transport wheels are provided for transport work on roads and for preventing the edges of the discs from damage. Mounted type disc harrows do not require wheels for transport work.

Scraper: It prevents disc from clogging. It removes the soil that may stick to the concave side of the disc.

Weight box: A box like frame is provided on the main frame of the harrow for putting additional weight on the implement. Additional weight helps in increasing the penetration of the disc in the soil.

There are several factors which affect the penetration of disc harrow in the field. If the disc gangs are set perpendicular to the line of draft, the penetration is not adequate. Penetration can be increased by adding some additional weight on the frame of the harrow. For obtaining maximum penetration, the gangs should be set with the forward edges of the discs parallel to the direction of motion. If the hitch point is lowered, better penetration is achieved.

A sharp edged disc has more effective penetration compared to blunt edged disc. It is observed that penetration is better in low speed than in high speed. The following are a few adjustments for obtaining higher penetration

i. By increasing the disc angle
ii. By adding additional weight in harrow
iii. By lowering the hitch point
iv. By using the sharp edged discs of small diameter and lesser concavity
v. By regulating the speed.

Spike tooth harrow

It is a harrow with peg shaped teeth of diamond cross section to a rectangular frame. It is used to break the clod, stir the soil, uproot the weeds, level the ground, break the soil and cover the seeds. Its principle is to smoothen and level the soil directly after ploughing. Spike tooth harrows may be of rigid type and flexible type.

The animal drawn spike tooth harrow is usually of rigid type. These may or may not have provisions for changing the angle of spikes in operating conditions. Tractor

drawn harrows are usually flexible type (Fig.14.5). It has got the advantage of being turned up for transporting purpose. This harrow mainly consists of teeth, tooth bar frame, clamps, guard, braces, levers and hooks. The teeth are made up of hardened steel with square/triangular/circular in section. The teeth are so placed on tooth bar that no tooth is directly behind the other. Teeth are fastened rigidly to the tooth bar. Clamps are rigidly fixed so as not to be loose while in operation.

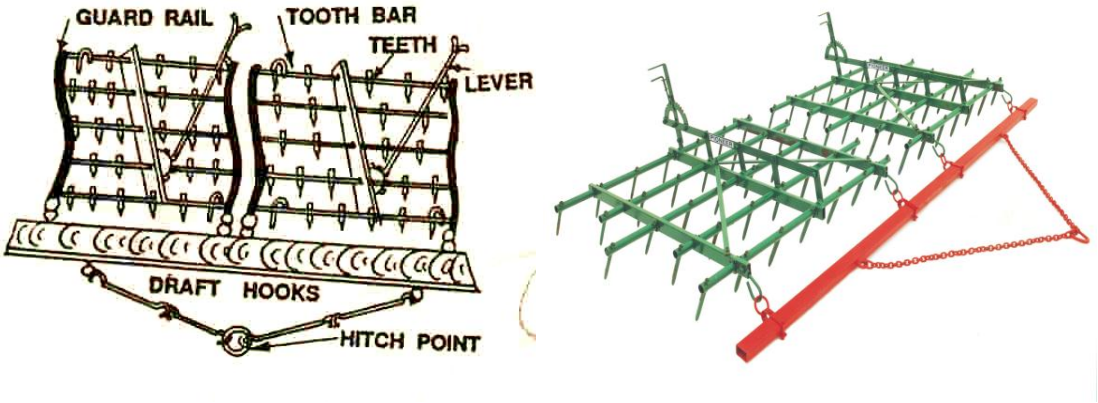

Fig. 14.5 line diagram of Spike tooth harrow

Spring tooth harrow

It is a harrow with tough flexible teeth, suitable to work in hard and stony soils. Spring tooth harrow is fitted with springs having loops of elliptical shape as shown in Fig. 14.6. It gives a spring action in working condition. It is used in the soil when obstruction like stone, roots and weeds are hidden below the ground surface. This type pulverizes the soil and helps in killing weeds. This type of harrow mainly consists of teeth, tooth bar, clamps, frame, lever and links. Usually the teeth are made of spring steel. Sometimes reversible points are provided so that one end may be used after the other end is worn out. The teeth are fastened to the tooth bar by means of tooth clamps. They are provided to give rigidity and support to the harrow. The levers are provided for setting the teeth for varying the depth of harrowing. For light harrowing, the adjustment is done in slanting position. Draft hooks on each corner of every section for hitching purpose.

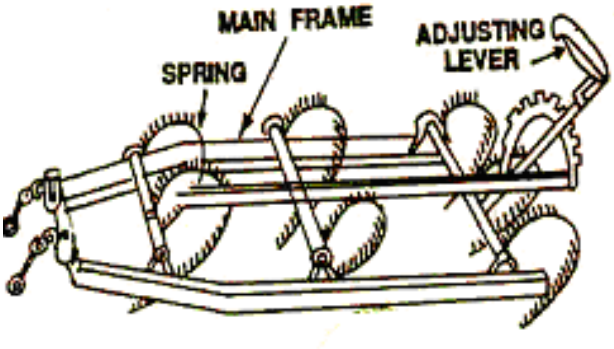

Fig. 14.6. Line diagram of spring tooth harrow

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Chapter 15

Cultivators, levelers, ridger and bund former

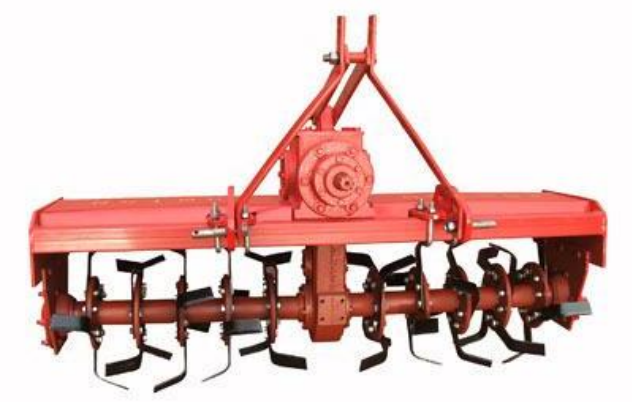
Cultivator

It is an implement for inter cultivation with laterally adjustable tines or discs to work between crop rows. This can be used for seed bed preparation and for sowing with seeding attachment. The times may have provision for vertical adjustments also.

The cultivator can be either Disc cultivator or Rotary cultivator or Tine cultivator.

Disc cultivator: It is a cultivator fitted with discs.

Rotary cultivator: It is a cultivator with tines or blades mounted on a power driven horizontal shaft as shown in Plate : 15.1.



(Courtesy: http://www.diytrade.com)

Plate : 15.1 Rotary cultivator

Tine cultivator: It is a cultivator fitted with tines having shovels. The rigid tine cultivator is shown in Plate : 15.2.

Plate : 15.2 Rigid tyne cultivator

The cultivator stirs the soil, and breaks the clods. The tines fitted on the frame of the cultivator comb the soil deeply in the field. A cultivator performs functions intermediate between those of plough and the harrow. Destruction of weeds is the primary function of a cultivator.

The following are a few important functions performed by a cultivator.

- Interculture the fields.
- Destroy the weeds in the field.
- Aerate the soil for proper growth of crops.
- Conserve moisture by preparing mulch on the surface.
- To sow seeds when it is provided with sowing attachments.
- To prevent surface evaporation and encourage rapid infiltration of rain water into the soil.

Depending upon the type of power available for the implement, the cultivator can be classified as either Tractor drawn or Animal drawn. The tractor drawn cultivators are further classified as Trailed type or Mounted type.

