STUDY MATERIAL

DA 252 (2+2)

FARM POWER AND MACHINERY




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Chapter - 1

SOURCES OF FARM POWER

The mechanization of Indian farms is imperative to enhance input use efficiency, reduce human drudgery, increase production and productivity of food-grains, reduce cost of production and to address issues of labour scarcity and timeliness of farm operations. The total farm power availability in Indian agriculture was 2.24 kW/ha in 2016-17. It had a share of 1.324,0.018, 0.021, 0.460, 0.193, 0.091 and0.130 kW/ha from tractors, power tillers, combine harvesters, diesel engines, electric motors, humans and draught animals, respectively. Indian agriculture employs about 52% of total work force with a GDP contribution of 15% (2016-17). The farm holdings in India are classified as: (a) Marginal <1 ha) (b) Small (1-2 ha) (c) Semi medium (2-4 ha) (d) Medium (4-10 ha) (e) & large (>10 ha).

Small and marginal land holdings (< 2.0ha) contribute to 86% of total operational land holdings and cover 47%of total operated area. The average land size in India is 1.08ha. The farm power availability from human was 0.091 kW/ha in 2016-17. The population of draught animals in the country reduced from 78.42 in 1971-72 to 47.46 million in 2016- 17. The power availability from this source has come down from 0.221 kW/ha in 1971-72 to 0.130 kW/ha in 2016-17. During the year 2016- 17, the population of tractors, power tillers, combine harvesters, diesel engines and electric motors was 6.35, 0.46, 0.04, 11.48 and 7.50 million, respectively. The corresponding farm power availability from tractors, power tillers, combine harvesters, diesel engines and electric motors was calculated as 1.324, 0.018, 0.021, 0.460 and 0.193 kW/ha, respectively.

The total farm power availability was 2.24 kW/ha during 2016-17. During the same period, the farm power availability from mobile (human, draught animal, tractor, power tiller and combine harvester) and stationary (diesel engine and electric motor) sources was 1.585 and 0.650 kW/ha, respectively. In the mobile power sources category, power availability from tractor was the highest (1.324 kW/ha) whereas in the stationary power availability, diesel engine had the highest share of 0.460 kW/ha. This indicated growing trend towards use of mechanically operated farm equipment over traditional human and animal powered equipment implying adoption of mechanization on Indian farms. The farm machinery industry has grown at Compound Annual Growth Rate (CAGR) of 7.5% and reached capital value of USD 7.30 billion. In monetary terms, tractor and major agricultural machinery industry has generated an amount of US$ 4.4 billion during 2015-16. The values of total

import and export of farm machinery during the year 2015-16 were US$ 530 and 1221 million, respectively. Power is the basic requirement for agriculture. Farming operations need some type of power unit at the farm to operate machineries for: (a) Seed bed preparation (b) Sowing (c) Water pumping (d) Spraying (e) Inter culturing (f) Harvesting g) Threshing (h) Processing, and (i) Hauling work These operations demand tractive power to pull the implements, rotative power to drive attached equipment ‘s, pulley power to operate stationary machines and automotive power for transport work.

Various types of agricultural operations performed on a farm can be broadly classified as:

1. Tractive work – such as seed bed preparation, cultivation, harvesting and transportation.
2. Stationary work- such as silage cutting, feed grinding, threshing, winnowing and lifting of irrigation water.

These operations are done by different sources of power, namely human, animal, mechanical power (oil engines and tractors), electrical power and renewable energy (solar energy, biogas, biomass and wind energy).

1.1 Human power

Human beings are the main sources of power for operating small tools and implements at the farm. They are also employed for doing stationary work like threshing, winnowing, chaff cutting and lifting irrigation water. Of the total rural population in India, only 30% is available for doing farm work. The indications are that the decline in number of labourers employed for agriculture. On an average, a man develops nearly 0.1 horse power (hp).

Advantages: Easily available and used for all types of work.

Disadvantages: Costliest power compared to all other farms of power, very low efficiency, requires full maintenance when not in use and affected by weather condition and seasons.

Fig. 1.1 Paddy Nursery collection

Fig.1.2 Nursery transport

Fig.1.3 Paddy transplanting

Fig.1.4 weeding

Fig.1.5 Weeding

Fig.1.6 Winnowing

1.2 Animal power

The most important source of power on the farm all over the world and particularly in India is animal. It is estimated that, nearly 80% of the total draft power used in agriculture throughout the World is still provided by animals. India is having 22.68 crore cattle, which is the highest in the World. Mainly, bullocks and buffaloes happen to be the principle sources of animal power on Indian farms. However, camels, horses, donkeys and elephants are also used for the farm work. The average force a bullock can exert is nearly equal to one tenth of its body weight. Power developed by an average pair of bullocks is about 1 hp for usual farm work.

Advantages

1. Easily available.
2. Used for all types of work.
3. Low initial investment.
4. Supplies manure to the field and fuels to farmers.
5. Live on farm produce.

Disadvantages:

1. Not very efficient.
2. Seasons and weather affect the efficiency.
3. Cannot work at a stretch.
4. Require full maintenance when there is no farm work.
5. Creates unhealthy and dirty atmosphere near the residence.
6. Very slow in doing work.

Fig.1.7 Ploughing a land

Fig.1.8 Ploughing a land

Fig.1.9 Bullock cart

1.3 Mechanical power

It is available through tractors, power tillers and oil engines. The oil engine is a highly efficient device for converting fuel into useful work. The efficiency of diesel engine varies between 32 and 38%, whereas that of the carburetor engine (Petrol engine) is in the range of 25 and 32%. In recent years, diesel engines, tractors and power tillers have gained considerable popularity in agricultural operations. It is estimated that, about one million tractors of 25 hp range are in use for various agricultural operations in India. Similarly, total number of oil engines of 5 hp for stationery work is 60 lakhs. Normally, stationery diesel engines are used for pumping water, flour mills, oil ghanis, cotton gins, chaff cutter, sugarcane crusher, threshers and winnowers etc.,

Advantages: Efficiency is high; not affected by weather; cannot run at a stretch; requires less space and cheaper form of power.

Disadvantages: Initial capital investment is high; fuel is costly and repairs and maintenance needs technical knowledge.

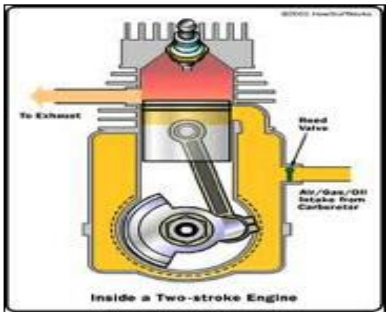


Fig.1.10 Two stroke engine Fig.1.11 Two stroke engine Fig.1.12 Four stroke Engine

Fig.1.13 Tractor Fig.1.14 Power Tiller

1.4 Electrical power

Now-a-days electricity has become a very important source of power on farms in various states of the country. Electrical power is used mostly for running electrical motors for pumping water, dairy industry, cold storage, farm product processing, and cattle feed grinding. It is clean source of power and smooth running. The operating cost remains almost constant throughout its life. Its maintenance and operation need less attention and care. On an

average, about 1/10th of the total electrical power generated in India, is consumed for the farm work, approximately it is 4600 megawatts.

Advantages: Very cheap form of power; high efficiency; can work at a stretch; maintenance and operating cost is very low and not affected by weather conditions.

Disadvantages: Initial capital investment is high; require good amount of technical knowledge and it causes great danger, if handled without care.

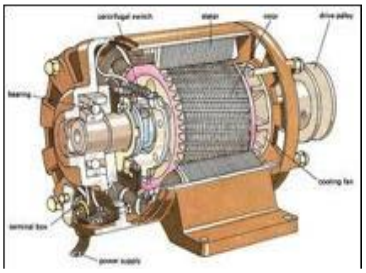




Fig. 1.15 Electric Motors

1.5 Renewable energy

It is the energy mainly obtained from biomass; biogas, solar and wind are mainly used in agriculture for power generation and various agricultural processing operations. It can b used for lighting, power generation, water heating, drying, greenhouse heating, water distillation, refrigeration and diesel engine operation. This type of energy is inexhaustible in nature. The availability of wind energy for farm work is quite limited. Where the wind velocity is more than 32 kmph, wind mills can be used for lifting water. Main limitation for this source is uncertainty. Average capacity of a wind mill would be about 0.5 hp. There are about 2540 windmills in India. It is the cheapest sources of farm power available in India.



Fig.1.16 Solar Panel Fig.1.17 Wind Mill Fig.1.18 Bio-Gas Plant

Chapter - 2

ENGINES

Fuel

Burning of chemical material in air releases energy and converted into heat energy. Chemical materials can be obtained either solid or liquid form.

Solid form of fuels 1. Char coal 2. Coke

Liquid form of fuels 1. Acetylene (C_2H_2) 2. Butane (C_4H_{10}) 3. Methane (CH_4)

Engine

Heat engine is a machine for converting heat, developed by burning fuel into useful work (or) it is equipment which generates thermal energy and transforms it into mechanical energy.

2.1 Types of Engines

I. Based on method of burning engines are classifies as two types

1. External combustion engine, and
2. Internal combustion engine.

II. Based on type of fuel

1. Petrol Engine
2. Diesel Engine

III. Based on cylinder number

1. Single Cylinder
2. Double or twin cylinder
3. Four cylinder
4. Multi cylinder (more than four cylinders)

IV. Based on method of cooling

1. Air cooling
2. Water colling

I.1 Internal combustion engine (I. C. Engine): It is the engine designed to derive its power from the fuel, burnt within the engine cylinder. Here combustion of fuel and generation of heat takes place within the cylinder of the engine.

Example: Tractor engine, motor car engine

I.2 External combustion engine: It is the engine designed to derive its power from the fuel, burnt outside the engine cylinder. Here combustion process uses heat in the form of steam, which is generated in a boiler, placed entirely separate from the working cylinder.

Example: Steam engine, rail engine

2.2 Components of Engine

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.

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

Cylinder head: It is detachable portion of an engine which covers the cylinder and includes the combustion chamber, spark plugs and valves.

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 liners 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. Liners are classified as: dry liner, and wet liner. *Dry liner* makes metal to metal contact with the cylinder block casting. *Wet liners* come in contact with the cooling water, whereas dry liners do not come in contact with cooling water.

Piston: It is a cylindrical part closed at one end which maintains a close sliding fit in the engine cylinder. It is connected to the connecting rod by a piston pin. The force of the expanding gases against the closed end of the piston, forces the piston down in the cylinder. This causes the connecting rod to rotate the crankshaft. 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 are preferred mainly due to its lightness.

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

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

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 functions 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 for 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 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.

Connecting rod: It is a special type of rod, one end of which is attached to the piston and the other 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.

Piston pin: It is also called wrist pin or gudgeon pin. Piston pin is used to join the connecting rod to the piston. It provides a flexible or hinge like connection between the piston and the connecting rod. It is usually made of case-hardened alloy steel.

Crankshaft: It is the main shaft of an engine which converts the reciprocating motion of the piston into rotary motion of the flywheel. Usually, the crankshaft is made of drop forged steel or cast steel. The space that supports the crankshaft in the cylinder block is called main journal, whereas the part to which connecting rod is attached is known as crank journal.

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.

Cam shaft: 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 speed of the camshaft is exactly half the speed of the crankshaft in four stroke engines. Camshaft operates the ignition timing mechanism, lubricating oil pump and fuel pump. It is mounted in the crankcase, parallel to the crankshaft.

Fly wheel: Fly wheel is made of cast iron. Its main functions are as follows: (a) It stores energy during power stroke and returns back the same energy during the idle strokes, providing a uniform rotary motion by virtue of its inertia. (b) It also carries ring gear that meshes with the pinion of the starting motor. (c) The rear surface of the flywheel serves as

one of the pressure surfaces for the clutch plate. (d) Engine timing marks are usually stamped on the flywheel, which helps in adjusting the timing of the engine. (e) Some times the flywheel serves the purpose of a pulley for transmitting power.

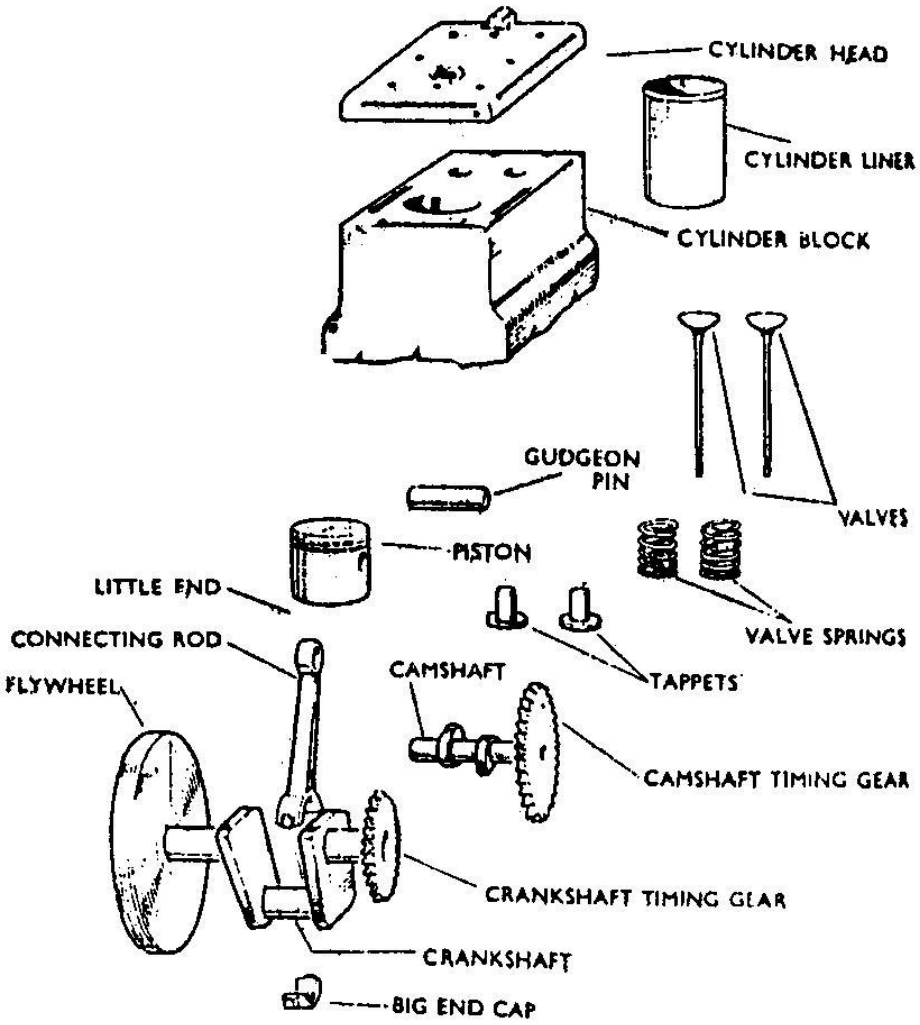


Fig. 2.1 Components of I.C Engines

Timing gear: Timing gear is a combination of gears, one gear of which is mounted at one end of the camshaft and other gear on the end of 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 losing 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 valves as well as fuel injection timing.

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.

Exhaust manifold: It is that part of the engine through which exhaust gases go out of the engine cylinder. It is capable of with-standing high temperature of burnt gases. It is fitted by the side of the cylinder head.

2.3 Engine Terminology

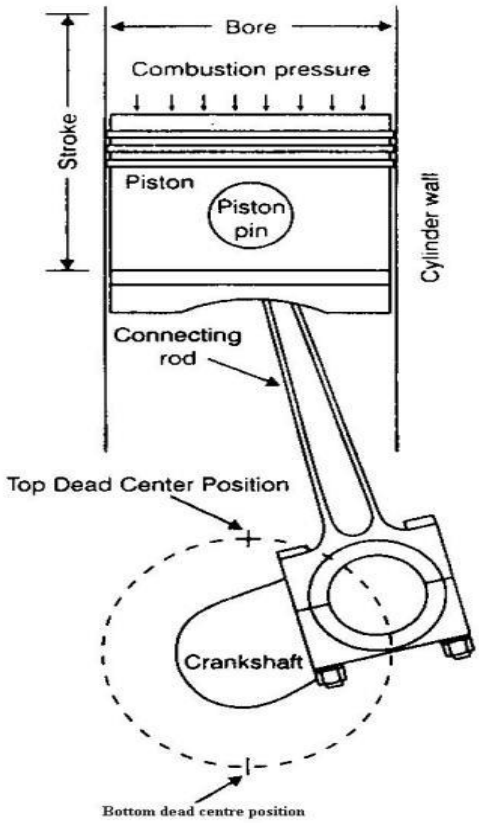


Fig.2.2 Diagram showing TDC and BDC positions

Bore: Bore is the diameter of the engine cylinder (Fig.5).

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

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

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

Compression ratio: It is the ratio of the volume of the charge at the beginning of the compression stroke to that at the end of compression stroke, i.e., ration of total cylinder volume to clearance volume. Compression ration of diesel engine varies from 14:1 to 20:1, carburetor engine varies from 4:1 to 8:1.

Power: It is the rate of doing work. Unit of power in SI units - Watt (Joule/sec).

Horse power: It is the rate of doing work. One HP is equivalent to 75 kg-m / sec.

Indicated Horse Power (IHP): it is the total horse power developed by all the cylinders and received by pistons, without friction and losses within the engine.

$$\text{IHP} = \frac{PLAN}{4500} \times \frac{n}{2} \quad \text{(for four stroke engine)}$$

$$\text{IHP} = \frac{PLAN}{4500} \times n \quad \text{(for two stroke engine)}$$

Where

P - Mean effective pressure in Kg/cm2

L- Length of the piston stroke in meters

A -Cross sectional area of piston in cm2

N- rpm of the engine

n - Number of cylinders in the engine

Brake horse power (B.H.P): It is the horsepower delivered by the engine and is available at the end of the crankshaft and it is measured by suitable dynamometer.

Frictional horse power (F.H.P): It is the power required to run the engine at a given speed with out producing any useful work. It represents the friction and pumping losses of the engine.

$$\text{F.H.P= I.H.P - B.H.P}$$

$$\text{I.H.P = B.H.P + F.H.P}$$

Drawbar horse power (DBHP): It is the power of a tractor measured at the end of the drawbar. It is the power required to pull the loads.

Brake mean effective pressure (BMEP): It is the average pressure acting throughout the entire power strokes which are necessary to produce BHP of the engine.

$$\text{BMEP} = \frac{BHP \times 75 \times 60}{L \times A \times N \times \frac{n}{2}} \quad \text{(for four stroke engine)}$$

$$\text{BMEP} = \frac{BHP \times 75 \times 60}{L \times A \times N \times n} \quad \text{(for two stroke engine)}$$

Thermal efficiency: It is the ratio of the horse power output of the engine to the fuel horse power.

Mechanical efficiency: It is the ratio of the brake horse power to the indicated horse power.

$$\text{Mechanical efficiency} = \frac{BHP}{IHP} \times 100$$

Piston speed (Np): It is the total length of travel of the piston in a cylinder in one minute. Piston speeds of the high-speed tractor engine range between 300 to 500 m/m.

Displacement volume (Vd): It is the total swept volume of all the pistons during power strokes occurring in a period of one minute.

$$Vd = ALn$$

A – piston area L – piston stroke N – number of power strokes per minute for all cylinders.

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 engines.

2.4 Working Principle of Petrol Engine

In such engines, the whole sequence of events i.e. suction, compression, power and exhaust are completed in two strokes of the piston and in one complete revolution of the crankshaft (Fig.4). There is no valve in this type of engine. Gas movement takes place through holes called ports in the cylinder. The crankcase of the engine is gas tight in which the crankshaft rotates.

First stroke (suction + compression)

When the piston moves up the cylinder, it covers two of the ports, the exhaust port and the 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 suction port. 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 as in the four-stroke cycle.

Second stroke (Power + exhaust)

The rise in pressure in the cylinder caused by the burning gases forces the piston to move down 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 movements of the piston uncover 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.

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 the case in case of four stroke cycle engine.

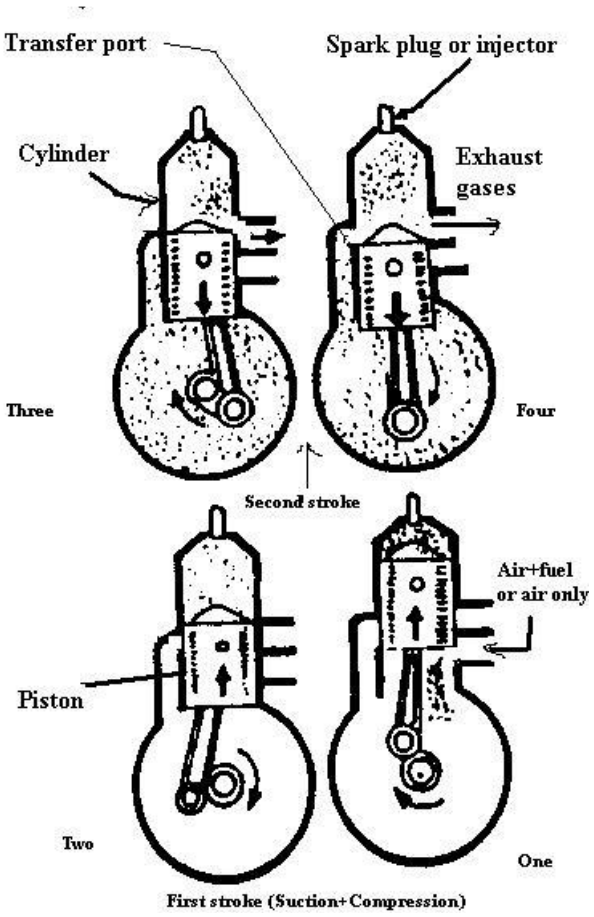


Fig. 2.3. Working of two stroke cycle engine

2.5 Working Principle of Diesel Engine

In four stroke cycle engine, all the events taking place inside the engine cylinder are completed in four strokes of the piston i.e., suction, compression, power and exhaust stroke. This engine has got valves for controlling the inlet of charge and outlet of exhaust gases. In two stroke cycle engine, all the events take place in two strokes of the piston.

The four strokes of the piston are as follows:

1. Suction stroke: During this stroke, only air or mixture of air and fuel are drawn inside the cylinder. The charge enters the engine through inlet valve which remains open during admission of charge. The exhaust valve remains closed during this stroke. The pressure in the engine cylinder is less than atmospheric pressure during this stroke.

2. Compression strike: The charge taken in the cylinder is compressed by the piston during this stroke. 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 the case of diesel 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 the case of spark ignition engine i.e., petrol 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.

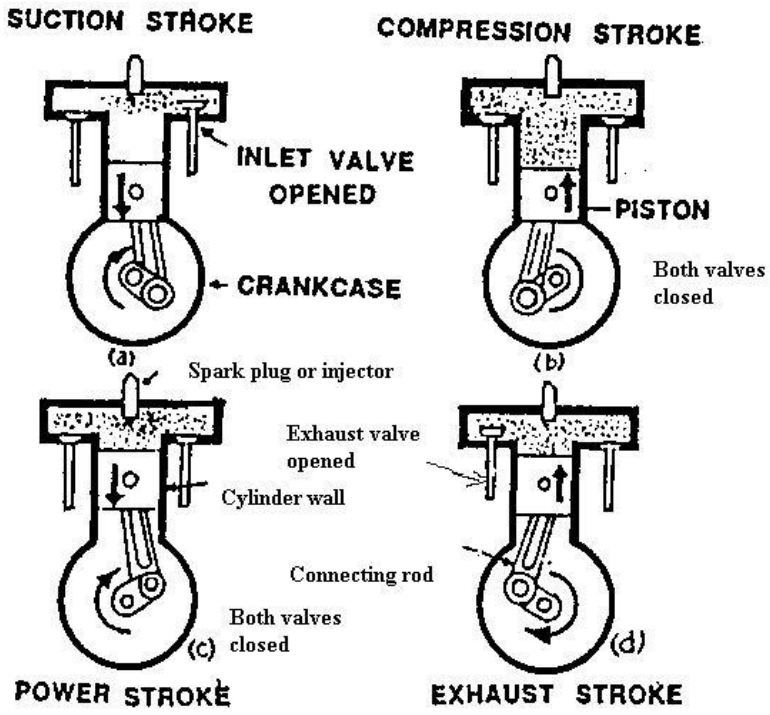


Fig. 2.4. Working of four stroke cycle engine

3. Power stroke: During power stroke, the high pressure developed due to combustion of fuel causes the piston to be forced downwards. 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.

4. 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. The exhaust valve is closed just after the end of the exhaust stroke, and the inlet valve is opened just before the burning of the suction stroke to repeat the cycle of operation.

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 useful work.

Comparison between diesel and petrol (Carburetor) engines

S.No.	**Diesel engine**	**Petrol engine**
1.	Diesel fuels are used.	Vapourizing fuels such as petrol, powerine or kerosene are used.
2.	Air alone is taken in during suction stroke.	Mixture of air and fuel is taken in.
3.	Fuel is injected into super-heated air of the combustion space where burning takes place.	Air-fuel is compressed in the combustion chamber where it is ignited by an electric spark.
4.	Air-fuel ratio is not constant as the quantity of air drawn into the cylinder is always the same. To vary the load and speed the quantity of fuel injected is changed.	Air and fuel are almost always in the ratio of 15:1, but to vary the engine power, quantity of mixture is varied.
5.	Compression ratio of the engine varies from 14:1 to 20:1.	Compression ratio of the engine varies from 5:1 to 8:1.
6.	Specific fuel consumption is about 0.2 kg per BHP per hour.	Specific fuel consumption is about 0.29 kg per BHP per hour.
7.	4.5 litres of fuel is sufficient for nearly 20 hp hour.	4.5 litres of fuel will last about 12 hp hour.
8.	Diesel engine develops more torque, when it is heavily loaded.	This characteristic is not present in carburetor engines.
9.	Thermal efficiency varies between 32 and 38%.	Thermal efficiency varies between 25 and 32%.
10.	It runs at a lower temperature on part load.	Combustion gas temperature is slightly higher under part load.

11.	Engine weight per horse power is high.	Engine weight per horse power is comparatively low.
12.	Initial cost is high.	Initial cost is low.
13.	Operating cost is low.	Operating cost is comparatively high.

Chapter - 3

FUEL SUPPLY SYSTEM

Fuel is a substance consumed by the engine to produce energy. The common fuels for IC engines are: (i) petrol, (ii) power kerosene, (iii) high speed diesel oil (H.S.D oil) and (iv) light diesel oil (L.D.O)

3.1 Fuel characteristics

S.No	Fuel	API Degree	Specific Gravity	Calorific value
1.	Light diesel oil (LDO)	22	0.920	10300
2.	High speed diesel oil (HSD)	31	0.820	10550
3.	Power kerosine	40	0.827	10850
4.	Petrol	63	0.730	11100

3.2 Quality of Fuel

The quality of fuel mainly depends upon the following properties: (i) volatility, (ii) calorific value and (iii) ignition quality of fuel. A good fuel contains a combination of qualities such as good volatility, high antiknock value, chemical purity, and freedom from gum.

Volatility: It is the vapourizing ability of a fuel at a given temperature. It indicates the operating characteristics of the fuel inside the engine. It is measured by means of distillation tests on the fuel.

In IC engine, all the liquid fuel must be converted into vapour fuel before burning. Petrol which shows lower initial and final boiling points, compared to other fuels, vapourizes at a lower temperature. HSD oil is most difficult to vapourize. Its vapourizing temperature is higher than that of the petrol, hence the petrol vapourizes quicker than diesel oil in the engine cylinder. This helps in easy starting of petrol engines. The oil that vapourizes quickly can be distributed well in different cylinders of the engine, hence distribution of fuel in different cylinders is better in petrol engine than that of diesel engine.

Calorific value: The heat liberated by combustion of a fuel is known as calorific value or heat value of the fuel. It is expressed in kcal/kg of the fuel.

Ignition quality: It refers to ease of burning the oil in the combustion chamber. Octane number and cetane number are the measures of ignition quality of the fuel. Octane number is standard yardstick for measuring knock characteristics of fuels.

Cetane number is the relative measure of the interval between the beginning of injection and auto-ignition of the fuel. The higher the cetane number, the shorter the delay interval and the greater its combustibility. Fuels with low cetane Numbers will result in difficult starting, noise and exhaust smoke.

Detonation: Detonation or engine knocking refers to violent noises heard in an engine during the process of combustion after the piston has passed over the TDC. It is an undesirable combustion and results in sudden rise in pressure, a loss of power and overheating of the engine. This may cause damage to pistons, valves, gasket and other parts. Detonation is caused by improper combustion chamber, high compression pressure, early ignition timing, improper fuel and inadequate cooling arrangement.

Pre-ignition: Burning of air-fuel mixture in the combustion chamber before the piston has reached the TDC is called pre-ignition. This may be due to excessive heat in the cylinder.

3.3 Fuel Quality Test

Few important tests are recommended to determine the stability of fuels for the I.C engine. The following are the important tests.

1) Gravity test
2) Distillation test
3) Vapour pressure test
4) Sulphur test
5) Carbon residue
6) Colour test
7) Gum test
8) Flash test

3.4 Qualities of Diesel Fuel

The diesel fuel is of two types

1. High speed diesel oil (HSD)
2. Light diesel oil (LDO)

High speed diesel oil is used for high-speed diesel engines. It is lighter than LDO. Lighter diesel oil the main source of the fuel for slow speed engines.

1. Diesel fuel should be free from acid or any foreign matter, dirt and moisture
2. It must be able to lubricate the fuel pumps and fuel injector nozzles. Light fuels lack sufficient lubricating qualities.
3. Diesel fuels are rated according to the cetane number, which is the indication of ignition quality of the fuel. The higher the cetene number, the better the ignition quality of the fuel.

3.5 Fuel Supply System of Compression Ignition Engine or Diesel Engine

The main components of the fuel supply system in diesel engine are: (i) fuel tank, (ii) primary fuel filter, (iii) fuel transfer pump or fuel lift pump, (iv) secondary fuel filter, (v) fuel injection pump, (vi) high pressure pipes, (vii) fuel injection nozzles or fuel injectors and over flow pipe (Fig.6).

During engine operation, the fuel is supplied by gravity from fuel tank to the primary filter where coarse impurities are removed. From the primary filter, the fuel is drawn by fuel transfer pump. This pump is also known as fuel lift pump, is activated by a cam on the engine camshaft. The fuel lift pump forces fuel under low pressure (2.5 kg/cm2) through the secondary fuel filter to the injection pump, which is generally driven by the camshaft. The purpose of fuel injection pump is to deliver a metered quantity of fuel at a predetermined time under pressure (120 to 175 kg/cm2 or more) through the high pressure tubes to the injection nozzles or injectors. The fuel that leaks out from the injection nozzles passes out through leakage pipe and returns to the fuel tank through the over flow pipe. In some tractors and industrial engines, the fuel supply is by gravity and hence no fuel lift pump is provided.

