FARM MACHINERY AND POWER

THEORY NOTES

Course No. - ENGG-232

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Lecture No. 1

Sources of Farm Power in India

Farm Power

Farm Power is an essential input in agriculture for timely field operations for increasing production and productivity of land. Farm power is used for operating different types of machinery (Tractive work) like tillage, planting, plant protection, harvesting and threshing machinery and other stationary jobs like operating irrigation equipment, threshers/ shellers / cleaners/ graders, silage cutter, feed grinder, winnower, etc. These operations are done by different sources of power.

Sources of farm power in India:

1) Human power
2) Animal power
3) Mechanical power (Tractors + Power tillers + Oil engines)
4) Electrical power
5) Renewable energy (Biogas + Solar energy + Wind energy)

Developing countries of South and South East Asia are characterised with high population densities and generally small farm holdings. In this region, the human and animal power still continue to be the major source of power for farm operations. In spite of that the agricultural mechanization is gaining importance as it helps in improving land labour productivity, improving timeliness of operations, increasing cropping intensities and reducing drudgery from farm operations.

1. Human Power:

The human labour has played important role in agricultural production and related food processing activities in the world since time immemorial. In India about 1.5 workers per hectare of arable land is reported to be available for use. In middle ranged farm mechanized countries like India, Pakistan, Thailand, etc. where rural labour is gradually migrating to urban centres in search of better paid jobs, the labour shortage is increasing on agricultural and horticultural farms. Of the total rural population, the agricultural workers are estimated to be about 4o percent. Human power is the main source for operating small implements and tools at the farm.

- Stationary work like transplanting, sowing, weeding, grass cutting, cereal harvesting, threshing, winnowing etc. are also done by manual labour.
- An average man can develop maximum power of about 0.1 hp for doing farm work.
- Due to the human drudgery associated with ploughing, digging, harvesting, transportation, rural workers are reluctant to work on farm.
- Day by day increasing farm labour shortage is indicating greater investment in labour saving devices and mechanization.
- In order to increase returns from the farm business Peak labour requirements in crop production systems needs to be managed by increasing working hours, adjusting cropping pattern, reducing intensity of some operations and mechanising the operations.

MERITS:1. Easily available. 2. Used for all types of work. 3. No investment required

DEMERITS:

1. Costliest power compared to all other forms of power.

2. Very low work capacity & efficiency.
3. Requires full maintenance when not in use.
4. Affected by weather condition and seasons
5. Cannot work at stretch

2. Animal Power:

For small farms in Asia, Africa and Latin America, the animal power is the major power source. In these countries, the progenies of the milch animals are readily available for use as draught animals on farms. About 2/3rd of the total cultivated area is managed by draught animals. Among the draught animals the bullocks, buffaloes and camels are extensively used for draft purposes. Traditionally, the animals are employed for tillage, sowing, weeding, intercultural operations and transport. Selection of matching improved implements coupled with efficient harnessing would definitely enhance the power output and area covered by a pair of draught animals. Increase in mechanization of different farm operations, there is a decline in use of number of animals in farm activities.

●Power developed by an average pair of bullocks is about 1 hp for usual farm work. Bullocks are employed for all types farm work in all seasons.

●Besides bullocks, other animals like camels, buffaloes, horses, donkeys, mules and elephants are also used at some places.

●The average force a draft animal can exert is nearly 1/10thof its body weight.

Merits:

1. Easily available & can be reproduced on farm.
2. Adapted to almost all draft work.
3. Can be reared on farm waste, roughages, bi-products.
4. Supplies organic manures to field & fuel to farmers
5. Initial cost is less as compared to tractor

Demerits:

1. Costliest power compared to all other forms of power.
2. Low efficient.
3. Requires full maintenance when not in use.
4. Affected by weather condition and seasons.
5. Cannot work at stretch

3. Mechanical Power:

Mechanical power has become the main power source in modern Indian agriculture.

●It includes stationary oil engines, tractors, power tillers and self-propelled combines.
●Internal combustion engine is a good device for converting liquid fuel into useful work (mechanical work).
●These engines are of two types:
1) Spark ignition engines (Petrol or Kerosene engine)
2) Compression ignition engines (Diesel engines)
●The thermal efficiency of diesel engine varies from 32 to 38 per cent whereas that of petrol engine varies from 25 to 32 per cent.
●Almost all the tractors and power tillers are operated by diesel engines.

●Diesel engines are used for operating irrigation pumps, flour mills, oil *ghanis*, cotton gins, chaff cutter, sugarcane crusher, threshers, winnowers, etc.

The use of mechanical power in India has shifted from single cylinder diesel engines, stationary prime movers to multi-cylinder, high speed diesel engines, tractors, power tillers, petrol engines for stationary and tractive works. These machines are used by the farmers for self-use and also to provide custom hire services to others. The light weight, highly fuel efficient and trouble-free new models of self-propelled machines are used to perform farm activities like ploughing, harrowing, sowing, transplanting, spraying, harvesting, threshing and transportation. Tractors of small size (5-10 hp), medium size (15-20 hp) and large size (25-35 hp) are used for different cropping pattern and soil conditions.

Merits:

1. Efficiency is high.
2. Not affected by weather.
3. Can run at a stretch.
4. Requires less space.
5. Cheaper form of power.

Demerits:

1. Initial capital investment high.
2. Fuel is costly.
3. Repairs and maintenance cost high & needs technical knowledge.

4. Electrical Power

Electricity is the most efficient and clean source of power used on agricultural farms. On an average about 1/10th of the total electrical power generated in India, is consumed for the farm work. The largest use of electric power in the rural areas is for irrigation and domestic water supply and now the demand for electricity on Indian farms is increasing for farm produce processing machineries. The electricity in the country is mainly generated from thermal, hydro, nuclear and wind sources and now efforts are made to generate electricity from solar, ocean currents and tides, geothermal, agro-wastes, and hydrogen cell systems.

●Motor is a very useful machine for farmers. It is clean, quiet and smooth running.

●It's maintenance and operation needs less attention and care.

●The operating cost remains almost constant throughout its life.

●Electrical power is used for water pumping, diary industry, cold storage, farm product processing, and many similar things.

Irrigation is the major input which Indian farmers have adopted to increase productivities. The state and central governments are encouraging the farmers to install water lifting pump sets, sprinkler and drip systems, and greenhouse for increasing quality production.

Merits:

1. Cheap source of farm power.
2. Require little attention and care.
3. Operate quietly, smoothly at stretch without creating pollution.
4. Efficient and high useful life.
5. Not affected by weather conditions

Demerits:

1. Initial capital investment high.
2. Fatal and dangerous if improperly handled
3. Low voltage hamper operation

5. RENEWABLE ENERGY

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

Usage of renewable energy sources:

Solar energy- Solar dryers, lantern, cooker, solar still, solar refrigeration, solar lighting etc.
Wind energy- Water pumping, electricity generation etc.
Biomass energy- Gasifiers to produce producer gas, pyrolysis to produce liquid fuels, Biogas etc.
Tidal energy – electricity generation
Geothermal energy- Heat and electricity production

Wind Power

Wind energy has been in use for thousands of years to propel boats and ships and to provide rotary windmill power for lifting water and grinding grain. The availability of wind power for farm work is quite limited. Where the wind velocity is more than 32 kmph, wind mills can be used for lifting water. The windmill as a source of power was introduced in the country after the establishment of National Aeronautical Laboratory at Bangalore. The horizontal axis multi blade type mills were established in different climatic zones but could not make much impact due to unfavourable economics, breakdowns under high wind speeds and non-availability of repair facilities in rural areas. As compared to traditional windmills the modern windmills of different designs are more stable and can produce high voltage current and are connected in grid system. Sail windmill, Fan wheel wind mill, Savonius rotor windmill, Bicycle-wheel turbine type, Electro-generator, etc. are some of the examples of windmills designed using current technology. The fan wheel type wind mill having 3.6 m diameter, mounted on 12 m tower can generate 0.1-0.9 hp (100-750 Watts) power with wind velocity ranging from 6.4 to 37 kmph. Thus, an average capacity of a wind mill would be about 0.5 hp. The output of power in windmill is derived from aero-generators. There is large scope of exploiting this source of power in many unexplored regions in the country. The reliability of the power supply from wind mill is dependent on the wind stream velocity. It is reported that theoretical power that can be extracted by a wind mill is 59.3 per cent. It is one of the cheapest sources of farm power available in the country.

The Ministry of Non-Conventional Sources of Energy, Govt. of India has taken steps to popularize the wind mills for lifting water and generating electricity in rural areas. But this source could not become attractive due to the following limitations of the system:

• Initial investment is high,

• Repair facilities are not available in rural areas,

• Even the matching pump sets and electric generators are not readily available in the country, • It not suitable for all situations in the country.

Concept of Farm Mechanization:

The main concept of farm mechanization is to apply the principles of engineering and technology to do the agricultural operations in a better way to increase crop yield.

This includes the development, application and management of all mechanical aids for field operation, water control, material handling, storage and processing.

Mechanical aids include hand tools, animal drawn implements, power tillers, tractors, engines, electric motors, grain processing and hauling equipments.

Scope of Farm Mechanization:

Improved irrigation facilities, introduction of high yielding varieties, use of higher doses of fertilizers and pesticides have increased the scope for greater farm mechanization.

Farm mechanization helps for proper utilization of basic inputs like water, seed and fertilizer, optimum placement of the seed and fertilizer, ploughing, removal of weeds, levelling of uneven land and land reclamation.

If machines are used, farmer and his animals are relieved of hard work.

With the support of machines farmer can do his job better and quicker. He will get more leisure and devote his time to other works. He can earn better living.

Benefits of Farm Mechanization:

1) Timeliness of operation
2) Precision of operation
3) Enhancement of safety
4) Reduction of drudgery of labour
5) Reduction of loss of crops and food products
6) Increased productivity of land
7) Increased economic return to farmer
8) Improved dignity of farmer
9) Progress and prosperity in rural areas

Constraints in Farm Mechanisation (Limiting Factors in Farm Mechanization):

1) Small land holdings
2) Less investing capacity of farmers
3) Adequate availability of draft animals
4) Lack of suitable farm machine for different operations
5) Lack of repair and servicing facilities for machines
6) Lack of trained man power
7) Lack of coordination between research organization and manufacturer
8) High cost of machines
9) Inadequate quality control of machine

Lecture No. 2 - 3

Principle of Operation of I.C. Engine

Engine: It is a mechanical device which converts one form of energy into another form.

I.C. Engine: Engine in which combustion takes place inside engine cylinder is called IC engine. Ex. Automobile engine, aircraft engine, etc.

Classification of Heat Engines:

Heat engines are classified on different basis as follows:

1. On the basis of operating cycle – 1. Otto cycle engine, ex. SI engine
   2. Diesel cycle engine, ex. CI engine

2. On the basis of ignition method – 1. Spark ignition (SI) & 2. Compression ignition (CI) engine

3. On the basis of working stokes – 1. Four stroke engine, 2. Two stroke engine

4. On the basis of fuel used – 1. Petrol or gasoline engine & 2. Diesel engine

5. On the basis of cooling system – 1. Air cooled engines & 2. Water or coolant cooled engines

6. On the basis of cylinder arrangement – 1. Line arrangement 2. V-engine
   3. Radial engine 4. Opposed cylinder engine

7. On the basis of ignition system – 1. Magneto ignition system & 2. Battery ignition system engine

Construction of an IC Engine:

• I.C. engine converts reciprocating motion of piston into rotary motion of the crankshaft.

• Piston provided with rings in its grooves reciprocates in cylinder & has very close fit in it.

• Piston & rings prevent leakage of gases from sides of the piston.

• Cylinder is bored in a cylinder block & a gasket, made of copper sheet or asbestos is inserted between the cylinder & cylinder head to avoid any leakage.

• Combustion space is provided at top of cylinder head

• Connecting rod connected to piston by gudgeon pin & its other end connected to crank shaft

• Motion of piston is transmitted to crank shaft by the connecting rod & crank shaft makes rotary motion.

• Flywheel is provided at one end of the crankshaft for smoothing the uneven torque produced by engine

• Oil sump is provided at bottom of engine for lubrication of different moving parts

- Most common form of heat engines used in vehicles, boats, ships, airplanes & trains.
- Named so because the fuel is ignited inside the engine cylinder in order to do work.
- The burnt gases are emitted as exhaust
- This can be done using piston (called reciprocating engine) or with a turbine.