Trailed type cultivator

It consists of a main frame which carries a number of cross members to which tines are fitted. At the forward end of the cultivator, there is a hitch arrangement for hitching purpose. A pair of wheels is provided in the cultivator. The life is operated by both wheels simultaneously so that draft remains even and uniform. The height of the

hitch is adjusted so that main frame remains horizontal over a range of depth setting. The tines in each row are spaced widely to allow free passage of the soil and trash around them. The tines in subsequent rows are staggered so that the implement can cover the entire width nicely. The depth of working is set roughly by adjusting the tine in their clamps and the final depth control is done by a screw lever. Usually the tines are damaged due to turning the implement at the headland without lifting it up. Care should be taken to lift the tines off the ground before turning.

Mounted type Cultivator

Tractors fitted with hydraulic system operate the mounted type cultivators. A rectangular frame of angle iron is mounted on three point hydraulic linkage of the tractor. The cross members carry the tines in two staggered lines. For actual cutting the soil, different types of shovels and sweeps are used. A few important shovels and sweeps are a) Single point shovel b) Double point shovel c) Spear head shovel d) Sweep e) Half sweep f)Furrower.

Depending upon the type of soil and crop, shovels are chosen for use on the cultivators. Usually tractor drawn cultivators are of two types, depending upon the flexibility and rigidity of tines (i) Cultivator with spring loaded tines (ii) Cultivator with rigid tines.

Cultivator with spring loaded tines

A tine hinged to the frame and loaded with a spring so that it swings back when an obstacle is encountered, is called spring loaded tine as shown in Fig.15.1. Each of the tine of this type of cultivator is provided with two heavy coil springs pre tensioned to ensure minimum movement except when an obstacle is encountered. The springs operate, when the points strike roots or large stones by allowing the tines to ride over the obstruction, thus preventing damage. On passing over the obstruction, the tines are automatically reset and work continues without interruption. The tines are made of high carbon steel and are held in proper alignment on the main frame members. This type of cultivator is particularly recommended for soils which are embedded with stones or stumps. A pair of gauge wheel is provided on the cultivator for controlling the depth of

operation. The cultivator may be fitted with 7, 9, 11, 13 tines or more depending upon the requirements.

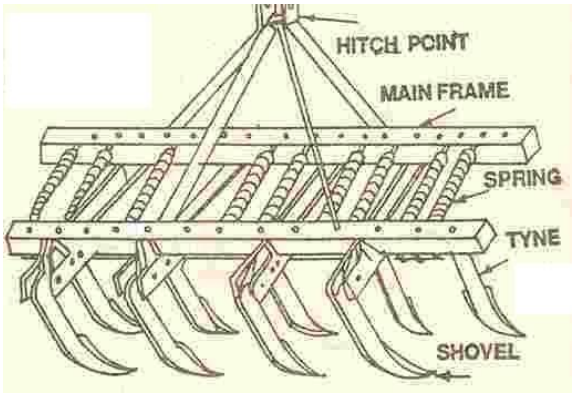


Fig. 15.1 Tractor drawn cultivator

Cultivator with rigid tines

Rigid tines of the cultivators are those tines which do not deflect during the work in the field. The tines are bolted between angle braces, fastened to the main bars by sturdy clamps and bolts. Spacing of the tines are changed simply by slackening the bolts and sliding the braces to the desired position. Since rigid tines are mounted on the front and rear tool bars, the spacing between the tines can be easily adjusted without getting the tines choked with stubbles of the previous crop or weed growth. A pair of gauge wheel is used for controlling the depth of operation.

Duck foot cultivator

It is a type rigid cultivator which is used mostly for shallow ploughing, destruction of weeds and retention of moisture. It consists of steel frame and rigid tines to which sweeps are attached as shown in Plate : 15.2. The implement is attached to the tractor with three point hitch system and is controlled by hydraulic system. The sweeps are fabricated from high carbon steel. Number of sweeps can be adjusted according to requirement. Usually this cultivator is about 225 cm long; 60 cm wide with 7 sweeps.

Plate : 15.2 Duck foot cultivator

Terms used for evaluation of an implements

Theoretical field capacity

It is the rate of field coverage of the implement, based on 100 per cent of time at the rated speed and covering 100 per cent of its rated width.

$$\text{Theoretical field capacity} = \frac{W \times S}{10} \quad \ldots\ldots\ldots\ldots \text{ ha/hr}$$

Where,

W – Width of the implement in meters (m)

S - Speed of operation in Kilometers per hour (Km/hr)

Effective field capacity

It is the actual area covered by the implement based on its total time consumed and its actual width of operation.

Field efficiency

It is the ratio of effective field capacity and theoretical field capacity expressed in percent.

$$\text{Field efficiency} = \frac{\text{Effective field capacity}}{\text{Theoretical field capacity}}$$

Effective field capacity is calculated as follows

$$C = \frac{S \times W \times E}{\quad}$$

1000

Where,

C - Effective field capacity, hectare per hr (ha/hr).
S - Speed of travel in km per hour.
W - Theoretical width of cut of the machine in metre, and
E - Field efficiency in per cent.

Problem 1: A 5 x 20 cm double action disc harrow is operated by a tractor having a speed of 5 km/h. Calculate the actual field capacity, assuming the field efficiency of 80 percent.

Solution:

Size of the harrow (width) = 5 x 20 = 100 cm = 1 meter

$$\text{Actual field capacity, } C = \frac{S \times W \times E}{1000}$$

$$= (1 \times 5 \times 80) / 1000$$

Actual field capacity = 0.4 ha/hr.

Problem 2: A 3 x 30 cm plough is moving at a speed of 4 km/h. calculate how much time it take to plough 500 x 500 m field when the field efficiency is 70 %.

Solution:

Width of the plough = 3 x 30 = 90 cm = 0.9 m

$$\text{Effective field capacity, } C = \frac{S \times W \times E}{1000}$$

$$= (0.9 \times 4 \times 70)/ 1000$$

Effective field capacity, C = 0.25 ha/hr = 2500 m^2/hr

(1 ha = 10,000 m^2)

Time required = 500 x 500/ 2500 = 100 hr.

Problem 3: A 4 bottom 40 cm mould board plough is operating at 5.5 km/h speed with 75 % field efficiency . Calculate the rate of doing work in hectares per hour.

Solution :

Width of the plough = 4 x 40 = 160 cm = 1.6 m

Rate of doing work = 1.6 x 5.5 x 75/1000

Rate of doing work = 0.66 ha/h

Problem 4: An indigenous plough has a 20 cm wide furrow at the top and 10 cm depth. Calculate the volume of soil handled per day 8 hours if the speed of working is 2.5 km/h.

Solution:

Furrow cross section = 10 x20/2

= 100 cm^2

Distance traveled in 8 hours = 8 x 2.5 x 1000 = 20,000 m

Volume of soil handled = 20000 x 100/ 10000

Volume of soil handled = 200 m^3

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Levelers

In irrigated areas land leveling is an essential operation of farming. Leveled fields receive uniform penetration of irrigation water with high efficiency. The possibility of water logging and soil erosion is reduced considerably. The entire leveled field becomes ready to receive timely agricultural operations like ploughing, seeding and interculturing without any delay. Smooth fields also facilitate the operation of field equipment and are highly desirable for using mechanical harvesters. Land leveling is usually done in the slack season when the field is free from crops, and the Labours and bullocks are idle.