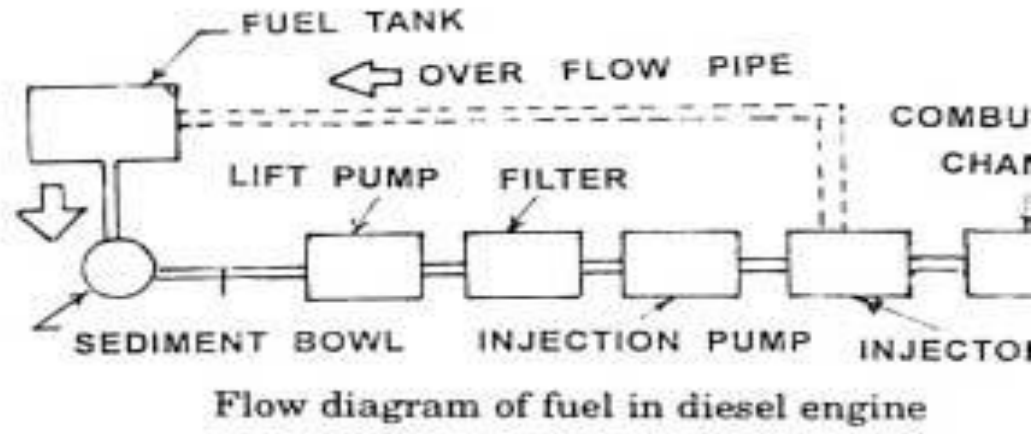


Fig. 3.1 Flow diagram of fuel in diesel engine

Two conditions are essential for efficient operation of the system:

(a) The fuel should be clean, free from water, suspended dirt, sand or other foreign matter.

(b) The fuel injection pump should create proper pressure, so that diesel fuel may be perfectly atomized by injectors at proper time and quantity.

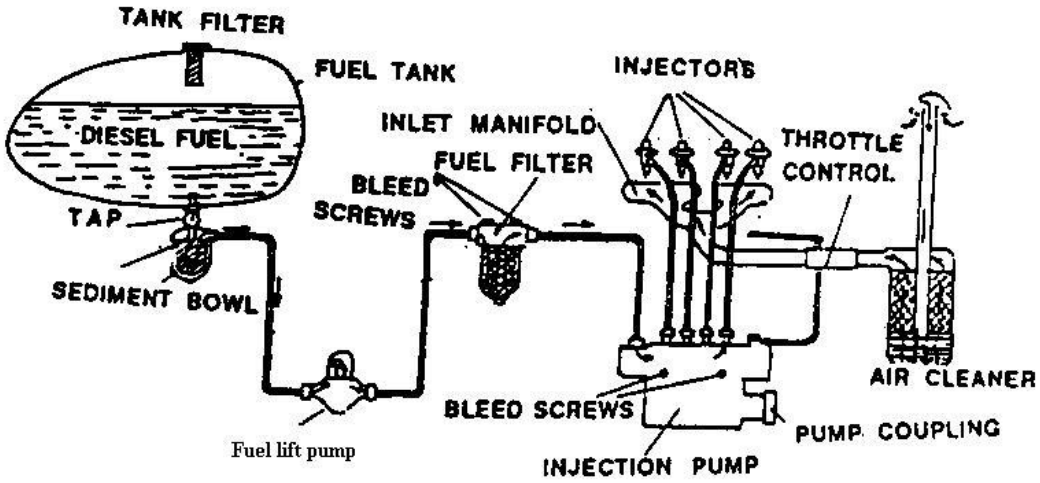


Fig.3.2 Fuel flow in diesel engine

3.6 Fuel Supply System of Spark Ignition or Petrol Engine

The fuel supply system of spark ignition engine consists of

1. Fuel tank
2. Sediment bowl
3. Fuel lift pump
4. Carburetor
5. Fuel pipes

In some spark ignition engine the fuel tank is placed above the level of the carburetor. The fuel flows from fuel tank to the carburetor under the action of gravity. There are one or two filters between fuel tank and carburetor. A transparent sediment bowl is also provided to hold the dust and dirt of the fuel. If the tank is below the level of carburetor, a lift pump is provided in between the tank and the carburetor for forcing fuel from tank to the carburetor of the engine. The fuel comes from fuel tank to sediment bowl and then to the lift pump. From there the fuel goes to the carburetor through suitable pipes. From carburetor the fuel goes to the engine cylinder through inlet manifold of the engine.

Carburetor The process of preparing air-fuel mixture away from the engine cylinder is called carburetion. and the device in which this process takes is called carburetor.

Functions of carburetor

1. To mix the air and fuel thoroughly
2. To atomize the fuel
3. To regulate the air- fuel ratio at different speeds and loads on the engine.
4. to supply correct amount of mixture at different speeds and loads

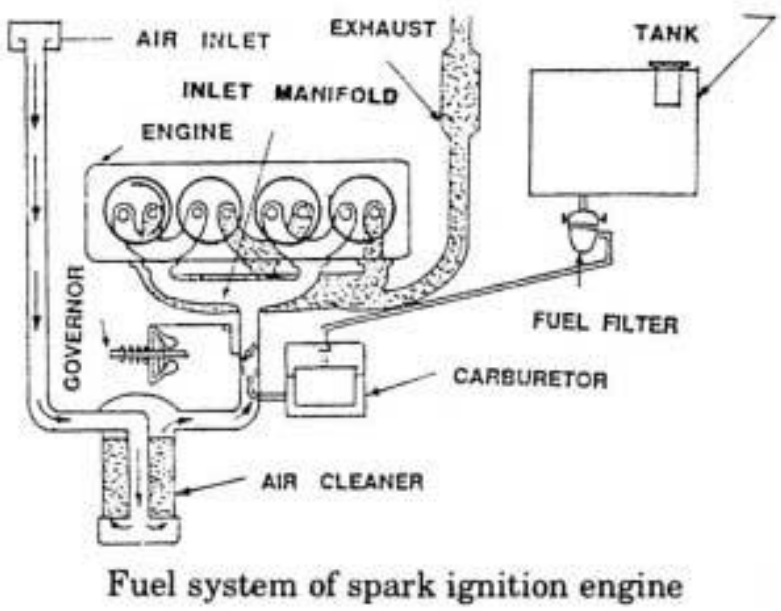


Fig.3.3 Fuel system of spark ignition engine

Chapter – 4

LUBRICATION SYSTEM

IC Engine is made of many moving parts. Due to continuous movement of two metallic surfaces over each other, there is wearing of moving parts, generation of heat and loss of power in the engine. Lubrication of moving parts is essential to prevent all these harmful effects.

4.1 Purpose of Lubrication

Lubrication of the moving parts of an IC Engine performs the following functions:

(i) Reduces the wear and prevents seizure of rubbing surfaces (Reduce wear)

(ii) Reduces the power needed to overcome the frictional resistance (Reduce frictional effect).

(iii) Removes the heat from the piston and other parts (Cooling effect)

(iv) Serves as a seat between piston rings and cylinder (Sealing effect)

(v) Removes the foreign material between the engine working parts (Cleaning effect).

Reducing frictional effect

The primary purpose of the lubrication is to reduce friction and wear between two rubbing surfaces. The continuous friction produces heat which causes wearing of parts and loss of power. This can be avoided by proper lubrication, which forms an oil film between two moving surfaces.

Cooling effect

The heat generated by piston, cylinder and bearings is removed by lubrication to a great extent. Lubrication creates cooling effect on the engine parts.

Sealing effect

The lubricant enters into the gap between the cylinder liner, piston and piston rings. Thus, it prevents leakage of gases from the engine cylinder.

Cleaning effect

Lubrication keeps the engine clean by removing dirt or carbon from inside of the engine along with the oil.

Types of Lubricants

Lubricants are obtained from animal fat, vegetables and minerals. Lubricants made of animal fat, does not stand much heat. It becomes waxy and gummy which is not very suitable for machines.

Vegetable lubricants: are obtained from seeds, fruits and plants. Cotton seed oil, Olive oil, linseed oil and Castor oil are used as lubricant in small simple machines.

Mineral lubricants: are most popular for engines and machines. It is obtained from crude petroleum found in nature. Petroleum lubricants are less expensive and suitable for IC Engines.

4.2 Engine Lubrication System

The lubricating system of an engine is an arrangement of mechanism and devices which maintains supply of lubricating oil to the rubbing surface of an engine at correct pressure and temperature. The parts which require lubrication are:

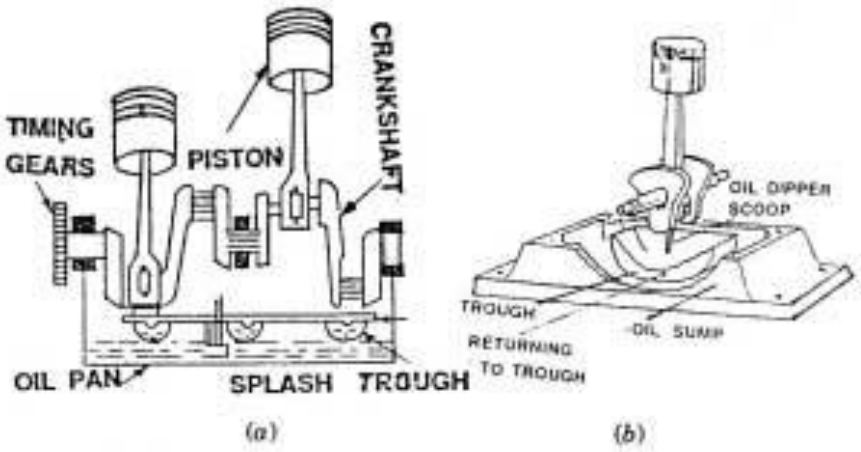
(i) cylinder walls and piston,
(ii) piston pin
(iii) crankshaft and connecting rod bearings
(iv) cam shaft bearings
(v) valves and valve operating mechanism
(vi) cooling fan
(vii) water pump and
(viii) ignition mechanism.

There are three common systems of lubrication used on stationery engines, tractor engines and automobiles:

(i) splash system,
(ii) forced feed system, and
(iii) combination of splash and forced feed system.

i. Splash system

In this system, there is an oil trough, provided below the connecting rod. Oil is maintained at a uniform level in the oil through. This is obtained by maintaining a continuous flow of oil from the oil sump or reservoir into a splash pan which has a depression or a trough like arrangement under each connecting rod. 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 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.



(a) Splash lubrication system, (b) Splash unit

Fig.4.1 Splash lubrication system and Splash Unit

This system is usually used on 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. 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, blue 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.

ii. Forced feed system

In this system, the oil is pumped directly to all the moving parts (i.e., crankshaft, connecting rod, piston pin, timing gears and cam shaft) of the engine through suitable paths of oil (Fig.14). Lubricating oil pump is a positive displacement pump, usually gear or vane type, which is driven by the camshaft, forces oil from the crankcase to all crankshaft, and connecting rod bearings, cam shaft bearings and timing gears. Usually, the oil first enters the main gallery, which may be a pipe or a channel in the crankcase casting. From this pipe, it passes to each of the main bearings through holes. From main bearings, it passes to big end bearings of connecting rod through drilled holes in the crankshaft. From there, it passes to lubricate the walls, pistons and rings. There is separate oil gallery to lubricate timing gears. The oil also passes 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. The system is commonly used on high-speed multi-cylinder engine in tractors, trucks and automobiles.

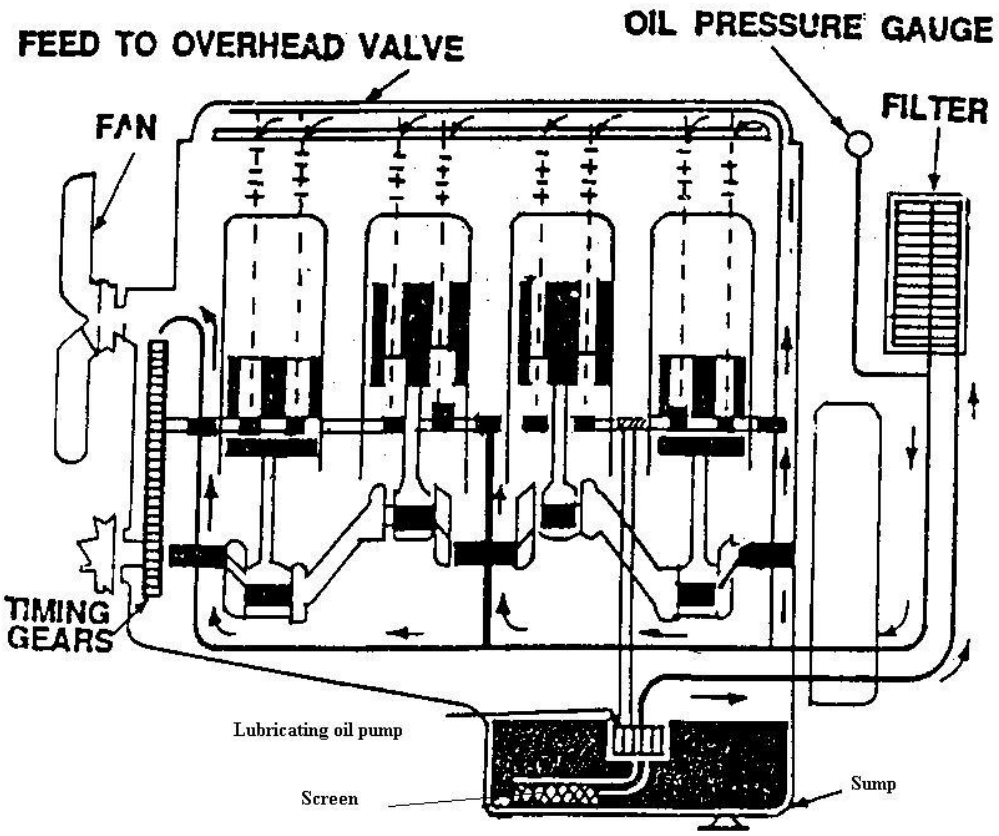


Fig.4.2. Working of forced circulation lubrication system

Chapter – 5

COOLING SYSTEM

Fuel is burnt inside the cylinder of an internal combustion engine to produce power. The temperature produced on the power stroke of an engine can be as high as 1600ºC and this is greater than melting point of engine parts. The cylinder and cylinder head are usually made of cast iron and pistons in most cases are made of aluminum alloy. It is estimated that about 40 % of total heat produced is passed to the atmosphere via the exhaust, 30 % is removed by cooling system and only about 30% is used to produce useful power.

Bad effect of high temperature in the engine

(i) Cylinder and piston may expand to such an extent that the piston would seize in the cylinder and stop the engine.

(ii) Lubricating quality of the oil inside the cylinder would be destroyed due to high temperature and there may not be sucking of air in the cylinder.

(iii) Pre-ignition of fuel mixture would take place and would 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 I.C engine lies between 140ºF to 200 ºF, depending upon types of engines and load conditions.

5.1 Purpose of Cooling System

(i) To maintain optimum temperature of engine for efficient operation under all conditions.

(ii) To dissipate surplus heat for protection of engine components like cylinder, cylinder head, piston, piston rings and valves.

(iii) To maintain the lubricating property of the oil inside the engine cylinder for normal functioning of the engine.

5.2 Types of Cooling System

There are two different methods of cooling: (i) air cooling and (ii) water cooling.

5.3 Air Cooling System

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.

Principle of air cooling

The cylinder of an air cooled engine has fins to increase the area of contact of 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 finned cylinder. For maintenance of air cooling system, passage of air is kept clean by removing grasses etc. 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 cooling It is simpler in design and construction. Water jackets, radiators, water pump, thermostat, pipes, hoses etc. are not needed. It is more compact. It is comparatively lighter in weight.

Disadvantages There is uneven cooling of the engine parts. Engine temperature is generally high during working period.

5.4 Water Cooling System

Engines, using water as cooling medium is called "water cooled engines". The liquid is circulated round the cylinders to absorb heat from the cylinder walls. In general, water is used as cooling liquid. The heated water is conducted through a radiator which helps in cooling the water.

There are three common methods of water cooling:
(i) Open jacket or hopper method,
(ii) Thermo siphon method, and
(iii) Forced circulation method.

(i) Open jacket method

There is a hopper or jacket containing water which surrounds the engine cylinder. So long as the hopper contains water the engine continues to operate satisfactorily. As soon as the water starts boiling it is replaced by cold water. The hopper is large enough to run for several hours without refilling. A drain plug is provided in a low accessible position for draining water as and when required.

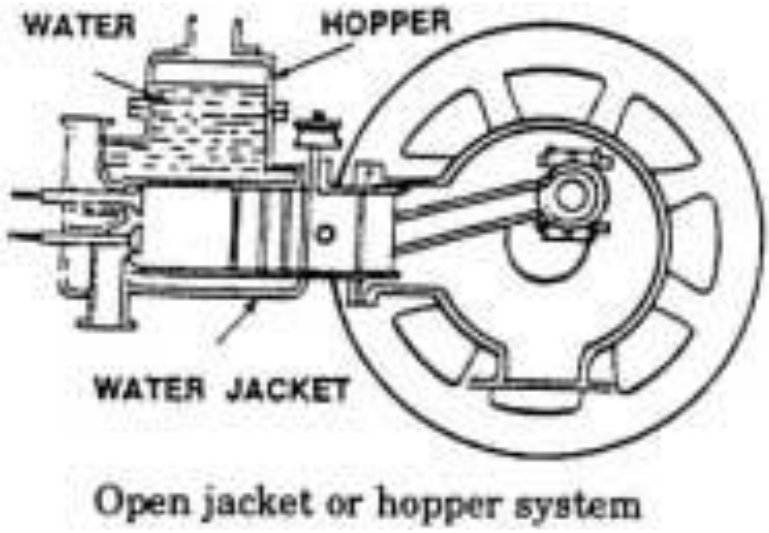


Fig.5.1 Open Jacket or Hopper System

(ii) Thermo siphon method

It consists of a radiator, water jacket, fan, temperature gauge and hose connections. The system is based on the principle that heated water which surrounds the cylinder becomes lighter and it rises upwards 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 reason that water jacket and radiator are connected at both sides i.e. at top and bottom. A fan is driven with the help of a V belt to suck air through tubes of the radiator unit, cooling radiator water. 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 causing over heating of the engine.

(iii) Forced circulation method

The system consists of the following components

1. Water pump
2. Radiator
3. Fan
4. Fan-belt
5. Water jacket
6. Thermostat valve
7. Temperature gauge and
8. Hose pipe

In this method, a water pump is used to force water from the radiator to the water jacket of the engine. After circulating the entire run of water jacket, hot water goes to the

radiator, where it passes through tubes surrounded by air. A fan is driven with the help of a V-belt to suck air through tubes of the radiator unit, cooling radiator water. 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 engine attains the desired temperature. Then thermostat valve opens and the by-pass is closed, allowing the water to go to the radiator.

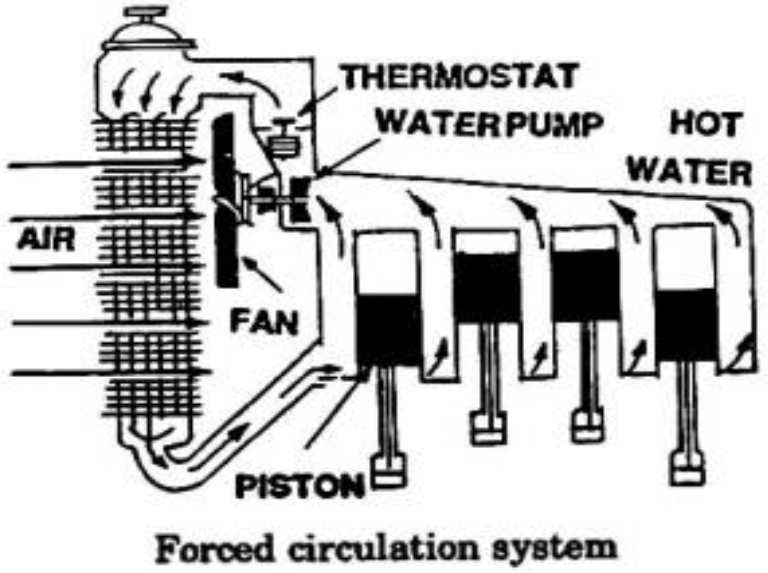


Fig.5.2 Forced circulation system

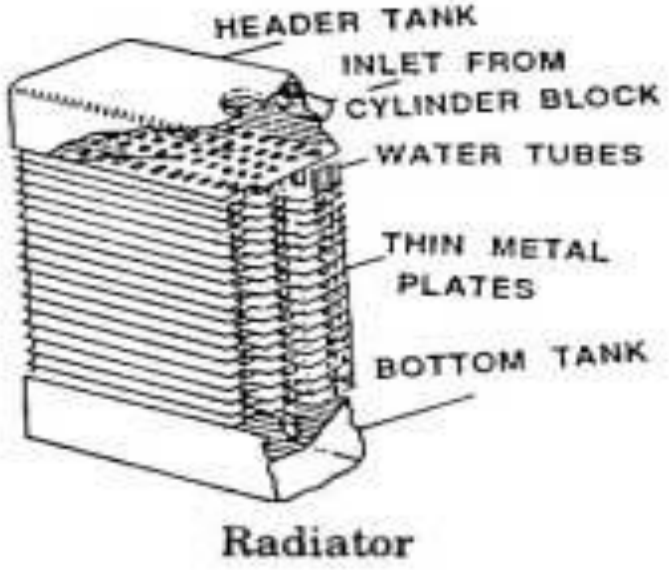


Fig.5.3 Radiato

Chapter – 6

TRACTORS

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 machinery through power take-off shaft (PTO) or belt pulley.

6.1 Classifications of Tractors

Tractors can be classified into three classes on the basis of structural design

1. Wheel tractor
2. crawler tractor
3. walking type tractor

Wheel tractor Tractors having three or four pneumatic wheels are called wheel tractors. Four-wheel tractors are popular everywhere

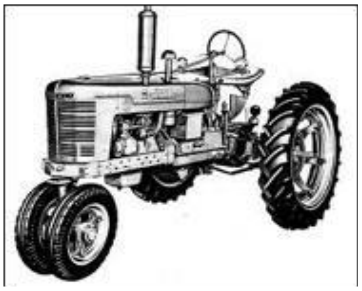


Fig.6.1 Three-wheel tractor

Fig.6.2 Four-wheel tractor

Crawler tractor This type is also called Track type tractor or Chain type tractor. In such tractors, there is endless chain or track in place of pneumatic wheels

Fig.6.3 Crawler tractors

Power tiller Power tiller is a walking type tractor. This tractor is usually fitted with two wheels only. The direction of travel and its controls for field operation is performed by the operator, walking behind the tractor

Fig.6.4 Power tillers

Classification of wheel tractors: On the basis of purpose, wheeled tractors are classified into three groups

a. General purpose tractor

b. Row crop tractor and

c. Special purpose tractor

a) General purpose tractor: It is used for major farm operations such as ploughing, sowing, harvesting and transporting works. Such tractors have

i) low ground clearance ii) Increased engine power iii) good adhesion and iv) wide tyres

Fig.6.5 General purpose tractors

b) Row crop tractors: It is used for row crop cultivation. Such tractor is provided with replaceable driving wheels of different tread widths. It has high ground clearance to save damage of crops. Wide wheel track can be adjusted to suit inter row distance

Fig.6.6 Row crop tractors

c) Special purpose tractor It is used for definite jobs like cotton fields, marshy lands, hill sides, garden etc. special designs are there for special purpose tractor. Eg. a) Tractor with winch unit b) multi drive tractor c) tractor for golf grounds etc.

Fig.6.7 Tractor with winch unit Fig.6.8 Multi drive tractors

Selection of tractor

Selection of tractors depend up on following factors

1. **Land holding:** Under a single cropping pattern, it is normally recommended to consider 1 hp for every 2 hectare of land. In other words, one tractor 20-25 hp is suitable for 40 hectare farm

2. Cropping pattern: Generally 1.5 hectare/hp has been recommended where adequate irrigation facility are available and more than one crop is taken. So a 30-35 hp tractor is suitable for 40 hectare of land.

3. Soil condition: A tractor with less wheel base, higher ground clearance and low overall weight may work successfully in lighter soils buy will not be able to give sufficient depth in black cotton soils

4. Climatic condition: 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 cooled engines are liable to be frozen at high altitudes

5. Repair 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 the machine.

6. Running cost: Tractors with less specific fuel consumption should be preferred over others so that the 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 have to be paid.

6.2 Tractor Components

A tractor is made of following main components:

(1) Engine

(2) Clutch

(3) Transmission

(4) Wheels

(5) Steering mechanism

(6) Brake system

(7) Battery system

(8) Hydraulic lift

(9) Radiator

(10) P.T.O shaft

1. Engine: Internal combustion of suitable horse power is used as a prime mover in a tractor. Engines ranging from 8 to 200 hp are used in agricultural tractors. In India , four wheel tractors for agricultural operations are fitted with 25-80 hp. Walking type tractors are fitted with 8-12 hp engines

2. 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

3. Transmission: Transmission is a speed reducing 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. A tractor runs at high speed, but the rear wheel of the tractor requires power at low speed and high torque.

4. Wheels: Usually two front small front wheels and two rear large wheels of pneumatic tyre are used in tractor. However rear wheels are the power wheels.

5. Steering mechanism: The system, governing the angular movement of front wheels of a tractor is called steering system. This system minimizes the efforts of the operator in turning the front wheels with the application of leverages. The different components of steering system are i) steering wheel ii) steering shaft iii) steering gear iv0 drag link v) steering arm vii) tie rod viii) king pin When the operator turns the steering wheel, the motion is transmitted through the steering shaft to the angular motion of the pitman arm through a set of gears. The angular movement of the pitman arm is further transmitted to the steering arm through drag link and tie rods. Steering arm are keyed to the respective king pins which are integral part of the stub axle on which wheels are mounted. The movement of steering arm affects the movement of front wheel

6. Brake system: Brake is used to stop or slow down the motion of the tractor. It is mounted on the driving axle and operated by two independent pedals. Each pedal can be operated

independently to assist the turning of tractor during field work or locked together by means of a lock. Types of brakes – a) Mechanical brake b) hydraulic brake.

7. Battery system: Storage battery is a device for converting chemical energy into electrical energy. There are several types of battery, but lead-acid battery is most common for IC engines, used for tractors and automobiles. A battery consists of plates, separators, electrolyte, container and terminal wire. The purpose of the dynamo is to keep the battery charged and to supply current for ignition, light and other electrical accessories. The dynamo supplies direct current to the battery and keeps it fully charged.

Plates are of two types: (i) positive and (ii) negative. All positive and negative plates are rectangular in shape. All positive plates are connected together to form a positive group and negative plates are connected together to form a negative group. Positive plates are made of lead and antimony and negative plates are made of spongy lead. Separators are used to act as insulators between the plates to prevent them from touching each other to avoid short-circuiting. Usually separators are made of wood, rubber and cellulose fibre. Electrolyte is the chemical solution used in battery for chemical reaction. It consists of 35% sulphuric acid and 65% distilled water by weight with a specific gravity of 1.280 in fully charged condition. The specific gravity is measured by hydrometer. The electrolyte level should be 12 to 14 mm above the top edge of the plates. Specific gravity of the electrolyte should be checked at suitable interval. If the specific gravity is below 1.225, it should be charged. Container is usually made of hard rubber. The tops are covered with rubber material and sealed with a water proof compound**.** Terminal wires are two in number, one connects the positive terminal and other connects the negative terminal with the electric circuit.

8. Hydraulic lift: A hydraulic lift is a device for moving objects using force created by pressure on a liquid inside a cylinder that moves a piston upward. Incompressible oil is pumped into the cylinder, which forces the piston upward. The principle for hydraulic lifts is based on Pascal‘s law for generating force or motion, which states that pressure change on an incompressible liquid in a confined space is passed equally throughout the liquid in all directions.

9. Radiator: Radiator is a device for cooling the circulating water in the engine. It holds a large volume of water in close contact with a large volume of air so that heat is transferred from the water to the air easily. Hot water flows into thee radiator at the top and cold water flows out from the bottom. Tubes or passages carry the water from the top of the radiator to

the bottom, passing it over a large metal surface. Air flows between the tubes or through the cells at right angles to the downward flowing water. This helps in transferring the heat from the water to the atmosphere. On the basis of fabrication, the radiator is of two types: tubular type and cellular type.

10. P.T.O shaft: 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 tortional power to another machine. A rigid guard fitted on a tractor covers the power-take-off shaft as a safety device. The guard is called power take off shield. As per ASAE standards PTO speed is 540+ 10 rpm when operating under load. In order to operate 1000 rpm PTO drive machine, a new standard has been developed.

Fig.6.9 PTO on a tractor PTO drive

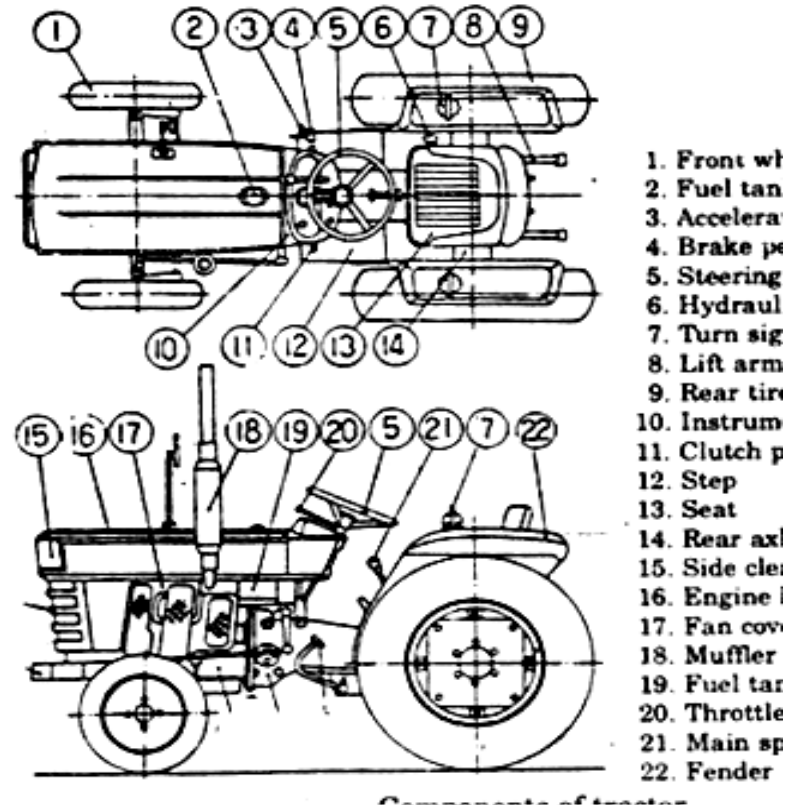


Fig.6.10 Components of Tractors

6.3 Technical Terms

1. Wheel base: Wheel base is the horizontal distance between the front and rear wheels of a tractor

2. Ground clearance: It is the height of the lowest point of the tractor from the ground surface, the tractor being loaded to its permissible weight

3. Track: Track in the distance between the two wheels of the tractor on the same axle., measured at the ground contact

4. Turning space: It is the diameter of the smallest circle , described by the outer most point of the tractor, while moving at a speed not exceeding 3 km/hr with thr steering wheels in full lock.

5. Cage wheels: It is a wheel or an attachment to a wheel with spaced cross bars for improving traction of the tractor in a wet field. It is generally used in paddy field.