COMPONENTS OF AN IC ENGINE

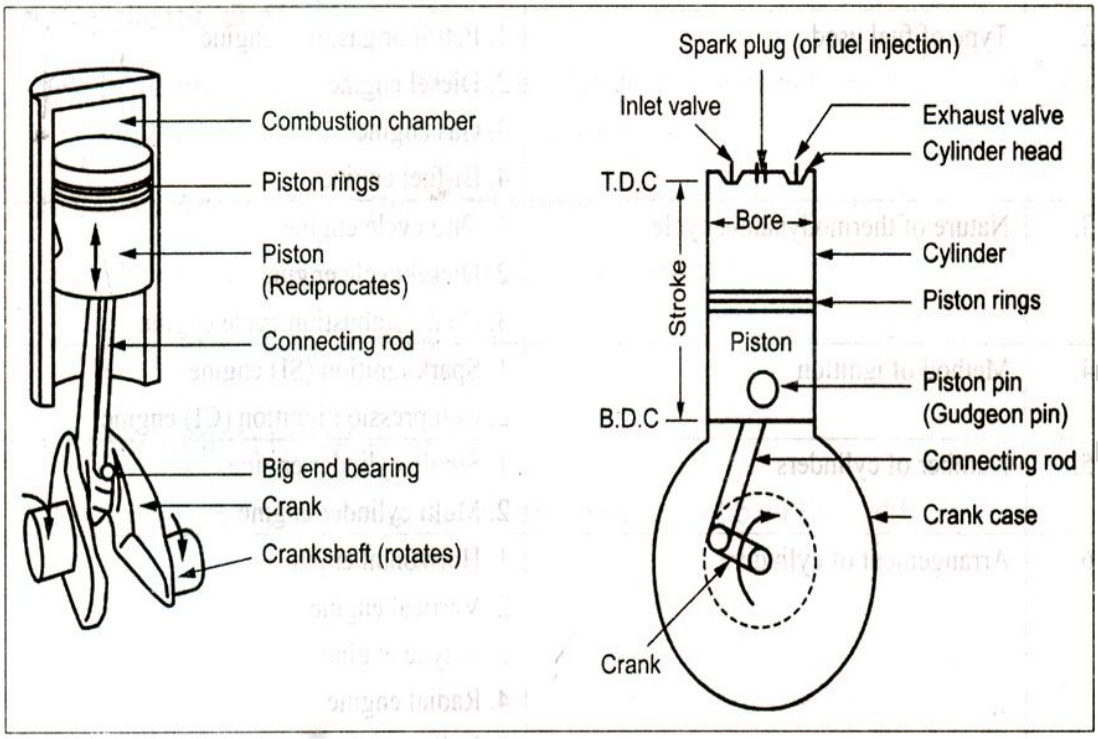


Fig. 2.1 Components of I.C. engine

- I.C. heat engine works on the principle of ideal gas law.
- Raising temperature of gas increases pressure that makes the gas want expand
- I.C. engine has chamber/cylinder which has fuel and air added to it which ignites in order to raise temp. of gas.
- In piston engine the expansion of burnt gases exerts pressure that is received by piston which can freely
- Thus, piston has reciprocating motion inside the cylinder
- To make vehicles run, rotary motion is needed
- To convert reciprocating motion into rotary motion, piston is connected to crank shaft through connecting rod.
- Thus, in IC engine heat energy released during explosive combustion of fuel is used for movement of piston and then rotary motion of crank shaft.
- This rotary motion is used for doing useful work like movement of vehicle, field work, cutting, grinding, water lifting, etc.

Working of IC engine includes four main operations:

1. Injection of fuel or air-fuel mixture in cylinder called suction

2. Compression of air/Air-fuel mixture (Compression)

3. Injection of fuel in compressed air for ignition of the fuel or ignition of air-fuel mixture by an electric spark using a spark plug to produce thermal power inside the cylinder (Power)

4. Removal of all burnt gases out of cylinder to receive fresh charge (Exhaust)

These four operations are repeated in a sequence called cycle. Based on the number of strokes of the piston used for completion of the cycle, IC engines are classified as four stroke and two stroke engines.

1. Four Stroke Cycle Engine (Diesel/ Petrol Engine):

• In four stroke cycle engines the four events namely suction, compression, power and exhaust take place inside cylinder.

• The four events are completed in four strokes of piston & two revolutions of the crank shaft.

• Engine has valves for controlling the inlet of charge and outlet of exhaust gases.

• Opening & closing of the valve is controlled by cams, fitted on camshaft driven by crankshaft with the help of suitable gears or chains.

• The camshaft runs at half the speed of the crankshaft.

• The events taking place in I.C. engine are as follows:

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

1. Suction stroke:

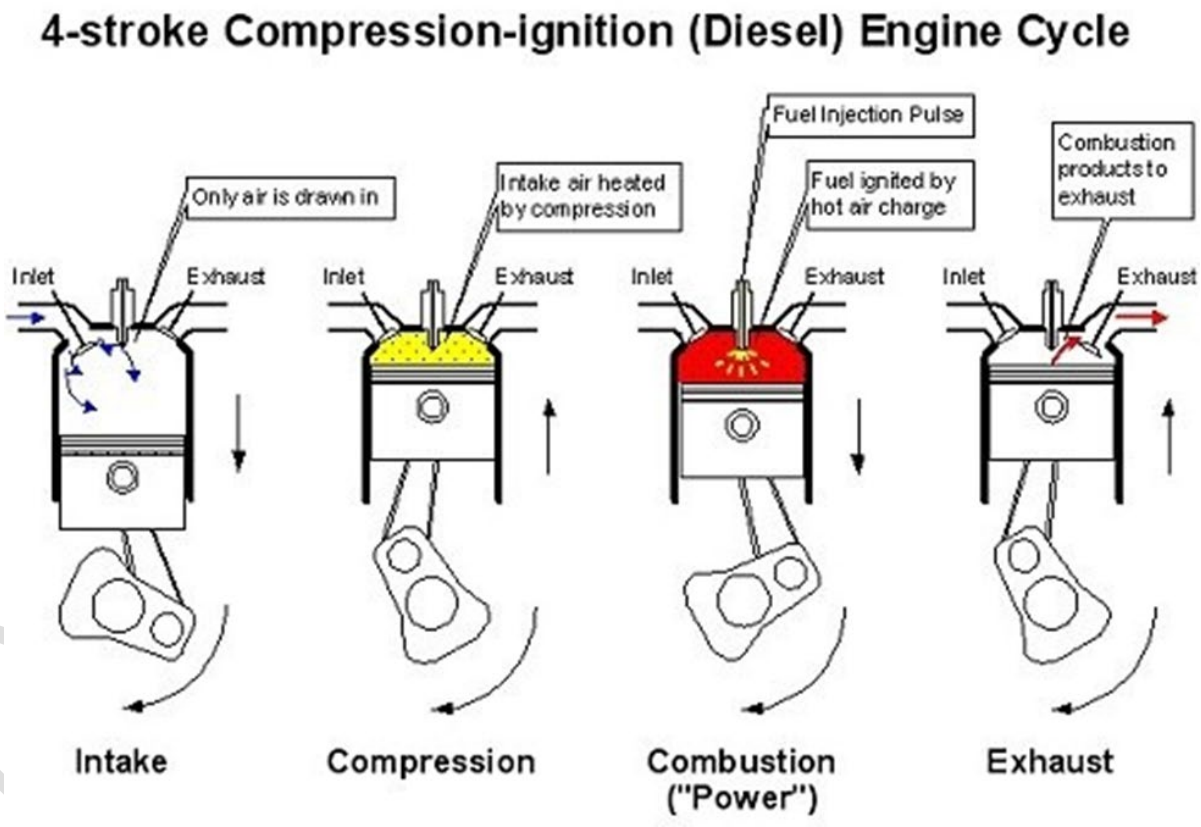


Fig. 2.2 Working of Four stroke cycle engine.

• During suction stroke inlet valve opens and piston moves downward.

• Only air or a mixture of air and fuel are drawn inside the cylinder.

• The exhaust valve remains in closed position during this stroke.

• The pressure in the engine cylinder is less than atmospheric pressure during this stroke (Fig. 2.2a)

2. Compression stroke:

• During this stroke the piston moves upward. Both valves are in closed position.

• The charge taken in cylinder is compressed by upward movement of piston (Fig. 2.2b).

• If only air is compressed (diesel engine) diesel is injected at the end of the compression stroke and ignition of fuel takes place due to high pressure and temperature of the compressed air.

• If a mixture of air and fuel is compressed in the cylinder (petrol engine) mixture is ignited by a spark plug.

3. Power stroke:

• After ignition of fuel, tremendous amount of heat is generated, causing very high pressure in the cylinder which pushes the piston downward (Fig. 2.2c).
• The downward movement of piston is called power stroke.
• Connecting rod transmits the power from piston to the crank shaft and crank shaft rotates.
• Mechanical work can be taped at rotating crank shaft.
• Both valves remain closed during power stroke.

4. Exhaust stroke:

• During this stroke piston moves upward.
• Exhaust valve opens and exhaust gases go out through exhaust valves opening.
• All the burnt gases go out of engine & the cylinder becomes ready to receive the fresh charge.
• During this stroke inlet valve remains closed (Fig. 2.2d).
• Thus it is found that out of four strokes, there is only one power stroke and three idle strokes in four stroke cycle engine.
• The power stroke supplies necessary momentum for useful work.

2. Two Stroke Cycle Engine:

• In two stroke cycle engines, the whole sequence of events i.e., suction, compression, power and exhaust are completed in two strokes of the piston & one revolution of the crankshaft (Fig. 2.3a).
• There is no valve in this type of engine.
• Gas movement takes place through holes called ports in the cylinder.
• The crankcase of the engine is air tight in which the crankshaft rotates.

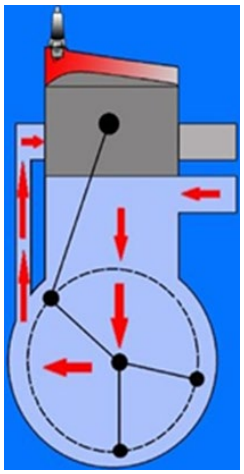


Fig. 2.3a Two stroke petrol engine

1. Upward stroke of the piston (Suction + Compression):

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

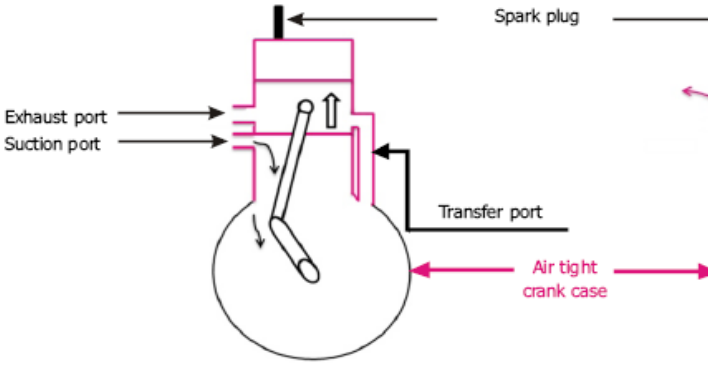


Fig. 2.3b Two stroke petrol engine

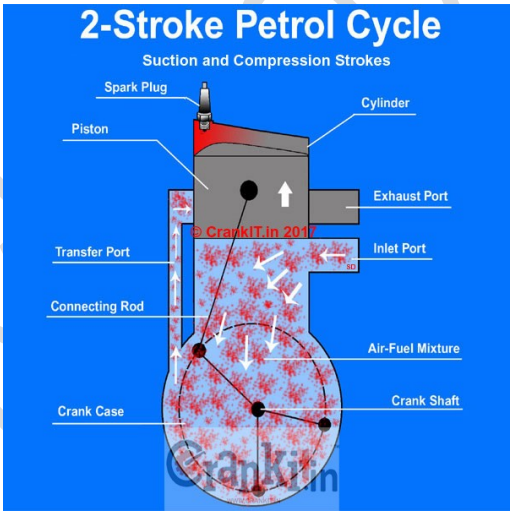


Fig. 2.3c Two stroke petrol engine

2. Downward stroke (Power + Exhaust):

• Burning of the fuel rises the temperature and pressure of the gases which forces the piston to move down the cylinder (Fig. 2.3d).

• When the piston moves down, it closes the suction port, trapping the fresh charge drawn into the crankcase during the previous upward stroke.

• Further downward movement of piston uncovers first the exhaust port and then the transfer port.

• Now fresh charge in the crankcase moves in to the cylinder through the transfer port driving out the burnt gases through the exhaust port.

• Special shaped piston crown deflect the incoming mixture up around the cylinder so that it can help in driving out the exhaust gases.

• During the downward stroke of the piston power and exhaust events are completed.