Wooden logs or planks are the most common type of land levelers used by Indian farmers. They are operated in ploughed land to collect loose soil form high spots and to dump in into depressions. While operating in the field, the leveler is raised from the rear to take more cut and then it is tilted up side down to fill up the low spots elsewhere. The other improved type of land leveler which is used on the medium size farms, is called the leveling karaha or scraper. The scraper essentially consists of a bowl or 'U' shaped steel sheet made of 3 mm thick metal. Its cutting edge is generally made of high carbon steel. It is also provided with a wooden handle in the middle or two handles on the sides at the rear end. Provision is made at the front end for hitching. For taking the wear an extra steel sheet is welded underneath at the centre. The implement is pulled by a pair of bullocks. Two men are needed to operate it. One man controls the bullocks and the other

man does the loading and unloading. The amount of work done in a day depends upon various factors such as hardness of the soil, transportation distance (lead) and volume of the soil cut each time. If the soil is hard, it is always helpful to loosen the soil first by ploughing or by any other means and then proceed with leveling. Tractor mounted type (plate : 15.4) or animal operated improved levelers are also used in India. The laser guided leveler operated by tractor is shown in Plate : 15.5. The laser guided leveler has a transmitter which is fitted outside the field to be leveled. The leveler is fixed with a receiver of the laser beam. It works automatically and the operator need not adjust the leveling blade.

Plate : 15.4 Tractor drawn leveller

Plate : 15.5 Laser guided leveler in operation

Ridger

A ridger (Plate : 15.5) is an implement which cuts and turns the soil in two opposite directions simultaneously for forming ridges. It is also known as Furrower. Ridger is used to form ridges, for sowing row crop seeds and plants in well tilled soil. The ridger is also used for forming field furrows or channels, earthing up and similar other operations. Ridgers are also known ridging plough, middle buster plough and double mouldboard plough. The ridger generally has V-shaped or wedge-shaped share, fitted to the frog. The nose or the tip of the share penetrates into the soil and breaks the earth. The mouldboards lift, invert and cast aside the soil, forming deep channels and ridges of the required size.

(Courtesy: http://www.scotlandfarm.co.uk)

Plate : 15.5 Tractor operated ridger in operation

A Ridger required for row planted crops. It is also used for making field furrows or channels, earthing up, and similar other operations. It generally has a 'V' shaped share either rigidly fixed or hinged to the mould boards. The short beamed ridger is provided with a gauge wheel attached to the front end of the beam. This gauge wheel facilitates movement and control of the ridger. It may be operated by one or two pair of bullocks are a tractor. A ridger consists of beam, clevis, frog, handle, mouldboards, braces, share, and sliding shoe.

Bund former

It is used for making bunds or ridges by collecting the soil. Bunds are required to hold water in the soil, thereby conserve moisture and prevent run off. The size of the bund former is determined by measuring the maximum horizontal distance between the

two rear ends of the forming boards. A bund former consists of forming board, beam and a handle.

Plate 15.6 Bullock drawn bund former

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Chapter 16

Sowing equipment

Sowing or seeding is an art of placing seeds in the soil to have good germination in the field. A perfect seeding gives correct amount of seed per unit area, correct depth at which seed is placed in the soil and correct spacing between row-to-row and plant to plant.

Methods of sowing

There are different methods of sowing such as Broadcasting, Dibbling, Drilling, Seed dropping behind the plough, Transplanting, Hill dropping and Check row planting.

i) Broadcasting

Broadcasting is the process of random scattering of seed on the surface of seedbeds. It can be done manually or mechanically both. When broadcasting is done manually, uniformity of seed depends upon skill of the man. Soon after broadcasting the seeds are covered by planking or some other devices. Usually higher seed rate is obtained in this system. Mechanical broadcasters are used for large-scale work. This machine scatters the seeds on the surface of the seedbed at controlled rates.

ii) Dibbling

Dibbling is the process of placing seeds in holes made in seedbed and covering them. In this method, seeds are placed in holes made at definite depth at fixed spacing. The equipment used for dibbling is called dibbler. It is a conical instrument used to make proper holes in the field. Small hand dibblers are made with several conical projections made in a frame. This is very time consuming process, so it is not suitable for small seeds. Mostly vegetables are sown in this way.

iii) Drilling

Drilling consists of dropping the seeds in furrow lines in a continuous flow and covering them with soil. Seed metering may be done either manually or mechanically. The number of rows planted may be one or more. This method is very helpful in achieving proper depth, proper spacing and proper amount of seed to be sown in the field. Drilling can be done by (1) Sowing behind the plough (2) Bullock drawn seed drills (3) Tractor drawn seed drills.

iv) Seed dropping behind the plough

It is very common method used in villages. It is used for seed like maize, gram, peas, wheat and barley. A man drops seeds in the furrow behind the plough. Sowing behind the plough can be done by a device known as malobansa. It consists of a bamboo tube provided with a funnel shaped mouth. One man drops the seeds through the funnel and other man handles the plough and the bullocks. This is a slow and laborious method.

v) Transplanting

Transplanting consists of preparing seedlings in nursery and then planting these seedlings in the prepared field. It is commonly done for vegetable and flowers. It is very time consuming operation. Equipment for placing plants in the soil is called transplanter.

vi) Hill dropping

In this method, seeds are dropped at fixed spacing and not in a continuous stream. Thus the spacing between plant to plant in a row is constant. In case of drills, the seeds are dropped in continuous stream and the spacing between plant to plant in a row is not constant.

vii) Check row planting

It is a method of planting, in which row-to-row and plant-to-plant distance is uniform. In this method, seeds are planted precisely along straight parallel furrows. The rows are always in two perpendicular directions. A machine used for check row planting is called check row planter.

Seed drill

Seed drill is a machine for placing the seeds in a continuous flow in furrows at uniform rate and at controlled depth with or without the arrangement of covering them with soil.

The different functions of seed drill are:

i) To carry the seeds.
ii) To open furrow to an uniform depth
iii) To meter the seeds
iv) To place the seed in furrows in an acceptable pattern
v) To cover the seeds and compact the soil around the seed.

Seed cum fertilizer drill

Seed drills, fitted with fertilizer dropping attachment, distribute the fertilizer uniformly on the ground. It is called seed cum fertilizer drill (Plate : 16.1 and 16.2) Such a drill has a large seed box which is divided lengthwise into two compartments, one for seed and another for fertilizers. Seed drill may be classified as (i) Bullock drawn (ii) Tractor drawn.

Plate : 16.1 Tractor drawn Seed cum fertilizer drill

Plate : 16.2 Seed cum fertilizer drill in operation

Depending upon the method of metering the seeds, bullock drawn seed drill can be further divided into two groups based on the type of seed dropping as by hand or mechanically. There are a number of bullock drawn implements which are used for sowing seeds in which seeds are dropped by hand. The most popular implement is three lined cultivators with seeding attachment. In different parts of the country it is made in different sizes and shapes.

Components of seed drill

A seed drill with has mechanical seed metering device mainly consists of : (i) Frame (ii) Seed box (iii) Seed metering mechanism (iv) Furrow openers (iv) Covering device and (vi) Transport wheels.

Frame

The frame is usually made of angle iron with suitable braces and brackets. The frame is strong enough to withstand all types of loads in working condition.

Seed box

It may be made of mild steel sheet or galvanized iron with a suitable cover. A small agitator is sometimes provided to prevent clogging of seeds.

Covering device

It is a device to refill a furrow after the seed has been placed in it. Covering the seeds are usually done by patta, chains, drags, packers, rollers or press wheels, designed in various sizes and shapes.

Transport wheel

There are two wheels fitted on the main axle. Some seed drills have got pneumatic wheels also. The wheels have suitable attachments to transmit power to operate seed dropping mechanism.