6.4 Power Transmission System

Transmission is a speed reducing mechanism, equipped with several gears (Fig.11). 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 that 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.*

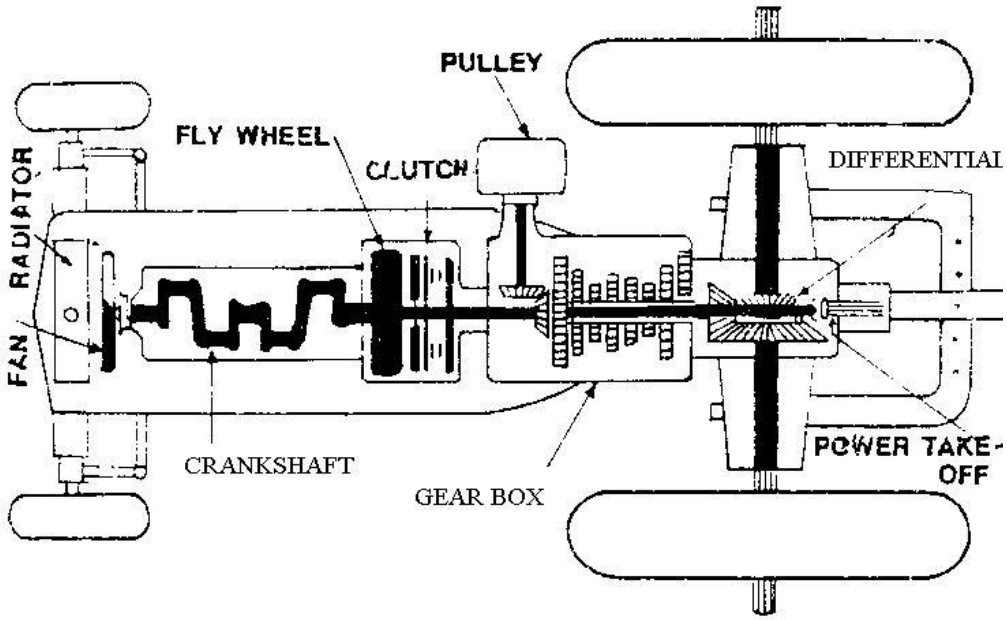


Fig. 6.11. Power transmission system of tractor

Function of power transmission system

(i) to transmit power from the engine to the rear wheels of the tractor.

(ii) to make reduced speed available, to rear wheels of the tractor.

(iii) to alter the ratio of wheel speed and engine speed in order to suit the field conditions.

(iv) to transmit power through right angle drive, because the crankshaft and rear axle are normally at right angles to each other.

6.5 Different Types of Gears

Straight spur gear: Spur gears or straight-cut gears are the simplest type of gear. They consist of a cylinder or disk with teeth projecting radially. Viewing the gear at 90 degrees from the shaft length (side on) the tooth faces are straight and aligned parallel to the axis of rotation.

Helical gear: Helical gears are one type of cylindrical gears where the teeth are curved into a helix shape. Compared to spur gears (straight teeth), properly designed helical gears can have a larger total contact ratio which can improve vibration and noise. Badly designed helical gears can be noisier than well designed spur gears.

Herringbone gear: A herringbone gear, a specific type of double helical gear, is a special type of gear that is a side-to-side (not face-to-face) combination of two helical gears of opposite hands.

6.6 Tractor Repair and Maintenance

Periodical maintenance of tractors

A. At 8 to 10 engine working hours:

1.Tractor and implements should be cleaned

2.Check oil level in crankcase and hydraulic oil chamber and if necessary, top up

3.Remove sediments from the air pre-cleaner bowl Clean the hath of the air cleaner if the tractor operates in dusty conditions.

4.Tip up the fuel tank, if necessary, preferably in the evening after day's work

5. Clean the radiator Remove dust and dirt, accumulated in core and top up the water in the radiator. Use clean water

6 Check the tension of the V-belt

7. Check the tightness of the fuel pipes, oil pipes, water pipes, hoses and drain plugs to avoid leakage.

8. Check the air pressure in front and rear tyres, and maintain recommended pressure.

9. Check that the end of the cables are properly connected to the terminals

10.Check the level of the electrolyte in the battery and if necessary, top up with distilled water.

11.Grease all the points recommended by manufacturers

12.Check the ball joints of the steering linkage. Tighten the balls of the front axle and wheel hubs.

13.Start the engine and check:

(a) Whether the oil pressure gauge is showing sufficient pressure

(b) Whether dynamo is generating proper current.

B. At 50 to 60 engine working hours:

1. Carry out all the operations given in (A)

2. Clean the filters.

3. Check the clearance between clutch thrust bearing and disengaging levers

4. Make sure that the brakes are in good working condition.

C. At 100 to 120 engine working hours:

1. Carry out all the operations given in (B)

2 Disconnect the cables of the electrical equipment from the terminals, apply grease and connect it.

3. Make sure that there is no leakage in the water pump.

4 Lubricate the dynamo, by putting a few drops of engine oil in each of the oil caps.

D. At 200 to 250 engine working hours:

1. Carry out all the operations given in (C).

2. Drain oil from oil sump and flush with flushing oil. Refill with
new oil up to mark.

3. Lubricate the throttle control linkage and ball joints.

4. Check the clearance of the front wheel hub bearing.

5. Check the toe-in of the front wheel.

E. At 480 to 500 engine working hours:

1. Carry out all the operations, given in (D).

2. Add rust removing compound to the radiator and flush the cooling system

3. Interchange the tyres of the front wheels to secure uniform wearing.

4. Flush the fuel tank.

5. Clean the self-starter and dynamo of the tractor.

6. Check the injector and adjust if necessary.

F. At 960 to 1000 engine working hours:

1. Carry out all the operations given in (E).

2. Check the oil in the gear box, steering housing, power take-off case and hydraulic system of tractor.

3. clean and adjust the brake lining.

4. check the compression pressure of the engine and if necessary, overhaul the engine.

Trouble: Engine does not start

S. No	Causes	Remedy
1	Battery not fully charged	Charge the battery fully
2	Starter pinion jammed	Adjust the pinion
3	Faulty switch	Repair or charge the switch
4	Battery terminals not connected	Connect the terminals
5	Starter out of order	Check the starter and repair it
6	Engine too stiff	Use lubricating oil of low viscosity
7	Air lock in fuel system	Bleed the fuel line
8	Fuel pump fault	Repair it in peculiarised shop
9	Fuel filter blocked	Clean the fuel filter
10	Water in fuel line	Change the fuel oil
11	Pump timing not correct	Check up the timing
12	Injections faulty	Check it on injector testing machine

Trouble: Engine does not take sufficient load

S. No	Causes	Remedy
1	Valve clearance incorrect	Adjust the correct gap
2	Valve spring broken	Replace it
3	Head gasket damaged	Replace it
4	Ring stuck or worn	Change it
5	Decompression mechanism incorrectly adjusted	Adjust it correctly
6	Fuel filter partially chocked	Clean it well
7	One or more injectors faulty	Check it on injector testing machine
8	Injection timing incorrect	Check it & correct it

Chapter-7

AGRICULTURAL TILLAGE IMPLEMENTS

Tillage

Mechanical manipulation of soil to provide favourable condition for proper crop growth is called tillage. 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.

7.1 Objectives of Tillage

- To obtain deep 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
- To reduce the soil erosion.

7.1.1 Classification of Tillage

Tillage operations for seed bed preparations are classified as:

- Primary tillage
- 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.

The objectives of primary tillage are

- To reduce soil strength
- To rearrange aggregates
- To cover plant materials and burry weeds
- To kill insects and pests

Secondary Tillage

Lighter and finer tillage operations performed in the soil after primary tillage to create proper soil tilth and. surface configuration for seeding and planting are called secondary tillage operations. Secondary tillage operations are generally done on the surface soil. They do not cause much soil inversion and shifting of soil from one place to other. They consume less power per unit area compared to primary tillage operations.

The main objectives of secondary tillage are

- To break the big clods and make the soil surface uniform and levelled as needed fora seed bed
- To destroy grasses and weeds in the field.
- To cut crop residues and mix them with top soil.

7.2 Primary Tillage Implements

The implements used for secondary tillage operations are called secondary tillage implements. They include different types of harrow, cultivators, sweeps, clod crushers, levellers, bund formers, ridge ploughs etc.

- Ploughs
- Mould Board plough
- Disc plough
- Chisel plough

Ploughs

Ploughing is the primary tillage operations, which are 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.

Country or Indigenous plough

An indigenous plough is one of the most common implements used by Indian farmers. It is an animal drawn plough. It penetrates into the soil and breaks it open. It forms V shaped furrows with 15-20 cm top width and 12-15 cm depth. It can be used for ploughing in dry land, garden land and wetlands. The main parts of the plough are (1) body (2) shoes 3) share (4) beam, and (5) handle.

The body is the main part of the plough, and is attached to the shoe with which it penetrates into the soil and breaks it open. The beam is generally a long wooden peace which connects the main body of the plough to the yoke, A wooden piece which is attached vertically to the body to enable the operator to control to plough is called the handle.

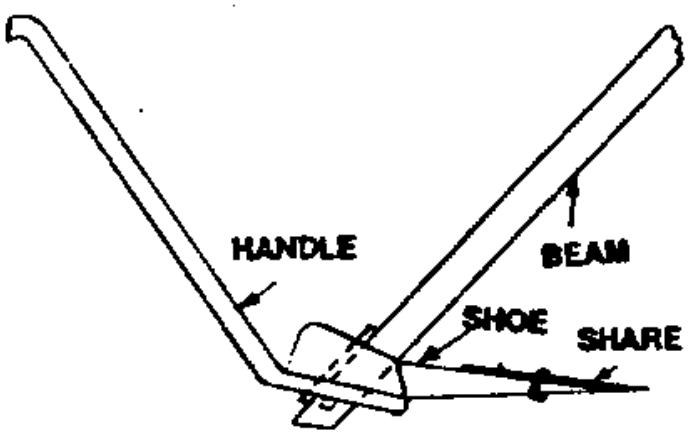


Fig.7.1 Indigenous plough

Mouldboard Plough

Mouldboard plough is one of the oldest of all agricultural implements and is generally considered to be the important tillage implement. Ploughing accounts for more traction energy than any other field operation. Mouldboard ploughs are available for animals, power tiller and tractor operation.

Functions of a Mouldboard plough:

- Cutting the furrow slice
- Lifting the furrow slice
- Inverting the furrow slice and
- Pulverizing the furrow slice

The components of mouldboard plough are frog or body, mouldboard or wing, share, landside, connecting, rod, bracket and handle. This type of plough leaves no unploughed land as the furrow slices are cut clean and inverted to one side resulting in better pulverisation. The animal drawn mouldboard plough is small, ploughs to a depth of 15 cm, while two mouldboard ploughs which are bigger in size are attached to the tractor and ploughed to a depth of 25 to 30 cm. Mouldboard ploughs are used where soil inversion is necessary.

Components of a Mouldboard Plough

An animal drawn mouldboard plough consists of

- Plough bottom
- Plough accessories

Plough bottom

The part of the plough which actually cuts, lifts, pulverizes and throw the soil out of the furrow. It is composed of those parts necessary for the rigid structure required to cut, lift, turn, and invert the soil.

Parts of the mouldboard plough bottom is

a) Share

b) Mould board

c) Land side

d) Frog and

e) Tail piece.

Share, landside, mouldboard is bolted to the frog which is an irregular piece of cast iron.

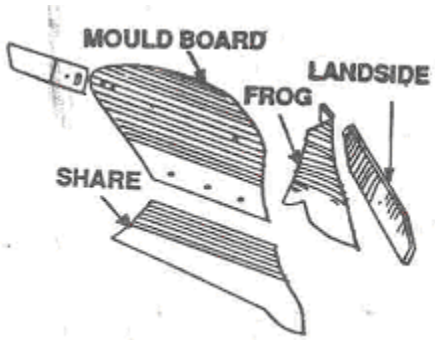


Fig.7.2 Components of M B Ploughs

Share - It penetrates into the soil and makes a horizontal cut below the soil surface. It is a sharp, well-polished and pointed component.

Different portions of the share are called by different names such as

a) Share point

b) Cutting edge

c) Wing of share

d) Gunnel

e) Cleavage edge and

f) Wing bearing.

a) Share point: It is the forward end of the cutting edge which actually penetrates into the soil

b) Cutting edge: It is the front edge of the share which makes horizontal cut in the soil. It is bevelled to some distance.

c) Wing of share: It is the outer end of the cutting edge of the share. It supports the plough bottom

d) 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. **e) Cleavage edge:** It is the edge of the share which forms joint between mouldboard and share on the frog.

f) Wing bearing: It is the level portion of the wing of the share, providing a bearing for the outer corner of the plough bottom.

Land side: It is the flat plate which presses 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 mouldboard. It also helps in stabilizing the plough while in operations. 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.

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

Tail piece: It is an important extension of mouldboard which helps in turning a furrow slice.

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 otherminor elements.

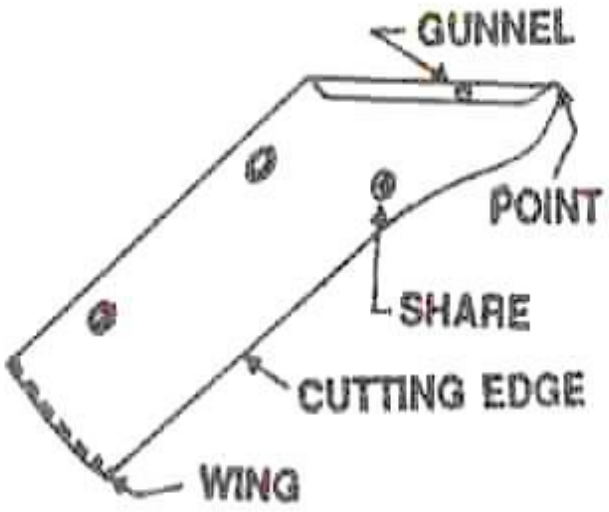


Fig. 7.3 Parts of a share

Types of Shares

i) Slip share

ii) Slip nose share

iii) Shin share

iv) Bar point share.

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 the share point can be replaced as and when required. If the point is worn out, it can be changed with a new nose 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 mouldboard.

iv) **Bar point share**: It is the share in which the point of the share is provided by an adjustable and replaceable iron bar. This bar serves the purpose of share point and land side of the plough.

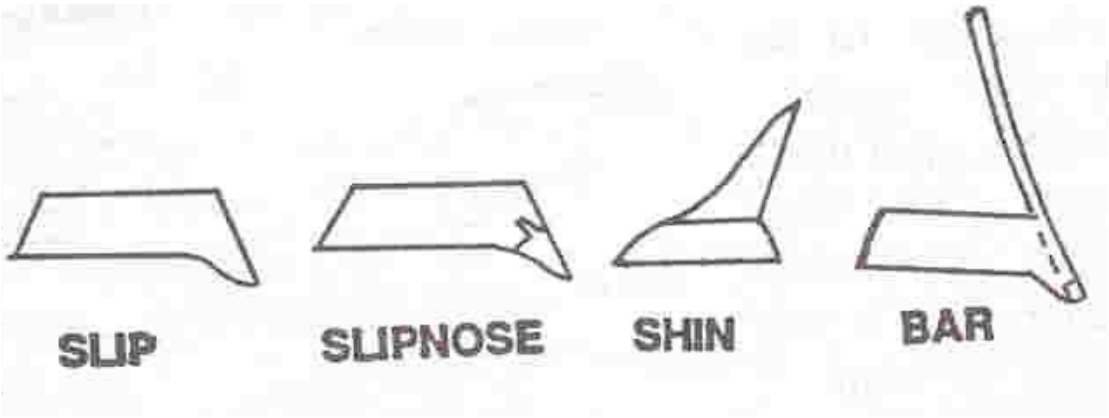


Fig.7.4 Types of Shares

Mouldboard: It 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, mouldboard has been designed in different shapes.

The mouldboard is of following types:

a) General purpose:

It is a mouldboard having medium curvature lying between stubble and sod types. The mouldboard is fairly long with a gradual twist, the surface being slightly convex. The sloping of the surface is gradual. It turns a well-defined furrow slice and pulverizes the soil thoroughly.

b) Stubble type:

It is short but broader mouldboard with a relatively abrupt curvature which lifts, breaks and turns the furrow slice. 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 mouldboard is not suitable for lands with full of grasses.

c) Sod or Breaker type:

It is a long mould board with gentle curvature which lifts and inverts the unbroken furrow slice. It turns over thickly covered 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 (soil with much of grass).

d) Slat type:

It is a mouldboard whose surface is made of slats placed along the length of the mouldboard, so that there are gaps between the slats. This type of mouldboard

is often used, where the soil is sticky, because the solid mouldboard does not scour well in sticky soils.

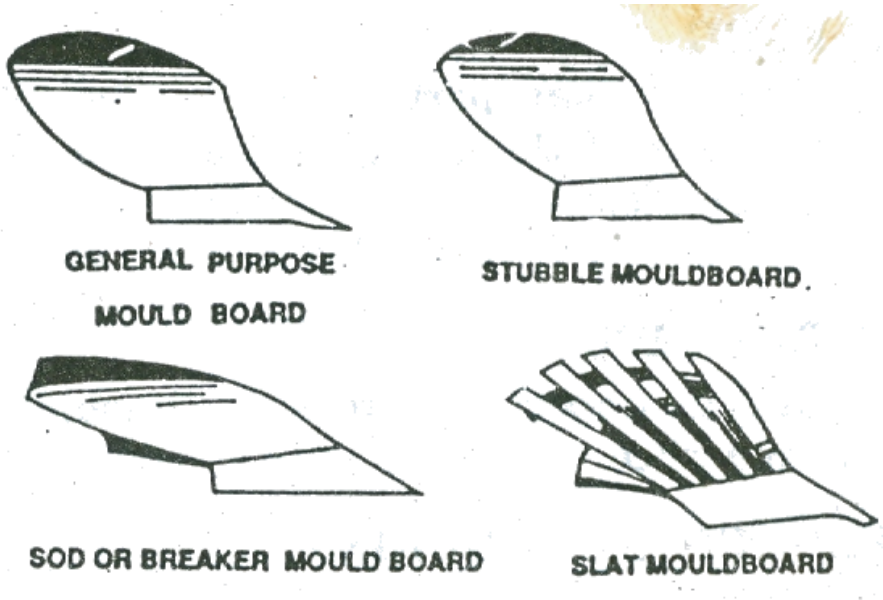


Fig.7.5 Types of mouldboards

Plough Accessories

There are a few accessories necessary for efficient function of the plough.

They are (i) Jointer (ii) Coulter (iii) Gauge wheel (iv) Land wheel and (v) Furrow wheel.

i) 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.

ii) 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) Rollingtype disc coulter or (b) Sliding type knife coulter.

iii) Gauge wheel

It is an auxiliary wheel of an implement to maintain a 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.

iv) Land wheel - It is the wheel of the plough which runs on the ploughed land.

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

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

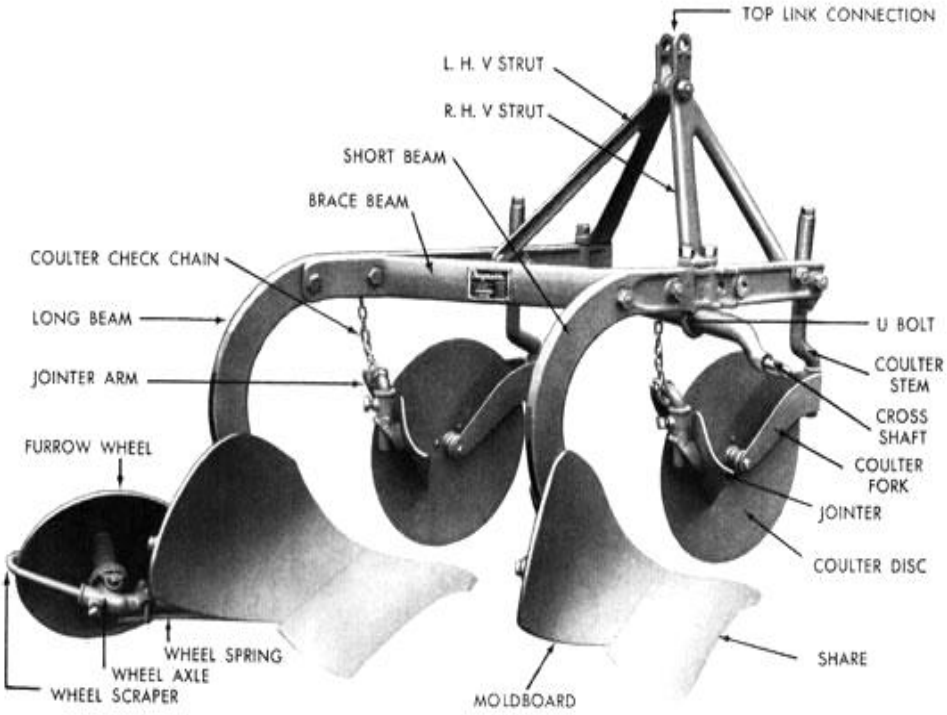


Fig. 7.6 Plough Accessories

Adjustment of Mouldboard Plough

For proper penetration and efficient work by the mouldboard plough, some adjustments are made from time to time. They are (i) Vertical suction and (ii) Horizontal suction.

a) 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 also defined as 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.

Fig.7.7 Vertical clearance

Fig. 7.8 Horizontal clearances

b) Horizontal suction (Horizontal clearance)

It is the maximum clearance between the land side and the furrow wall. This suction helps the plough to cut the proper width of furrow slice. This clearance also varies according to the size of the plough. It is also known as side clearance.

c) Throat clearance

It is the perpendicular distance between share point and lower position of the beam of the plough.

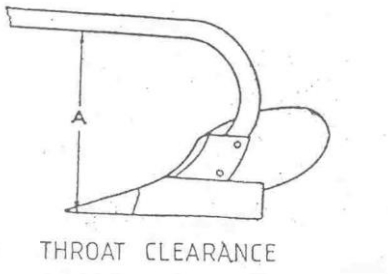


Fig.7.9 Throat clearance of plough

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 works well in the conditions where mould board plough does not work satisfactorily.

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 mouldboard plough does.
- Comparatively, the disc plough leaves the soil in rough and more cloddy condition than that of mouldboard plough.
- Disc plough is much heavier than mouldboard plough for equal capacities because penetration of this plough is affected largely by its weight rather than suction.

Types of Disc Plough

Disc ploughs are of two types

(i) Standard disc plough

(ii) Vertical disc plough

(iii) Reversible 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. 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 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. Disc is made of heat-treated steel of 5 mm to 10 mm thickness. 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.

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.

Scraper - It is a device to remove soil that tend 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.

Draft of disc plough

The disc plough is lighter in draft than the mouldboard plough, turning same volume of soil in similar conditions. In very hard soil, some extra weight is added to the wheel.

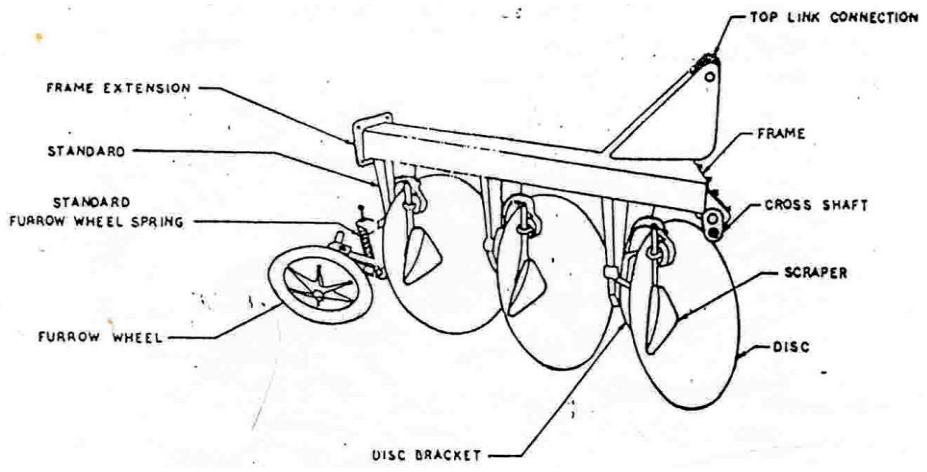


Fig.7.10 Disc plough

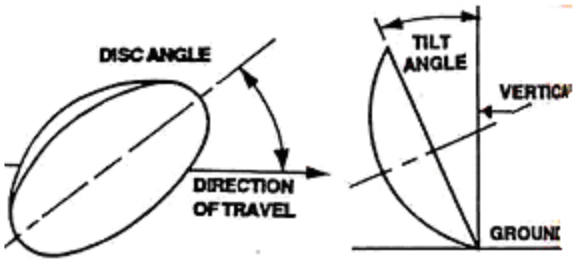


Fig.7.11 Angles of disc plough

Vertical Disc Plough

It is the plough which combines the principle of regular disc plough and disc harrow and is used for shallow working in the soil.

(iii) Reversible disc plough

It is similar to standard disc plough, except that it can turn over the furrow sliceto left or right side. It not only improves the rate of work but also leaves the field flat and level. This plough is found very successful for contour ploughing because the operation can be performed back and forth. on the contour line without any problem. The soil is turned in the

direction required to prevent soil erosion. Slopes can also be gradually levelled just by ploughing down the slope every year. It saves water and time, improves irrigation efficiency and ensures an even crop growth. and no water wastage. The disc is rotated from one side to another by using a lever.

Fig. 7.12Reversible disc plough

Animal drawn disc plough

The animal drawn standard disk plough has also been introduced in Indian agriculture. The animal drawn disk plough available in the country is attached to a Universal frame which is mounted on two wheels. The frame is pulled by a pair of bullocks and it is provided with a seat for the operator. (Walking types of animal drawn disk ploughs are not available, as they would be very heavy to carry to the fields and difficult to balance while ploughing). There is only one-disc blade on these ploughs and it can be tilted backward from 15° to 25° (tilt angle) in the vertical plane. It also makes an angle of about 45° (disk angle) with the direction of motion. However, a small adjustment is possible in the disk angle. The diameter of the disk is 45 cm. A rear furrow wheel provided with the plough takes care of the side thrust of the plough.

7.3 Secondary Tillage Implements

Tillage operations performed after primary tillage to create proper soil tilth for seeding and planting are called secondary tillage. These operations are lighter and finer operations performed on the soil after primary tillage operations. Secondary tillage operations do not cause much soil inversion and shifting of soil from one place to another place. These operations consume less power per unit area compared to primary tillage operations. The

implements used for secondary tillage operations are called secondary tillage implements they include different types of harrows, rollers and pulverizers, rotary tillers, tools for mulching and fallowing, cage wheels etc.

The objectives of secondary tillage

1. To improve the seed bed by greater pulverization of the soil
2. To destroy grasses and weed seeds in the field.
3. To cut crop residues and mix them with top soil
4. To break the big clods and to make the field surface uniform and levelled.

It is secondary tillage operation which pulverizes, smoothens and packs the soil in seed bed preparation and /or control weeds.

There are several types of harrow used in India, such as:

1. Harrows
2. Guntaka
3. Bund former
4. Ridger
5. cultivator
6. Rotavator

Types of harrows

1. Disc harrow
2.spring tooth harrow
3. spike tooth harrow

Animal drawn disc harrow

Disc harrow is used for breaking clods while preparing seed beds. It has usually six or eight discs fixed in two gangs, each gang has three or four discs. There is a strong frame made of mild steel, on which gangs with the discs are mounted. An operator's seat is also provided in the frame. Usually transport wheels are provided easy movement of the harrow from place to place. The size of the harrow is determined by the maximum width of cut of the soil. The weight of the disc harrow varies between 80 to 100 kg only.

Tractor drawn disc harrow

1.Single action disc harrow
2.Double action disc harrow
3.Offset disc harrow

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.

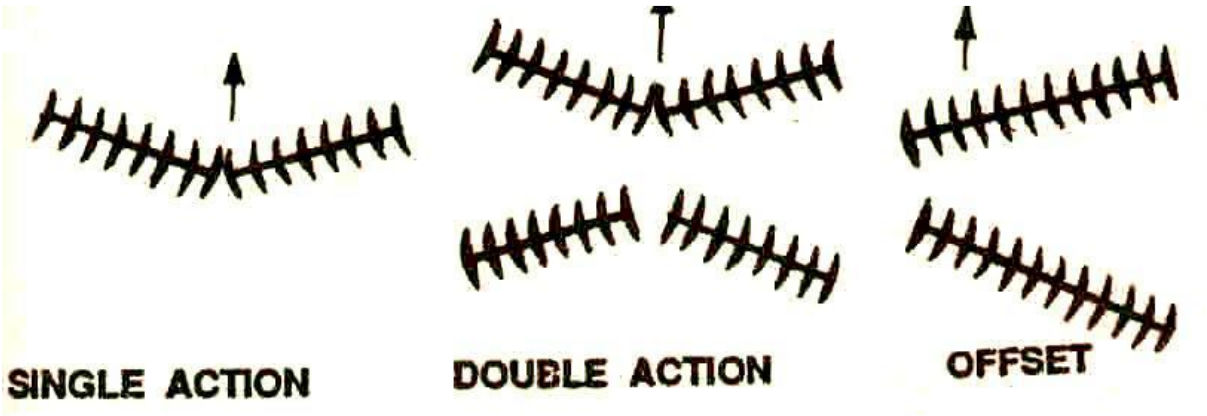


Fig.7.13 Types of harrows

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 back gangs throw the soil in opposite directions. Thus, the entire field is worked twice in each trip. It may be of two types a) Tandem and b) Off-set.

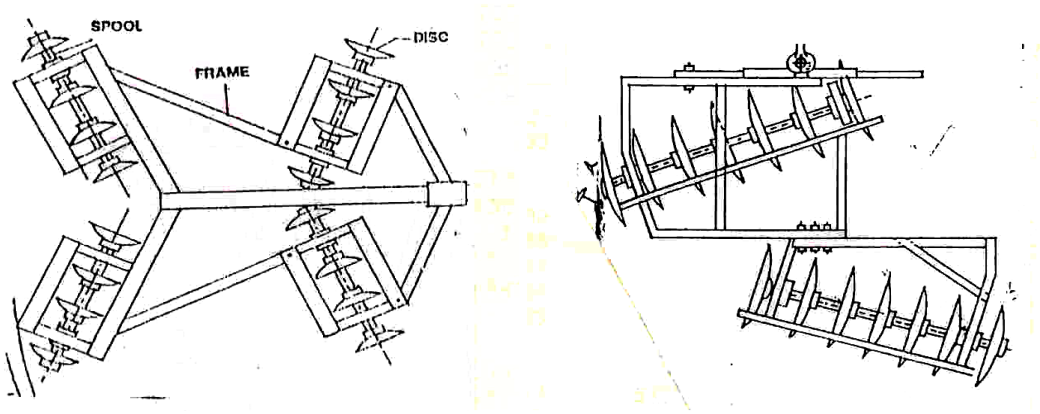


Fig.7.14 Tandem and offset harrows

Tandem disc harrow

The double action disc harrow is often called a tandem harrow because a set of two gangs follows behind the front gangs and is arranged in such a way that the discs on the front gangs throw the soil in one direction (usually outward), and the discs on the rear gangs throw the soil in the opposite direction (outward) Thus the entire field is worked twice in each trip.

Off-set disc harrow

Offset disk harrow has one right-hand gang (throwing the soil to the right) and one left hand gang (throwing the soil to the left), operating in tandem. The harrow is given this

name because harrow can be operated in offset position in relation to the tractor. A change in hitch can cause the harrow to run either to the left or right of the tractor. It is possible to operate the harrow under limbs, near trees in an orchard.

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. It gives a springing action in working condition. It is best suited or hard and stony ground. It is used in the soil where obstructions like stones, roots and weeds are hidden below the ground surface. It pulverizes the soil and helps in killing weeds. This type of harrow mainly consists of teeth, tooth bar, clamps, frame, clevis, 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 bars by tooth clamps.