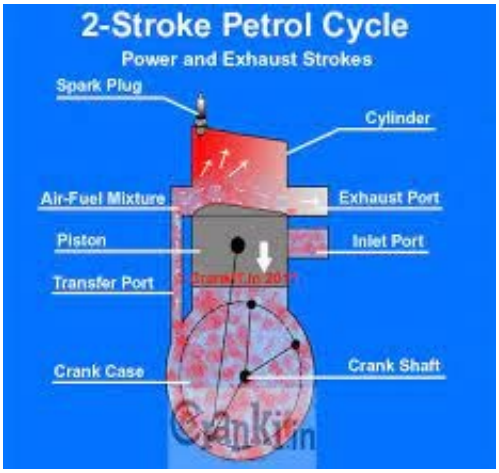


Fig. 2.3d Two stroke petrol engine

Comparison between Two stroke & Four stroke engine:

Sr. No.	Basis of comparison	Four Stroke Engine	Two Stroke Engine
1.	No. of power stroke	One power stroke for every two revolutions of crankshaft	One power stroke for each revolution of crankshaft
2.	Presence of valves/ ports	There are inlet & exhaust valves	There are inlet & exhaust ports
3.	Crankcase covering	Not fully closed & air tight	Fully closed & air tight
4.	Compression of charge	Top of piston compresses the charge	Both sides of piston compress the charge
5.	Size of flywheel	Comparatively larger	Comparatively smaller
6.	Combustion of fuel	Fully combusted	Not fully combusted
7.	Weight of engine per HP	High	Low
8.	Thermal efficiency	high	Low
9.	Ease of scavanging	Removal of burnt gases easy	Removal of burnt gases is comparatively difficult
10.	Torque production	Torque produced is even	Torque produced is less even
11.	High/Low speed	All types of speed are possible	Mostly high-speed engines are there
12.	Direction of operation	It can be operated in one direction only	It can be operated in both directions.

Comparison of diesel engine and petrol engine:

Sr. No.	Basis of comparison	Diesel Engine	Petrol Engine
1.	Fuel used	diesel	Petrol/Kerosene
2.	Charge/air taken during suction	Only air is sucked	Air-fuel mixture is taken
3.	Presence of carburetor, spark plug, coil	No carburetor, spark plug and ignition coil	It has got carburetor, ignition coil and spark plug
4.	Compression ratio	Varies 14:1 to 22:1	5:1 to 8:1
5.	Fuel injection pump	It has got fuel injection pump	It has no fuel injection pump
6.	Fuel supply	Fuel injected in the compressed air through injector	Air-fuel mixture is prepared in carburetor & supplied
7.	Ignition	By heat of compression	By electric spark
8.	Specific fuel consumption	0.2 kg/bhp/hour	0.28 kg/bhp/hour
9.	Thermal efficiency	32 to 38%	25 to 32%
10.	Engine weight per HP	High	Low
11.	Compression pressure	35 to 45 kg/cm^2	6 to 10 kg/cm^2
12.	Temperature during compression	About 500 °C	About 260 °C
13.	Engine weight per hp	High	Comparatively low
14.	Operating cost	Low	Comparatively high

Lecture No. 4-5

I.C. Engine Systems

An IC engine consists of different systems in order to supply the necessary inputs at correct time, in desired form, in correct amount and in proper way so that it can run smoothly without any trouble. The important systems installed on the engine are fuel supply system, ignition system, cooling system and lubrication system.

1. Fuel Supply System

A) Fuel supply system for S.I. engines:

Different systems available for efficient functioning of an engine are as follows

1. Fuel supply system
2. Lubrication system
3. Ignition system
4. Cooling system
5. Governor

Fuel is a substance consumed by the engine to produce power. The common fuels used for InternalCombustion engines are:

1. Petrol
2. Power kerosene
3. High speed diesel

Calorific value of fuel

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.

Sl. No.	Name of fuel	Calorific value, kcal/kg
1	Light Diesel Oil (L.D.O)	10300
2	High speed diesel oil (HSD)	10550
3	Power kerosene	10850
4	Petrol	11100

Fuel Supply System of S.I 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 engines, the fuel tank is placed above the level of the carburettor. The fuel flows from fuel tank to the carburettor under the action of gravity. There are one or two filters between fuel tank and carburettor. A transparent sediment bowl is also provided to hold the dust and dirt of the fuel. If the tank is below the level of carburettor, a lift pump is provided in between the tank and the carburettor for forcing fuel from tank to the carburettor 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 carburettor through suitable pipes. From carburettor the fuel goes to the engine cylinder through inlet manifold of the engine.

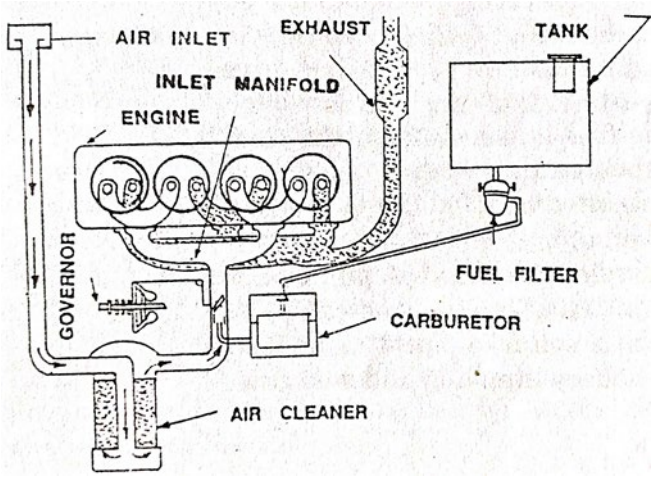


Fig. 4.1 Fuel supply system for S.I. Engine

Carburettor:

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 carburettor. The main components of a simple carburettor are:

1. Float chamber,
2. Float,
3. Nozzle,
4. Venturi,
5. Throttle valve,
6. Inlet valve and
7. Metering jet.

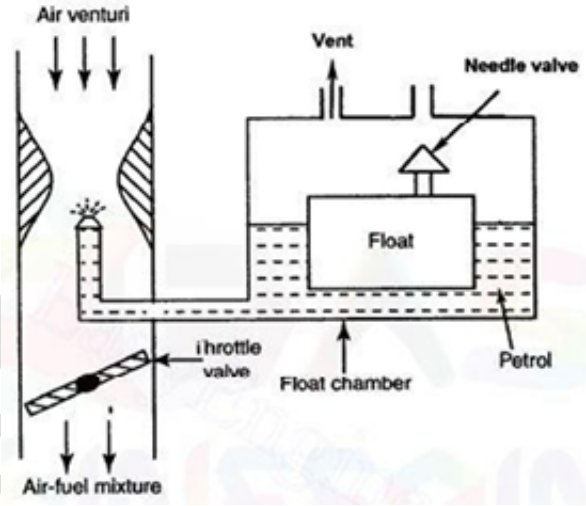


Fig. 4.2 Carburettor

Functions of carburettor:

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.

B) Fuel supply system for diesel engine:

Fuel supply system of diesel engine consists of the following components (Fig. 4.3a & b):

1. Fuel tank
2. Fuel lift pump or fuel feed pump
3. Fuel filter
4. Fuel injection pump
5. High pressure pipe
6. Over flow valve
7. Fuel injector

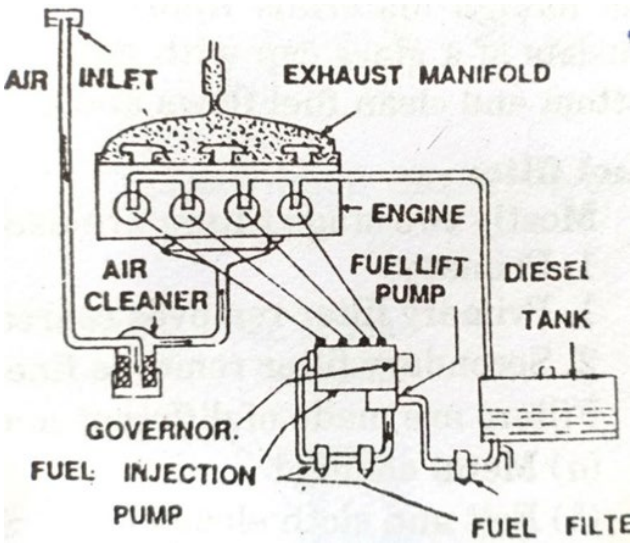


Fig. 4.3a Fuel supply system for diesel engine

Fuel is drawn from fuel tank by fuel feed pump and forced to injection pump through fuel filter. The injection pump supplies high pressure fuel to injection nozzles through delivery valves and high-pressure pipes. Fuel is injected into the combustion chamber through injection nozzles. 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. Over flow valve installed at the top of the filter keeps the feed pressure under specified limit.

If the feed pressure exceeds the specified limit, the over flow valve opens and then the excess fuel returns to fuel tank through over flow pipe.

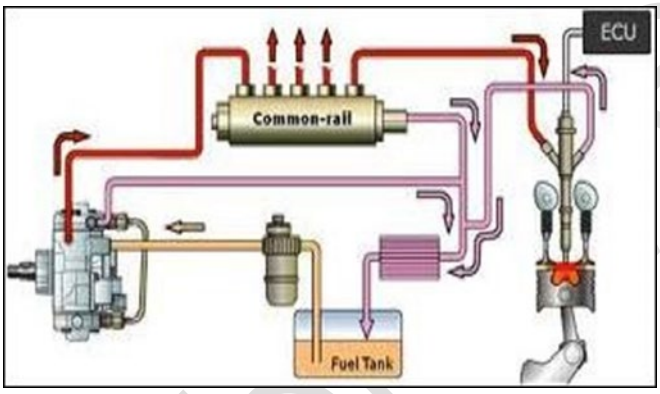


Fig. 4.3b Fuel supply system for diesel engine

Fuel tank: It is a storage tank for diesel. A wire gauge strainer is provided under the cap to prevent foreign particles entering the tank.

Fuel lift pump: It transfers fuel from fuel tank to inlet gallery of fuel injection pump.

Preliminary filter (sediment bowl assembly):

This filter is mostly fitted on fuel lift pump. It prevents foreign materials from reaching inside the fuel line. It consists of a glass cap with a gasket.

Fuel filter: Mostly two stage filters are used in diesel engines.

1. Primary filter 2. Secondary filter

Primary filter removes coarse materials, water and dust. Secondary filter removes fine dust particles.

Fuel injection pump: It is a high-pressure pump which supplies fuel to the injectors according to the firing order of the engine. It is used to create pressure varying from 120 kg/cm2 to 300 kg/cm2. It supplies the required quantity of fuel to each cylinder at appropriate time.

Air venting of fuel system: When air has entered the fuel lines or suction chamber of the injection pump, venting should be done properly. Air is removed by the priming pump through the bleeding holes of the injection pump.

Fuel injector: It is the component which delivers finely atomized fuel under high pressure to combustion chamber of the engine. Modern tractor engines use fuel injectors which have multiple holes. Main parts of injectors are nozzle body, and needle valve. The needle valve is pressed against a conical seat in the nozzle body by a spring. The injection pressure is adjusted by adjusting

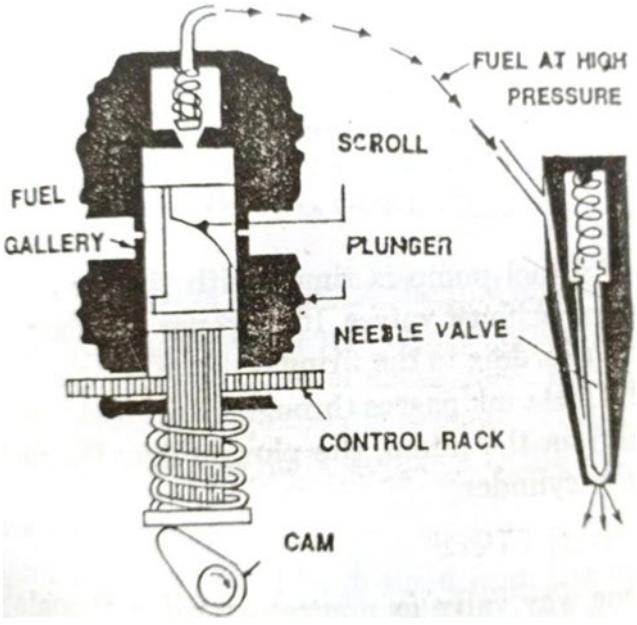


Fig. 4.4 Fuel injection pump and fuel injector

a screw. In operation, fuel from injection pump enters the nozzle body through high pressure pipe (Fig. 4.4). When fuel pressure becomes so high that it exceeds the set spring pressure, the needle valve lifts off its seat. The fuel is forced out of the nozzle spray holes into the combustion chamber.

2. 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 1600 ºC and this is greater than melting point of engine parts. The best operating temperature of IC engines lie between 140 F and 200 ºF and hence cooling of an IC engine is highly essential. It is estimated that about 40% of total heat produced is passed to atmosphere via exhaust, 30% is removed by cooling and about 30% is used to produce power.

Purpose of cooling:

1. To maintain optimum temperature of engine for efficient operation under all conditions.

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

3. To maintain the lubricating property of oil inside engine

Methods of cooling:

1. Air cooled system
2. Water cooled system

1. 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. Principle of air cooling- The cylinder of an air-cooled engine has fins to increase the area of contact of air for speedy cooling (Fig. 4.5). The cylinder is normally enclosed in a sheet metal casing called cowling. The fly wheel has blades projecting from its face, so that it acts like a fan drawing air through a hole in the cowling and directed it around the finned cylinder. For maintenance of air-cooled system, passage of air is kept clean by removing grasses etc. by a stiff brush of compressed air.