Seed metering mechanism

The mechanism of a seed drill or fertilizer distributor which deliver seeds or fertilizers from the hopper at selected rates is called seed metering mechanism. There are a number of seed metering mechanism such as : Fluted roller feed type, internal double run type, cup feed type, cell feed mechanism, brush feed mechanism, auger feed mechanism, picker wheel mechanism and star wheel mechanism.

a) Fluted roller feed type

It is a seed metering device with adjustable fluted roller to collect and deliver the seeds into the seed tube. Fluted roller feed type mechanism (Fig.16.1) consists of a fluted wheel, feed roller, feed cut-off and adjustable gate for different sizes of grains.

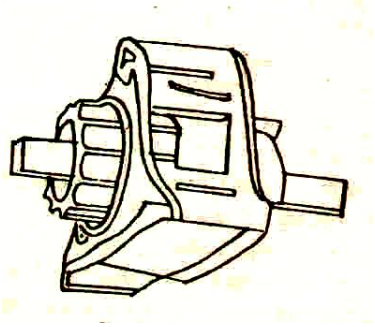

Fig. 16.1 Fluted roller type

The feed roller and the feed cut-off device are mounted on a shaft, running through the feed cups. The roller carries grooves throughout its periphery. It rotates with the axle over which it is mounted throws the grains out on the adjustable gate from where it falls into the seed tube. The fluted rollers which are mounted at the bottom of the seed box, receive seeds into longitudinal grooves and pass on to the seed tube through the holes provided for this purpose. By shifting the fluted wheel side ways, the length of the grooves exposed to the seed can be increased or decreased and hence the amount of seed is controlled. Thus a number of selection is available between closed position and full exposure of fluted wheel. The fluted feed mechanism is more positive in its metering action than the internal double run method.

b) Internal double run type

It is a seed metering device in which the feed wheel is provided with fine and coarse ribbed flanges as shown in Fig. 16.2. It consists of discs, mounted on a spindle and housed in a casing fitted below the seed box. It has double faced wheel. Internal double-run type roller one face has a larger opening for larger seeds and the other face has smaller opening for smaller seeds. A gate is provided in the bottom-of the box to cover the opening not in use. The rate of seeding is varied by adjusting the speed of the spindle which carries the discs.

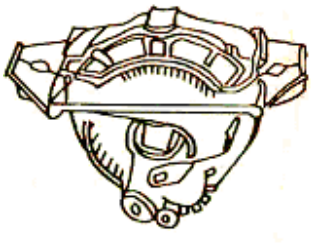

Fig. 16.2 Internal double run type

c) Cup feed mechanism

It is a mechanism consisting of cups or spoons on the periphery of a vertical rotating disc which picks up the seeds from the hopper and delivers them into the seed tubes as shown in Fig.16.3. It consists of a seed hopper which has two parts. The upper one is called grain box and the lower one is called feed box. The seed delivery mechanism consists of a spindle, carrying a number of discs with a ring of cups attached to the periphery of each disc. The spindle with its frame and attachment is called seed barrel. When the spindle rotates, one disc with its set of cups rotates and picks up few seeds and drops them into small hoppers. The cups have two faces, one for larger seeds and the rate at which the seed barrel revolves. This type of mechanism is common on British seed drills.

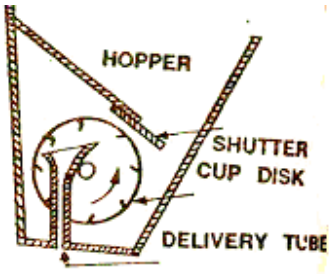

Fig. 16.3 Cup feed mechanism

d) Cell feed mechanism - It is a mechanism in which seeds are collected and delivered by a series of equally spaced cells on the periphery of a circular plate or wheel.

e) Brush feed mechanism - It is a mechanism in which a rotating brush regulates the flow of seed from the hopper. A number of bullock drawn planters in the country have Brush feed mechanism.

f) Auger feed mechanism - It is a distributing mechanism, consisting of an auger which causes a substance to flow evenly in the field, through an aperture at the base or on the side of the hopper. Many of the fertilizer drills on the country have got Auger feed mechanism.

g) Picker wheel mechanism - It is a mechanism in which a vertical plate is provided with radially projected arms, which drop the large seeds like potato in furrows with the help of suitable jaws.

h) Star wheel mechanism - It is a feed mechanism which consists of a toothed wheel, rotating in a horizontal plane and conveying the fertilizer through a feed gate below the Star wheel.

Furrow openers

The furrow openers are provided in a seed drill for opening a furrow. The seed tube conducts the seed from the feed mechanism into the boot from where they fall into the furrows.

Type of furrow openers

There are different type of furrow openers, which are: a) Shovel type, b) Shoe type and c) Disc type (single disc, double disc).

a) Shovel Type

Shovel type furrow opener are the widely used in seed drills. There are three of shovels in use. They are: (a) reversible shovel (b) single point shovel and (c) spear point shovel.

Shovel type openers are best suited for stony or root infested fields. These shovels are bolted to the flat iron shanks at the point where boots are fitted which carry the end of the seed tubes. In order to prevent shock loads due to obstructions, springs are provided. It is easy in construction, cheaper and easily repairable. It is very common with usual seed drill.

b) Shoe Type

It works well in trashy soils where the seed beds are not smoothly prepared. They are made from two flat pieces of steel welded together to form a cutting edge. It is specially suited for black cotton soil. Shoe is made of carbon steel having minimum carbon content of 0.5 per cent with a minimum thickness of 4 mm.

c) Disc Type

They are two types: (i) Single disc type and (ii) Double disc type.

i) Single disc type

It is furrow opener consisting of one concave disc. Disc type furrow openers are found suitable where plant debris or trash mulches are used. It consists of a curved disc made of hardened steel. It is set at an angle which while operating, shift the soil to one side making a small ridge. The disc is kept clean by two scrapers, one toe shaped at the convex side and one 'T' shaped at the concave side. It works in sticky soils also, but the discs are costly and maintenance work is a bit difficult.

ii) Double disc type

In double disc type furrow opener there are two flat discs, set at an angle to each other. The disc opens a clean furrow and leaves a small ridge in the center. The seeds are dropped between the two discs, providing more accurate placement. It is suitable for trashy lands. Seed drills attached with tractors having high speeds, usually use this type of furrow opener.

The furrow opener consists of Tine, shovel, seed tube and boot for seed and fertilizer.

1) Tine: A thin pointed projection of a implement such as fork or pitchfork

2) Shovel- It is made of carbon steel having carbon content of 0.5 per cent and a minimum thickness of 4.0 mm.

3) Seed tube - It is a tube which carries the seeds from the metering device to the boot. Seed tubes are provided at the lowest lines through suitable boots and furrow openers. The most common to the furrow lines through suitable boots and furrow openers. The most common type of seed tube is the steel ribbon one. The ribbon is rolled in the form in such a way that lower edge of the tube is thinner than the edge. Polythene or rubber tubes are also used of this purpose. The minimum diameter of seed and fertilizer tube is 25 mm.

4) Boot - It is a part of the sowing machine which conveys the seeds or fertilizers from the delivery tube to the furrow. It is bolted or welded to the tine. It is a harrow casting, into which the lower end of the seed tube is inserted and to which the furrow openers are attached.

PLANTER

Planter is normally used for those seeds which are larger in size and can not be sown by usual seed drills. The main functions of the planter are:

(i) To open the furrow

(ii) To meter the seed

(iii) To deposit the seed in the furrow

(iv) To cover the seeds and compact the soil over it.

A planter consists of hopper, seed metering device, knock out arrangement, cut-off mechanism, furrow opener and other accessories.

Hopper : A planter has seed hopper for each row. Hopper is usually made of mild steel or any other suitable material.