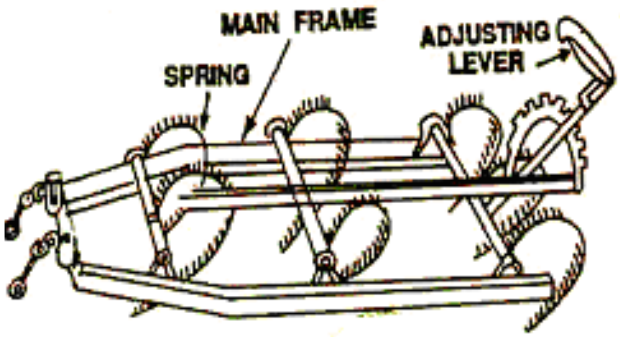


Fig. 7.15 Spring tooth harrow

Spike tooth harrow

It is a harrow with pegs as working parts, fitted on a rigid articulated or flexible frame. The peg shaped teeth of diamond cross section are attached to a rectangular frame. It is used to break clods, stir the soil, uproot the weeds, level the ground, break the soil crust and cover the seeds. Its principle is smoothening and level the soil directly after ploughing. It is of two types:

1. Rigid type 2. Flexible type

The animal drawn spike tooth harrow is of rigid type. There may or may not be provision for changing or the angles of spike in operating conditions. Tractor drawn harrows are usually of flexible type. It has got advantage of being rolled up for transporting purpose. This harrow mainly consists of teeth are made of hardened steel. The teeth may be square, triangular or circular in section. The teeth are so placed on tooth bar that no tooth is directly behind the

other. Tooth bars are made of wood or steel. Steel bars may be round, flat or channel shaped. All the teeth are fastened rigidly to the tooth bar. Clamps are used to fasten the teeth to the tooth bars tightly so as not to lose while in operation.

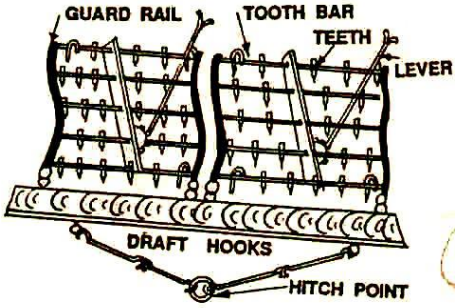


Fig7.16. Spike tooth harrow

Guntaka

It is an improved type of blade harrow. It is an implement, which consists of one or more blades attached to a frame or beam. It is used for shallow working of the soil with minimum soil inversion. It is mainly used to prepare the seed bed mostly in clay soils. The function of Bakhar the same as that of the guntaka.

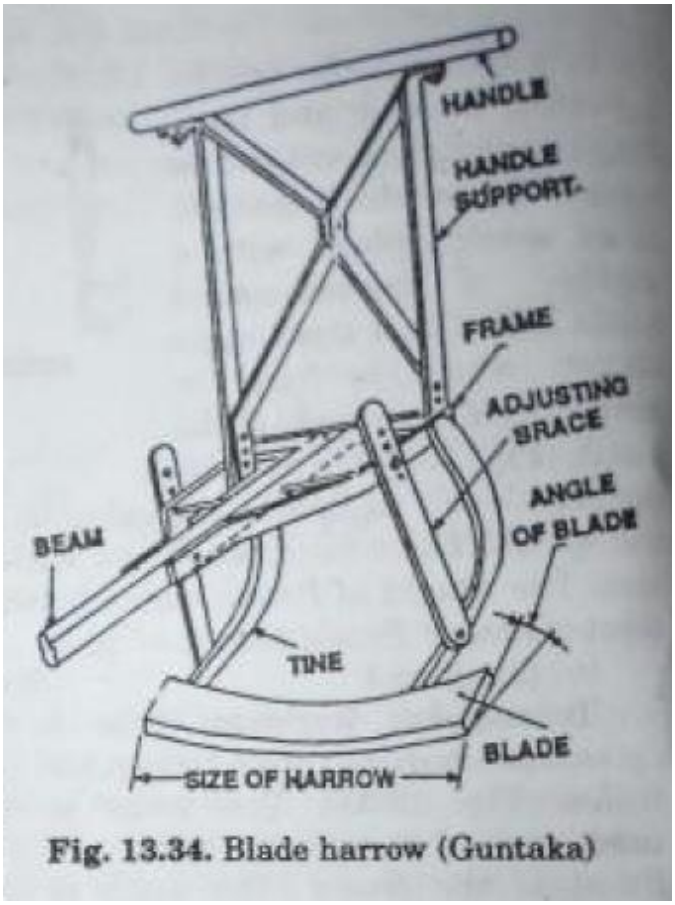


Fig. 7.17 Guntaka

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. Bund former consists 1. Forming board 2. Beam 3. Handle

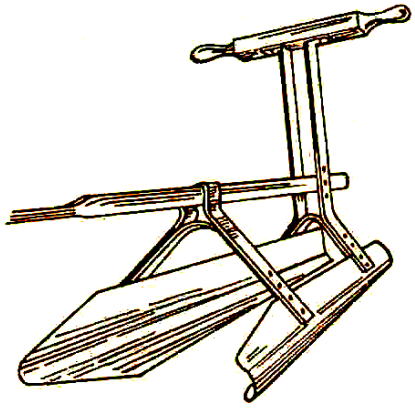


Fig. 7.18 Bund former

Ridger (animal drawn)

It 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 by the names ridging 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. A ridger consists of beam, clevis, frog, handle, mouldboards, braces, share, and sliding shoe.

Fig. 7.19 Ridger

Soil scoop (animal drawn)

Soil scoop is used in excavating ditches, cleaning drains and moving soil over short distances. It consists of 1. Blade 2. Soil trough 3. Hitching loop and 4. Handle

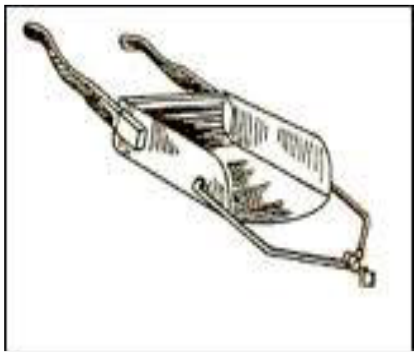


Fig. 7.20 Soil scoop

Blade: Blade is made of high carbon steel with carbon content varying between 0.5 to 0.6% The angle of the cutting blade varies from 12° to 15° only. The blade is riveted or bolted to the soil trough.

Soil trough: It is made of mild steel sheet. It has two handle holders when wooden handles are to be inserted.

Hitching loop: Two ends of the loop are fitted to the sides of the soil trough. The loop is made of mild steel round.

Handle: There are two handles made of timber or mild steel flat.

7.4 Other Tillage Implements

Cultivators

Usually, tractor drawn cultivators are of two types depending upon the flexibility and rigidity of the tines

1. Cultivator with a spring-loaded tine
2. Cultivator with rigid tines

Cultivator with rigid tines

Rigid tines of 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 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 tine choked with stubbles of the previous crop or weed growth. A pair of gauge wheel is used or controlling the depth of operation.

Cultivator with Spring Loaded Tine

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 cultivator. Each of the tine is provided with two heavy coil springs, pretension to ensure minimum movement except when the obstacle is encountered.

Fig.7.21 Spring tyne cultivator

The springs operate when the points strike roots or large stones by allowing the tines to ride on passing 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. A pair of gauge wheel is provided on the cultivator for controlling the depth of operation. The cultivator may be fitted with the 7,9,11, 13 tynes or more depending on the requirements.

Duck foot cultivator

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

Fig.7.22 Duck foot cultivator

Puddler (Animal drawn).

It is an implement used for churning the soil in standing water. Puddler is used for preparation of paddy fields with standing water after initial ploughing. It breaks up the clods and churns the soil. The purpose of puddling is to reduce leaching of water, to kill weeds by decomposing and to facilitate the transplanting of paddy seedling by making the soil softer. Puddling is done in a standing water of 5 to 10 cm depth. A common puddler used in this country has three puddling units, each having four paddles mounted on an axle. The axle with the puddling units is freely mounted on two bearings, fitted on a frame, made of metal or wood. The weight of the puddler including its beam is within range of 30 to 40 kg only. The puddler consists of:

1. Frame
2. Paddles
3. Metal cross
4. Axle
5. Beam
6. Handle

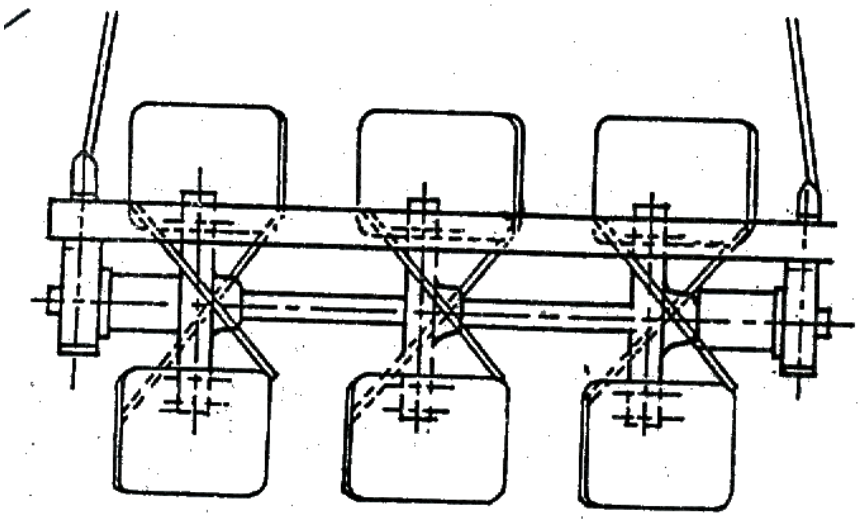


Fig.7.23 Puddler

Chapter-8

SOWING AND INTER CULTURAL EQUIPMENTS

8.1 SOWING EQUPMENTS

Sowing is an art of placing seeds in the soil to have good germination in the field. A perfect sowing gives

a. Correct amount of seed per unit area.

b. Correct depth of sowing

c. Correct spacing between row-to-row and plant to plant.

d. Correct seed rate

1. Direct sowing 2. Transplantation

Sowing Methods

(i) Broadcasting

(ii) Dibbling

iii) Seed dropping behind the plough

Broadcasting

Broadcasting is the method of random scattering of seeds on the surface of seedbed. It can be done manually or mechanically. When broadcasting is done manually, uniformity of seed placement depends upon the skill of the man scattering the seeds. 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 sowing. The device scatters the seeds on the surface of the seedbed at controlled rates.

Dibbling

Dibbling is the process of placing seeds in holes made in the seedbed and closing the seed with soil. 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 shape 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.

Seed dropping behind the plough

It is a very common method of sowing followed by farmers in villages. This method is used for seeds like maize, gram, peas, wheat and barley. A woman/ man walks behind a

plough ploughing the land and drop the seeds in the furrows made by the plough. Sowing behind the plough can be done by a device known as Malbasa. It consists of a bamboo tube provided with a funnel shaped mouth. It is fitted to the handle of the plough. One man drops the seeds through the funnel and other man handles the plough and the bullocks. This method is a slow and laborious method.

Transplanting

Transplanting consists of rising the seedlings in a nursery bed and then planting the seedlings in another field (main field). It is commonly done for paddy, vegetable and flowers. It is a time-consuming operation. Equipment used for planting the seedlings in the main field is called trans planter.

Seed Drill

Seed drill is a machine used for placing the seeds in a continuous stream in furrows at uniform rate and at controlled depth with an arrangement of covering the seeds with soil.

According to the power source used, seed drills may be classified in to

(i) Bullock drawn seed drills

(ii) Tractor drawn seed drills.

According to the type of seed metering done animal drawn seed drills may be classified into i) manually metered seed drills and ii) mechanically metered seed drill. In manually metered seed drills a person drops the seeds in the furrows, in mechanically metered seed drills a mechanical device called seed metering mechanism is used to meter the seeds. There are many designs of bullock drawn seed drills and tractor drawn seed drills which are used for sowing.

Functions of a seed drill:

Seed drill performs the following functions

i) To carry the seeds.

ii) To open furrows at uniform depths

iii) To meter the seeds

iv) To deposit the seeds in furrows in an acceptable pattern

v)To cover the seeds and compact the soil around the seed.

Fig. 8.1 Animal drawn seed drill

Fig. 8.2 Tractor drawn seed drill

Components of a Seed Drill

A seed drill with mechanical seed metering device mainly consists of:

i. Frame
ii. Seed box
iii. Seed metering mechanism
iv. Drive transmission system
v. Furrow openers
vi. Covering device

vii. clutch
viii. hitch frame and
ix. Transport wheels.
x. Seed tube
xi. Boot

Frame

The frame is usually made of mild steel angle section and flat. It is strong enough to withstand all types of loads in working condition. All other parts of a seed drill are fitted to the frame.

Seed box

It is a box like structure made up of either mild steel or galvanized iron and provided with a lid. In some designs a small agitator is provided at the bottom of the box which agitates the seeds while the drill in operation and prevents clogging of seeds. Seed metering mechanism is placed at the bottom of the box.

Seed metering mechanism

The mechanism which picks up seeds from the seed box and delivers them in to the seed tube is called seed metering mechanism. Seed metering mechanism may be of several types:(a) Fluted feed type (b) Internal double run type (c) Cup feed type (d)Cell feed type (e) Brush feed type (f) Auger feed type (g) Picker wheel type and (h) Star wheel type. Usually seed metering mechanism is provided at the bottom of the box.

Drive transmission system

The drive transmission mechanism consists of a wheel, sprocket-chain assembly and a driven shaft that carry the seed picking discs. When the seed drill moves in the field, the drive wheel rotates due to its contact with soil and the sprocket wheel also rotates. The chain connecting the drive wheel sprocket and driven wheel sprocket rotates the shaft carrying the seed metering discs.

Furrow openers

These are the parts which open up furrows in the soil for placing the seeds. Different types of furrow openers in use namely 1. Hoe type 2. Shoe type 3. Stub runner type 4. Full or curved runner type 5. Single disc type 6. Double disc type etc. In cultivator type seed drills the tines work as furrow openers.

Covering device or furrow closer

It is a device which closes the furrow with soil after the seed has been dropped init. Covering the seeds is usually done by chains, bars, packers, rollers or press wheels, designed in various shapes and sizes

Transport wheel

There are two wheels fitted on an axle for transporting the drill on roads. Iron wheels are used as transport wheels. Some manufacturers use pneumatic wheels. One of the transport wheels is fitted with a suitable attachment to transmit the motion of the wheel to the seed metering mechanism when the drill is in operation.

Seed tube - Seed tubes are provided at the lower end of the feed cups. They conduct seeds from feed cups to the furrow lines through suitable boots and furrow openers Polypropylene, rubber and steel tubes are used as seed tubes. Minimum diameter of seed and fertilizer tube is 25 mm.

Boot - It is a part of the sowing equipment which receives the seeds or fertilizers from the seed tube and delivers to the furrow. It is made up of cast iron or mild steel.

8.2 Inter Cultivation Equipment's

The operations performed in the field after sowing but before harvesting the crop are called as intercultural operations. Interculturing is described as breaking the upper surface of soil, uprooting the weeds (unwanted plants), aerating the soil, thereby promoting the activities of microorganism and making good mulch, so that moisture inside the field is properly retained from evaporation. These operations are accomplished by means of many tools an equipment's, such as hoes, cultivators, harrows, rotary hoes etc.

The main objectives of weed control are to improve the soil conditions for healthier growth of plant. Weeds growing along with crops compete for moisture, light and nutrients Hence, it is essential to remove them. Following are some of the weeding devices used by the farmers

Hand Hoe

Hand hoe is the most popular manually operated weeding tool use in the farm. It consists of an iron blade and a wooden handle. The operator holds the handle and cuts the soil with the blade to a shallow depth of 2-3 cm thereby weeds are cut and soil is stirred. The handle is short (30-40cm long) hence the operator uses the tool in bending posture. The coverage is 5-7 cents per day.

Fig. 8.3 Hand hoe

Hoe Come Rake

The hoe cum rake is multipurpose hand tool, which consists of a flat blade on one side like powrah and prongs on the other side. The blade and prongs are either made from single stock with an eye in the centre or joined to an eye by welding. A wooden handle is fitted to the eye for operation. The flat blade is used for digging and rake side for weeding and collection of weeds and trashes. The hoe cum rake is a secondary nursery bed preparation tool and is used for lighter operations. The flat end of the tool is operated with impact action.

Fig.8.4 Hoe cone rake

Long Handle Weeders

Hand hoes exert greater strain on the operator because of the short handle with necessitates the operator to do weeding job in bent posture. To avoid this nowadays long handles are used in hoes and hence they are called as long handle weeders. The popular long handle weeders available are a) star type weeder b) peg type weeder. These weeders are also called as dry land weeders since they are used in dry lands

a) Star type weeder:

It is suitable for weeding in dry lands. It can be used in garden lands also when the soil moisture is low (10-15 %). One limitation is that it works well inline sown crops and not in broadcasted fields. It consists of a blade for cutting the weeds, a fulcrum wheel for push-pull movement and a long handle for easy operation. Long handle reduces strain on the

operator. The radial arms of the fulcrum wheel is cut in to star like projections and hence the name star type weeder. Star wheel is designed for loamy soils. The operating width of the blade is 120 mm. The coverage is 0.05ha/day.

b) Peg type weeder:

It is suitable for weeding in dry lands. It can be used in garden lands also when the soil moisture is low (10-15 %). One limitation is that it works well I line sown crops and not in broadcasted fields. It consists of a blade for cutting the weeds, a fulcrum wheel for push-pull movement and a long handle for easy operation. Long handle reduces strain on the operator. There are pegs welded on the periphery of the wheel hence the name peg type weeder. Peg type wheel is designed for clayey soils. The operating width of the blade is 120 mm. The coverage is 0.05 ha/day. Both star type and peg type weeders are also called as dry land weeders.

c) Wheel hoe

The wheel hoe is a widely accepted weeding tool for weeding and intercultural in row crops. It is a long-handled tool operated by pushes and pull action. The general construction of wheel hoe comprises of a wheel, tool frame, a set of replaceable tool sand a handle Different types of soil working tools such as straight blade, V - blade, sweep, shovel, etc. can be used for different works namely weeding, soil mulching, stirring etc. Long handle reduces drudgery to operator. Wheel reduces energy requirement for pushing. All the soil working components of the tool are made from medium carbon steel. The coverage is 0.05 ha/day.

Fig.8.5 Wheel hoe

Cono weeder

Cono weeder is useful for uprooting and burying weeds in line planted rice fields in wetlands. It disturbs the topsoil and increases aeration. This facilitates better growing environment to the crop. The weeder consists of a long handle, two numbers of truncated conical rollers, and a float. The rollers are fitted at the bottom of the handle in opposite direction one behind other. The conical rollers have serrated blades on the periphery. When the weeder is operated in between two rows of standing crop, the rollers up root the weeds and burry them. Cono weeder operation triggers root growth. The float prevents the unit from sinking into the soil. Soil should be moist and little firm at the time of using the weeder, the coverage is 0.05 ha/day.

Fig.8.6 Cono weeder

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, Bar dole hoe or two blades how are the most popular implements different regions for row crop interculture operations. It is essential to provide wider spacing (above 10 mn) for movement of animals and implement if animal drawn weeders are to be used.

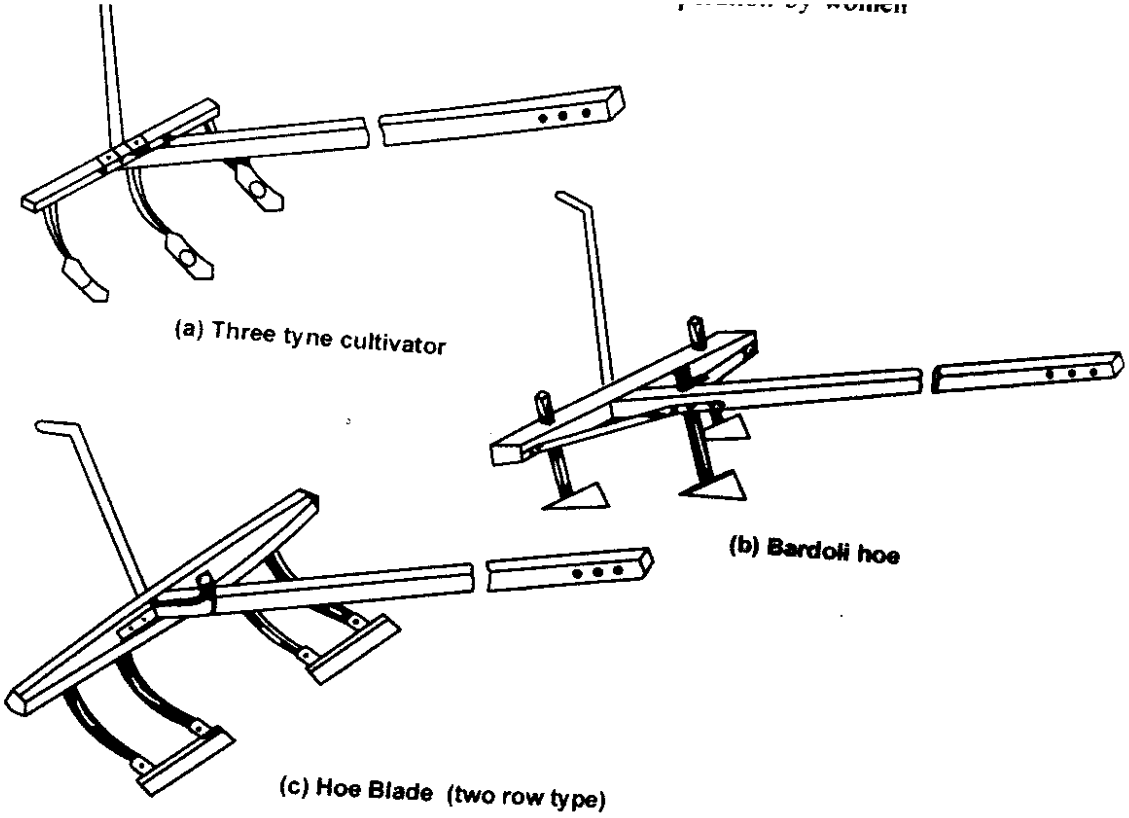


Fig. 8.7 Animal drawn weeders

Chapter-9

PLANT PROTECTION EQUIPMENTS

Insect pests and weeds cause considerable damage to the commercial crops. If not controlled in time, the entire crop gets lost and, therefore, farmers are likely to suffer in many ways. Among the important methods of weed control and plant protection systems, the following methods have been recognized as the effective and economical ones under different situations:

i. Mechanical control
ii. Chemical control
iii. Biological control
iv. Agronomical methods
v. Bio-physical methods
vi. Fire as control

Sprayers

Sprayer is a machine to apply fluids in the form of droplets. Sprayer is used for the following purpose:

(i) Application of fungicides to minimize fungal diseases,
(ii) Application of insecticides to control insect pests,
(iii) Application of herbicides to remove weeds and
(iv) Application of micronutrients on the plants.

The main functions of sprayer are:

(i) To break the liquid into droplets of effective size,
(ii) To distribute them uniformly over the plants, and
(iii) To regulate the amount of liquid to avoid

excessive application

9.1 Sprayer's classification

a) Based on power source, sprayers may be classified as:

i. Hand operated machines – suitable for small holdings. They are operated at pressure ranging from 1 to 7 kg/cm2.
ii. Power operated machines – suitable for treating a large area. They are operated at pressure ranging from 20 to 55 kg/cm2.
iii. Air planes – suitable for large scale work.

b**) Based on spray volume, sprayers may be classified as:**

i. High volume sprayer - More than 400 litres of spray liquid per hectare is used.

ii. Low volume sprayer – Spray volume ranges between 5 to 400 litres per hectare is used.

iii. Ultra-Low volume sprayer – Spray volume less than 5 litres per hectare is used.

Manual operated sprayers

Bucket type sprayer

It consists of a hand operated single or double acting pump which may be placed into any ordinary bucket containing spraying solution. Plunger rod is hollow and serves as the compression chamber. Liquid is discharged in both suction and delivery strokes; hence a continuous application can be made. One hand operates plunger, while another hand keeps the pump in stable position. This pump is mostly made of brass. It is very light and easily handled and develops sufficient pressure to spray small gardens and low trees. It develops a pressure of 4 -10 kg/cm2.

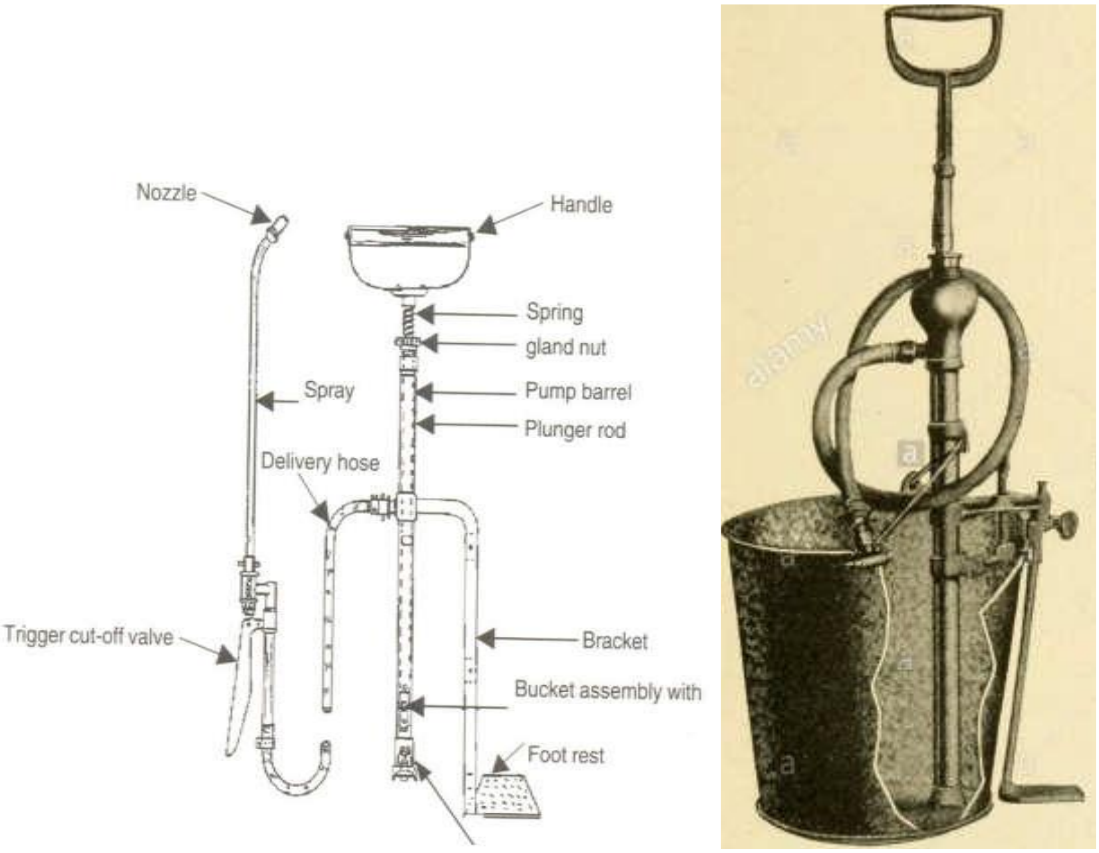


Fig. 9.1 Bucket type sprayer

Knapsack sprayer

It is very common type of sprayer, is provided with a pump and a large air chamber permanently mounted in a 9 to 22.5 litres tank. The handle of the pump extending over the shoulder or under the arm of operator, which makes it possible to pump with one hand and spray with other hand. Spray liquid is delivered through the delivery system, consisting of lance and nozzle, which is connected with the pump by a flexible hose. A uniform pressure can be maintained by keeping the pump in operation. It is generally carried on the back of the operator. It is quite useful for spraying small trees, shrubs and row crops up to 2.5 m height. These sprayers are useful because of their simplicity in operation, durability and for diverse use including spraying bushes of tea and coffee. One man can spray about 0.4 – 0.5 ha in a day, thus spraying about 90 lts of spray liquid. A pressure of 3 -5 kg/cm2 is maintained in the pressure chamber.

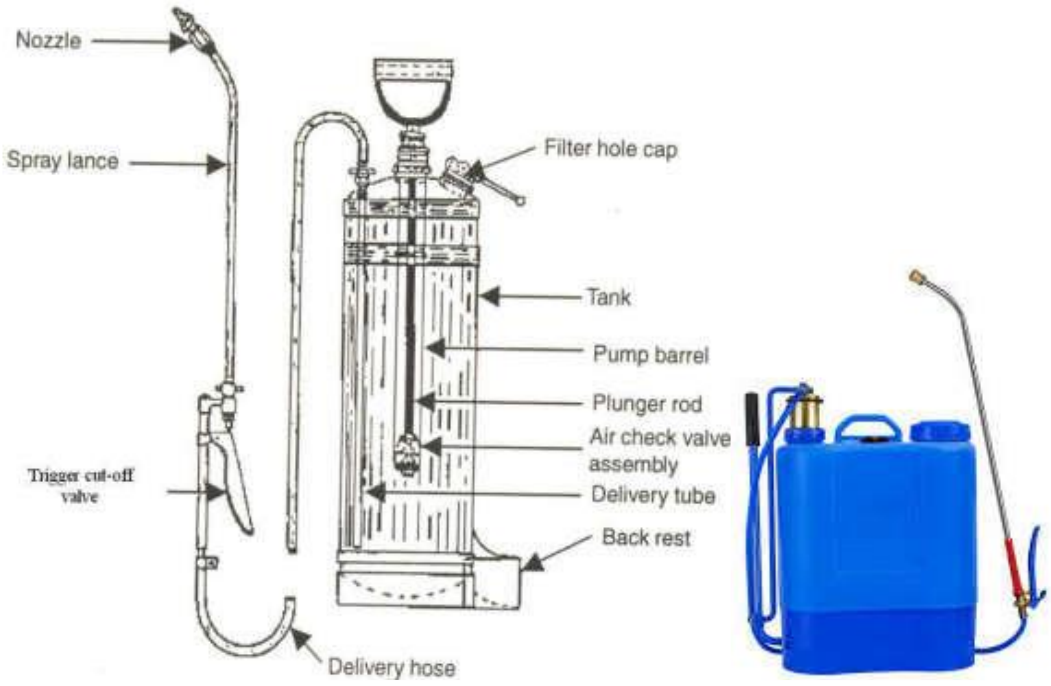


Fig.9.2 Knapsack sparyer

Foot - operated sprayer

It consists of a plunger assembly, stand, suction hose, delivery hose and an extension rod with nozzle. One end of suction hose is fitted with a strainer and other end with a flexible coupling. Similarly, one end of delivery hose is fitted with a cut-off valve and other end with a flexible coupling. An additional container is required to hold spray fluid, as this sprayer does not have a built-in tank. Continuous pedalling is required for uniform spray. It can develop a pressure of 17-21 kg/cm2. It is easy to operate and can be used for spraying tall

crops and fruit trees up to 4 m height. Sprayer can be used to spray trees up to 6 m height with additional hose.