Fig. 4.5 Air cooled engine

Advantages of air-cooled engine:

1. It is simple in design and construction
2. Water jackets, radiators, water pump, thermostat, pipes, hoses are not required
3. It is more compact
4. Lighter in weight

Disadvantages

1. There is uneven cooling of engine parts
2. Engine temperature is generally high during working period

2. Water cooling system:

Engines using water as cooling medium are called water cooled engines. Water is circulated round the cylinders to absorb heat from the cylinder walls. The heated water is conducted through a radiator to remove the heat and cool the water.

Methods of water cooling:

1. Open jacket or hopper method
2. Thermo-siphon method
3. Forced circulation method

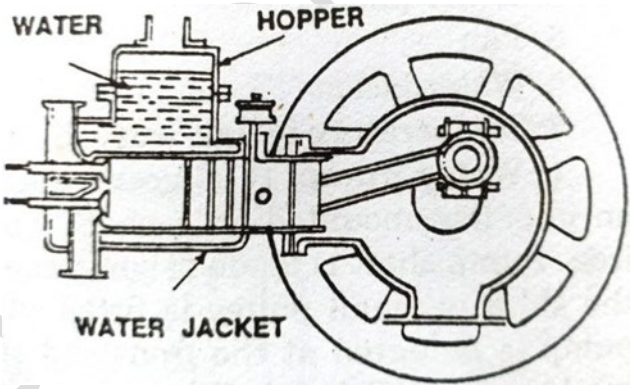


Fig. 4.6 Open jacket water cooling system

1. 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.

2. Thermo-siphon method:

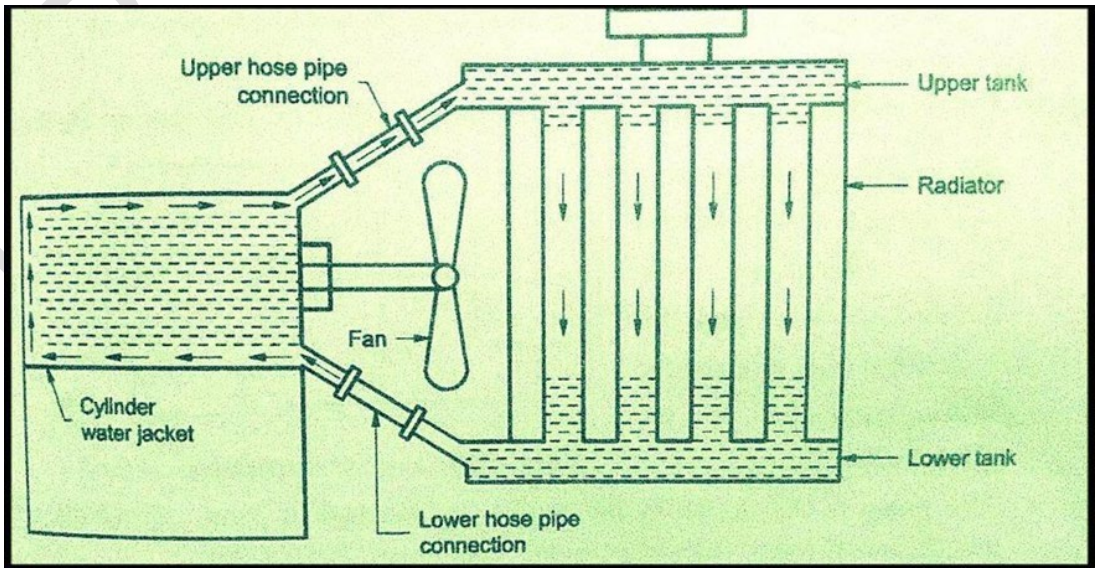


Fig. 4.7 Thermosiphon method of cooling engines

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 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.

3. Forced Circulation system:

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

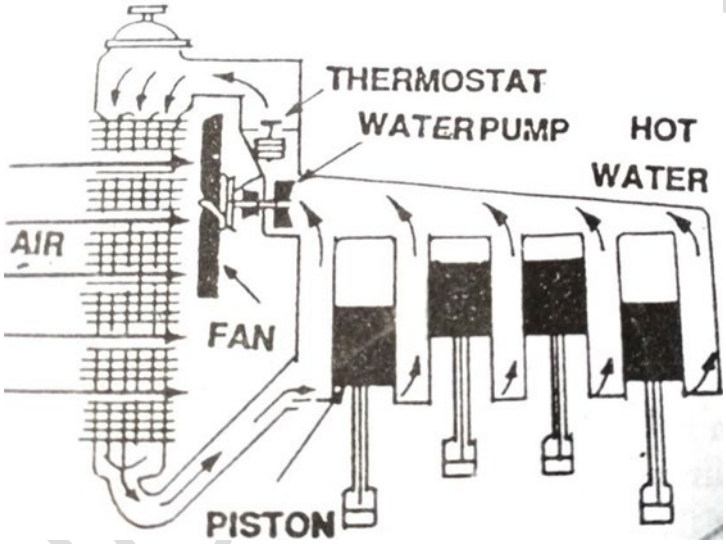


Fig. 4.8 Forced circulation system.

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, 8. Hose pipe.

Water pump: It is a centrifugal pump. It draws the cooled water from bottom of the radiator and delivers it to the water jackets surrounding the engine.

Radiator: (Fig. 4.9)

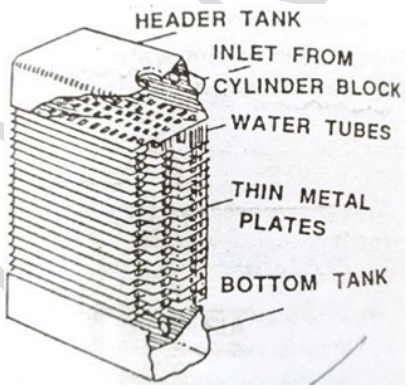


Fig. 4.9 Radiator

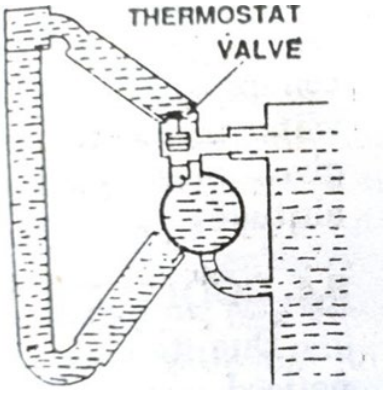


Fig. 4.10 Thermostat valve position in cooling system

Thermostat valve: It is a control valve used in cooling system to control the flow of water when activated by a temperature signal (Fig. 4.10).

Fan: The fan is mounted on the water pump shaft. It is driven by the same belt that drives the pump and dynamo. The purpose of radiator is to provide strong draft of air through the radiator to improve engine cooling

Water jacket - Water jackets are passages cored out around the engine cylinder as well as around the valve opening

3. Engine Lubrication System:

The lubricating system of an engine is an arrangement of mechanisms which maintains the supply of lubricating oil to the rubbing surfaces of an engine at correct pressure and temperature. IC engine is made of moving parts. Duo to continuous movement of two metallic surfaces over each other, there is wearing of moving parts, generation of heat and loss of power in engine. Lubrication of moving parts is essential to prevent all these harmful effects.

Types of lubricants: Lubricants are obtained from animal fat, vegetables and minerals.

1. Vegetable lubricants- are obtained from seeds, fruits and plants. Cotton seed oil, olive oil, linseed oil, castor oil are used as lubricants.
2. Animal fats- are obtained from animals but not suitable at high temp.
3. 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 internal combustion engines.

Importance of engine lubrication system:

1. Minimizes power loss by reducing the friction between the moving parts.
2. Reduces the wear and tear of the moving parts.
3. Provides cooling effect to the hot engine parts.
4. Provides cushioning effect against vibrations caused by the engine.
5. Carries out the internal cleaning of the engine.
6. Helps piston rings to seal against high-pressure gases in the cylinder.

Engine lubrication system supplies the engine oil to the following parts:

1. Crankshaft main bearings
2. Big end bearings
3. Piston pins and small end bushes
4. Cylinder walls
5. Piston rings
6. Timing Gears
7. Camshaft and bearings
8. Valves
9. Tappets and push-rods
10. Oil pump parts
11. Water pump bearings
12. In-Line Fuel Injection Pump bearings
13. Turbocharger bearings (if fitted)
14. Vacuum pump bearings (if fitted)
15. Air-compressor piston and bearings (in commercial vehicles for air-brake)

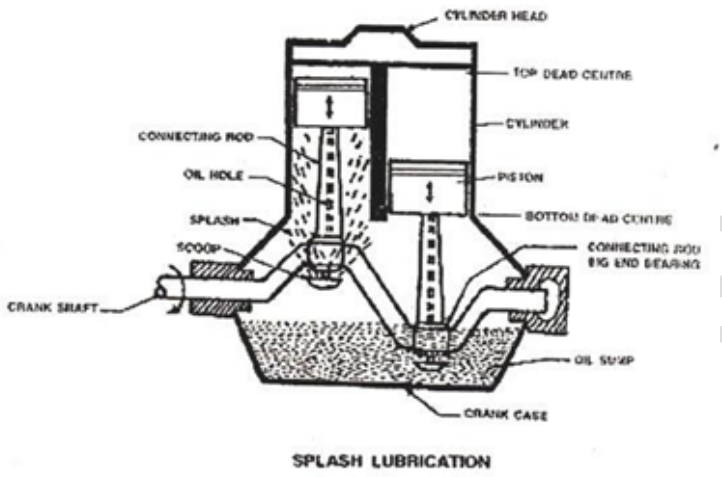
Types of engine lubrication system:

There are mainly four types of lubrication systems used in automotive engines which are:

1. Splash System
2. Forced feed system (Pressure system)
3. Combination of splash and forced feed system
4. Dry-Sump System

Components of engine lubrication system:

1. Oil Sump
2. Engine oil filter
3. Piston cooling nozzles
4. Oil Pump
5. The Oil Galleries
6. Oil Cooler
7. The Oil pressure indicator/light



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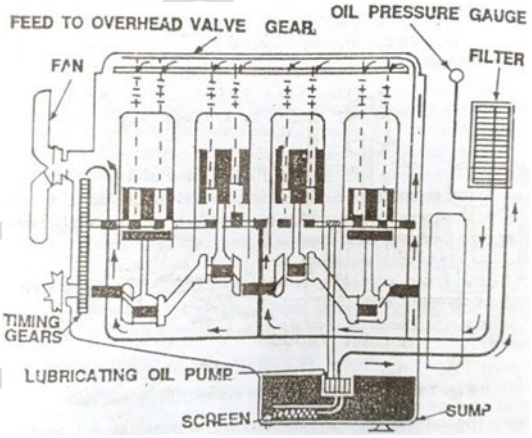
4.11 Splash lubrication system

1. Splash lubrication system: In splash lubrication system the lubrication oil is picked from the oil sump or a pan by a dipper provided at the bottom of the connecting rod for piston in each cylinder. The connecting rod picks the oil from the bottom and moves upward to the engine components. Some oils is also reached to different components like bearings, connecting rod through splash as mechanical turbulence is generated in the crankcase by the moving components which further makes the oil spread in the form of mist in the crankcase. This mist further reaches to other engine components like piston, piston pin and cylinder walls. The camshaft and valve mechanism are also lubricated by the oil. Although the splash type lubrication system is still being used in the engines these days but its usage has been found to be limited to small or single cylinder engines as the splash only is not sufficient to make oil to reach all critical components of the engine.

2. Force feed lubrication system:



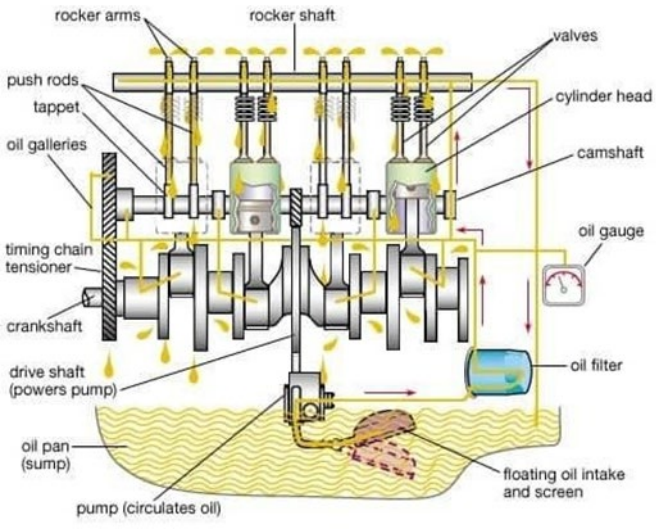


Fig. 4.12 Forced feed system of engine lubrication.