Seed metering device in a planter : There are a number of seed metering devices in a planter but the most common device consist of a rotating plate at the bottom of seed hoppers. In some planters, vertical rotors as well as inclined rotors are also used. The most common is the horizontal seed plate used in planters. The horizontal seed plates have got suitable notches or holes called cell. Depending upon the type of notches on the plates, it is of three types. (i) Edge drop (ii) Flat drop (iii) Hill drop. The edge drop carries the seed on edge in the cell of the plate. The flat drop carries the seed on a flat in the cell of the plate. Only one seed is allowed in the cell at each time. In hill drop, the cells round the edge of the plate are large enough to admit several seeds at a time.

The rotating plate receives the seeds from the hopper. The plate moves under an arrangement called cut-off which allows only those seeds which are accommodated in the cells. Cut-off mechanism cuts-off or brushes out excess seeds from the cells of the feed mechanism.

Knock out arrangement : This mechanism is a device which knocks out the seeds from the cells or picker heads of the mechanism. It consists of rollers, star wheels or rounded points which are forced into the cells by the pressure of a spring and eject seeds out of the cells.

The spacing of seeds or hills in the row is determined by the ratio of linear or peripheral speed of the cells to the forward speed of the planter and by the distance between the cells in the metering unit. The accuracy of the planter depends upon several factors such as: (i) speed of seed plate (ii) shape and size of cells (iii) shape of hopper bottom and (iv) uniformity of seed size.

Planter is usually used for those seeds which are required to be sown at equal intervals between plant to plant.

Calibration of seed drill :

The procedure of testing the seed drill for correct seed rate is called calibration of seed drill. It is necessary to calibrate the seed drill before putting it in actual use to find the desired seed rate. It is done to get the pre determined seed rate of the machine. The following steps are followed for calibration of seed drill.

Procedure :

i. Determine the nominal width (W) of seed drill .

$W = M \times S,$

Where, M = Number of furrow openers

S = Spacing between the openers, m

ii. Find the length of the strip (L) having nominal width (W) necessary to cover 1/25 ha (1 /25 x 10000 m^2).

$L = 400/W$, meter

iii. Determine the number of revolutions (N) of the ground wheel of the seed drill required to cover the length of the strip (L).

$L = \Pi \times D \times N = 400/W$

$N = 400/\Pi \times D \times W$ revolutions per minute

iv. Jack the seed drill so that the ground wheels turn freely. Make a mark on the drive wheel and a corresponding mark at a convenient place on the body of the drill to help in counting the revolutions of the ground wheel..

v. Fill the selected seed in the seed hopper. Place a container under each boot for collecting the seeds dropped from the hopper.

vi. Set the seed rate control adjustment for maximum position and mark this position on the control for reference.

vii. Engage the clutch and rotate the ground wheel for $N = 400/\Pi \times D \times N$, revolutions per minute.

viii. Weigh the quantity of seed collected in the container and record the observation.

ix. Calculate the seed rate in kg/ha.

x. If the calculated seed rate is higher or lower than the desired rate of selected crop, repeat the process by adjusting the seed rate control adjustment till the desired seed rate is obtained.

Problem 1 : Calculate the cost of seeding one hectare of land with bullock drawn seed drill of 5 x 22 cm size. The speed of bullocks is 3 km/hr. Hire charge of bullocks Rs.200/- per pair, hire charges of seed drill Rs.50/- per day and wage of operator Rs.150/- per day of 8 hours.

Solution :

Width of seed drill = 5x22 = 110 cm = 1.1 m

Area covered/hr = width x speed = 1.1 x 3x1000 m = 0.33 ha

Time taken/ha = 1/0.33 = 3.03 hrs.

Hiring cost of per hour = $\frac{200+50+150}{8}$ = Rs 50.

Cost of seeding per hectare = 3.03 x 50= Rs. 151.50

Potato planter

Planting equipment for commercial crop like Potatoes were considered essential due to excessive labour requirements in traditional methods of planting these tubers and, therefore, few machines have been developed and commercialised.

Potato tubers are planted either on flat bed or on ridgers or in small furrows depending upon the soil types and moisture content of soils. While planting potato tubers on flats or in furrows, the ridging operation is carried out at later dates. In improved method of potato planting, fertilizers are placed at the time of planting at a depth greater than that of the tubers. An improved potato planter cum fertilizer applicator is meant for drilling the fertilizer, dropping of tubers on flat surface and subsequently covering those with soils making a small ridge in one operation. However, the machine has not become a commercial unit for a wide spread acceptance.

Tractor operated potato planter-cum-cultivator is a commercial machine. It is used for planting tubers with 60 cm spacing of rows. However, the plant to plant spacing can be adjusted between 20 and 45 cm distance. The graded tubers of 2.5 to 4 cm size weighing 50-60 gm each are suitable for machine planting. By removing the hopper, the furrow opener and power transmitting mechanism, the machines suits well for earthing operations. Ridgers are so adjusted that earthing operation suits the row spacing.

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Chapter 17

Crop propagation tools, Cutting, Grafting, pruning tools

Plant propagation

Most plants reproduce more of their kind through production of seed. This is Sexual reproduction and it involves the exchange of genetic material between tow parent plants. Many ornamental plants do come “true” from seed.

To increase the numbers of these plants, gardeners and horticulturists use Asexual propagation. In asexual propagation, the new plants are genetically exact copies or clones of a single parent plant. The methods used in asexual propagation range from taking leaf cutting of African violets to grafting apple cuttings onto root stocks.

Techniques for vegetative propagation : There are different techniques for vegetative propagation such as Air or ground layering, Division, Grafting and bud grafting which is widely used in fruit tree propagation, Micro propagation, Stolen or runners, Storage organs such as bulbs, corms tubers and rhizomes, Striking or cuttings and Twin-scaling.

Fruit tree propagation is usually carried out through asexual reproduction by grafting or budding the desired variety onto a suitable rootstock.

Grafting is a method of asexual plant propagation widely used in agriculture and horticulture where the tissues of one plant are encouraged to fuse with those of another. It is most commonly used for the propagation of trees and shrubs grown commercially. (Grafting is limited to dicots and gymnosperms. Monocots lack the vascular cambium required).

In most cases, one plant is selected for its roots, and this is called the stock or rootstock. The other plant is selected for its stems, leaves, flowers, or fruits and is called the **scion.** The scion contains the desired genes to duplicated in future production by the stock/scion plant.

In stem grafting, a common grafting method, a shoot of a selected, desired plant cultivar is grafting onto the stock of another type.

In another common from called budding, a dormant side bud is grafting on the stem of another stock plant, and when it has fused successfully, it is encouraged to grow by cutting out the stem above the new bud.

For successful grafting to take place, the vascular cambium tissues of the stock and scion plants must be placed in contact with each other. Both tissues must be kept alive until the graft

has taken, usually a period of a few weeks. Successful grafting only required that a vascular connection takes place between the two tissues. A physical weak point after still occurs at the graft, because the structural tissue of the two distinct plants, such as wood may not fuse.

Reasons for Grafting and Budding

1. Change varieties or cultivars
2. Optimize cross-pollination and pollination.
3. Take advantage of particular rootstocks
4. Benefit from inter stocks
5. Perpetuate clones
6. Produce certain plant forms
   Repair damaged plants
7. Increase the growth rate of seedlings
8. Index viruses

Grafting tools

The grafting tool is a simple product, which will allow to make flawless grafts. The grafting tool can graft all kinds of plants, and is particularly well suited to grafting fruit trees. The clean cuts made by the tool allow to get a perfect graft, every time.