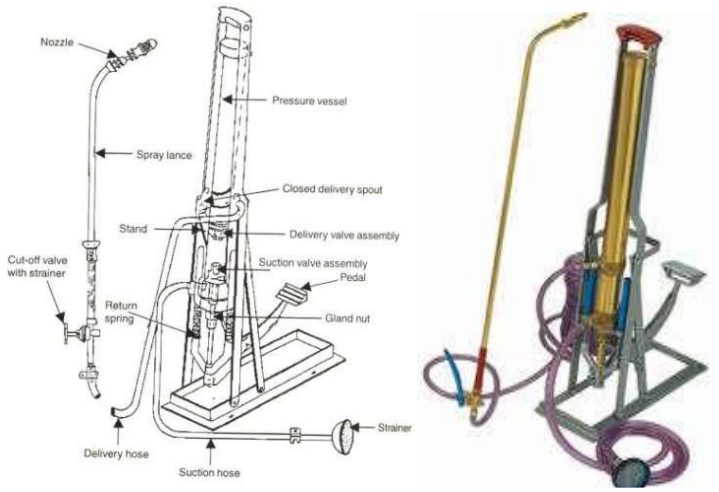


Fig.9.3 Foot operated sprayer

Rocking sprayer

This type of sprayer consists of a lever operated pump assembly which rests on a wooden platform. Suction hose with a strainer is immersed in a separate container containing the spray liquid. Delivery system consists of a separate pressure chamber, a flexible hose, spray lance, and a spray nozzle. The lever attached to the pump is operated by the rocking-forward and backward movement of the handle. Pressure is developed in the pressure chamber, which may attain pressure of 14-18 kg/cm2. Such sprayers are used for spraying tall plants like coconut and sugar cane plants. Uniform spraying can be done if sufficient pressure is maintained in the pressure chamber. It needs two persons to operate the sprayer, one for operating the pumping system and another for the application of spray liquid.

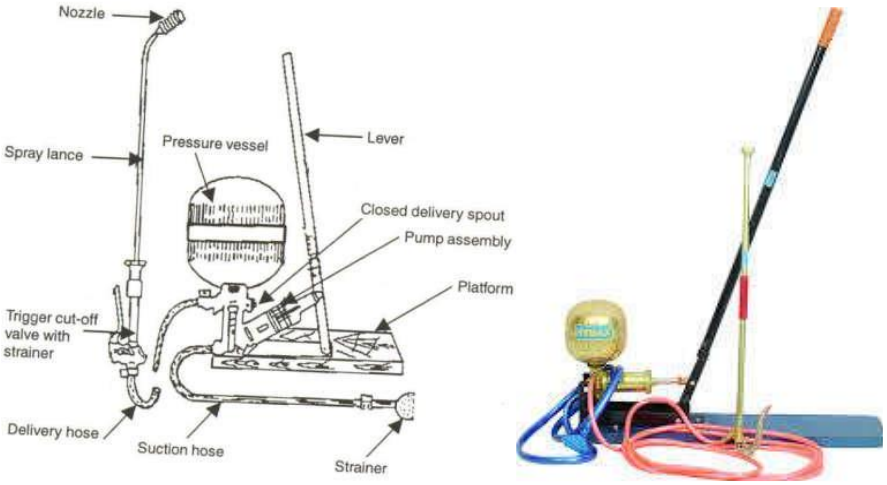


Fig. 9.4 Rocker sprayer

Power sprayers

Power sprayers are operated usually with IC engines. The prime mower capacity varies from 1 to 5 hp. The pressure pump is operated by a small power unit ensuring a constant steady pressure. These sprayers are essentially high-volume sprayers and operated at pressure ranges from 20 to 55 kg/cm2. These machines are usually portable type. Sometimes, power sprayers are operated by the PTO shaft of the tractor. Power sprayers can cover much larger area, and do the job efficiently.

Fig.9.5 Power sprayer

A power sprayer essentially consists of:

- ✓ Prime mower,
- ✓ Tank,
- ✓ Agitator,
- ✓ Air chamber,
- ✓ Pressure gauge,
- ✓ Pressure regulator,
- ✓ Strainer,
- ✓ Boom and
- ✓ Nozzles

Prime mower: Prime mower is needed to supply power to the power sprayer. It is usually internal combustion engine. The power generally varies from 1 to 5 HP.

Tank: Steel tank is widely used to prevent corrosion. Plastic tanks are also getting popular due to freedom from corrosion and ease of moulding into smooth shape. A covered opening, fitted with a removable strainer is provided for easy filling, inspection and cleaning. A drain plug is provided at the bottom of tank for draining the liquid.

Agitator: Agitators are needed to agitate the liquid in the tank. Propeller or paddle type mechanical agitators are provided to agitate the liquid. Horizontal shaft with flat blades rotating at about 100 to 200 rpm may be used. Paddle tip speed in excess of 2.5 m/s may cause foaming.

Air chamber: An air chamber is provided on the discharge line of the pump to level out the pulsations of the pump thereby providing a constant nozzle pressure.

Pressure gauge: It is provided on the discharge line to guide the operator regarding spray pressure. It should be under specified limit.

Strainer: It is provided in the suction line between the tank and the pump to remove dust, dirt and other foreign materials.

Boom: It is driven by a tractor, has a long boom in a horizontal plane on which nozzles are fixed at specified spacing. The boom can be adjusted vertically to suit the height of plants in different fields.

Nozzle: It is used to break the liquid into the desired spray and deliver it to plant

Types of nozzles

a. Regular flat-fan nozzles

These are used for most solid applications of herbicides and for certain pesticides when it is not necessary to penetrate foliage. These nozzles produce a tapered-edge flat-fan spray that requires overlapping of pattern to obtain uniform coverage. The spray angle varies from 65° to 110° with 80° being the most common. Nozzle spacing is generally 50 cm on the boom. The boom height varies with spray angle and the amount of overlap desired. A minimum of 50% overlap is needed for uniform coverage. The operating pressure is generally 100 to 200 kPa (15 to 30 psi) when applying herbicides to produce medium to coarse droplets that are not susceptible to drift.

b. Even flat-fan spray nozzles

These nozzles provide a spray density that is more even across the width of the spray, as compare d to the standard flat-fan spray with its tapered spray distribution. Since overlapping would produce a very uneven spray pattern, these nozzles are only for band application over or in-between rows. The band width is determined by adjusting the boom height. The common spray angles are 80° and 95° and the operating pressures range from 100 to 200 kPa (15 to 30
psi).

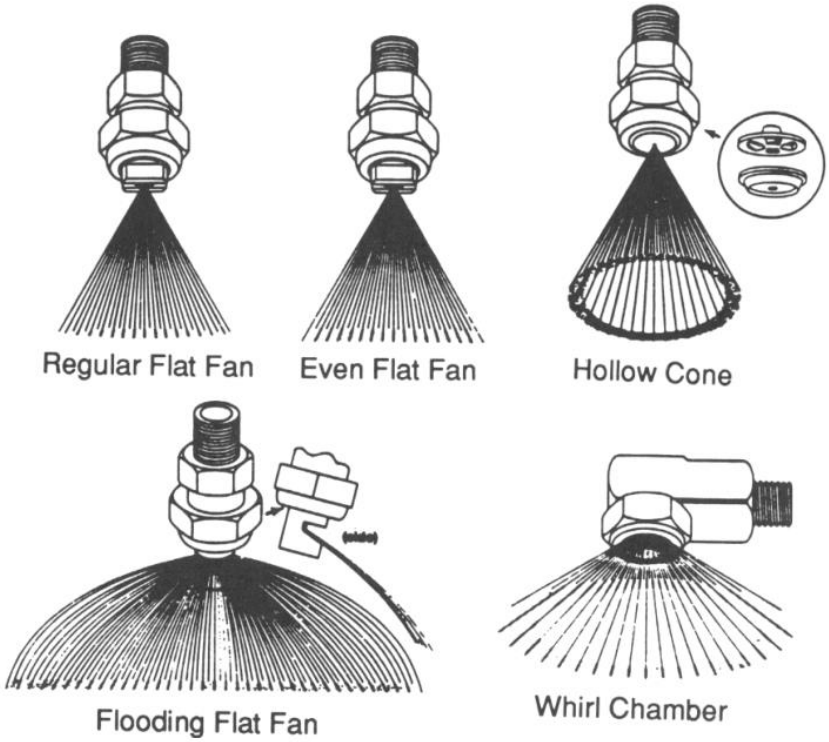


Fig.9.6 Type of nozzles

c. Flooding flat-fan nozzles

These nozzles produce a wider spray pattern than the other flat-fan nozzles. They are most suited for broadcast applications where uniform surface application is critical. Uniform spray application is obtained by 100% overlap of individual spray patterns. These nozzles produce large droplets and reduce drift, when operated at 55 to 170 kPa (8 to 25 psi) pressure.

d. Hollow-cone spray nozzles (both disk and core types)

These utilize a two-piece, disk-core, hollow-cone spray tip. The core gives the fluid a swirling action before it is metered through the orifice disk, resulting in a circular, hollow-cone, spray pattern. These nozzles are most suited for directed spray in row-crop applications

when drift is not a concern, as these nozzles are operated at 275 to 550 kPa (40 to 80 psi) pressures.

e. Whirl-chamber hollow-cone nozzles

These nozzles have a whirl-chamber above a conical outlet that produces a hollow-cone pattern of cone angles up to 130°. These nozzles are best suited for broadcast surface applications of herbicides. For best results the nozzle is tilted towards the rear at a 45° angle. The operating pressure ranges from 35 to 138 kPa (5 to 20 psi).

Tractor Mounted Boom Sprayer

These are hydraulic energy sprayers. They utilize PTO power of the tractor to operate the pump of the sprayer. Basically, the spray boom can be arranged in two ways; ground spray boom and I overhead spray boom. The overhead spray boom is designed for tall field crops and the planting is done in such a way that it leaves an unplanted strip of about 2.5 m width for operation of the tractor. Therefore, a planted strip may be 18-20 m wide and after every planted strip a fallow strip has to be left for tractor operation. For ground spray boom the planting has

to be done in rows keeping in view track width of the tractor. It is suitable for use when the crop is small. The sprayer essentially consists of a tank which is made of fibre glass or plastic, pump assembly, suction pipe with strainer, pressure gauges, pressure regulators, air chamber, delivery pipe, spray boom fitted with nozzles. The complete sprayer is mounted on 3-point linkages of the tractor. It uses high pressure and high discharge pump as the number of nozzles may be up to 20 depending upon the crop and make of the sprayer.

Fig. 9.7 Tractor mounted boom sprayer

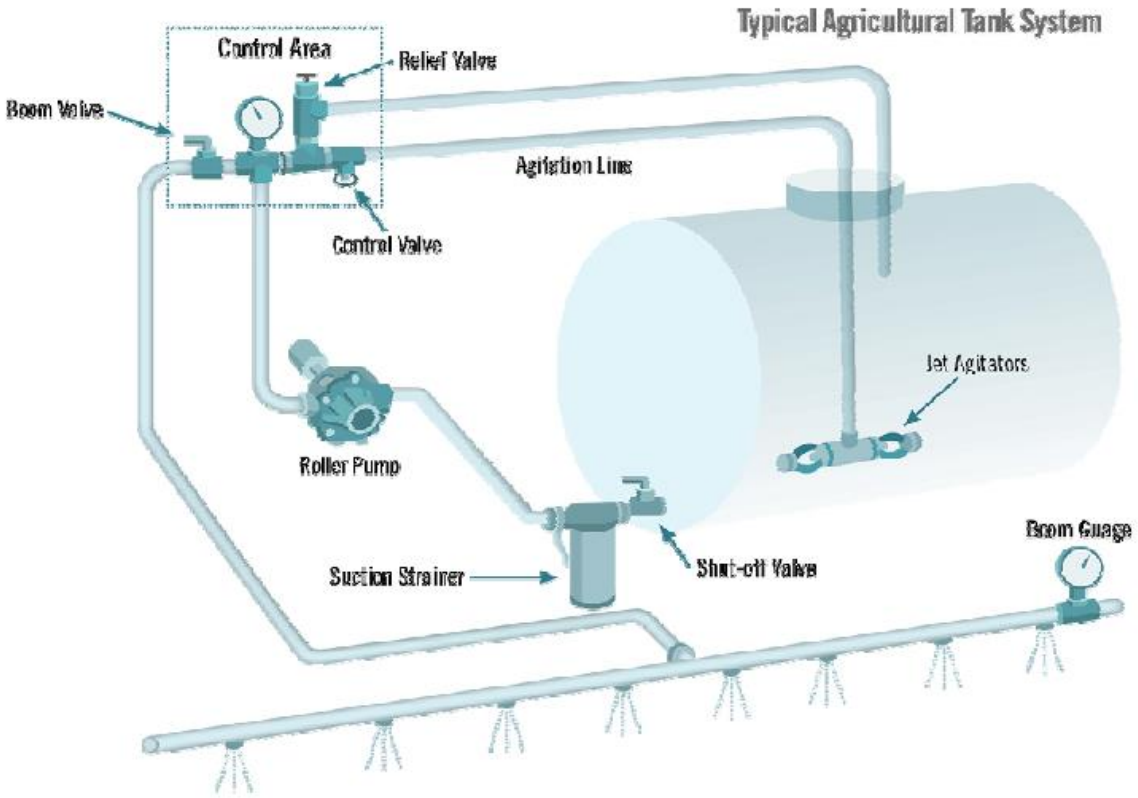


Fig. 9.8 Construction lay out of boom sprayer

9.2 Dusters

Duster is a machine to apply chemical in dust form. Dusters make use of air streams to carry pesticides in finely divided dry form on the plants. A duster essentially consists of:

(a) hopper,

(b) agitator,

(c) feed control,

(d) fan or blower and

(e) delivery nozzle.

9.2.1 Types of Dusters

- Hand operated
- Power operated
    1. Plunger type
    2. Knapsack type
    3. Rotary type
    4. Power operated duster

Plunger type hand duster

This machine consists of a chamber for the dust, outlet, a cylinder with piston, piston rod and handle. Sometimes the dust chamber is placed below the cylinder. By moving the piston back and forth in the cylinder, dust is forced through the outlet. This type of duster is suitable for dusting a small area.

Fig. 9.9 Plunger type hand duster

Power duster

The power duster of small capacity is generally mounted on the back of the operator. It consists of cylindrical container, blower, high speed engine and discharge hose pipe. The cylindrical container is provided with two compartments, one for gasoline, and the other for the powder to be dusted. The blower is directly mounted on the crankshaft of the high speed (4000 rpm) air cooled engine. The air pressure is utilized to agitate the dust in the container in order to blow it through the flexible hose pipe. The direction of the dust is regulated by a movable delivery spout suitably fitted with the unit. The dust can be blown up to about 6 meters height. Such a duster can cover about a hectare in a day. This type of duster can be converted into a sprayer with little modifications. Portable type power dusters are also in use. They are mounted on two-wheel trolleys.

Rotary type hand duster

This type of duster is provided with an enclosed fan geared to a hand crank and a hopper holding the dust. It is equipped with an agitator to stir the dust and a regulator to control the discharge opening. The duster is usually fastened to the operator by means of shoulder strips. The right hand is used for cranking and the left hand to guide the discharge tube. These dusters can hold about 3.6 to 4.5 kg of dust and are large enough to treat 0.4 to

0.6 hectare of cropped area in a day. Ordinarily they are not found suitable for dusting over 3 meters height. The line diagram of Rotary type hand duster is shown in Fig.

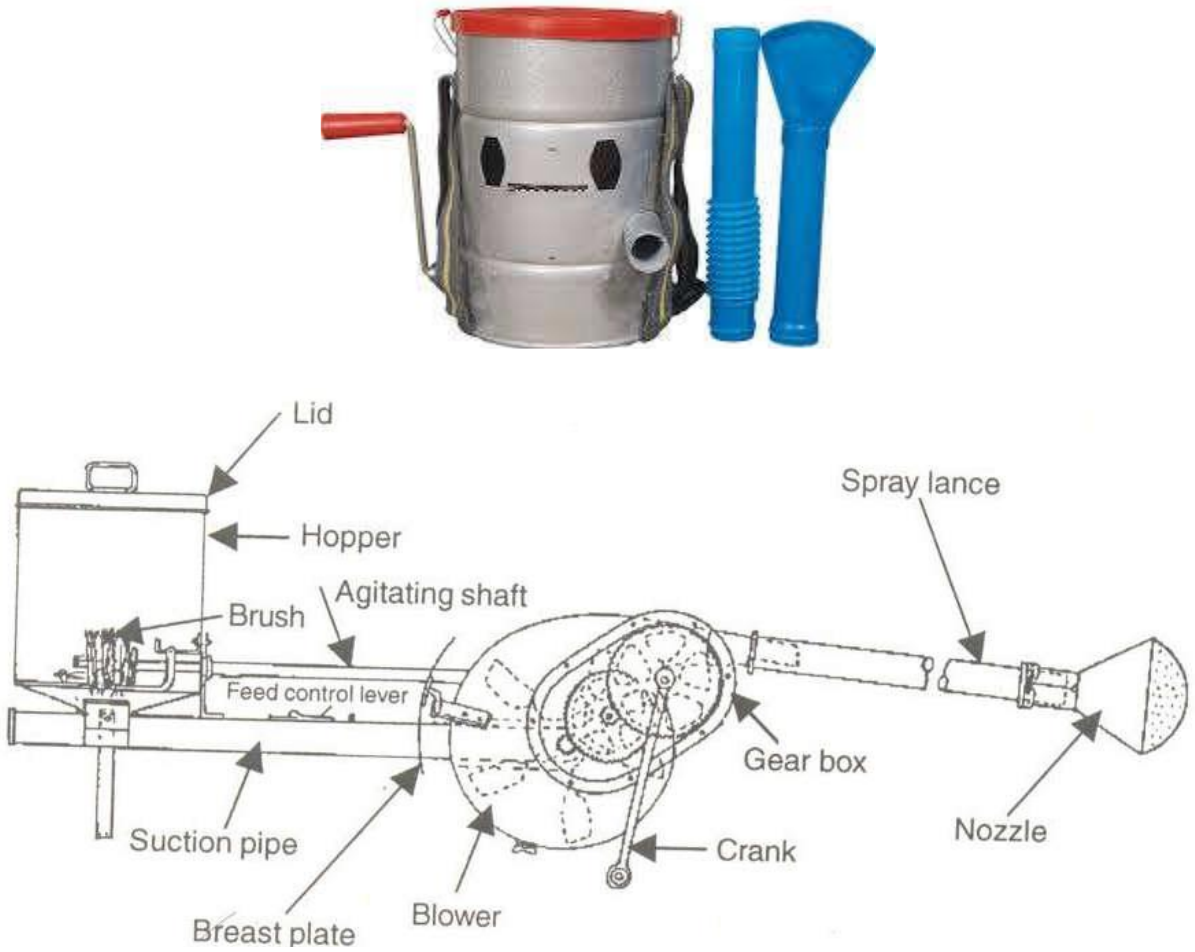


Fig. 9.10 Components of rotary type hand duster

9.2.2 Care and maintenance of sprayer

(i) All washers and packings should be soaked in oil or water before use.

(ii) The ends of the nozzle should be unscrewed and cleaned before starting the work.

(iii) When spraying is over, the sprayer should be operated for some time with clean water to remove sediments from the pressure vessel and the discharge tube.

(iv) Special attention has to be paid in case of power sprayers for the following:

(a) Lubricating oil of the engine should be changed for every 100 working hours unless otherwise advised by the manufacturers.

(b) Do not disturb the packing until a leak is observed.

(c) The spray pump should not be worked at more than recommended pressure.

(d) Oil level in the pump of the engine should be checked every time and all grease points should be greased once in a day.

(e) Recommended oils and fuels should always be used in the engine.

(f) Nozzle should be thoroughly cleaned after use by blowing air through it.

Chapter-10

THRESHING MACHINERY

Introduction

Threshing is the process of removal of grain from the plant by striking, treading or rubbing. Common methods of threshing are threshing by manual labour, threshing by animals, and threshing by machines

Threshing by manual labour

It is done either by treading the grain under the feet of men or striking the grains with stick or striking the plant against a hard object. It is a slow and labour consuming process. It is suitable for small quantity of harvests and output is 17-20 kg grains per hour.

Threshing by animals

Threshing by animals is very common method used in villages**.** In India, the indigenous method is bullock treading in which the crop is spread on threshing floor in a circle, and bullocks are made to walk on it in circular path. The repeated trampling under the bullock feet results separation of grains from straw. The trampling is continued till the grains are completely separated from straw. On an average, a pair of bullocks can thresh 140 kg grains per hour. With the advancement, farmers started the use of dragging devices like rollers, wooden planks, disc harrow and finally Olpad thresher.

Threshing by machines

If the farmers get busy in threshing crops manually, it will not be possible for them to spare time for timely preparation of land for the next crop. Delayed threshing will cause not only spoilage of grains, but also increase the broken rice percentage during milling. To meet this requirement, threshing either needs to be delayed or the farmers are bound to use 11 power threshers. The delayed threshing accounts huge grain losses. Hence, the use of stationery thresher (a faster method of grain detachment) is a viable option. The machine used for the purpose of grain detachment and separation is called a thresher and was introduced in India during 1960. With the increase of mechanization in farms, many new threshing machines are getting popular day by day. Threshing can be achieved by three methods: rubbing action, impact and stripping.

Olpad thresher:

It is a mainly a wheat thresher. It is said to have origin at a small place named Olpad in Gujarat state. It consists of 14 to 21 plain or serrated disks mounted on a rectangular wooden or iron frame in three axils with bearings, on which a seat and a platform are

provided. It is operated by pair of bullocks. Output is 75 kg of grains per hour and Rs. 3.00 to 3.50 per quintal cost of threshing, which is almost half the cost of bullock trampling. The thresher is useful for threshing wheat, barley, gram etc., on a threshing floor. This thresher has three to four wheels to facilitate its movement from one place to another place.

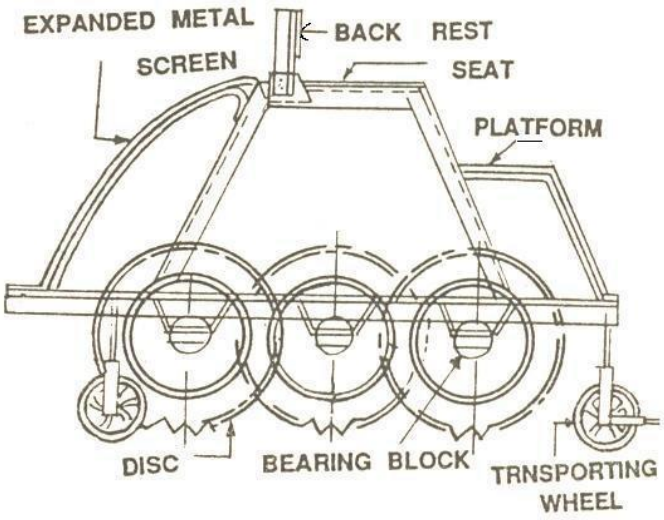


Fig.10.1 Olpad thresher

Principles of Threshing

Removal of grains from the plant stalk is done by rotating cylinders, whose threshing action depends primarily upon impact. “Hold-on” and “Throw-in” are the two major types of threshers available in India.

Hold-On thresher

The plant stalks are held in bundles against the rotating cylinder and the grains are stripped off and collected. Eg. Pedal operated paddy thresher.

Throw-in thresher

Plant stalks are fed into the machine continuously which produces grain and threshed straw in the respective outlets. Eg. Power thresher or all crop thresher.

Pedal operated paddy thresher

Pedal operated paddy thresher is a manually driven medium size thresher for threshing paddy. The pedal operated paddy thresher consists mainly a well-balanced threshing cylinder, driving mechanism and supporting frame.

Threshing cylinder

The cylinder is usually available in two sizes. One size is about 450 mm in length when one man operates thresher. The other size is 700 mm in length when it is to be operated

by two persons. The threshing cylinder is made with iron or wood and suitably reinforced at its center for proper rigidity. The cylinder is usually made with wooden, to make the thresher light in weight. The cylinder is provided with a series of threshing teeth in the shape of loops fixed on wooden slats all round its circumference. The diameter of the cylinder used on common threshers is about 43 cm but its width may vary from 40 to 76 cm. The cylinder is supported by two ball bearings on the frame.

Drive mechanism

The drive of the pedal operated thresher is of eccentric type. Drive consists of a crank, one end of which is connected to a spur gear. The other end of the crank is connected suitably to the pedal frame fulcrum, which is welded to the pedal frame. The normal operating speed is about 400 revolutions per minute.

Gear housing: Gear housing is made of cast iron. It consists of two spur gears provide an over-all ratio of 1:4 speed gain from a pedal, to achieve a cylinder speed of 400 rpm.

Crank: The crank is made of mild steel bar.

Pedal frame fulcrum: The fulcrum is made of either mild steel tube or a bar.

Pedal frame: It is made of mild steel flat.

Pedal board: The pedal board is made of wooden plank.

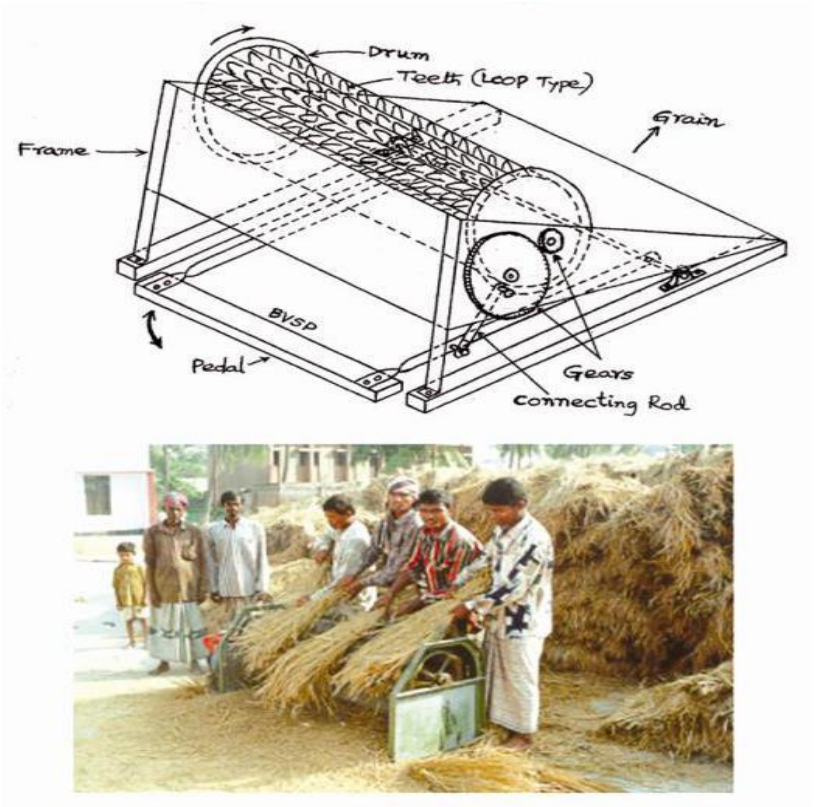


Fig.10.2 Pedal operated paddy thresher

Supporting frame

The body frame of the thresher consists of the base, the side frame, the front grain shield and rear grain shield.

Base: The base is made of mild steel angle section or wood. It is suitably fixed to the side frame of the body.

Side frame: The side frames are made of mild steel angle section. The side frame support side boards, which are usually made of mild steel sheet.

Front grain shield: The front grain shield is made of wooden plank of about 12 mm thick and is fitted suitably to the side frame.

Working Principle

Threshing of paddy crop is done by holding the bundle against the teeth of the threshing cylinder. While the cylinder is rotated at high speed, the paddy bundles of suitable size are held against the teeth. The grains are separated by the combing as well as by hammering action of the threshing teeth. The grains are thus separated or combed out easily. The direction of the cylinder is marked on it. If the mark is not there, the cylinder shall be operated in such a way that the grains are thrown away from the operator. This type of thresher has become very popular among small farmers. The capacity of the single man operated pedal operated thresher is about 1.5 to 1.9 quintals per day. The cost of threshing will be about Rs. 6/- per quintal of grain.

Thresher

Functions of a thresher

Thresher is a machine operated by a prime mover such as electric motor, engine, tractor or power tiller, used for threshing. It performs the following functions such as:

1. To feed the harvest to the threshing cylinder
2. To thresh the grain out of the ear head
3. To separate the grain from the straw
4. To clean the grain
5. To put the grain in a bag
6. To make the chaff suitable for animal feeding.

Removal of grains from the ear heads is done by rotating cylinders, whose threshing action depends primarily upon impact. When a slow-moving material comes in contact with

the high-speed cylinder, the heads or pods are shattered and the grains are separated from straw. Further threshing is done when the material passes through the restricted clearance space between the cylinder and the concave portion of the unit. Output is 200-500 kg grains per hour. **Components of mechanical thresher**

The main components are: (i) cylinder (ii) concave and (iii) cleaning unit.

Cylinder

It is the most important component of the thresher. It is cylindrical in shape and has projections or undulations on its surface arranged in regular array form, to meet the threshing requirement of different crops. It is a balanced rotating assembly, threshes the grain against the bars or teeth of the concave. The cylinders are made of either metal (steel) or well-seasoned hard wood. There are five types of threshing cylinders commonly used in the country.

a) Peg tooth or spike tooth cylinder

b) Rasp bar cylinder

c) Angle bar cylinder

d) Loop type cylinder

e) Hammer mill type cylinder.

Peg tooth cylinder:

The threshing cylinder has rows of projections in the form of short metal pegs. These peg tooth rows are also present on the concave. Teeth on the concave and cylinder are so arranged that, the cylinder teeth pass midway between the staggered teeth on the concave. The concave assembly is pivoted at the rear portion of the machine. Clearance space between the cylinder and concave can be adjusted according to the requirement by swinging the concave. As the stalks pass through the clearance space, the grains get separated from the ear heads due to impact and stripping action between the teeth. Peripheral speed of the cylinder is about 1500-1800 m3/min.

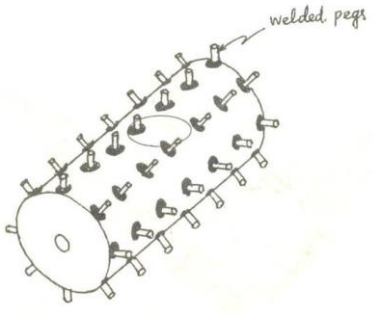


Fig.10.3 Peg tooth cylinder

Loop type cylinder:

The cylinder is studded with a number of wire loops throughout its outer periphery. This is mostly used on paddy threshers. Thick wires are bent as loops and are arranged in rows on the cylinder surface. Smooth surface of the loops gives gentle combing action, which does not damage the grains.

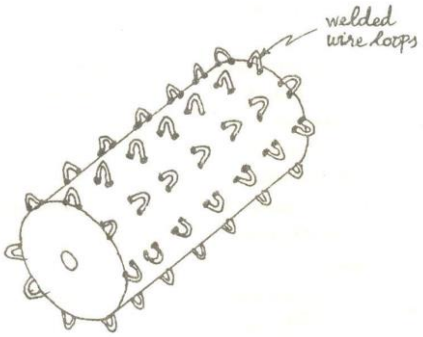


Fig.10.4 Loop type cylinder

Angle bar cylinder:

Cylinders of this type are provided with angle iron bars, helically fitted on the cylinders. The bars are provided with rubber pads on their faces. The concave unit is fitted with a rubber faced shelling plate and steel jacketed rubber bars. The clearance between the cylinder and concave unit at the entrance is from 13 to 19 mm and reduces to about 6 to 9 mm at the end. The threshing action caused by the straight bars is through sudden impact, whereas threshing action caused by helical bars are smooth.