As splash system has limitations to lubricate all the critical components in an engine, force feed system is used to generate additional pressure to ensure oil reaching to all essential and desired components for lubrication purposes. Generally, a gear type pump driven by the camshaft generates the pressure in oil to move from the crankcase to crankshaft, connecting rod,

bearings pistons and valves. The lubricating oil is supplied to the engine components under pressure, hence; the reach of oil is enhanced to lubricate the remote and farthest points. This helps in efficient lubrication of engine components and hence in achieving better engine performance.

Oil Pan / Sump:

An Oil Pan / Sump is just a bowl-shaped reservoir. It stores the engine oil and then circulates it within the engine. Oil sump sits below the crankcase and stores the engine oil when the engine is not running. It is located at the bottom of the engine in order to collect and store the engine oil. The oil returns to the sump by pressure/gravity when the engine is not in use. Bad road conditions could cause damage to the Oil Pan / Sump. So, the manufacturers provide a stone guard/sump guard underneath the sump. The sump guard absorbs the hit from the uneven road and protects the sump from any damage.

Air Cleaner:

Definition: It is a device which filters and removes dust, moisture and other foreign matter from the air before it reaches the engine cylinder. Air cleaners are of three type:
1. Oil soaked element type, 2) Dry type air cleaners and
3. Oil bath type air cleaner

Fig. 4.13 Oil soaked air cleaner

1. Oil soaked element type:

The oil soaked type cleaner consist of a container filled with wire screens saturated with lubricating oil used in the crankcase. The dust particles are held by the oil film when the air stream comes in contact with it. This type of air cleaner is one often used in its smaller size on crankcase ventilation systems. It is also used on stationary engines which are not expected to work under very dusty conditions. This filtering element is periodically cleaned by blowing off the accumulated dirt with compressed air. If too much air has accumulated it should be washed in kerosene and subsequently cleaned by pressurized air to remove all traces of kerosene. It should then be thoroughly soaked in new oil before being installed.

2. Dry Type Air Cleaner:

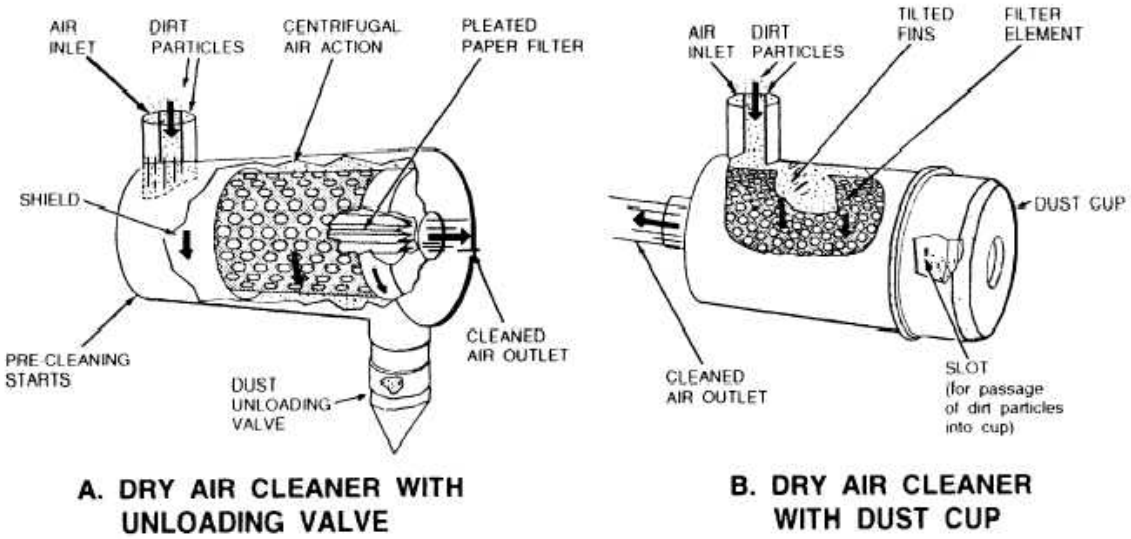


Fig. 4.14 Oil bath type air cleaner

These types of air cleaner contain three main parts viz. pre-cleaner, main housing and cleaning element. These are sealed into one unit. The filtering element in this case is dry type of filter. The air passes through the element. The element has got larger surface area so the air speed becomes relatively low and consequently particle or dirt in the air is deposited on or stopped by its surface.

3. Oil bath Type Air Cleaner: In this type of air cleaner, the incoming air impinges upon surface of oil, kept in a container in the lower part of casing. The foreign particles of the air are trapped in the oil and then air passes through a wire element before reaching the inlet manifold of the engine (Fig. 4.15). The wire element also arrests the remaining dirt particles of the air.

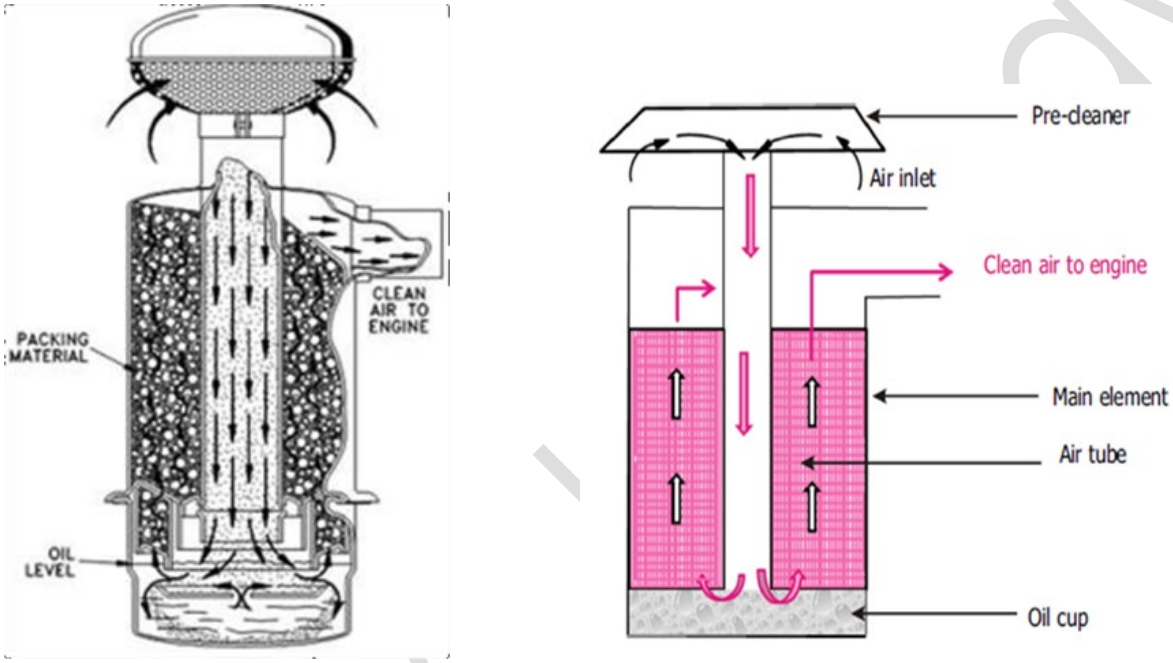


Fig. 4.15 Oil bath type air cleaner

Lecture No. 6-7

Tractor Types and Their Selection

Definition: Tractor is a self-propelled machine, used either for pulling or pushing loads or for stationary belt work.

It gets its drive force in combination with an engine and driving wheels or tracks. Engine power is transmitted to the driving wheels through a series of intermediaries called power train. These power train consist of Clutch, Transmission, Differential, Final drive and Driving axles. Tractor power is used from its PTO (Power Take Off) shaft, Pulley, Hydraulic system and Drawbar. Tractor engine is used as a prime mover for active tools and stationary farm machinery through power take-off shaft (PTO) or belt pulley. To meet various requirements of farm operation, manytypes of tractors have been produced.

Tractor Development:

The present tractor is the result of gradual development of machine in different stages. History of tractor development in chronological order is as:

- 1890: The word tractor appeared first on record in a patent issued on a tractor or tractorengine invented by **George H. Harris of Chicago**.
- 1906: Successful **gasoline tractor** was introduced by Charles W. Hart and Charles HParr of IOWA
- 1920-24: All-purpose tractor was developed
- 1936-37: **Diesel engine was used in tractor and pneumatic tries** were introduced.
- 1960-61: **Tractor manufacturing was started in India** by first manufacturer M/s EicherGood Earth.
- 1971: Escort tractor Ltd. Started producing Ford tractor.
- 1982: Universal tractors were established.

Classification of Tractors: These are broadly classified as –

1. Wheel Tractor
2. Crawler Tractor (track type or chain type)
3. Walking Tractor (power tillers)

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

Crawler Tractors: This is also track type or chain type tractor. In such tractors there is endless chain or track in place of pneumatic wheels.

Walking Tractors (Power tillers): Power tiller is a walking type tractor. This tractor is usually fitted with two wheels only. The direction of travel and its control for field operation is performed by operator, walking behind the tractor.

On the basis of purpose, wheeled tractor is classified into three groups:

a) General purpose b) Row crop c) Special purpose

General purpose Tractor: It is used for major farm operations such as ploughing, harrowing, sowing, harvesting and transportation work. Such tractors have i) low ground clearance ii) increased engine power iii) Good adhesion iv) wide tyers.

Row Crop Tractor: It is mainly designed to work in rows like planting, interculture etc. Such tractor is provided with replaceable driving wheels of different thread wheels. It has high ground clearance to save damage of crops. Wide wheel track can be adjusted to suit inter row distance.

Orchard tractor: These are special type of tractor mainly used in orchards. Such tractors have i) less weight ii) less width and iii) no projected parts.

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.

Factors Affecting Selection of Tractor: Selection of tractor depends upon following factors:
1. Land holding: too big tractor for small size field unnecessarily add to fixed cost for single cropping pattern 1 hp for 2 ha land is recommended (20 -25 hp for 40 ha farm)
2. Cropping pattern: for irrigated & more than one crop, 1 hp for 1.5 ha land (30 – 35 hp tractor for 40 ha).
3. Soil condition: for light soil tractor with less wheel base, higher ground clearance & low overall weight may work successfully. In deep black soils - wide wheels & high weight tractor works well.
4. Climatic condition: for hot zones & desert area, air cooled engines preferred over water cooled engines. At higher altitudes – air cooled engines are preferred as water may freeze in winter
5. Repair facilities: should be available with nearby dealer
6. Running cost: tractors with less specific fuel consumption preferred over others to reduce fuel consumption and thereby running cost.
7. Initial cost & Resale value: while keeping resale value in mind the initial cost should not be more otherwise higher interests will have to be paid.

Estimation of the cost of Tractor power:
The cost of operation of tractor is divided under two heads known as: Fixed cost and Operating cost.
Fixed cost include: 1. Depreciation 2. Interest on capital 3. Housing 4. Insurance 5. Taxes
Operating cost include: 1. Fuel 2. Lubricants 3. Repair and maintenance 4. wages

A. Fixed Cost:

1. Depreciation: It is the loss of value of a machine with the passing of time.

$$D = \frac{C-S}{L \times H}$$

Where D = Depreciation per hour, C = Capital investment, S = Salvage value, 10 % of capital, H = Number of working hours per year, L = Life of machine in years

2. Interest: Interest is calculated on the average investment of the machine taking into consideration the value of machine in first and last year.

$$I = \frac{C+S}{2} \times \frac{i}{H}$$

Where I = Interest per hour, C = Capital investment, S = Salvage value, 10 % of capital, H = Number of working hours per year, i = % rate of interest per year
3. Housing: Housing cost is calculated on the basis of prevailing rates of the locality but roughly speaking, the housing cost may be taken as 1 % of the initial cost of the machine per year.
4. Insurance: Insurance charges are taken on the basis of the actual payment to the insurance company but roughly speaking, it may be taken as 1% of the initial cost of the machine per year.
5. Taxes: Taxes are calculated on the basis of the actual taxes paid per year but roughly speaking, it may be taken as 1 % of the initial cost of the machine per year.

B. Operating Cost:

1. Fuel Cost: Fuel cost is calculated on the basis of actual fuel consumption of the tractor.
2. Lubricants: Charges for lubricants should be calculated on the actual consumption, but roughly speaking the lubricants cost varies between 30 to 35 % of the fuel cost.
3. Repair and maintenance: Cost of repair and maintenance varies between 5 to 10% of the initial cost of the machine per year.
4. Wages: wages are calculated on the basis of actual wages of the workers.

Example 1: Find the cost of using a tractor per hp-hr when the cost of 35 hp tractor is Rs. 3,00,000 /- , life of the tractor is 10 years, rate of interest 10 % and working hours per year is 1000 hours.