The main features of the grafting tool are:

- Easy to use - Create precise grafts quickly.
- Trimming blades - prepare stock for grafting.
- Replaceable grafting blade - make sure you always get a clean cut.
- Use of high carbon steel blades - longer lasting strength.
- Quickly and easily create professional quality grafts.
- The clean cuts made by the grafting tool should allow to get a perfect fit, every time.
- This increases the likelihood of the graft 'taking', leading to much less wastage.
- The 2 in 1 tool contains both a pruner and grafting guillotine. This allows to first prepare the plants to be grafted, by trimming away excess leaves and twigs. Then using the special grafting guillotine one can make a perfect cut into the grafting stock.
- Ergonomic handles: The handle should be ergonomically designed for the operator.

Tools used for budding and grafting : The different simple tools used are Dibber, Budding and grafting knives, Grafting Tools, Grafting Tape, Pruning and lopping shears

Dibber : Dibber are used to make holes in seed bed to plant seeds, seedlings and bulbs. They are ergonomically designed consisting of a stainless steel sharp dibber and a hard wood handle joined together using a ferrule. The sharp dibber glides effortlessly into all soils.

Grafting and Budding knives : Budding and grafting knives are designed specifically for these purposes and should not be used for carving and whittling wood. Using them for other purposes will make cutting edge blunt very quickly. Grafting and budding knives must be kept razor sharp so they will cut smoothly. They are available in either left or right-handed models. The blade is beveled on only one side, unlike conventional knives, which have blades that bevel on both sides down to the cutting edge.

Grafting Tools - Grafting tool is designed for making the cleft graft. It is used when the rootstock's diameter is greater than 1 inch. The wedge-shaped blade is used to split the stock, and the flat pick opens the cleft so that scions can be inserted. Once in place, the flat pick is removed and the cleft comes together to hold the scions in position.

Grafting Tape - It can be used for many things… Grafting…utilized as a cover/protecting bandage when using a splint for broken/cracked branches, twigs. It is also used to hold the soil and roots for the root over rock design of Bonsai styling.

Pruning and Lopping Shears : Pruning and Lopping Shears are the scissors or sliding blade type rather than the blade and anvil type. If use to harvest scion wood or bud sticks, blade and anvil pruner will crush plant tissue. As with knives, pruning and lopping shears should be kept razor sharp to give clean, close cuts.

Pruning tools

Plants differ from other living things in one important respect: one can improve a plant's vigor by removing healthy parts of it. This is known as pruning. It is a process of carefully removing the parts of the plant - even healthy parts - to make it healthier still or more attractive, or to improve other qualities, such as its fruit-bearing ability. It's important to point out that the emphasis here is on improvement, not removal. While tools like chain saws can be effective pruning devices, they are principally designed for large-scale removal.

(Courtesy: http://4.bp.blogspot.com & http://www.manualpolesawsviews.tk)

Plate : 17.1 Secateur & Saw tooth knife

There are two types of pruning tools such as Anvil and Bypass. Anvil pruners and loppers have a blade that closes against an anvil on the lower jaw. The anvil is a softer metal than the blade. Bypass pruners and loppers have a blade that sweeps past the lower jaw. There's an important difference between the two. Anvil loppers and pruners tend to crush the material that is being cut and are used where cleanliness of cut is not as important as removal. This occurs when cutting dead material or making preparatory cuts - those cuts that occur before the final cut is made. For example, in some cases to shorten a branch before removing it. The preparatory cuts are those that reduce the branch's length before making the final cut. At other times, naturally fallen or pruned branches will need to be cut into small lengths for disposal. The anvil pruners and loppers are used to make all these cuts, as well as for thinning brush.

A bypass pruner or lopper is reserved for cuts that affect the health of the plant. It should be kept razor sharp - again, save the grunt work for anvil pruners and loppers. Finally, pruning tools that are used in one hand are known as pruners (or hand shears) while large tools that require you to use both hands are known as loppers.

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Chapter 18

Inter-culture equipment

The intercultural equipments are mainly used for removing the weed and control of weeds. Weeds grow along with the plants and compete with them for their nutrients. The weeds growing along with crops compete for moisture, light and nutrients. Hence, it is essential to remove them.

The following weeding tools and implements are used by the farmers.

1. Traditional hand tools.
2. Traditional and Improved hoes.
3. Wheel hoes.
4. Animal drawn multipurpose hoe.
5. Tractor drawn interculture equipment.
6. Power weeders.

Among the traditional hand tools, the Khurpi and the weeding hooks are popular tools made by local antisense for the use on small and marginal farms. Khurpi is used in India may vary in their size: shape and weight, but they have common basic parts i.e., a cutting blade and a small wooden handle for the grip. A person used it while squatting on the ground. The khurpi with a long narrow blade is preferred for weeding around the flower plants, broad casted crops and vegetable crops. One with wider blades is generally used for earthing up operations or for weeding crops sown in lines. However, a man covers about 0.025 hectare in a day under normal working condition.

The hoe is a versatile form of implement used for many operations, i.e. seed bed preparation, ridge making, channel shaping and weeding. It is also used for removing plant roots, harvesting root crops and thinning drilled crops. The two common types of hoes used by Indian farmers are hand hoes and animal drawn hoes.

Hand hoes are used to cultivate small area of land by human labour. Among the indigenous types of hand hoes, the Kodali (narrow spade) is the most popular one. Kodali is similar to a phawara (broad spade), the difference being that instead of a wide thin cutting blade, a narrow long pointed thicker section blade is attached to the handle. The person working with it has to bend his body. It is used for inter cultivating maize and

sugarcane crops, and for earthing up the potato crops sown in lines. About 0.04 hectare can be covered in a day by one man. An improved hand hoe is operated in the standing position. It is provided with a long handle fitted in the middle of the cutting blade. One end of the blade is about 10 cm wide sharp edge and the other end is pointed narrow one for making small furrows. It can be used for cultivating and weeding very close to the individual plant.

The Grubber is a manual pull type hoe suitable for weeding and inter culture of upland row crops in black cotton soil regions. It is provided with 3 blades and the field capacity is 0.005 ha per hour.

The wheel hoe is another implement which is used for cultivating the land between rows. It consists of a wheel, two handles and a tyne to place the cutting tool on. Either a reversible shovel or a 3 prong fork or rake or a sweep is used as cutting tool, depending upon the weeds and moisture condition. A man operates the hoe in standing position by pushing through a short length each time. In a working day, about 0.04 hectare can be covered.

Animal drawn weeding implements are pulled either by single animal or a pair of animals. These implements may either be single row type or multi row units. The three tyne cultivator or 'Triphali', Akola hoe, Bardole hoe or two 'Blade hoe' are the most popular implements in different regions for row crop interculture operations. It is essential to provide wider spacing (above 30 cm) for movement of animals and implement if animal drawn weeders are to be used.

The main parts of the blade hoe are:

1. Head piece
2. Prong
3. Blade
4. Handle and
5. Beam

The prongs make an angle of about 45^{o} downward with the horizontal plane. At the end of each prong, the blade is attached. It loosens the upper surface of the soil and is generally used for interculturing sorghum (jowar), cotton, groundnut and other kharif

crops. The hoe width is maintained between 25 and 75 cm depending upon the size of the bullocks and type of soil.

Dry land weeder

Dry land weeders with long handles are suitable for weeding in row crops in rainfed and garden lands. The long handle eliminates the back strain and provides comfort to the operator for continuous operation in standing posture**.** This is a long handled tool and consists of 25 mm diameter, 1200 mm long conduit pipe over which 520 mm long handle is fitted (Fig. 18.1). To the bottom of the vertical pipe frame, two arms made of 250 x 25 x 3 mm of MS plates are fitted. At the extreme end of the arm 120 mm diameter star wheel is fixed. The cutting blade is fitted to the bottom portion of the arm, and 200 mm to the back of the star wheel. The star wheel facilitates easy movement of the tool. The cutting blade cuts the weeds. The operating width of the blade is 120 mm. The star type is suitable for operation in loamy and sandy soil. In the peg type the star wheel is replaced by pegs facilitating easier operation in clay soil. The area covered by the weeder is about 0.08 ha/day.