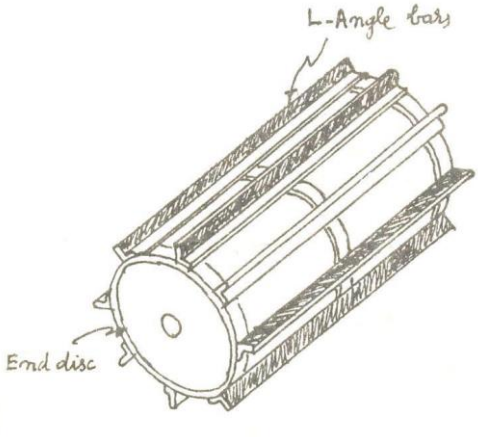


Fig.10.5 Angle bar cylinder

Rasp bar cylinder:

Rasp bars are thick cast flats with inclined ridges or serrations. The cylinder has corrugated rasp bars around it. Threshing is accomplished between corrugated cylinder bars and stationery bars of the concave portion. The rotating cylinder takes the grains out from the

ear heads as it is drawn over the bars on the concave unit. Usually, 6 to 8 bars are fixed on the cylinder in straight or helical configuration. Rasp bars are generally used in all-crop threshers.

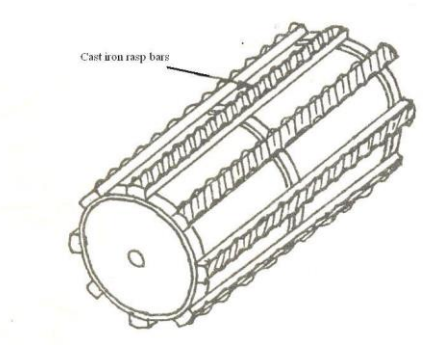


Fig.10.6 Rasp bar cylinder

Hammer mill cylinder:

Beaters or hammers of the hammer mill cylinders are metal pieces hinged at one end so that it swings freely. The beaters are in the shape of hammers of a hammer mill. These are attached to the beater arm at the tip. Beater arms are rigidly fixed to a hub, which is mounted on main shaft. The hammer assembly is arranged inside a closed cylinder casing and concave. When the cylinder rotates, the swinging beaters fly away and become straight and stiff and perform the threshing. If the hammers come across heavy obstruction such as stone, the hammers swing back without damaging the concave and the cylinder elements.

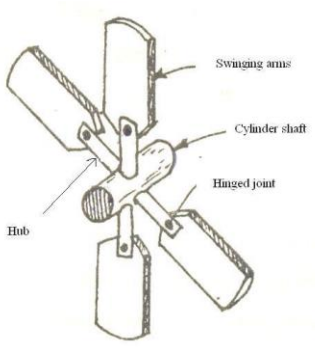


Fig.10.7 Hammer mill cylinder

Concave

It is a concave shaped metal grating, partly surrounding the cylinder against which the cylinder rubs the grain from the plant or ear heads and through which the grains fall on the sieve.

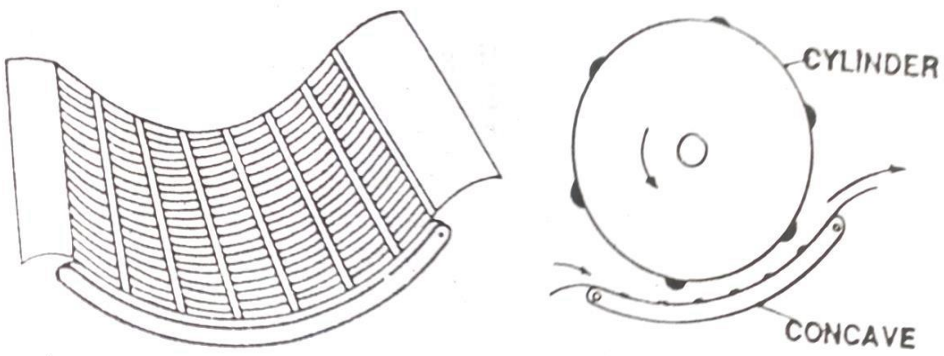


Fig.10.8 Cylinder and concave

Cleaning unit

The function of the cleaning unit is to separate and clean the threshed grain. The cleaning unit mainly consists of two or more oscillating sieves, a fan and an air sucking duct known as aspirator. The aspirator is used for cleaning the grain by drawing air through the grain mass. Usually it contains two ducts, one is primary duct and other is secondary duct. The function of the primary duct is to remove major portion of straw, dust and other foreign matter. The secondary duct is used for final cleaning of the grains.

All-crop thresher

The all-crop thresher is a high capacity threshing machine, with a rasp bar cylinder and open grate concave. With proper adjustment of cylinder speed and cylinder-concave clearance, paddy, wheat, maize, jowar, bajra and other cereal grains can be threshed quickly and economically. Feeding hopper, threshing cylinder, concave, straw rack, beaters, blower and sieve assembly are the various components of all-crop thresher. A 5 H.P. oil engine or electric motor or power tiller is required to drive the machine. A flat or V- belt drive can be used.

Sunflower thresher

India has the third largest area under sunflower and accounts for 10% of the world acreage. Sunflower, an oilseed crop, is grown in Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, Uttar Pradesh and Madhya Pradesh. The separation of seed from sunflower head is generally done manually (beating with stick), bullock trampling and tractor treading. These processes are cumbersome, time consuming and total losses are also high which directly affect the quality of produce.

Wire mesh type thresher:

It consists of a square frame having each side of 600 mm and a height of 200 mm and is made up of 30 × 30 × 3 mm MS angle. Wire mesh with mesh size of 10 × 10 mm is welded with the main frame and serves as the threshing surface. The workers rub the cubs over the wire mesh and the seeds are dropped at the ground, which are collected later and cleaned manually.

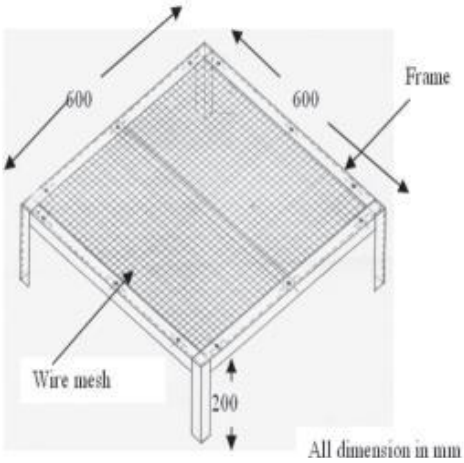


Fig.10.9 Wire mesh type sunflower thresher

Power operated sunflower thresher (3.75 kW capacity) has been developed at ANGRAU, Hyderabad centre of AICRP on FIM which has good output capacity (200 kg/h) and efficient threshing. An axial flow sunflower thresher has been developed by the PAU centre of AICRP on FIM, giving 6-9 q/h output and 100% threshing efficiency.

Decortication

The process of obtaining kernels from the stripped groundnut pods is known as decortication. Mostly decortication is usually done by breaking the shell by hand pressure 89 under the thumb. Manual decortication by hand is laborious, expensive and less productive. But now, the commercial hand and power operated groundnut decorticators are being used in the country. Both these machines work on the same principles. The main difference lies in their capabilities. After decortication, separation of grain from a mixture of grain and split shells is done in an air stream. The separation is achieved by allowing the air stream created artificially or naturally and passing the mixture vertically down, perpendicular to the air blast. The grain being heavier gets collected almost at the place of dropping, whereas the lighter material (split shells) is blown away to a greater distance. The hand operated one has a capacity of about 200 kg/h and the mechanical decorticator has 500 kg/h capacity.

The Groundnut decorticator performs essentially three operations namely 1) Feeding groundnut to the shelling unit, 2) Shelling groundnuts and separating nuts from the shell and 3) Cleaning the nuts from the mixture.

Classification of Manual type Decorticators

Manual type groundnut decorticators are further classified into:

(a) Hand operated rotary decorticator

(b) Pedal operated rotary decorticator.

(c) Hand operated " rocking type" decorticator.

Hand operated rotary type decorticator

It consists of a wooden or cast-iron shelling drum and a steel grate. Shelling of the nuts is accomplished in the clearance between the drum and the grate. The output of the machine is 0.4 to 0.6 quintals of pods/hour.

Pedal operated rotary type decorticator

It is operated by foot. The motion from the foot pedal is transmitted to the cylinder through a connecting rod and a set of spur gears. This machine provided with a fan. The fan is operated by means of pulley mounted on the cylinder shaft. The kernels are separated from the shell by the winnowing fan.

Hand operated rocking type decorticator

It consists of the following parts: (a) angle iron frame, (b) trough of radius 28 cm (c) steel handle, and (d) beaters. The beaters are fixed to the handle at the bottom and operate in to and fro motion.

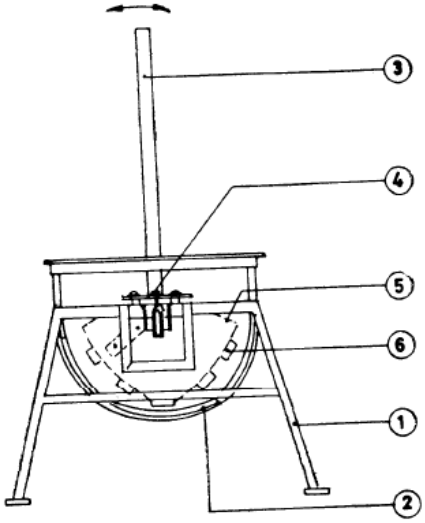


Fig.10.10 Hand operated groundnut decorticator

1.Stand 2. Sieve 3. Handle 4. Cleaning adjusting 5. Oscillating sector 6. Pegs

The pods are put into the trough and the handle is operated to and fro to decorticate the pods. The decorated pods are collected beneath the through. It requires two persons to operate and can shell 1 to 1.25 quintals of pods/hour. It can also be run by a small 1.5 Hp engine.

Power operated rocking type decorticator

A power operated groundnut decorticator requires 8 hp engine to shell about 75 to 80 bags (1875 to 2000 kg) of groundnut per hour. The machine has to perform the following functions: (a) Feeding of groundnuts to the shelling unit, (b) Shelling of groundnuts and separating nuts from the shell and (c) Cleaning the nut from the mixture. It consists of the following main parts: Feeder mechanism, Shelling unit and Crushing section. The feeder mechanism consists of a hopper, feeder shaft and pawl and ratchet wheel to drive the shaft. Groundnuts are fed to the machine at a uniform rate. Feed rate can be varied by adjusting the stroke of the pawl. The shelling unit is provided with two main parts, namely crushing plate and a grate. The crushing plates are made of close-grained semi steel. Six small externally grooved channels are mounted on radial arms of the main rotor shaft which rotates at about 110 rpm.

As the main rotor shaft is operated, the external grooved surface channels, roll and shell groundnuts. The crushing plates are bolted to the externally grooved channels and mounted at an angle resulting in unequal gaps on both ends between the plates and the grate. The minimum uniform gap of 2.5 to 3.2 cm between the lower edge of the plates and inner surface of the grate gives satisfactory operation. The grate is composed of a flat steel bars placed horizontally on their edges with a small space between the bars can be done by changing the thickness of the washers used on them, to suit any size of pods. A fan, which is operated at 450 rpm by the main rotor shaft, is the basic part of the cleaning section. The blades of the fan are made of iron sheets bolted to angle iron arms on both sides. The blast of air created by the fan is strong enough to blow away the broken empty shell, so that the heavy nuts fall into the bottom pan by gravity.

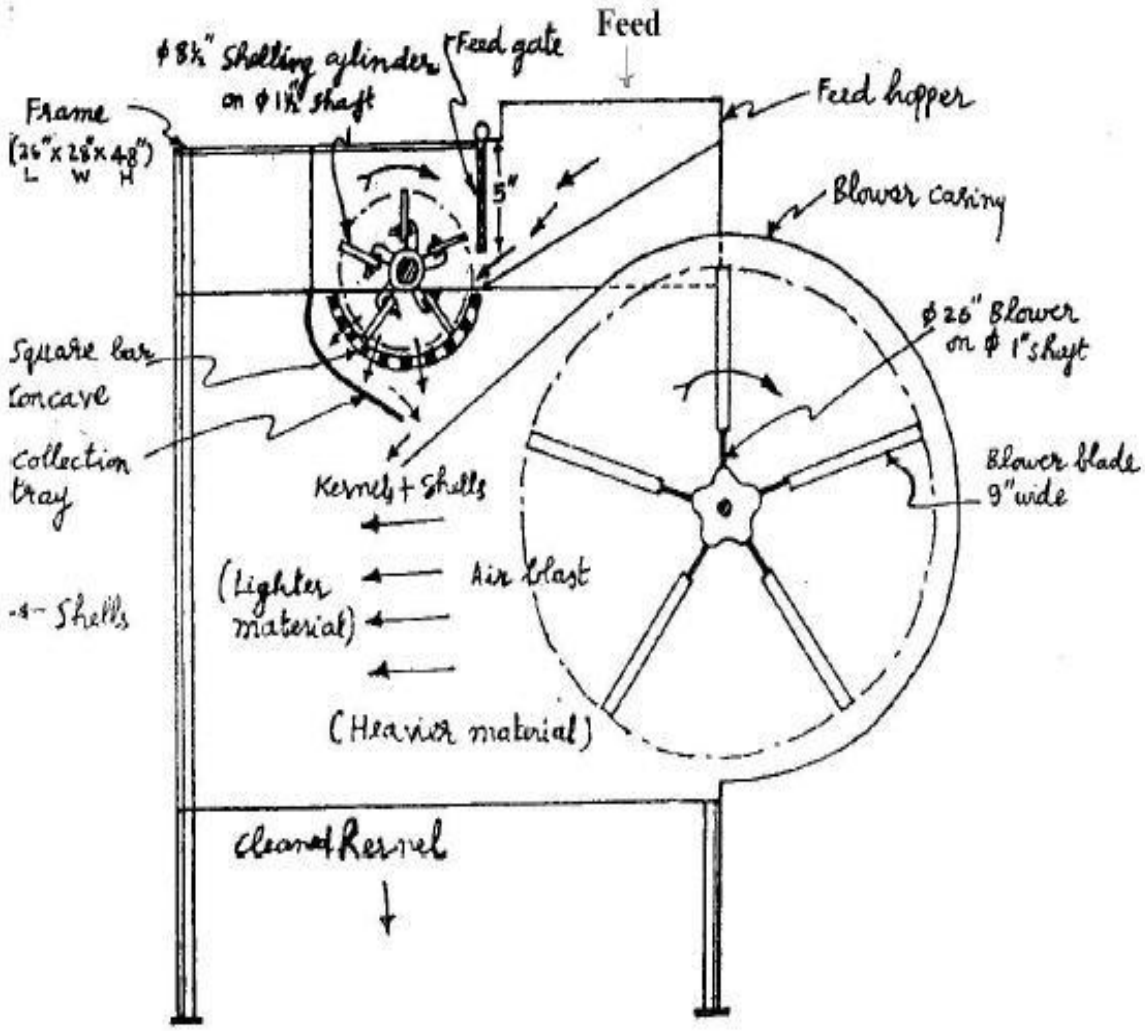


Fig.10.12 Power operated rocking type decorticator

ANGRAU castor sheller

This castor sheller was developed at Farm Implements and Machinery (FIM) Scheme, ANGRAU, Hyderabad. The machine can be operated by two persons and has a working capacity of 100 kg/h. Cleaning of the shelled kernels should be done separately. The breakage of beans in hand operated sheller is less than 2.0%.

Working principle: The chief component of the sheller is the wooden ribbed cylinder or drum of 320 mm length and 380 mm diameter. The other parts are concave, cylinder cover, feeding chute, discharge chute, drive mechanism and crank. The clearance between the cylinder and concave can be adjusted to shell different sizes of castor beans. Since the force required to break the shell and release the seed is moderate, wooden ribbed cylinder is the proper choice, which produces lesser broken seeds and also reduces the overall weight of the

machine. Shelling cylinder is operated by crank through a gear unit which increases the speed of the cylinder.

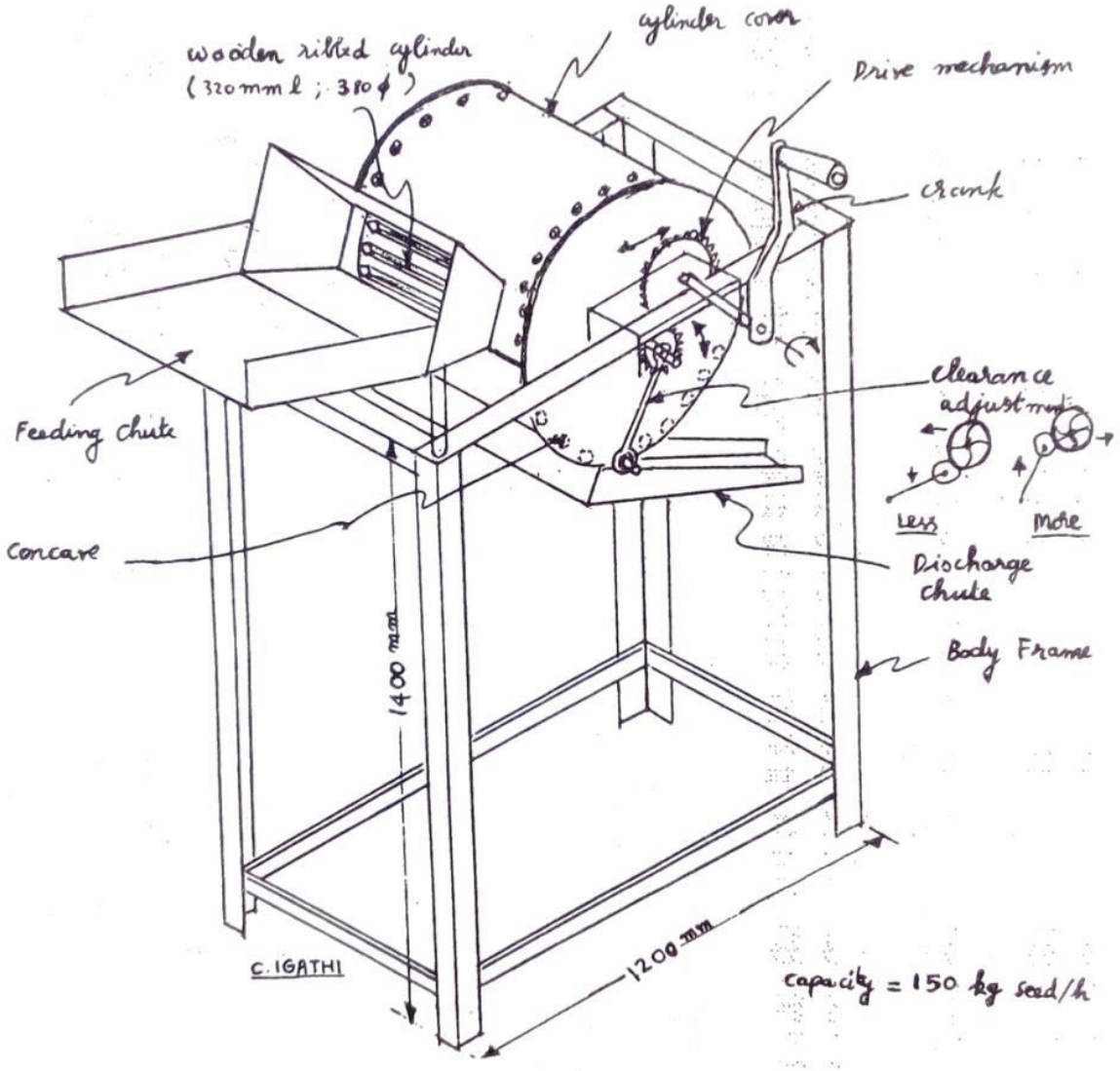


Fig.10.13 Hand operated castor sheller

The dried pods fed to the inlet chute will be gradually fed to the clearance and shelling takes place due to crushing and rubbing action between the cylinder and concave. Shelled output consists of the seeds and broken hull pieces, which can easily be separated by a manual cleaning process of winnowing. While the unit is in operation, one person operates the sheller by cranking and another is required to feed, collect and clean the materials.

Sugarcane Crusher

Crushing: When an external force applied on a material excess of its strength, the material fails because of its rupture in many directions. The particles produced after crushing are irregular in shape and size. The type of material and method of force application affects

the characteristics of new surfaces and particles. Food grain flour, grits and meal, ground feed for livestock are made by crushing process. Crushing is also used to extract oil from oilseeds and juice from sugarcane.

Crushing rolls

In agricultural operations crushing rolls are mainly used for extraction of juice from sugarcane. The crushing rolls are of two broad types; (1) smooth-roll crusher and (2) serrated or toothed-roll crushers.

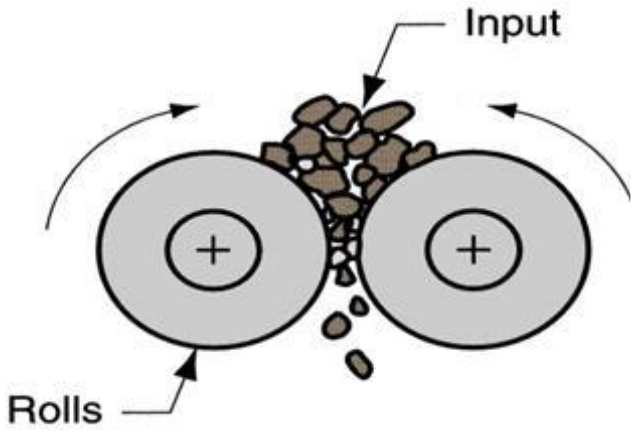


Fig. 10.14 Schematic diagram of a smooth roll crusher

Two heavy smooth-faced metal rolls rotating towards each other at same speed on parallel horizontal axes are the working elements of the smooth-roll crusher. The size of the articles/material that can be caught by the rolls depends upon the coefficient of friction between the material and the roll surface and can be estimated by the following equation

$$dp=0.04R+g$$

Where, dp = maximum size of particle

R = roll radius

g = half of the width of gap between the rolls

The rolls exert great force and to avoid any damage to roll surface because of some unbreakable material coming with the feed, at least one of the rolls should be spring loaded. Apart from extraction of juice the smooth-roll crushers are used to make grits or meal from food grains. These are also extensively used for making food grains flakes.

Chapter-11

WINNOWING AND CHAFF CUTTERS

Winnowing

Winnowing is the process of separating grain from a mixture of grain, chaff and other impurities in an air stream from a natural or artificial source. The winnowing operation is very common in India. It is done on the threshing floor where the entire harvested crop is threshed. Usually, one or more persons pour the threshed material with a basket from slightly above their own height. For more effective cleaning, they shake the basket while pouring the mixture against the effective direction of air stream. Before the winnowing is started, the threshing floor is thoroughly cleaned and sometimes plastered with cow dung, so that the soil may not mixed with the grain. Winnowing of crops like paddy, in which chaff is very small fraction is accomplished in one operation only. But the second winnowing becomes necessary for cops like wheat, barely, gram etc, in which *bhusa* (chaff) constitutes about 1/2 to 2/3 of the total weight of the mixture.

Principle of winnowing

Separation is achieved by allowing the air stream to pass through the mixture falling vertically down. Density difference of the components of mixture, namely, heavier grain, lighter chaff and bhusa, is responsible for separation when suspended grain is in air steam. The grain being the heavier material gets deposited almost at the place of dropping, whereas the lighter material (chaff) is blown away to a greater distance.

Winnowing Devices

The following devices are commonly adopted for winnowing process:

1. Winnowing basket 2. Winnowing fan 3. Winnower

Winnowing basket

The use of winnowing basket is the oldest and common method of winnowing in India. It makes use of the natural wind, which is very frequent and effective at the time of harvesting. For this purpose, a convenient place is selected, high enough from the general field level. The thresher grain is collected near the winnowing platform. One man stands on the platform with the basket full of grain to be winnowed. Keeping his hand up and continuously stirring the basket, very slowly, he drops the grain. As the grain falls, the broken straw and chaff, being lighter than the seed, are taken at a far distance by the blowing wind. The grain being heavier than the straw, falls very near to the platform. Thus, two heaps are formed, one of grain and the other of straw, which are collected separately.

11.3.2 Winnowing Fans

When the natural wind velocity is not adequate, artificial means are used to create a sufficiently strong air blast. Winnowing fans either manually operated or mechanically operated, are mostly used. Manually, operated fans of various types are available for use in India. Most often, the hand operated or pedal operated winnowing fans are used by farmers. In either case, the fan blades create a steady blast of air at the front side of the fan. One or more workers standing on the front side can drop the threshed material for effective separation. The distance where the threshed material is poured on the front side of the fan has the most important effect in winnowing. Some of the experiments performed with a pedal operated winnowing fan revealed that effective cleaning could be obtained at about 1.8 m distance from the fan, along its central line.

Various type of hand operated and pedal operated winnowing fans are being manufactured by many firms in India. The number of blades on their impellers is either three or four. The diameter of the impellers vart from about 0.90 to 1.25 m. Mostly, the blades are made of mild steel sheet and their frames are made of either wood or welded steel or a combination of the two. In order to increase the rotational speed, various driving mechanisms are employed, namely sprocket and chain, V-belt pulleys and single or double reduction gears. All these fans are without casing around the impeller and they are expected to be operated in the speed range of 200-350 rpm.

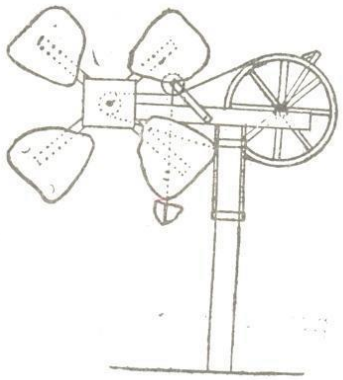


Fig.11.1 Winnowing fan

Winnower

The winnower consists of wooden or angle iron frame, housing, blower, feed hopper, feed and purity adjustment mechanisms, grain outlet, immature grain outlet, chaff and dust outlets and blower hand wheel with gears and pulley arrangement. Walls of the feed hopper taper towards inside from all sides and ensures gravity flow. Flow of the mixture is regulated

by the feed rate adjustment mechanism, which makes the mixture to fall as a thin stream perpendicular to the air current, is essentially a gate obstructing the flow below the feed hopper. Blower consists of four curved blades mounted horizontally on a shaft with two ball bearings. The shaft carries a small gear (pinion) at its one end that meshes with a bigger gear. The bigger gear is rotated by handle provided at its periphery. On the other end of the shaft, a V-belt pulley is attached for possible mechanized operation and also it acts as a flywheel. Ring gear has 66 teeth and the pinion has 20 teeth giving a speed ratio of 3.3: 1 or 4:1 i.e., the diameter of big gear is 3.3 or 4 times bigger than the pinion. For one revolution of bigger gear will give four revolutions to the blower. Thus, if the handle is turned at a speed of 50 revolutions per minute (rpm), the blower will rotate at a speed of 165 or 200 rpm. The sieve is placed in front of the fan at the lower end of the winnower. A set of sieves are supplied with machine to suit the different sizes of grains. These sieves have holes of 12, 8, 6, 4, 3 and 2mm diameter. The sieve is reciprocated by an eccentric roller which gets its motion from the axle of the blower. The reciprocating action of the sieve permits the grains and dirt particles to fall down, while the straw is blown out.

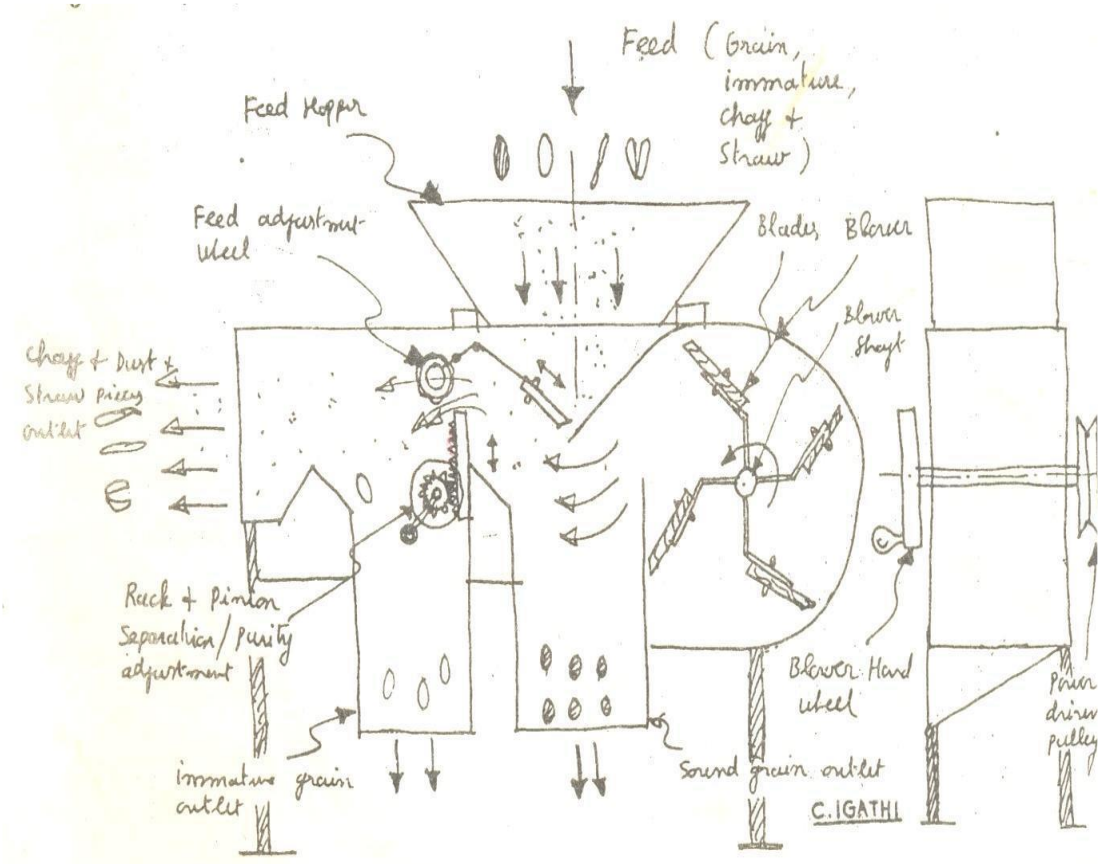


Fig.11.2 Winnower

Chaff cutters

Green fodder crops are essential food requirement for on-farm animals. These fodder crops are harvested from the field daily either by sickles or reapers. Then crop is collected from the field and carried to the farmhouse where it is cut into small pieces. This is done to save storage, to aid in curing and to make it more palatable. The cutting of fodder into small pieces is done either manually using 'Gandasa' or by using manually or power operated chaff cutters.

Flywheel type Chaff cutter

It consists of a cast iron flywheel and radial mounted knives. Straight knives are used on power chaff cutters and curved knives on hand chaff cutters. The number of knives varies from two to six depending upon the type of chaff cutters and size of chaff desired. Hand operated chaff cutters are provided with two knives only. Some power chaff cutters of large size have blower used for silo filling. The average working speed of hand chaff cutter is 50 rpm with one knife and 35 rpm with two knives. The power operated chaff cutters are operated at working speed of 600-1000 rpm. For proper cutting of silage, knife should operate close to the shear plate without striking. Clearance between the shear plate and knife can be adjusted by a set of screws provided for the purpose. The knife is fastened on the flywheel by means of two or three counter sunk bolts.

Fig.11.3 Flywheel type chaff cutter

The size of chaff or length of cut can be changed by changing the speed of feed rollers. Hand operated chaff cutters are provided with a two-speed worm for adjusting the length of cut whereas two or three speed gearboxes has been provided on power operated chaff cutters. Reducing or increasing the number of knives on the flywheel can also changes

the length of cut of silage. This can be done easily on the hand operated chaff cutters. On power operated chaff cutters, length of cut of silage can be adjusted by increasing the speed of cutter head. The length of cut of silage varies from 20-40 mm and for green fodder 25-50 mm or sometimes more.