Solution: A . Fixed Cost:

1. Depreciation: D = Depreciation per hour =?

- C = Capital investment = Rs. 3,00,000
- S = Salvage value, 10 % of capital
- H = Number of working hours per year = 1000 h
- L = Life of machine in years = 10 years

$$D = \frac{C-S}{L \times H} = \frac{300000 - \frac{10}{100} \times 300000}{10 \times 1000} = Rs.27$$

D= 27 Rs/h

2. Interest:

$$I = \frac{C+S}{2} \times \frac{i}{H} = \frac{300000+30000}{2} \times \frac{12}{10 \times 1000}$$

I = 16.50 Rs/h

3. Housing: Housing @ 1 % of the initial cost of the machine.

$$H = \frac{300000 \times 1}{10 \times 1000} = 3.0\ Rs/h$$

Housing cost = 3.0 Rs/h

4. Insurance: Insurance @ 1 % of the initial cost of the machine

$$Insur = \frac{300000 \times 1}{10 \times 1000} = 3.0\ Rs/h$$

5. Taxes: Taxes @ 1 % of the initial cost of the machine.

$$Taxes = \frac{300000 \times 1}{10 \times 1000} = 3.0\ Rs/h$$

Total Fixed cost / hour = 27 +16.5 + 3 + 3 + 3 = **52.50 Rs/h**

B. Operating Cost:

1. Fuel cost per hour: Take fuel consumption = 6 lit / h and cost of diesel as 95 Rs. per liter

Fuel cost/ hour = 6 x 95 = Rs. 570.0

2. Cost of lubricants: @ 30 % of the fuel cost

= 0.30 x 570 = 171 Rs/h

3. Repair and maintenance cost /hour: Assume 6 % of the capital cost per year

$$R\&M = \frac{300000 \times 6}{10 \times 1000} = 18.0\ Rs/h$$

4. Wages of operator / hour: Assume wage of operator per day as Rs. 400/-.

$$Wages = \frac{400}{8} = 50.0\ Rs/h$$

B. Total Operating costs = 570 +171+18+50 = **809.0 Rs/h**

Therefore, Total Cost per hour = Fixed cost + Operating cost

= 52.50+ 809 = **Rs. 861.5**

Cost of using tractor per hp-hr = 736.7/35 = **Rs. 24.61**

Lecture No. 8

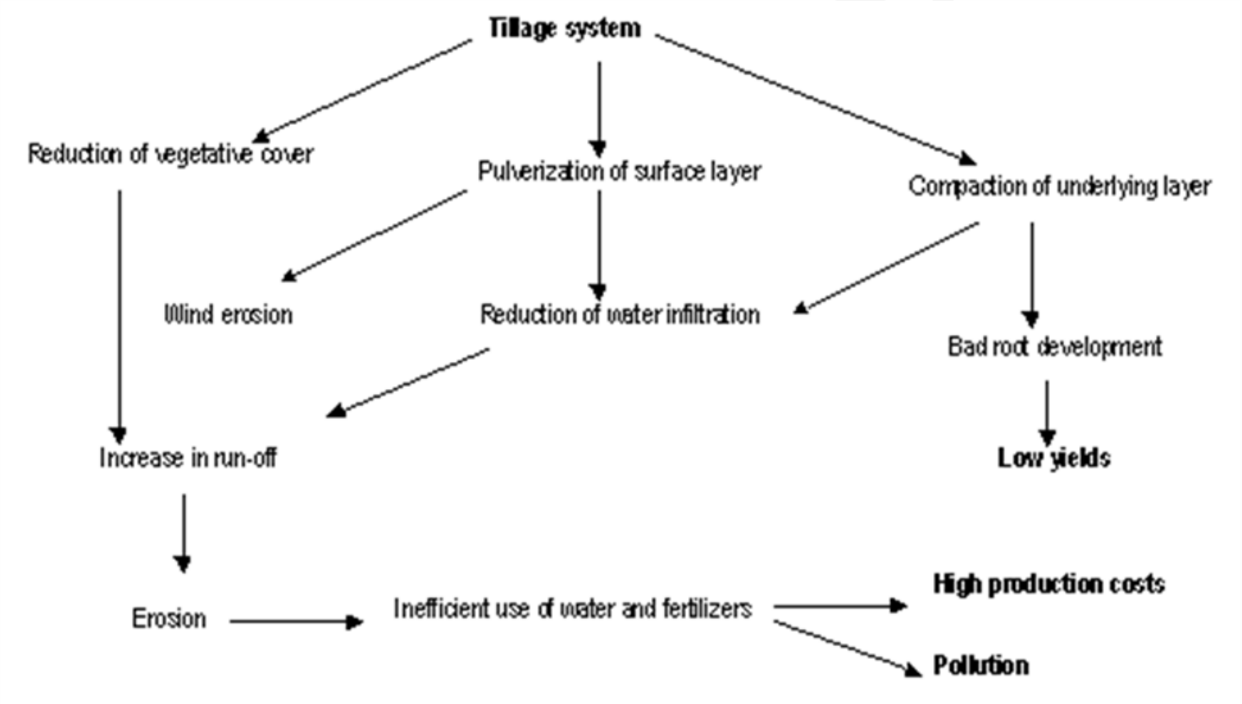
Tillage

– Definition – objectives – types of tillage - modern concepts of tillage – Equipments

Tillage: Tillage operations in various forms have been practiced from the very inception of growing plants. Crop production requires a number of operations like seed bed preparation, seeding, fertilizing, spraying, dusting, harvesting, etc. crop production starts with the first operation that is tillage which requires higher number of labours.

Definition: Tillage is the mechanical manipulation of soil with tools and implements for obtaining conditions ideal for seed germination, seedling establishment and growth of crops. Tilth is the physical condition of soil obtained out of tillage (or) it is the result of tillage. The tilth may be a coarse tilth, fine tilth or moderate tilth.

Necessity of tillage: The soil must be tilled in order to solve soil associated following problems.



Objectives of tillage: The main objectives of tillage are,

1. To prepare a good seed bed which helps the germination of seeds.
2. To create conditions in the soil suited for better growth of crops.
3. To control the weeds effectively.
4. To make the soil capable for absorbing more rain water.
5. To mix up the manure and fertilizers uniformly in the soil.
6. To aerate the soil. • To provide adequate seed-soil contact to permit water flow to seed and seedling roots.
7. To remove the hard pan and to increase the soil depth.

To achieve these objectives, the soil is disturbed or opened up and turned over.

Types of tillage: Tillage operations may be grouped into

1. On season tillage
2. Off-season tillage

1. On-season tillage: Tillage operations that are done for raising crops in the same season or at the onset of the crop season are known as on-season tillage. They may be preparatory cultivation and after cultivation.

A. Preparatory tillage: This refers to tillage operations that are done to prepare the field for raising crops. It consists of deep opening and loosening of the soil to bring about a desirable tilth as well as to incorporate or uproot weeds and crop stubble when the soil is in a workable condition.

Types of tillage a. Primary tillage b. Secondary tillage

a. Primary tillage: The tillage operation that is done after the harvest of crop to bring the land under cultivation is known as primary tillage or Operations performed to open up any cultivable land with a view to prepare seed bed for growing crops is called primary tillage.

It constitutes initial major soil working operations- it requires high power.

It is normally designed to – Reduce soil strength, Cover plant materials & Rearrange aggregates. Ploughing is the opening of compact soil with the help of different ploughs. Indigenous plough, mouldboard plough, disc plough, tractor and power drawn tiller implements are used for primary tillage.

b. Secondary tillage: The tillage operations that are performed on the soil after primary tillage to bring a proper soil tilth are known as secondary tillage or Operations following primary tillage & are performed to create proper soil tilth for seeding & planting are called secondary tillage.

Secondary tillage consists of conditioning soil to meet different tillage objectives of the farm.

These operations consume less power per unit area compared to primary tillage. There is less inversion & shifting of soil from one place to another place.

Secondary tillage consists of lighter or finer operation which is done to clean the soil, break the clods and incorporate the manure and fertilizers. Harrowing and planking is done to serve those purposes.

Objectives of Secondary tillage:

1. Pulverize soil
2. Destroy grasses and weeds
3. Cut crop residues & mix it with top soil of the field
4. Break big clods & make field surface uniform & levelled

Modern concepts of tillage:

Minimum Tillage: It is the minimum soil manipulation necessary to meet tillage requirements for crop production.

Strip Tillage: It is a tillage system in which only isolated bands of soil are tilled.

Rotary Tillage: It is the tillage operation employing rotary action to cut, break and mix the soil.

Mulch Tillage: It is preparation of soil in such a way that plant residues or other mulching materials are specially left on near the surface.

Combined Tillage: Operations simultaneously utilizing two or more different types of tillage tools or implements to simplify, control or reduce the number of operations over a field are

called combined tillage. Tillage is performed by tool, implement or machine.

Terms:

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

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

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

Types of tillage implements: Tillage equipment divided into two general classes,

(1) Primary tillage implements &
(2) Secondary tillage implements

1. Primary tillage implements: These implements may be tractor drawn or animal drawnThese are used to:

1. To break deeply and loosen the soil
2. To prepare a suitable seedbed

Animal drawn implements include indigenous plough & moldboard ploughs (MB).

Tractor drawn implements include MB plough, disc ploughs, subsoil ploughs or chisles, disc tiller ploughs and rotary tillers.

Secondary tillage implements: Implements used for secondary tillage are called as secondary tillage implements. These are carried out to conserve moisture and destroy weeds.
These include different types of harrows (disc, spike tooth, spring tooth), pulverizers, cultivators, weeders, land rollers & packers, rotary hoes and special tools.
Secondary tillage implements may be tractor drawn or animal drawn. Bullock drawn implements include harrows, cultivators, hoes, etc.

Tractor drawn implements:
Tractor drawn implements possess higher working capacity and are operated at higher speeds. These implements need more technical knowledge for operations and maintenance work. Tractordrawn implements may be:

a) Trailed type
b) Semi-mounted type and
c) Mounted type

a. Trailed type implement: it is one that is pulled and guided from single hitch point but its weight is not supported by the tractor.

b. Semi-mounted type implement: This type of implement is one which is attached to the tractor along a hinge axis and not at a single hitch point. It is controlled directly by tractor steering unit but its weight is partly supported by the tractor.

c. Mounted type implement: A mounted implement is one which is attached to the tractor, such that it can be controlled directly by tractor steering unit. The implement is carried fully by the tractor when out of work.
Terminology of Plough:
Centre of power: It is the true point of hitch of a tractor.

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

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

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

Draft: It is the horizontal component of the pull, parallel to the line of motion.

$$D = P \times Cos\theta$$

$$Draft\ power = \frac{Draft\ (kg) \times Speed(\frac{m}{s})}{75}$$

Where, D is draft (kgf) andP = pull in (kgf)
θ = angle between line of pull and horizontal.

Draft depends upon:

1. sharpness of cutting edge
2. working speed
3. working width
4. working depth
5. type of implement
6. soil condition
7. attachments.

Side draft: It is the horizontal component of the pull perpendicular to the direction of motion. This is developed if the centre of resistance is not directly behind the centre of pull.

Unit draft: It is the draft per unit cross sectional area of the furrow.

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

$$TFC\ (\frac{ha}{hr}) = \frac{Width\ (m) \times Speed(\frac{m}{hr})}{10000}$$

Effective field capacity: It is the actual area covered by the implement based on its total time consumed and its width.

$$EFC\ (\frac{ha}{hr}) = \frac{Width\ (m) \times Speed(\frac{m}{hr})}{10} \times \frac{E}{100}$$

Where C = effective field capacity, hectare per hr.
S = speed of travel in km per hour.
W = theoretical width of cut of the machine in metre, and
E = field efficiency in percent.

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

$$Field\ efficiewncy = \frac{EFC}{TFC} \times 100$$

Soil pulverization: It is the quality of work in terms of soil aggregates and clod size. This is measured by cone penetrometer.

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Lecture No. 9

Primary Tillage Implements

Equipment that is used to break deeply and loosen the soil to prepare a suitable seedbed may be considered as primary tillage equipment. This group includes various kinds of moldboard ploughs, disc ploughs, subsoil ploughs or chisels, disc tiller ploughs and rotary tillers.

Plough: Ploughing is the primary tillage operation, which is performed to cut, break and invert the soil partially or completely.

Ploughing essentially means:

i) Opening the upper crust of the soil,
ii) Breaking the clods and
iii) Making the soil suitable for sowing seeds.

Purpose of ploughing:

i) To obtain a deep seed bed of good texture.
ii) To increase the water holding capacity of the soil.
iii) To improve soil aeration
iv) To destroy weeds and grasses.
v) To destroy insects and pests.
vi) To prevent soil erosion and
vii) To add fertility to the soil by covering vegetation.

Types of Ploughing:

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

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

Types of Plough: Different types of plough are used at different places. These may be classified as:

1. Indigenous plough
2. Mould board plough
3. Disc plough
4. Chisel plough
5. Sub-soiler
6. Disc tiller plough
7. Rotary plough.

Fig. 9.1 Mould board plough

A. Mould Board Plough:

It is common implement used for primary tillage operations (Fig. 9.2). It performs several operations at a time.