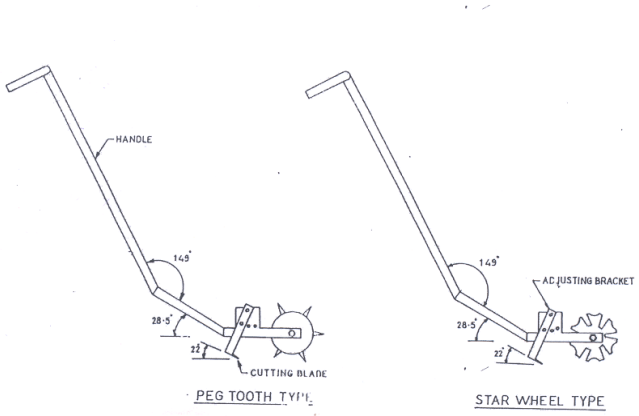

Fig. 18.1 Dry land weeders

Engine operated weeder

Usually a 3-hp petrol start kerosene run engine operates the weeder. The engine power is transmitted to ground wheels through V belt-pulley and sprocket - chain mechanism. At the back of the machine a replaceable sweep blade is fixed (Fig. 18.2). Sweep blades of different width can be fitted to the machine depending on the row to row

spacing of the crop. A tail wheel is provided at the rear to maintain the operating depth. The sweep blade can be raised or lowered so as to have the desired operating depth. The salient features of the unit are:

- □ Useful for weeding between rows of crops like tapioca, cotton, sugarcane, maize, tomato and pulses whose rows spacing is more than 45 cm
- □ Can also be used for weeding and intercultural operations in orchards, coconut and areca nut plantations.

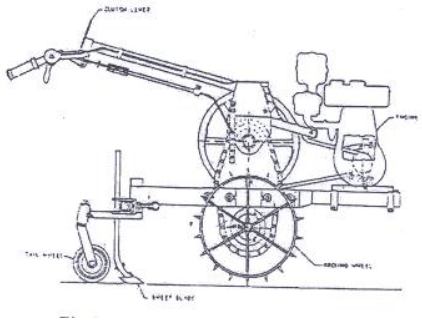

Fig. 18.2 Engine operated weeder

Sweep

It is an intercultural implement for removing shallow rooted weeds in between rows. The sweep consists of V shaped shovels with bevel edged wings. The shovels are held by the tynes fixed to a frame by means of counter sunk bolts and nuts. When the sweep is used for secondary tillage, five or six tynes may be clamped with the shovels in line having no gap in between them (Fig. 18.3). By just skimming under the soil at a shallow depth of 2 to 3 cm, the sweep breaks the capillary in the soil pores and provides soil mulch. When the sweep is used for intercultural operations, the space between the shovels is adjusted to suit the row spacing of the crop and with different sizes of blades. The area covered by sweep is 1.75 to 2.5 ha/day. The salient features of the unit are:

- □ Suitable for all row crops and soils; provides soil mulch and conserves soil moisture
- □ Suitable for inter cultural operations.

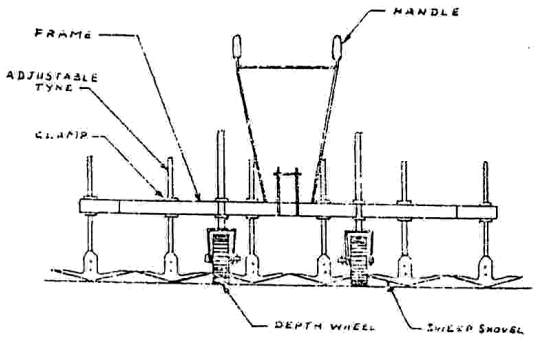

Fig. 18.3 Bullock operated sweeps

Junior hoe

It is intercultural equipment used primarily for weeding in between the rows of standing crops. It consists of reversible shovels with curved tynes attached to framework with hinge arrangement. A handle and beam are fixed to the framework for guiding and attaching the unit to the yoke (Fig. 18.4). The spacing between the shovel can be adjusted according to the row spacing of the crop. The area covered by the junior hoe is about 1.5 ha per day.

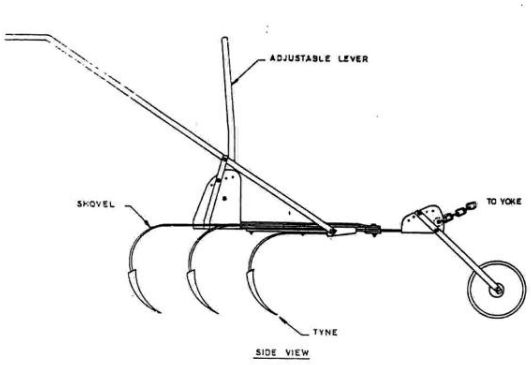

Fig. 18.4 Junior hoe

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Intercultural operations in horticultural crops

Sl No.	Crop	Intercultural operations
1	Beet	Weed Control, Thinning
2	Bitter Gourd	Weeding
3	Brinjal	Weeding By Shallow Cultivation, Earthing up
4	Carrot	Weeding and hoeing, Earthing up
5	Cauliflower	Weeding, hoeing, earthing up, Blanching
6	Cabbage	Weeding, hoeing, earthing up
7	Okra	Weeding
8	Onion	Weeding
9	Peas	Weeding, Vine Support
10	Radish	Weeding and hoeing, Earthing up
11	Tomato	Weed Control ,shallow Cultivation for aeration, earthing up, mulching
12	Mango	Training and pruning ,hoeing(crust breaking),Weeding and Ploughing
13	Citrus	Weed Control , Intercropping ,Training and Pruning
14	Papaya	Thinning, Weed Control, Intercropping

Tools used in intercultural operations

Sl. No.	Name of Tool/implements Used for inter cultivation	Intercultural operation
1	Hoe	Weeding, thinning, crust breaking, soil aeration.
2	Cultivator. Fork	Weeding, loosening the soil for aeration
3	Ridge Plough, Spade	earthing up
4	Poles	Wine support
5	Knife	Training
6	Rope Saws, Pole Pruner & Lopper, Folding Pruner	Pruning

Other hand tools used in horticulture

Sl. No.	Name of hand tool	Usage
1	Spade	Digging, trenching and removing soil
2	Fork	Used after the soil is turned by the spade for breaking clods and Weeding
3	Border fork	For weeding in borders
4	Potato fork	For digging out potatoes, for clearing compost and rubbish
5	Garden rake-	To break up the clods, leave to a fine tilth. It Can also be used for gathering stones, weeds and hedge clippings
6	Lawn rake	Used on lawns to rake out the dead grass and collect leaves
	The hay rake	It is used for raking together grass and leaves
	Draw hoe	It chops through the roots of the weeds, especially tap roots, and can also be used for making drills for seed sowing and for singling
	Dutch hoe	It is used for Weeding. It is given with a pushing action as the operator walks Backwards
	Triangular headed Hoe	Used with a pulling action for making a Shallow drill
	Trowels	They are small scoop shaped tools used for making small holes for planting plants
	Garden line	It is a very important horticultural tool used for setting out straight lines. It is used when seed sowing, trenching, lawn edging, transplanting and for many other garden operations
	Hand shears	Used for cutting grass and hedges
	Edging shares	Used for cutting lawn edges and because of the length of the handles they can be used when standing upright.