The capacity of the chaff cutters can be calculated by:

$$\mathbf{C = 60 \times 10\text{-}3\ D\ L\ W\ H\ n\ N} \text{ ---------- (1)}$$

Where,

C = capacity of machine, t/h

W = width of throat, m

H = height of throat, m

L = length of cut, m

N = number of knives on the flywheel

n = speed, rpm

D = bulk density, kg/m3

Length of cut of chaff can be determined by

Chapter-12

RICE MILLING AND WHITENING

Paddy or rice grain consists of husk and brown rice. Brown rice, in turn, contains bran which comprises the outer layer and the edible portion. Rice milling is removal or separation of husk (de husking) and bran to obtain the edible portion for consumption. The process has to be accomplished with care to prevent excessive breakage of the kernel and improve recovery of paddy or rice. The extent of recovery during milling depends on many factors like variety of paddy, degree of milling required, the quality of equipment used, the operators, etc. Milling is the process wherein the rice grain is transformed into a form suitable for human consumption, therefore, has to be done with utmost care to prevent breakage of the kernel and improve the recovery. Brown rice is milled further to create a more visually appealing white rice.

Husking

Husking or de-hulling is a process for removing the rice hull from the paddy without damage to the bran layer and rice kernel. Husking machines are known by different names such as huskers, de huskers, shellers and hullers.

12.1 Types of huskers

a) Impact type paddy husker

The working principle of the impact or centrifugal type husker is based on the utilization of impact and frictional force for husking of paddy. In the impact type husker, paddy is thrown against a rubber wall by a rotating disc. The impact on the rubber wall due to the centrifugal force of the rotating disc causes cracking to the hulls with a minimum damage to the kernel.

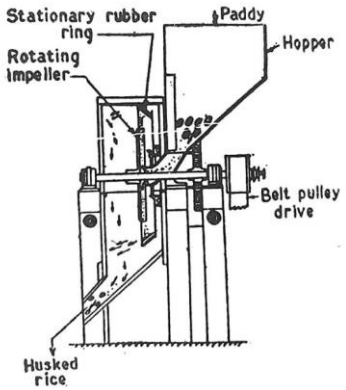


Fig.12.1 Impact type paddy husker

b) Rubber-roll Sheller:

Rubber-roll Sheller consists of two rubber rolls rotating in opposite direction at different speeds. A feeder feeds paddy uniformly to the machine. Paddy is fed in thin layers between the rotating roll by the feeder. One of the rolls is fixed while the other is adjustable to obtain desired clearance between them. The rolls are driven mechanically and the adjustable roll normally runs about 25% slower than the fixed one. Difference in surface speeds of rolls develop a shearing force on grain surface resulting in the opening and breaking of husk.

The clearance between the roll is kept smaller than the thickness of paddy grain. This clearance should be about half the thickness of paddy and may be adjusted subsequently by judging the shelling efficiency. If the gap between rolls is properly adjusted, this equipment can shell up to 95% of paddy fed to it. At decreasing gap excess pressure results which cause more breakage of grain and can also cause colouring of shelled rice. In modern machines, the gap between the rolls is adjustable by suction methods, as per need this gap is automatically maintained.

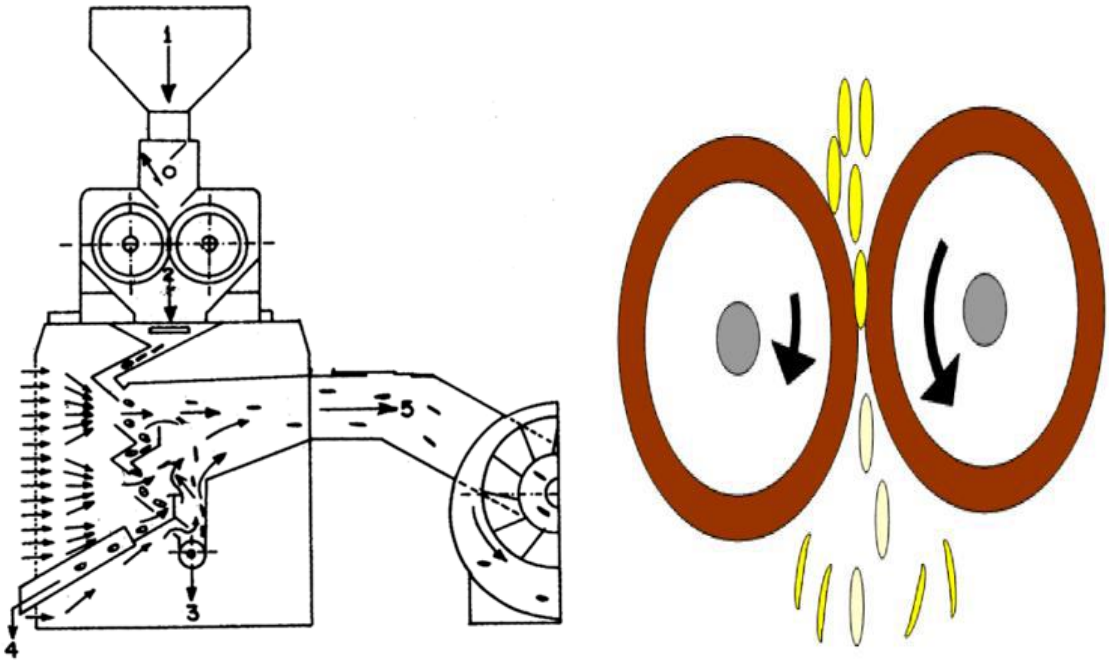


Fig.12.2 Working principle of rubber roller husker

Advantages

(1) High percentage of sound and whole husked rice is produced as the risk of breaking the kernel is small.

(2) The mixture of different sizes and varieties of paddy can be used without any significant increase of brokens in husked rice.

(3) It does not remove germ.

Disadvantages

(1) Operation costs are high due to wear of rubber rolls.

(2) Storage life of rubber roll is limited as storage deteriorate its quality and shortens working life.

(3) Requires skilled labour to operate the machine.

(4) The husking capacity of the rubber rolls in tropical countries is low due to high temperatures and humidity, structure and large surface area of long husk.

12.2 Types of Whitening Machines

White rice is produced from brown rice by removing the bran layer and the germ. The bran layer is removed from the kernel by applying friction to the grain surface either by rubbing the grains against an abrasive surface. It is also termed as "whitening". The amount of bran removed is normally between 8-10% of the total paddy weight but this will vary according to the variety and degree of whiteness required. The process used to whiten brown rice can be classified as either abrasive or friction.

Abrasive whitening

In this process the grain is whitened by the abrasive action of the rice kernel passing between a moving abrasive surface and stationary screen. The hard-rough surface is usually stone or a carborundum type material. The abrasive process peels off the bran layers from the brown rice and applies less pressure on the grain than a friction process and is therefore better suited for long grain varieties. Abrasive polishers can be either vertical or horizontal in design. The vertical cone whitener is very common in many Asian countries.

Friction whitening

In the friction whitener the grain kernels are forced against each other and a metal screen by a steel-ribbed cylinder rotating inside a metal-plated cylinder. The frictional forces created between individual rice grains and between the grains and the metal screen surface remove the bran layer from the grain. Friction polishers are always horizontal in design and apply more pressure on the grain than an abrasive whitener.

Three kinds of whitening machines are widely used in the rice processing industries, (1) the vertical abrasive whitening cone, (2) the horizontal abrasive Whitening machine.

a) The Vertical whitening cones

This machine basically consists of a cone shaped cast iron cylinder with an abrasive coating. The entire rotating cone is encased within a fixed perforated metal sheet known as crib. The

gap between the abrasive surface and the crib is about 10 mm. It is provided with rubber brakes, placed vertically and spaced equally which protrude into the gap between the abrasive cone and the crib. The clearance between the rubber brake and crib is about 2-3 mm. The pressure inside the whitening chamber can be adjusted by pushing in or pulling out the rubber brakes.

Brown rice is fed into the centre of the machine through a hopper. Feeding of brown rice is adjusted by a sleeve which also uniformly distributes the brown rice to entire surface of cone. The centrifugal force generated by rotation of cone feed the brown rice between the cone and wire mesh. Rubber brakes restrict the movement of rice, thus, applies pressure. As a result of pressure, brown rice is pressed against the abrasive coating of the cone.

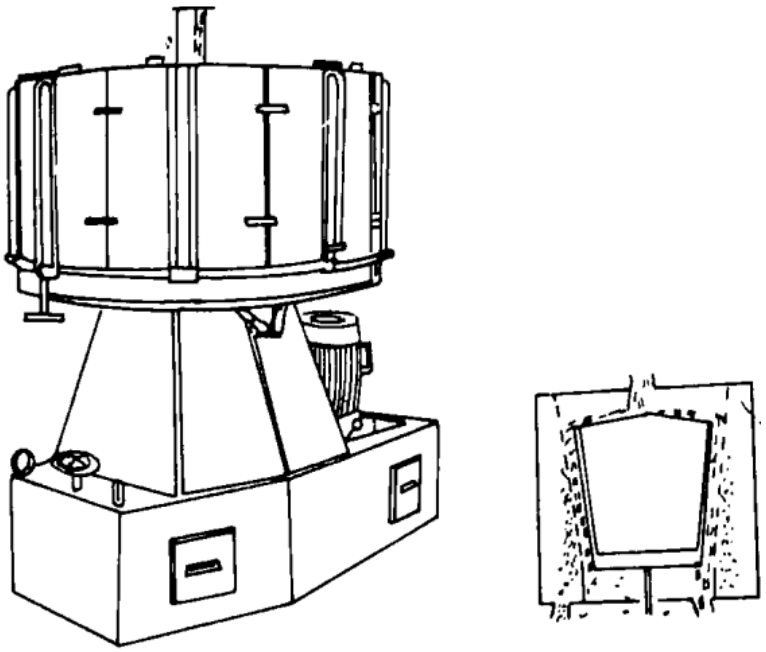


Fig.12.3 Vertical Whitening Cone

This friction removes bran layer, and partly or fully whitened rice leaves the cone through a self-unloading discharge spout. The peripheral speed of the cone should be about 13 m/s, thus larger the diameter of cone, lower the speed of shaft. Vertical whitening cone removes the bran from the brown rice by friction, and the friction produces heat. For removing all the bran in one pass, the residence time of the grain is increased and the clearance between cone and screen is reduced. This results in generation of heat and causes much breakage and reduces total rice recovery. It is therefore, recommended that the bran layer be removed in three or even more passes.

b) Horizontal abrasive whitener

The machine consists of an abrasive roll operating in a cylindrical metal perforated screen which is horizontally mounted. The screen cylinder covers the emery roll leaving a uniform gap where brown rice is fed through a *small screw* conveyor. The emery roll rotates while the screen cylinder remains stationary. Polishing is obtained due to rubbing of grains with emery roll, screen and rice grain. At the delivery end of polishing chamber one adjustable weight is placed by which degree of polishing is controlled. Adjustable brakes are also fitted to screen cylinder, to help in obtaining required polishing. Bran removed from rice escapes through holes and is aspirated out by a blower. The blower which collects and carries the bran also provides cooling to rice grains, emery roll and screen cage.

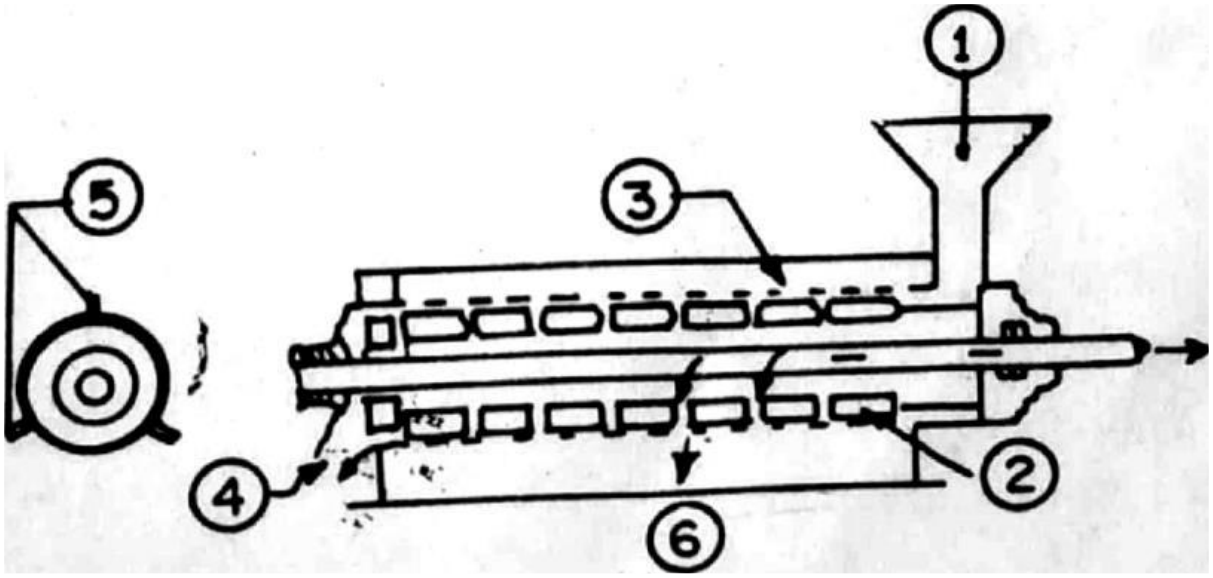


Fig.112.4 Horizontal abrasive whitener

1. hopper 2. abrasive roller 3. screened steel cylinder 4. White rice 5. brakes 6. Bran

Chapter-13
SEED DRYING

Introduction

The moisture content of oilseeds at the time of harvest is usually high and uncongenial for their safe storage. Consequently, all the oil seeds need to be dried prior to their storage. Sun drying is the traditional method used, however its limitation cannot be ruled out. Mechanical drying of oil seeds at 105-110^{0}C is preferable to minimize the quantitative and qualitative losses. The dried seeds also require adequate cleaning to remove sand, dirt, dust, leaves stems, weed seeds, stones, metal pieces, and other extraneous matter storing.

13.1 Methods of drying

13.1.1 Sun drying

This is a traditional method of drying of crops and grains. Sun drying involves using the energy of the sun to remove moisture from the product. Major portion of crops is left in the field and threshing yard for drying under sun. A major quantity of grain is still dried by the sun in most of the developing countries.

The advantages of sun drying are:

1. No fuel or mechanical energy is required.
2. Operation is very simple
3. Viability, germination, baking qualities are fully preserved.
4. Microbial activity and insect/pest infestation are reduced.
5. No pollution
6. Low capital requirement
7. Operating costs are considerable.

The disadvantages of the sun drying are:

1. Uncontrolled and non-uniform drying, results in sun checks or cracks in kernels.
2. Completely dependent on weather.
3. Not possible round the clock and round the year.
4. Excessive losses occur due to shattering, birds, rodents etc. It is usually 0.1 to 0.4%.
5. Require specially constructed large drying floor.
6. The entire process is unhygienic.

7. Unsuitable for handling large quantity of grain within a short period of time.

8. Require large number of unskilled labours.

13.1.2 Mechanical drying

This process utilizes mechanical means to circulate heated air at constant temperature and humidity, through the grain mass to accomplish the removal of excess moisture from the grain. Its features are: (a) The rate of drying can be controlled by adjusting the temperature of hot air circulating through the grain mass. (b) Grains can be dried irrespective of weather condition, day or night; the process does not depend on any natural sources like sun energy. (c) The process is automatic and requires unskilled labour, except a trained person to operate the dryer. (d) there are practically no losses due to birds, rodents and insects. (e) The entire process is hygienic. (f) Possible round the clock and round the year and (g) Suitable for handling of large quantity of grain within a short period of harvest.

Mechanical drying requires very little space for operation. Mechanical drying, in conjunction with early harvest, improves the milling quality of paddy considerably. The disadvantages of mechanical drying are: the process requires fuel and electrical or mechanical power to drive the blower, elevators etc. Therefore, cost of drying is relatively higher compared to sun-drying for commercial drying.

13.1.3 Radiation drying

It is based on the absorption of radiant energy of the sun and its transformation into heat energy by the grain. Sun drying is an example of radiation drying. Heat energy can be supplied to wet product by electromagnetic waves. Wavelength of electromagnetic radiation lies between 0.76 to 400μm. The radiation within this wavelength is also called as infrared radiation. Infrared radiation penetrates the surface of wet material and causes vibration of molecules, which creates thermal effect. Since the penetration depth of infrared waves is relatively small, this method of drying is commonly used for drying of thin materials. The moisture migration inside the material and diffusion of vapor follows the same laws as in convective or conduction drying.

13.2 Classification of Seed Drying

Grain drying is classified based on two principles: (i) Thin layer drying and (ii) deep bed drying.

13.2.1 Thin layer drying

Thin layer drying refers to the grain drying process in which all grains are fully exposed to the drying air under constant drying conditions, i.e., at constant temperature, and humidity. Generally, up to 20 cm thickness of grain bed is taken as thin layer. All commercial flow dryers are designed on thin layer drying principle. The features of thin layer method of grain drying are:

a) Limited to 20 cm of grain depth

b) Drying rate is independent of air velocity

c) At a given RH and moisture content, the drying rate is proportional to the difference between the dry bulb temperatures of air in equilibrium with the grain.

d) The rate of drying is proportional to the difference between the vapour pressure of moisture in the grain and vapour pressure of moisture in the drying air.

13.2.2 Deep bed drying

Deep bed drying process refers to the heterogeneous drying of grain in deep layer (more than 20 cm deep) where drying is faster at the inlet end of drying chamber than at the exhaust end. The drying of grain in a deep bin can be taken as the sum of several thin layers of grain arranged one above another. The rate of moisture removal is maximum for the bottom layer and decreased exponentially for subsequent layers. Dry air becomes cooler and moister as it moves up in the grain bed. Actually, all grains in the drying chamber may be considered to be in 3 zones: (a) dried zone; (b) the drying zone; (c) the wet zone. The dried zone will gradually move upward as drying proceeds in the direction of air movement. The air passes through the dried zone and picks up moisture in the drying zone until it reaches equilibrium moisture content (EMC) in the case of very wet grain. In this way, as the air moves, its drying capacity goes on decreasing. Drying will cease as soon as the product comes in equilibrium with the air. The upper edge of the drying zone at the interface with the wet zone is called the drying front. The drying front indicates the level of grains in the bin at which, the grain has just started losing moisture to the drying air. The volume of drying zone varies with the temperature and humidity of entering air, the moisture content of the grain and velocity of air movement. The drying rate in a bin varies from layer to layer from time to time and depends upon the characters of grains and the air used for drying.

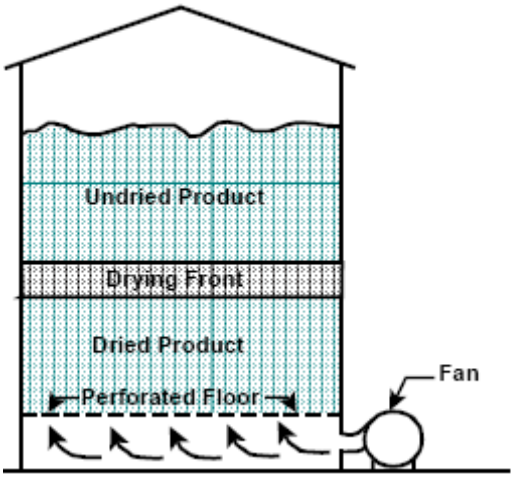


Fig. 13.1 Drying process in deep bin

13.2.3 Deep bed dryer

These are batch type large capacity dryers. Most common shapes of these dryers are round or rectangular. To operate deep bed dryers efficiently following rules may be adhered to.

1. An air flow rate of 2.94-3.92 m3/min per tonne is recommended.
2. If moisture content of grains is up to 18%, the layer depth of grain should be limited to 3m.
3. The net perforated area of the floor should be 15% of the total floor area. Air velocity of 300 m/min through the opening is preferable.

13.2.4 Flatbed dryer

The flat bed batch type dryer is similar to deep bed dryer except that the surface area of the dryer is more and the depth of the drying layer is less. These dryers are of usually 1-2 tonne capacity and are designed for farm level operation. Grains are spread 0.6 to 1.2 m deep over the perforated floor and dried.

Continuous flow dryers

These dryers are columnar type in which wet grains flow from the top to the bottom of dryers. The rate of flow of grains through columns can be regulated by conveyors. Types of dryers

Rotary Dryer

This dryer can be a batch or a continuous type. It is also called rotating drum dryer as it consists of a large drum 2 m in diameter and 3 to 6 m in length, placed on a slight incline. Grain is fed into the upper end and as the unit rotates the grain move downwards and mixes with the air flowing around the grain and finally drops down on the lower end (grain and the

air move in the same direction). This provides a continuous mixing of the grain with the drying air until the grain leaves the dryer at the lower end of the drum. Heated air acts here mainly as a carrier of moisture from the dryer. While traveling the grain from feed end to discharge end of the dryer, the parboiled paddy comes into contact with the steam heated pipes for a very short time in each rotation and is gradually dried. As parboiled paddy can stand high temperature without significant increase of cracks in grains, these dryers can be employed for rapid drying of parboiled paddy using temperatures as high as 100 to 110 ºC. The cylindrical shell of the dryer is rotated at 2 to 6 rpm by a motor through speed reduction gear, pulley and belt drive system. In India, the Jadavpur University, Calcutta introduced a rotary dryer of 1 tonne/hour capacity for the drying of parboiled paddy.

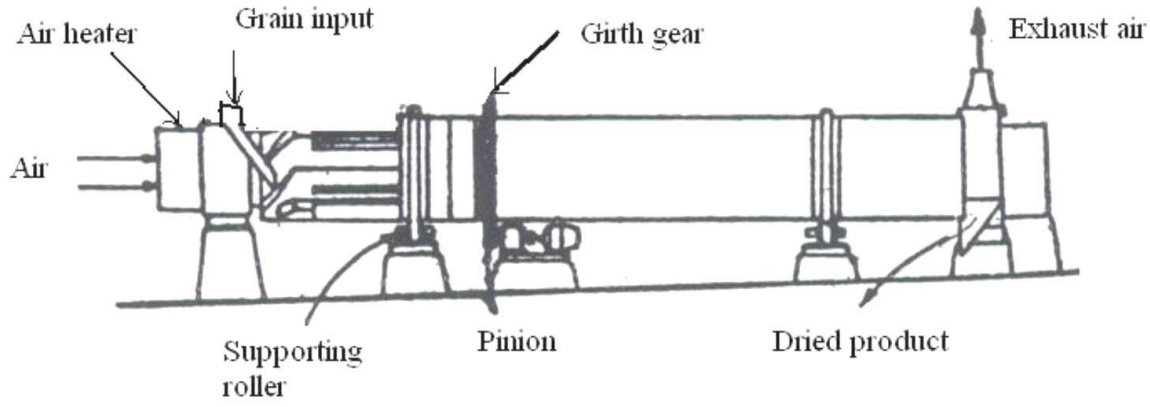


Fig.13.2 Rotary drayer

These dryers are two types namely mixing and non-mixing. If the grains flow in a straight path, the dryer is called a non-mixing type and when the grains are diverted in the dryer, it is called a mixing type dryer.

The main advantages of continuous flow dryers are:

1. A shorter drying period, which is necessary with less danger of spoilage during wet season.
2. Larger volumes of paddy can be dried in less time.
3. Drying losses are less
4. Drying is more uniform as there is mixing of grain with air
5. The milling quality of paddy is better
6. Higher air flow rates could be obtained
7. The drying parameters can be controlled and therefore, also the drying rate.

Recirculatory batch dryer (RPEC dryer):

This is continuous flow non-mixing type of dryer**.** This dryer was developed at Rice Processing Engineering Centre (RPEC), IIT, Kharagpur. It consists of two concentric circular cylinders made of perforated sheets of 20 gauge. The cylinders are set about 20 cm apart, to move the grain downward. These two cylinders are supported on four channel sections. A bucket elevator of suitable capacity is provided to feed and recirculate the grain into the dryer. A centrifugal blower blows the hot air into the inner cylinder which acts as a plenum. The hot air from the plenum passing the grain moving downward by gravity and comes out of the perforated cylinder. A torch burner is employed to supply the necessary heat with kerosene oil as fuel. RPEC dryers are made for half, one and two tones holding capacities.

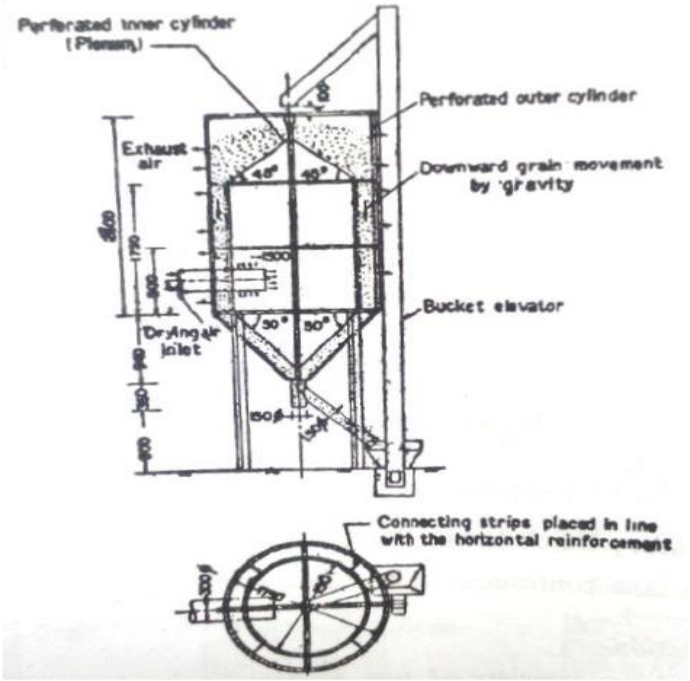


Fig.13.3 Recirculatory dryer

There are several types of continuous flow mixing type dryers. The most popular type in India and USA is the Lousiana State University (LSU) type. Baffle dryer is also a continuous flow mixing type dryer.

Baffle dryer: This is a continuous flow mixing type of grain dryer. The main advantage with the dryer is uniformly dried product is obtained.

a) Construction: The baffle dryer consists of; (1) grain receiving bin, (2) drying chamber fitted with baffles, (3) plenum fitted with hot air inlet, (4) grain discharge control devices and

(5) hopper bottom. A number of baffles are fitted with the drying chamber to divert the flow and affect certain degree of mixing of grain. The dryer is made of mild steel sheets.

b) Operation

Grain is fed at the top receiving bin and allowed to move downward in a zigzag path through the drying chamber where it encounters a cross flow of hot air. A bucket elevator can recirculate the grain till it is dried to the desired moisture level. This design helps in mixing of dried and undried grains.

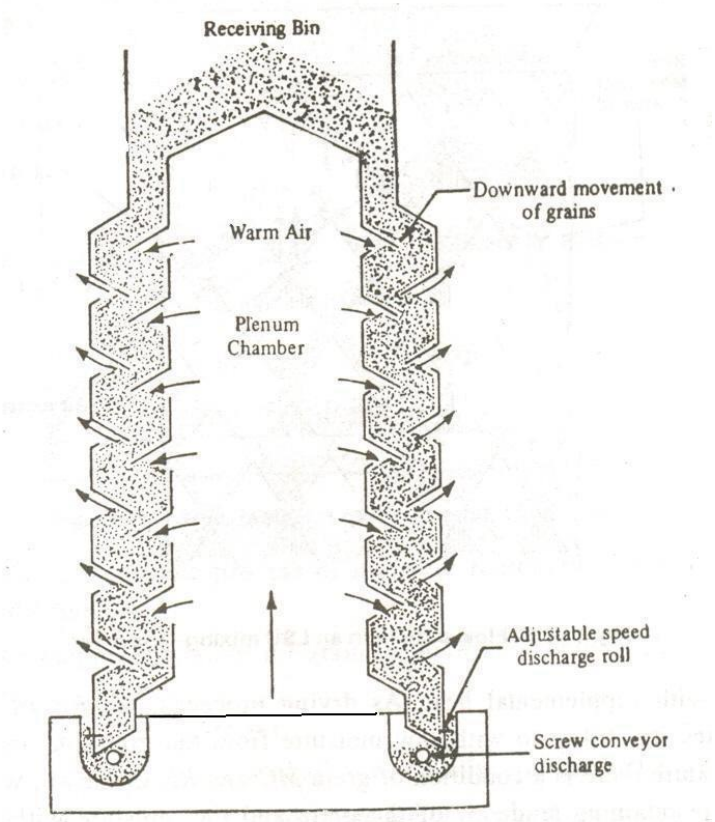


Fig 13.4 Baffle dryer

Louisiana state university (LSU) dryer: This is a continuous flow-mixing type of grain dryer which is popular in India and the U.S.A. It was developed at Louisiana State University, USA in 1949.

a) Construction: It consists of: (1) a rectangular drying chamber fitted with air ports and the holding bin, (2) an air blower with duct, (3) grain discharging mechanism with a hopper bottom, and (4) an air heating system.

(i) Rectangular bin: The rectangular bin can be divided into two sections, namely, top holding bin and bottom drying chamber. Usually the following top square sections of the bin are used for the design of LSU dryers:

(i) 1.2m x 1.2 m, (ii) 1.5 m x 1.5 m

(iii) 1.8 m x 1.8 m and (iv) 2.1 m x 2.1 m.

(ii) Air Distribution system: Layers of inverted trough or V- shaped channels (called inverted V-ports) are installed in the drying chamber. Alternate rows of these ports are opened on the blower and closed on the exhaust end. These are called inlet ports. Hot air enters the drying chamber through these ports. The other alternative rows of ports are closed on the blower end and are opened on the exhaust end. These are called outlet or exhaust ports as the drying air goes out through these ports. The inlet and outlet ports are of uniform sizes and equal in number with equal spacing in between them. Usually the inlet ports are given in 3 columns and outlet ports in 4 columns (2 column of full-size ports and 2 columns of half-size ports). The number of ports containing a dryer varies widely depending on the size of the dryer. The inlet and outlet ports are arranged one below the other in a zig-zag path, so that when paddy flows down between these ports, it takes a zig-zag path. Hot air enters the inlet ports from the blower end. Since these ports are closed on exhaust end, the hot air from these channels or ports flows down through the paddy and enter the outlet ports and leave the drying chamber through exhaust side. Some degree of mixing of hot air and paddy occurs in this chamber while air is flowing across it in zig-zag path and paddy flowing downwards. Three fluted rolls are attached at the bottom, which are rotated at a slow speed. The discharge of the paddy is regulated with these fluted rolls. To provide hot air for drying, fuel is burnt to raise the ambient air temperature. Heat may be supplied by the direct fired burners or direct or indirect heat exchangers.

In general, the capacity of the dryer varies from 2 to 12 tonnes of grain, but sometimes dryers of higher capacities are also installed. Accordingly, power requirement varies widely. Recommended air flow rate is 60-70 m3/min/tonne of parboiled paddy and optimum air temperatures are 60 °C and 85 °C for raw and parboiled paddy respectively. A series of dryers can also be installed. In continuous flow dryers, drying air temperature may be as high as 70 °C, whereas for batch dryers, this temperature seldom exceeds 45 °C.