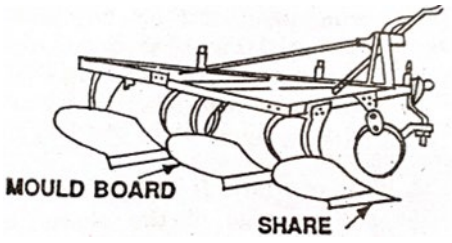
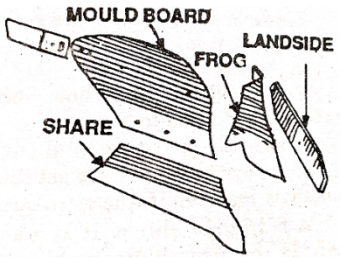


Fig. 9.2 M.B. Plough

Functions of M.B. Plough:

1. Cutting the furrow slice
2. Lifting soil
3. Turning furrow slice
4. Pulverization of soil



Components of MB Plough: (Fig. 9.3) Fig. 9.3 Components of M.B. Plough

1. Share: It is sharp, well-polished and pointed component.

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

Components of Share: (1) Share point (2) Cutting edge (3) Wing of share (4) Gunnels (5) Cleavage edge and (6) Wing bearing.

I) Share point: It is the forward end of the cutting edge which actually penetrates into the soil. It makes a horizontal cut below the soil surface.

II) Cutting edge: It is the front edge of the share which makes horizontal cut in the soil (Fig. 9.4). It is beveled to some distance.

III) Wing of share: It is the outer end of the cutting edge of the share. It supports the plough bottom (Fig. 9.4).

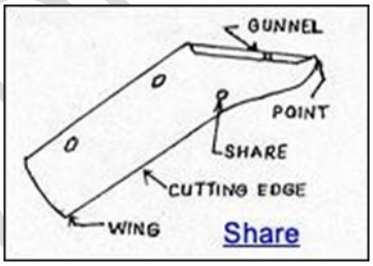


Fig. 9.4 Components of share

IV) **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 (Fig. 9.4).

V) Cleavage edge: It is edge of the share which forms joint between mould board and share on the frog (Fig. 9.5).

VI) Wing bearing: It is the level portion of the wing of the share, Providing a bearing for the outer corner of the plough bottom (Fig. 9.5).

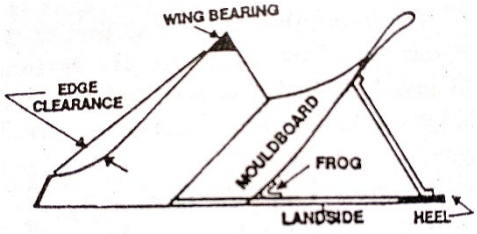
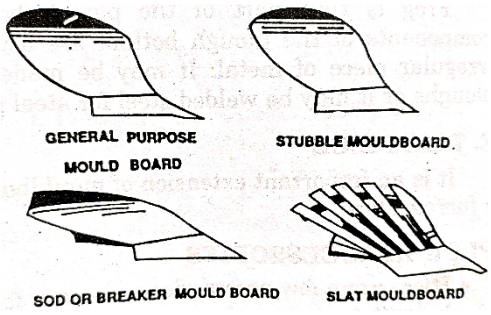


Fig. 9.5 Plough bottom

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

Types of share: 1) Slip share, 2) Slipnose share, 3) Shin share, 4) Bar point share

2. Mould board: It is that part of the plough which receives the furrow slice from the share. It is curved part which lifts, turns and breaks the furrow slice. To suit different soil conditions and crop requirements MB has been designed in different shapes. MB is of following types:



1) General purpose, 2) Stubble, 3) Sod or breaker & 4) Slat Fig. 9.6 Types of Mouldboard

1. General purpose: It is a mouldboard having medium curvature lying between stubble and sod. The sloping of the surface is gradual (Fig. 9.6). It turns the well-defined furrow slice and pulverizes the soil thoroughly. It has fairly long mouldboard with a gradual twist, the surface being slightly convex.

2. Stubble type: It is a short but broader mouldboard with a relatively abrupt curvature, which lifts breaks and turns the furrow slice used in stubble soils. It curvature is not gradual but it is abrupt along the top edge (Fig. 9.6). This causes the furrow slice to be thrown off quickly, pulverizing it much better than other types of mouldboard. 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 mouldborad is not suitable for lands full of grasses.

3. Sod or Breaker type: It is a long mouldboard with gentle curvature which lifts and inverts the unbroken furrow slice (Fig. 9.6). It is used in tough soil of grasses. 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 use in sod soils.

4. 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 (Fig. 9.6). This type of mouldboard is often used, where the soil is sticky, because the solid mouldboard does not scour well in sticky soils.

3. Landside:

It is the flat plate which bears against and transmits the rear side lateral thrust of the plough bottom to the furrow wall (Fig. 9.3). It helps to resist the side pressure exerted by the furrow slice on the mouldboard. It also helps in stabilizing the plough while it is in operation. Landslide is fastened to the frog with the help of plough bolts. The rear bottom end of landslide is known as heel, which rubs against the furrow sole.

4. Frog:

It is the part to which other components of the plough bottom are attached. It is an irregular piece of metal made of cast iron or it may be welded steel (Fig. 9.3).

5. Tail piece:

It is an adjustable extension, which can be fastened to the rear of a mouldboard to help in turning a furrow slice (Fig. 9.3).

Adjustment of mouldboard plough: Two types of adjustments are done to improve its performance either by increasing or decreasing vertical clearance or horizontal clearance.

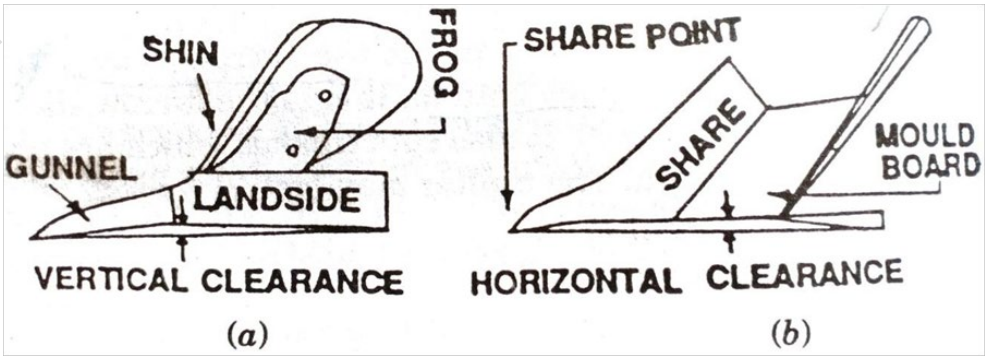


Fig. 9.7 Adjustments of mouldboard plough

1. Vertical suction (Vertical clearance):

It is the maximum clearance under the land side and the horizontal surface when the plough is resting on a horizontal surface in the working position.
It is the vertical distance from the ground, measured at the joining point of share and land side. (Fig. 9.7a)
It helps the plough to penetrate into the soil to a proper depth. This clearance varies according to the size of the plough.

2. Horizontal suction (Horizontal clearance):

It is the maximum clearance between the land side and a horizontal plane touching point of share at its gunnel side and heal of land side (Fig. 9.7b).
It helps the plough to cut the proper width of furrow slice. This clearance varies according to the size of the plough. It is also known as side clearance.

Tractor Drawn Implements: Tractor drawn implements possess higher working capacity and are operated at higher speeds. These implements need more technical knowledge for operations and maintenance work. Tractor drawn implements may be
a) Trailed type, b) Semi-mounted type and c) Mounted type
a) Trailed type implement: This type of implement is pulled and guided from single hitch point but its weight is not supported by the tractor.
b) Semi-mounted type implement: This type of implement is one which is attached to the tractor along a hinge axis and not at a single hitch point. It is controlled directly by tractor steering unit but its weight is partly supported by tractor.
c) Mounted type implement: A mounted implement is one which is attached to the tractor such that it can be controlled directly by the tractor steering unit. The implement is fully carried by the tractor when out of work.

Related Terms:

Throat Clearance of Plough: It is the perpendicular distance between point of share and lower position of the beam of the plough.

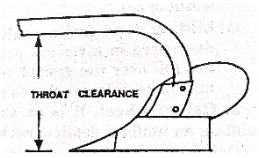


Fig. 9.8 Throat clearance of plough

2. Vertical Clevis: It is a vertical plate with number of holes at the end of the beam to control the depth of operation and to adjust the line of pull.

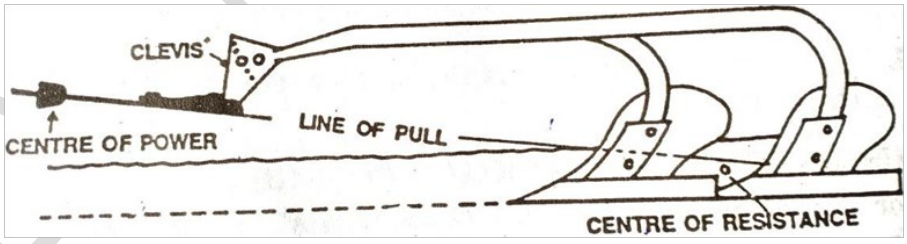


Fig. 9.9 Vertical clevis, centre of resistance and line of pull.

3. Plough size: The size of the MB plough is expressed by width of cut of the soil (Fig. 9.10).

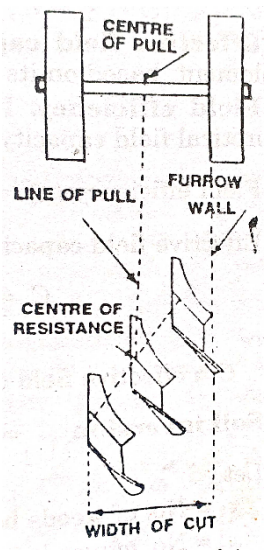


Fig. 9.10 Width of cut of furrow in the soil.

4. Line of pull: It is an imaginary straight line passing from the centre of resistance through the clevis to the centre of pull (power) (Fig. 9.9).

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

6. Draft: It is the horizontal component of the pull, parallel to the line of motion.

$$Draft, D = P \times cos\theta$$

Where, D is draft (kgf), P = pull in (kgf) and θ = angle between line of pull and horizontal.

$$Actual\ power = \frac{Draft\ (kg) \times Speed(\frac{m}{s})}{75}$$

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

8. Side draft: It is the horizontal component of the pull perpendicular to the direction of motion. This is developed if the centre of resistance is not directly behind the centre of pull.

9. Unit draft: It is the draft per unit cross sectional area of the furrow.

$$Unit\ draft = \frac{Total\ Draft\ (kg)}{Cross\ sectional\ area\ of\ furrow}$$

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

$$Theoretical\ field\ capacity = \frac{Width\ (m) \times Speed(\frac{m}{hr})}{10000}$$

11. Effective field capacity, EFC: It is the actual area covered by the implement based on its total time consumed and its width.

$$Effective\ field\ capacity = \frac{Width\ (m) \times Speed(\frac{m}{hr})}{10000} \times \frac{E}{100}$$

12. Field efficiency, E: It is the ratio of effective field capacity and theoretical field capacity expressed in percent.

$$Field\ efficiency = \frac{EFC}{TFC} \times 100$$

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 to reduce friction by making a rolling plough bottom instead of sliding plough bottom. A disc plough works well in the conditions where mouldboard plough does not work satisfactorily.

Advantages of disc plough:

i. A disc plough can be forced to penetrate into the soil, which is too hard and dry for working with a M.B. plough.
ii. It works well in sticky soil in which a mould board plough does not work.
iii. It is more useful for deep ploughing.
iv. It can be used safely in stony and stumpy soil without much danger of breakage.
v. A disc plough works well even after a part of the

disc is worn off in abrasive soil.
vi. It works in loose soil also (such as peat) without much clogging.

Disadvantages of disc plough:

i. Not suitable for covering surface trash and weeds as effectively as mould board plough does.
ii. Comparatively, the disc plough leaves the soil in rough and cloddy condition than that of mould board plough.
iii. Disc plough is much heavier than M.B. plough for equal capacities because penetration of this plough is affected largely by its weight rather than suction.
iv. There is one significant difference between mould board plough and disc plough i.e. MB plough is forced into the ground by the suction of the plough, while the disc plough is forced into the ground by its own weight.

Types of disc plough: Disc ploughs are of two types:

(i) Standard disc plough and (ii) Vertical disc plough

1. Standard disc plough: It consists of steel discs of 60 to 90 cm diameter, set at a certain angle to the direction of travel. Each disc revolves on a stub axle in a thrust bearing, carried at the lower end of a strong stand which is bolted to the plough beam (Fig. 9.11). The angle of the disc to the vertical and to the furrow wall is adjustable. In action, disc plough 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.