Chapter 19

Harvesting equipments

Harvesting

It is the operation of cutting, picking, plucking digging or a combination of these operations for removing the crop from under the ground or above the ground or removing the useful part or fruits from plants.

Harvesting action can be done by four ways:

1) Slicing action with a sharp tool.
2) Tearing action with a rough serrated edge.
3) High velocity single element impact with sharp or dull edge.
4) Two elements scissors type action.

The harvesting involves slicing and tearing action. The harvesting can be done either by manually operated tool or animal drawn equipment or mechanically operated machine.

Sickle: Sickle is a simple harvesting tool. It is used for harvesting crops and cutting other vegetations. The sickle mainly consists of a metallic blade and a wooden handle. Blade is the main metallic part of the sickle. The blade should be made of carbon steel. The blade is made in curved shape. There are two types of metallic cutting blade such as plain and serrated. The teeth of serrated sickle are made sharp for efficient working in the field. The handle of the sickle is made of well seasoned wood. The forged end of the blade for fixing the handle is called tang. Protective metallic bush fitted at the junction of the blade and the handle to keep the tang tight in the handle is called ferrule. The parts of sickle are shown in Figure 19.1. Harvesting by sickle is a very slow and labour consuming device.

Fig. 19.1 Sickle

Potato Harvester

On large size farms where potato cultivation is practiced on commercial scale, animal drawn cultivators or country ploughs were used for harvesting the potatoes. However, the implement consisting of a ridge bottom and a replaceable bar point share has been successfully employed for this purpose. The potato soil mass while moving on the rods provided at the back of the share, gets separated. The potatoes are then dropped on the ground which is later collected manually. The same implement has been modified and can be hitched by a power tiller also. The animal drawn groundnut digger can be successfully used for digging of potatoes.

A potato digger suitably designed to be operated as a mounted machine by a tractor. The potato harvester is used extensively for harvesting potatoes in Northern States of India. The machine uses conventional digging blade and a shaker conveyor made of steel rods. As the tractor with the machine moves over the field, the soil and potatoes are dug out and lifted on the conveyor chain. The soil is shaken out by agitation where as the potatoes are collected in bags.

The tractor operated potato digger consists of a three point hitch frame, main frame, and two column frames with blade. Blade is fixed to with two detachable ridge opening devices. On the sides of the columns, two furrow guides are provided for stability of the digger. Two replaceable high carbon steel shovels are fitted in front of the blade for easy penetration in dry field conditions and to prevent it from wear.

The tractor powered potato digger can be conveniently divided into four broad categories:

1. Blade type diggers,
2. Single row spinner digger type machines,
3. Single or double row elevator diggers,
4. Oscillating / vibrator diggers.

The most common among the four designs as stated above is the elevator type digger. The commercial machines are of both single row and two row types. The potato harvester is shown in plate: 19.1. The machine consists of a shovel type digger and endless elevator to complete the total operation.

Plate : 19.1 Tractor operated Potato harvester

(Source : http://img.esuppliersindia.com & http://www.huaxinmachine.com)

Tapioca harvester

The tapioca harvester is tractor operated implement. It consists of a main frame with three point hitch system, shank with depth adjustment and digging blades with pegs. Provision is made to for adding dead weight on the main frame. The digging blade is trapezoidal in shape and five pegs are fitted in front of the blade for easy penetration into the soil and reduce the draft requirement of the unit. Before digging operation the top portion of the plant has to be removed. When the implement is pulled forward, tapioca tubers are uprooted.

The salient features of the are : harvesting efficiency is about 98%, can be easily attachable to any make of 35 hp tractor, reduction in harvesting cost compared to manual

harvesting, tubers are not left as undug in the field and additional irrigation for manual digging is eliminated.

Turmeric harvester

Turmeric harvester is a power tiller operated unit. It consists of a blade with three bar points for easy penetration into the soil. To the rear end of the blade six slats spaced at 50 mm apart are hinged at both ends. The oscillating motion for the slats is obtained through eccentric provided on either side of the unit. The power is transmitted from the clutch pulley of the power tiller to a reduction gearbox mounted near the hitch bracket assembly of the power tiller. From the gear box, the power is transmitted to the shaft of the turmeric digger unit through V belt transmission.

Fruit harvester

It is estimated that 70% of the potential of lasting quality of many fruits is predetermined at harvest; post harvest factors accounting for the remaining 30%. Certain harvest factors such as time of harvest, or harvest maturity and method of harvest also influence the keeping quality of perishables like fruits, besides their mechanical properties. In India, manual harvesting is in vogue using ladders, poles, 'dhoti', chippers, etc. The large size of fruit trees poses a great problem in manual harvesting resulting in more damage.

Improved harvesting methods would help not only to reduce these losses but also improve harvesting to 40 to 65 kg/ha compared to 15 to 25 kg/ha with traditional methods.

There are two types of manually operated fruit harvesters such a fixed height type with wooden head and metal cutting blade and adjustable height type with metal head and metal cutting blade.

1. Fixed height with wooden head and metal blade harvester

This type of harvester has a light weight cutting mechanism made of a light bamboo pole. The components of the harvester include, a wooden head, a metal blade, a spring, a fruit collecting net, a wooden pole, a hand lever and nylon rope. The cutting mechanism of the harvester consists of the wooden head, the cutting blade and the retaining spring. The wooden head of 220 X 115 X 20 mm is stationary and acts as a support against the cutting blade when a fruit stem comes between the metal blade of 195

X 58 X 6 mm in size and the head. The failure of the stem takes place due to the cutting action of the sharp blade against the head. The blade is given proper sharpness and heat treatment to prevent fast wear. The blade is always held in open position by means of a soft spring of 64 mm in length and 90 mm in diameter. The blade moves against the tension of the spring while cutting is taking place. Immediately after cutting, the blade is pulled back to its original open position by the spring which is connected between the blade and the pole. A nylon net is fixed around a ring of 300 mm diameter made of 8 mm steel rod, just below the cutting mechanism to collect the cut fruit, thus a avoiding any damage. The net depth is kept at about 270 mm. The entire cutting mechanism was fitted to a bamboo pole of 12 mm diameter and 3.5 m length. At about 380 mm from the bottom end, a hand lever is fitted to the pole. The metal cutting blade on the top and the hand lever are connected by a nylon rope of 3.2 m length. By pushing the hand lever down, the blade moves against the head and cutting takes place.

2. Adjustable height with metal head and metal blade harvester

In this type of harvester, the cutting mechanism is similar to the fixed height type harvester. The variations are only in head and pole length to achieve increased adjustable height up to 5.4m. An additional base plate is provided at the bottom of the pole. The cutting head was fabricated out of angle iron of 191 X 115 X 6 mm size. The pole is composed of two G.I. pipes of 12 mm and 18 mm sizes. One can be inserted in to the other. This telescopic arrangement of poles is helpful in varying the height. The pole can be fixed at any desired height by a clamp arrangement, thus making it flexible, adjustable and not fixed as in earlier harvester.

The cutting mechanism is arranged at the top of a 12 mm pipe by means of a coupling. This facilitates dismantling and assembly of the cutting mechanism from the pole. Provision of base plate at the bottom of the pole with U-clamp arrangement helps to freely move pole in all directions to meet fruit orientation. This facilitates the operation of the harvester although it is heavier than the fixed type harvester discussed earlier.

Hoists

A hoist (Plate : 19.2) is a device used for lifting or lowering a load by means of a drum or lift-wheel around which rope or chain wraps. It may be manually operated,

electrically or pneumatically driven and may use chain, fiber or wire rope as its lifting medium. The load is attached to the hoist by means of a lifting hook.

Plate : 19.2 Petrol engine operated Hoist

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