(b) Advantages

1. Uniformly dried product can be obtained if the dryer is designed properly.
2. The dryer can be used for different types of grains

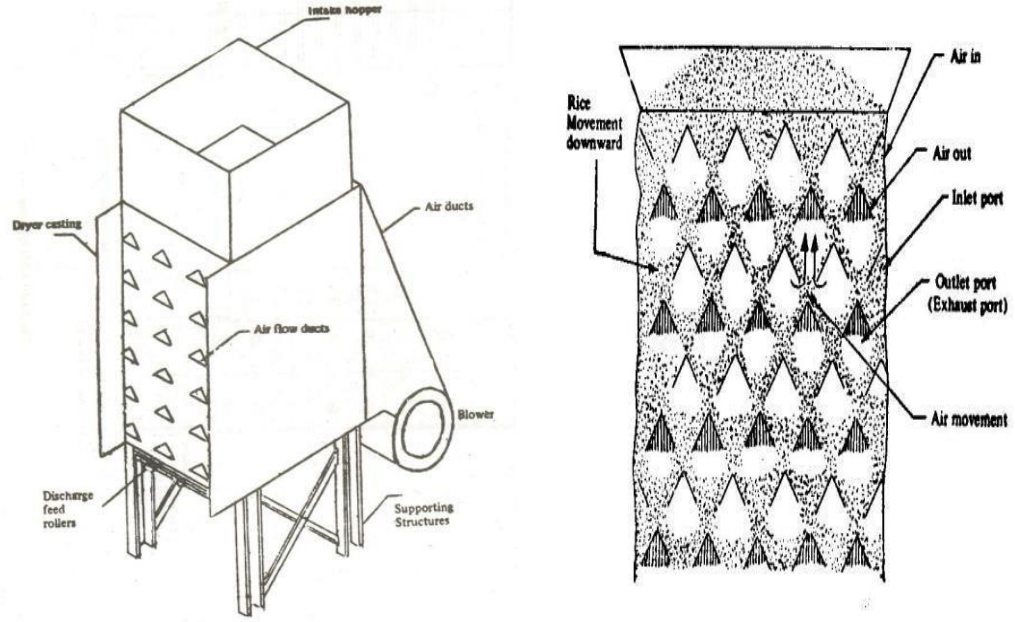


Fig.13.5 LSU type dryer and flow pattern in LSU dryer

(c) Disadvantages

1. High capital investment.
2. Cost of drying is very high if oil is used as fuel.

Following are some recommendations for the drying operation with particular reference to the operation of an LSU dryer:

1. A drying cycle chart in the control room will be a great help and to guide the operator.
2. The dryer should not be operated until it is filled completely with grain.
3. The recommended drying air temperature is 60 °C and the air flow rate is 70 cu m/min/ton of holding capacity of dryer.
4. Tempering in between drying process is recommended to reduce the total drying time. Normally, this tempering period is of 8-hour duration.
5. Feed roll clearance should be the same for all the fluted rolls for uniform drying.
6. The grain temperature during drying should not exceed 40 °C.
7. The burner should be started only after the blower has been started.
8. There should be appropriate controls to put the flame off in case of blower failure due to either power or mechanical failure. An automatic fuel cut-off valve is recommended for this purpose.

Chapter-14

GRAIN STORAGE STRUCTURES

Causes of Food Grain Losses

There has been a spectacular increase in food grain production in India. The annual production was 208.6 million tonnes in 2005-06. However, there has only been a marginal increase in the structure for grain storage. This has resulted in losses both in quality and quantity of the harvested grain. The qualitative loss may be due to chemical changes in the protein, carbohydrate and fat and by the contamination of mycotoxins, pesticide residues, insect fragments, excreta of rodents and birds and their bodies. The quantitative loss in storage may be on account of the activities of the birds, rodent, insects, enzyme activity of microorganisms etc. The losses in quantity also occur in threshing yards, processing plants and during handling. It is roughly estimated that about 60% of the total grain produced is retained by the farmers for their food and seeds. The remaining 40% quantity is considered as marketable surplus. The total storage capacity available with various agencies of the Government is of the order of about 15%. It is obviously quite in adequate and needs to be increased considerably in order to reduce losses. The main factors responsible for the losses in quality and quantity of grain are insects, rodents and dampness. Damage by insect pests' results in the food grain becoming weevilled, causing losses not only in weight but also in food value. Leakage of water through roof, and dampness in the structure through floors and side walls make the grain deteriorate in many ways. One of the several effects is excessive oxidation which causes a rise in temperature of the grain, including its heating and cake formation. Moisture also encourages fungus, mould and termite growth, at times rendering the entire grain stock unfit for human consumption. Beside this, rats cause serious loss by eating or breaking the grains into pieces

Requirement of Good Storage Structures

A good storage structure should satisfy the following requirements: (1) It should provide adequate protection from rodents, birds, insects, mites etc. (2) It should permit aeration and fumigation when required. (3) It should prevent losses due to moisture and temperature etc. (4) It should permit easy inspection. (5) It should facilitate proper cleaning and should be self-cleaning if it is silo. (6) It should be economical on unit storage cost basis.

14.1 Types of Storage Structures

Bukhari

Bukhari type structures are generally used for the storage of wheat, gram, paddy, maize and sorghum. Their capacity varies from 3.5 to 18 tonnes. The structure is cylindrical in shape and is made of mud or combination of mud and split bamboos. It is always placed on a wooden or masonry platform to avoid contact with ground. Roof is made of bamboo frame work and paddy or similar straw over the structure. Enough overhang is provided to protect it from rains.

In improved type structures, circular floor is made of wooden planks joined together with lap joints or a double layer of bamboo splits closely set at right angles to each other. Walls are made of two sets of sufficiently strong bamboo framework and the hollow space between is filled with rammed mud. Hollow rat proofing cones are placed on all the four pillars of support so that rats are not able to climb up.

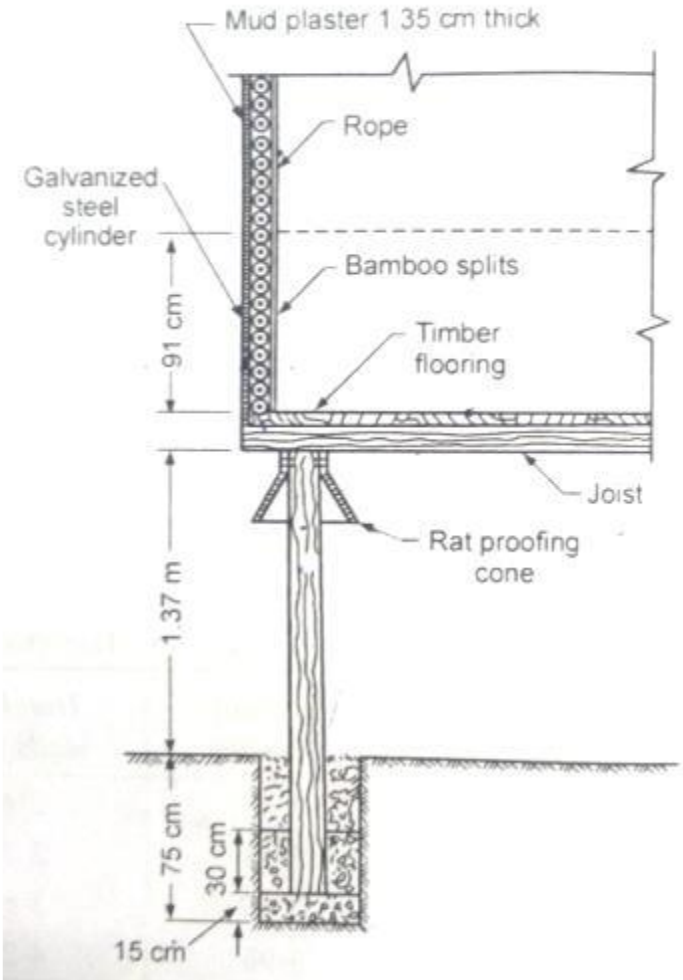


Fig.14.1 Bukhari type structure

Kothari

Capacity of these structures range from 9-35 tones and are used to store paddy, maize, sorghum, wheat and barley. Both floor and walls are made of wooden planks whereas the thatched or tiled roof is placed over it as protection from sun and rains. Improved structures are made of 5 cm thick wooden planks and beams. The gabled roof on the top may either be made of planks or 22 gauge (0.644 mm) corrugated metal sheets. The structure is commonly built in the rural areas of Jammu and Kashmir, Himachal Pradesh Uttarakhand and U.P.

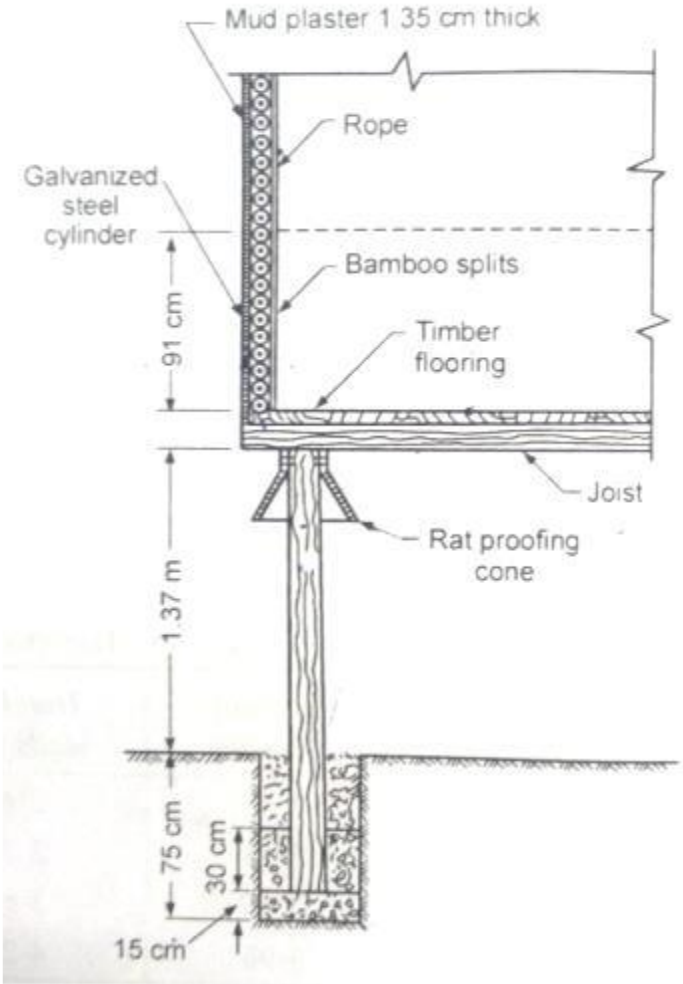


Fig.14.2 Kothari type structures

Morai

It is used to store paddy, maize and sorghum in the rural areas of eastern and southern regions of India. Its capacity varies from 3.5-18 tonnes. The structure consists of circular wooden plank floor supported on pillars by means of timber joints. The planks are joined together with lap joints. All around the wooden floor a 22-gauge corrugated metal cylinder of 90 cm height is nailed to it. Edge of the cylinder is flushed with the bottom end of floor. Inside the cylinder, 7.5 cm diameter ropes made of paddy straw or similar material are

placed, beginning from the floor level up to a height of 90 cm. then, bamboo splits are placed vertically along the inner surface without leaving any gap between them. Height of bamboo splits is equal to the total height of metal cylinder. Winding of the rope as well as the pouring in of grain are done simultaneously. Top most ring of rope is secured in position by tying to the lower four rings. A conical roof is placed on the top of structure having an ample overhand all round.

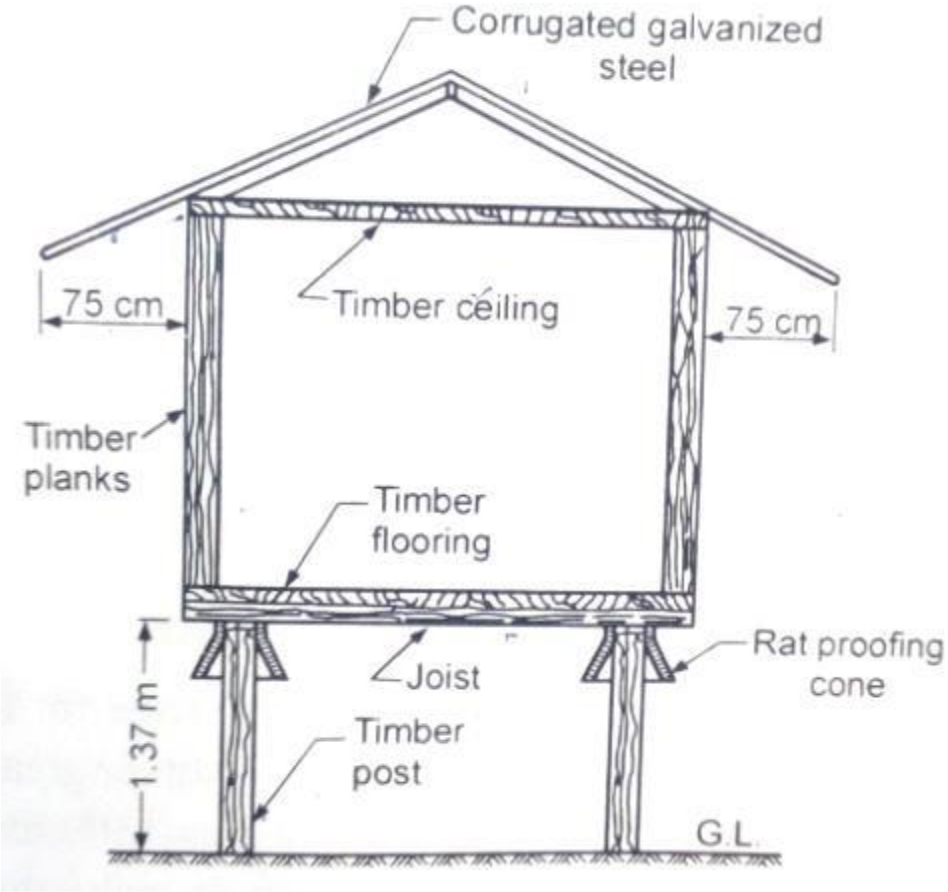


Fig.14.3 Morai type structures

Pusa grain bin

The Pusa bin was developed by Indian Agricultural Research Institute (IARI), New Delhi. It is a scientific storage bin in which LDPE film is sandwiched between two layers of inner and outer mud storage structure. This bin is popularly known as Pusa bin. The 59 LDPE film prevents moisture entering the bin and the mud walls keep the stored grain free from the effects of temperature changes.

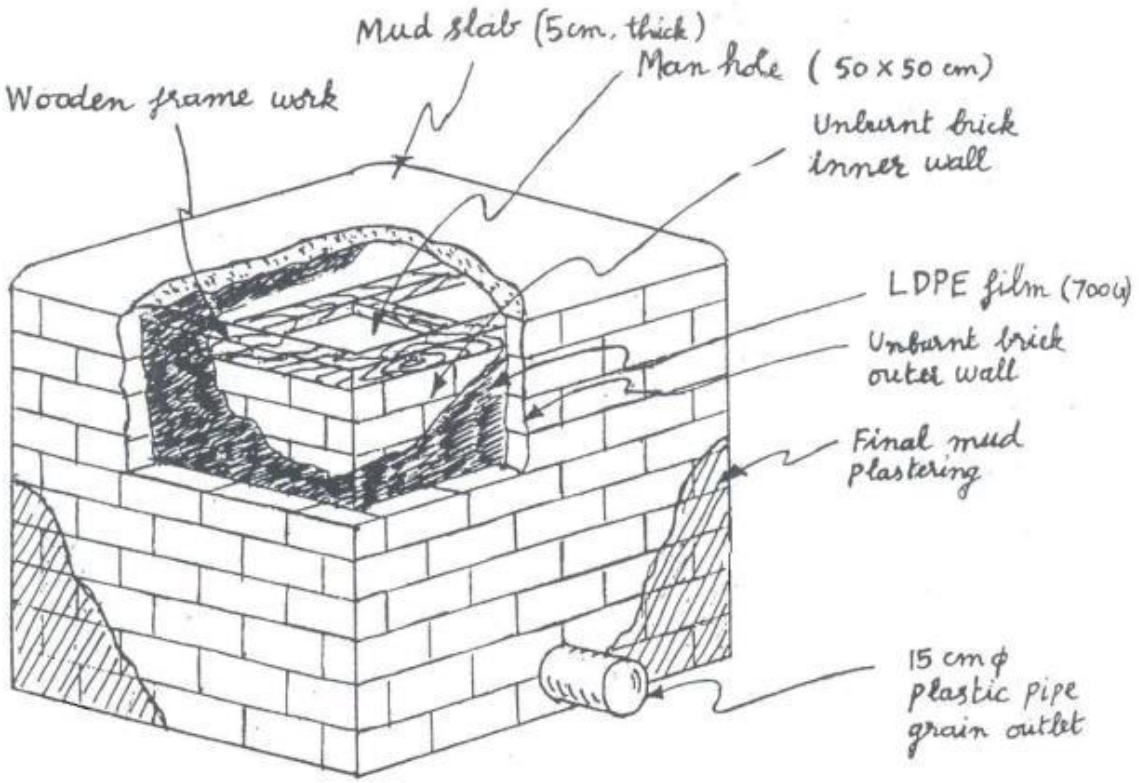


Fig.14.4 Construction details of Pusa bin

Cylindrical grain bin (RCC bin)

Cylindrical bulk storage structures are being used for storing different varieties of grain. Depending upon the size, the capacity may vary from 10 to 40 tonnes. The complete structure including its foundation is made of reinforced concrete. The minimum height of the bottom edge of spout should be about 1.2 m above the ground level. The entire structure rests on supporting columns. There are two openings provided in the structure for filling the grain and for taking it out. The top hole is made large enough to let a man enter for cleaning purposes. The size of the outlet is comparatively smaller. The outlet is placed at a point where the slope from all sides of the floor converges. It should have a hinged cap shutter with a locking device. The manhole at the top is also provided with a water tight steel lid. The roof on the top is provided with enough slope on all the sides and it overhangs to the extent of about 30 cm.

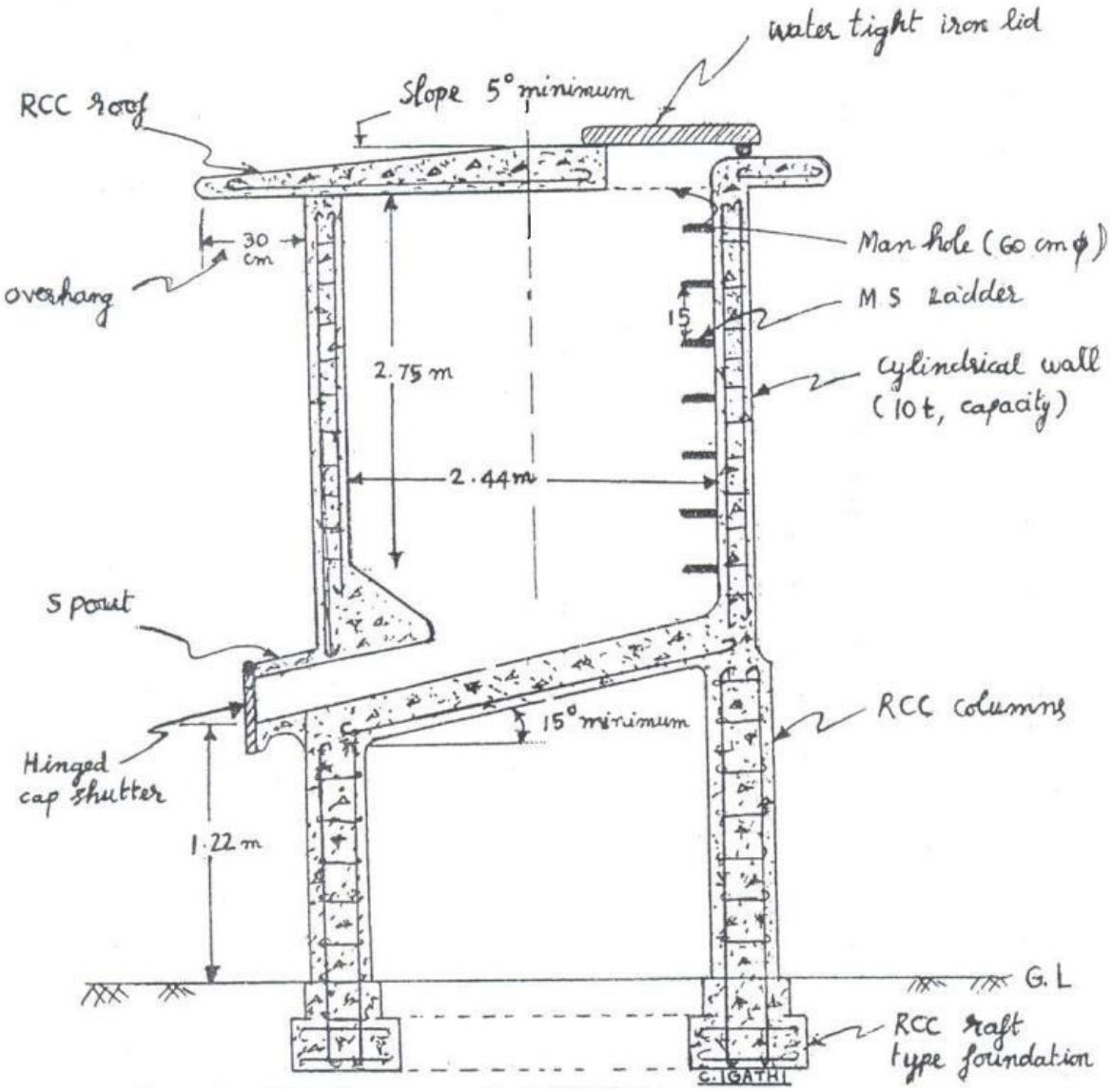


Fig.14.5 Construction details of cylindrical grain bin

Design of storage godowns.

Grain is generally stored either in bags or in bulk. A combined system of bag-cum-bulk storage is also practiced in some parts of the country. In villages, the bulk storage system is more common than the storage in bags which is considered to be a practicable method of storing grain in the government godowns as well as in trade. The size of a bag used for grain storage is large enough to contain about 93 kg of grain. These bags are made of jute fibers and are commonly known as gunny bags.

Improved Bag Storage Structure

These structures are generally used for the storage of 25 to 500 tonnes of grain. The length of the structure is about twice the width or greater than that. The structure should be large enough to store the required capacity and make the sides, floor and roof, moisture proof. Each of the structures are provided with two large size doors of 2.4 × 2.4 m and top ventilators. Each door is provided with a light over-hanging hood of 3.6 m, long and 2.4 m wide. A ground ventilator having an opening of 30 × 30 cm is provided below each corresponding top ventilator. The top of the ventilator is kept at a height of 60 cm above the floor level. It is also provided with iron rods, wire netting and a shutter. Besides this, a sun shade is provided on both the top and the ground ventilators. In order to ensure that the floor is damp-proof, it is made of different materials in six layers. Stacking plan for different capacities of godowns is shown in below Fig.

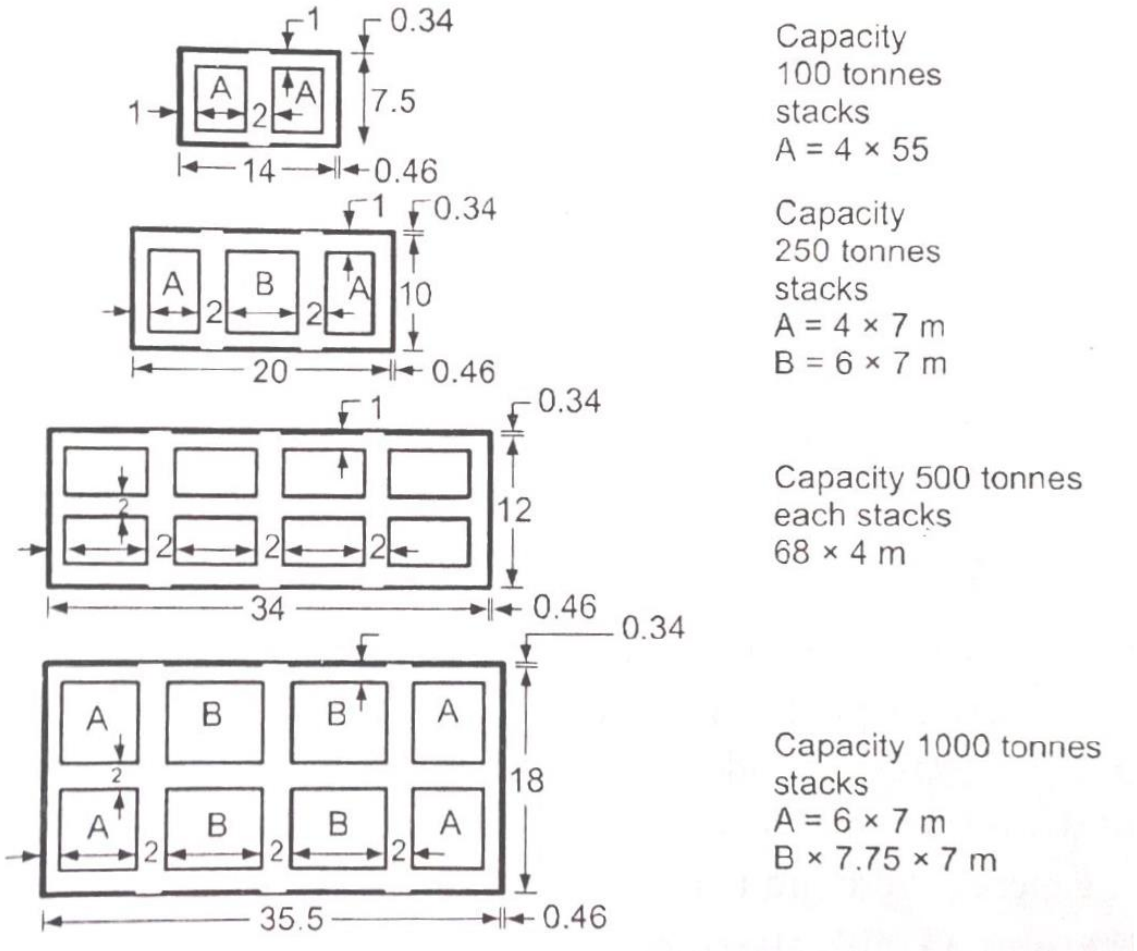


Fig. 14.6 Stacking arrangement inside a godown

Problem: Design a bag storage structure for storing 250 T of paddy. Assume reasonable data wherever necessary.

Solution:

Assumptions:

(i) Standard capacity of bag = 75 kg

(ii) Dimensions of 75 kg capacity bag are: 100 cm× 60 cm × 30 cm

(iii) Stack consists of 12 bags in length, 10 bags in width and 10 bags in height.

(iv) Distance between stack to stack = 2 m

(v) Distance between end of wall to stack = 0.8 m

No. of bags in bag storage structure (or godown) = 2, 50,000/75 = 3333.33 ≈ 3340

No. of stacks in godown =3340/1200 = 2.77≈ 3

Stack dimensions:

Stack length = 12 ×100 = 1200 = 12.0 m

Stack width = 10 × 60 = 600 = 6.0 m

Stack height = 10 × 30 = 300 = 3.0 m

Godown dimensions:

Length = 0.8 + 6 + 2 + 6 + 2 + 6 + 0.8 = 23.6 m

Width = 0.8 + 10+ 0.8 = 11.6 m

Height = 0.8 + 3+ 0.8 = 4.6 m

The dimensions of 250 T capacity bag storage structure are: 23.6 m × 11.6 m× 4.6 m.

14.2 Silos

A silo is a structure for storing bulk materials. Silos are used in agriculture to store grain or fermented feed known as silage. Silos are more commonly used for bulk storage of grain, coal, cement, carbon black, woodchips, food products and sawdust. A bin is typically much shorter than a silo, and is typically used for holding dry matter such as cement or grain. Grain is often dried in a grain dryer before being stored in the bin.

In general, there are two types of silos namely flat bottom type and hopper bottom type. Silos can also be classified as metal silos and concrete silos. Concrete silos are 150% expensive than metal silos of the same capacity. Major advantage of silo system is negligible loss of grain stored as compared to the grain stored in CAP and godown storage and also in handling. The absence of gunny bags entails major economy in operating expenses of the silo system. Metal silos are superior to concrete silos in respect of ease of installation, vermin resistance, flexibility, heat retention, construction /installation cost and maintenance costs.

CAP storage structure

The word CAP is used for cover and plinth, plinth from the bottom and cover from the top. This type of open storage is considered as transit storage and serves the purpose of storage of food grains in bags for short period. It is cheaper compared to conventional storage godowns. The cover is cuboidal in shape having five sides made from polyethylene

film of 1000 gauge, leaving the bottom side open. The cover is used for protecting stack of bags. Normally stack is built over a space of 9.11 × 6.1 m with a height of 18 bags which gives the storage capacity of around 150 tonnes. The cover having a dimension of 9.4m×6.4m×5.5m normally weighs around 52 kg. Following steps are required to be followed in the construction of CAP storage.

1. Select a high elevated ground and make it level.
2. Wooden sleepers are spread with one or two layers of bamboo mat cover on the top as dunnage.
3. The gutters are provided all around the area to drain off rain water easily.
4. The stacking is done to the height up to 18 bags on the dunnage and is covered with polyethylene.
5. The stacks are covered with polyethylene covers and tied with ropes to prevent from blowing off with high velocity wind.

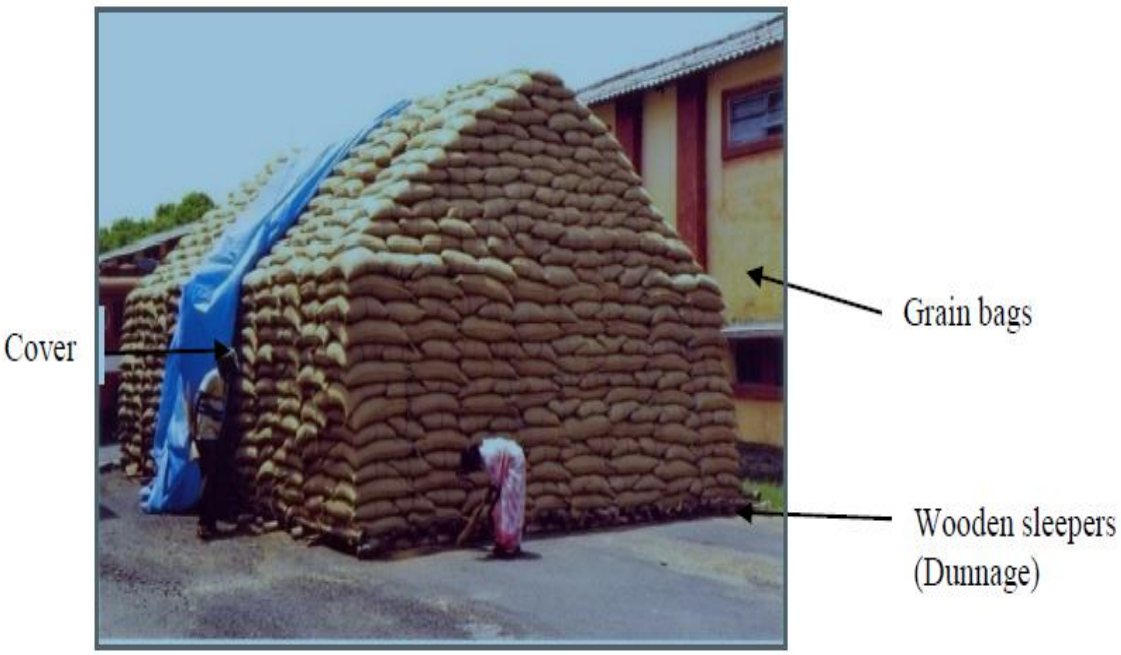


Fig.14.7 .CAP Storage structure