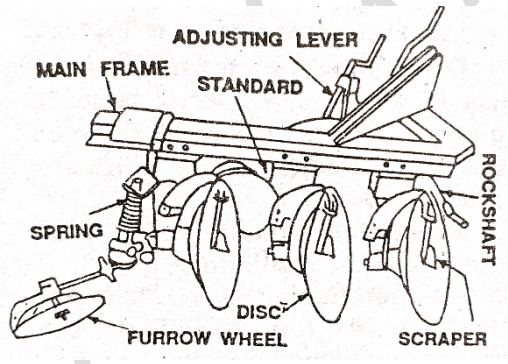


Fig. 9.11 Standard disc plough

The disc plough may be mounted type or trailed type. In mounted disc plough: the wheels of the tractor take side thrust. Sometimes a rear wheel is fitted to take side thrust of the plough In trailed type: the furrow wheel of the plough takes side thrust.

Construction: Disc is made of heat-treated steel of 5 mm to 10 mm thickness. The edge of the disc is well sharpened to cut the soil. The concavity of disc varies with the diameter & approximate values are - 8 cm for 60 cm diameter disc and 16 cm for 95 cm diameter.

A disc plough is designed with a view to reduce friction by making a rolling plough bottom instead of sliding plough bottom.

Suitability: works well in the conditions where M.B. plough does not work satisfactorily.

2. Vertical Disc Plough: Also called harrow plough or one way disc plough. It combines principles of regular disc plough & disc harrow. It is used for shallow working in soil. Its action is midway between terms connected with disc plough.

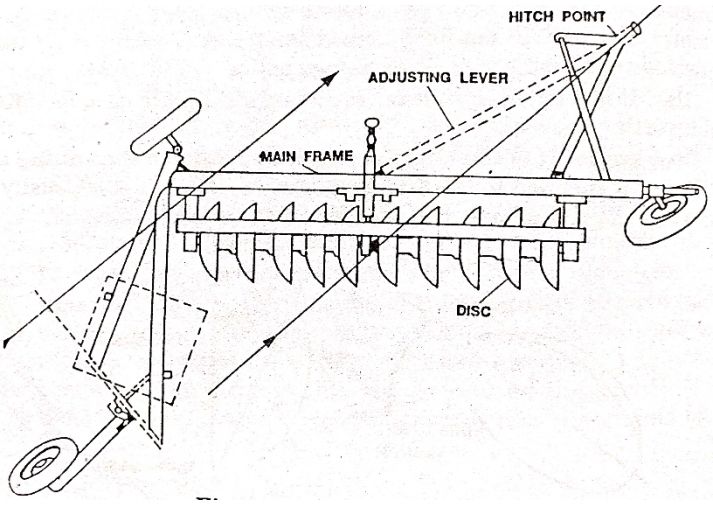


Fig. 9.12 Vertical Disc Plough

Construction & Specifications: It consists of Frame, wheel arrangement, depth adjusting devices. Discs fitted on single shaft but turn as one unit (Fig. 9.12).

Spacing of disc: 25 – 30 cm for regular tractor drawn harrow plough.

Size of disc: 50 – 65 cm Disc angle: 40 – 45° Attachment of seed box: mounted for seeding small grains.

Advantage: Energy Requirement Less than disc plough due to shallow working depth (8 to 10 cm).

Terms connected with disc plough:

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

Disc angle - It is the angle at which the plane of the cutting edge of the disc is inclined to the direction of travel. varies from 42° - 45° (Fig. 9.13).

Tilt angle- It is the angle at which the plane of the cutting edge of the disc is inclined to a vertical line. It varies from 15° to 25°.

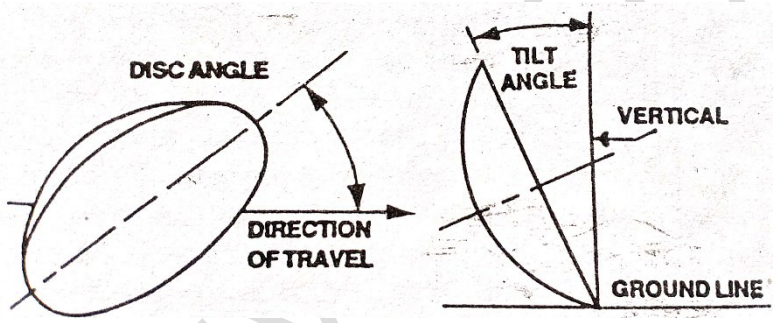


Fig. 9.13 Disc and Tilt angle

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.

Adjustments of Disc Plough: Various adjustments are done on disk plough for controlling depth or width of ploughing & increase pulverization. These are achieved as follows:

1. Penetration is improved by increasing disc angle (40 – 45°) & decreasing tilt angle on Standard disc plough
2. By increasing disc angle penetration is increased but width of cut is reduced
3. Penetration increased by adding additional weight on plough
4. Discs should be well polished & sharp
5. Width of cut is adjusted by adjusting angle between the land wheel axle and the frame.
6. Plough wheels should be properly adjusted to keep plough at operating level

Other ploughs:

1. Chisel plough
2. Subsoiler
3. Rotary plough
4. Rotavator
5. Rotary auger plough


Fig. 9.14 Chisel plough

2. Chisel plough: It is a plough used to break through and shatter compacted or hard soil layers by means of number of narrow tynes. It is used before using regular plough. Deep tillage breaks hard soil layers just below regular

ploughing depth. This compacted sub soil layer iscalled *Hard pan* or *Plough sole*. Breaking of hard pan helps in better infiltration, storage of rainwater in crop root zone, improved soil structure which results in better development of root system, increase in crop yield and their drought tolerance.

It has a relatively low initial cost as compared to other tools. It has the ability to till one bed at atime. It can be adjusted to till deep or shallow and it does not invert the soil profile.

2. Subsoiler: The function of the subsoiler is to penetrate deeper than the conventional cultivation machinery and break up the compacted or hard layers of the soil at a constant depth. These compacted areas prevent the natural drainage of the soil and also inhibit the passage of air and nutrients through the soil structure. The subsoiler consists of heavier tyne than the chisel plough to break through impervious layer shattering the sub-soil to a depth of 40 cm or more upto 100 cm and requires 60 to 100 hp to operate it.
Advantages: Breaks up hard pan to drain heavy soil and aeration of soil Stimulating deep rooted growth to help crops withstand drought conditions.

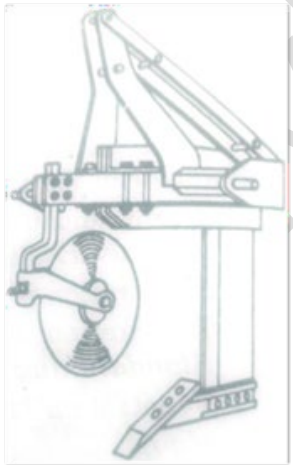




Fig. 9.15 Subsoiler

3. Rotavator (Tractor mounted): It is a semi- mounted implement that rests on its own land and skids when it works. It consists of 16 curved knives or blades bolted on a horizontal shaft driven by PTO. On this shaft 8 knives are bent at edge in right hand side and another eight in the left hand side. The knives are so arranged to give uniform cutting load on the shaft. Three main types of knives are used.

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

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

• iii) Straight blade - Employed on mulchers designed mainly for secondary tillage.

Fig. 9.15 Rotavator

It is operated by PTO shaft of the tractor attached to 3-point linkage. The depth can be controlled by linkage and hydraulic system. During rotation knives cut the soil slices and throw backward and upward against rear safety guard or hood. The impact causes soil slices to disintegrate into fine aggregates. Rotavator ploughs, pulverises mixes and levels dry and wet lands. It is used for seed bed preparation, weed control, mixing of soil with crop residue and fertilizer and puddling of soil. It replaces cultivator, disc harrow and puddler.

Problems 1: Find the operating cost in Rs/hr of ploughing by tractor purchased at Rs. 8,80,000/-. Fuel consumption of tractor is 6 liter per hour and cost of fuel is Rs. 79.0 per liter and wages of driver is Rs 480/- per day of 8 hours. Assume the life of tractor as 10 years with 1000 hours annual use and interest rate as 12%. Make necessary assumptions.

Ans. Assume No. of plough bottoms = 3 with bottom width = 30 cm, Plouhging speed = 5 kmph and cost of plough is Rs. 70,000/-
Area covered /hr = Width x speed = [30x3/100] x [(5x1000)/10000] = 0.45 ha [1 ha =10000 m^2]

For Tractor: A. Fixed cost:

i) Depreciation/hr: $D = \frac{C-S}{L \times H} = \frac{880000-\frac{10}{100}\times 880000}{10\times 1000} = 79.2\ Rs/h$

ii) Interest /hr = $I = \frac{C+S}{2} \times \frac{i}{H} = \frac{880000+88000}{2} \times \frac{12}{10\times 1000} = 65.34\ Rs/h$

iii) Housing: Housing @ 1 % of the initial cost of the machine. $H = \frac{880000\times 1}{10\times 1000} = 8.8\ Rs/h$

iv) Insurance: Insurance @ 1 % of the initial cost of the machine. $Insur = \frac{880000\times 1}{10\times 1000} = 8.8\ Rs/h$

v) Taxes: Taxes @ 1 % of the initial cost of machine. $Taxes = \frac{880000\times 1}{10\times 1000} = 8.8\ Rs/h$

Total Fixed cost / hr = 79.2 + 65.34 + 8.8 + 8.8 + 8.8 = Rs. 170.94

B. Operating cost:

1. Fuel cost per hr: Take fuel consumption = 6 lit / hr and cost of diesel Rs. 95 per lit
   Fuel cost/h = 6 x 95 = Rs. 570.0
2. Cost of lubricants: @ 30 % of the fuel cost = 0.30 x 570 = 171.0 Rs/h
3. Repair & maintenance cost /h: Assume 6 % of the capital cost per year
   $R\&M = \frac{880000\times 6}{100\times 1000} = 52.80\ Rs/h$
4. Wages of operator/hour: Assume wages of operator/day as Rs. 600/- and working hours as 8:
   Wages= 600/8 = 75 Rs/h

B. Total Operating cost = 570 +171+52.8+75 = 868.8 Rs/h

Total Cost per hour = Fixed cost + Operating cost = 170.94+ 868.8 = **1039.74 Rs/h**

For Plough: A. Fixed cost- [Assume life of plough 3000 hours for 10 years]

1) Depreciation, $D = \frac{C-S}{L\times H} = \frac{70000-\frac{10}{100}\times 70000}{10\times 1000} = 21.0\ Rs/h$

2) Interest, $I = \frac{C+S}{2} \times \frac{i}{H} = \frac{70000+7000}{2} \times \frac{12}{100\times 300} = 15.4\ Rs/h$

3) Housing: Housing @ 1 % of the initial cost of plough, $H = \frac{70000\times 1}{100\times 300} = 2.33\ Rs/h$

4) Insurance & Taxes: Nil

5) Repair cost @ 6% of the initial cost of plough per year = 70000x6/[100x 300] = Rs. 14.0

Total cost of using plough/h = 21.0 + 15.4 + 2.33 + 0 + 14 = **Rs. 52.73**

Total cost of ploughing with tractor = 1039.74+52.73= 1092.47 Rs/h

Area covered = 0.45 ha

Cost of ploughing per hectare = 1092.47/0.45= 2427.71 Rs/ha

Problem 2: A four bottom MB plough with 30 cm spacing is working to a depth of 18 cm. The speed of tractor is 6 kmph and resistance of soil on plough bottom is 0.7 kg/cm^2. Calculate the draft and HP required to pull the plough.

Ans: Step I: Given data: 1) No. of bottoms=4; (2) Bottom spacing=30 cm;
3) Depth of furrow=18 cm; (4) Speed=6 kmph;
5) Soil resistance =0.7 kg/cm^2; (6) Total draft=?; (7) Power=?

Step II: Width of ploughing = 30x4 = 120 cm
Furrow cross section = 120x18 = 2160 cm^2,
Step III: Total draft = Soil resistance x furrow cross section = 0.7 x 2160 = 1512 kg
Step IV: Horse power required to pull the plough can be calculated by the formula,

$$Power = \frac{Draft(kg) \times Speed(\frac{m}{s})}{75} = \frac{1512 \times 6 \times 1000}{75 \times 3600} = \mathbf{33.6 \approx 34\ hp}$$

Problem 3: Calculate the area covered per day of 8 hours by a tractor drawn four bottom 35 cm plough if the speed of the ploughing is 6 kmph, the time loss in turning is 6%.

Ans: Step I: Given data: 1) No. of bottoms=4; (2) Bottom spacing=35 cm;
3) Speed=6 kmph (4) Time loss =6%; (5) Area covered=?
Step II: Area covered /hr = [4 x 35/100] x [6 x 1000]/1 = 8400 m^2.
Area to be covered in 8 hours = 8400 x 8/10000 = 6.72 ha
Step III: Turning loss = 6.72 x 6/100 = 0.4 ha
Therefore, actual area covered in 8 hours = 6.72 – 0.4 = **6.32 ha**.

Problem 4: The total draft of a four bottom, 40 cm MB plough when ploughing 22 cm deep at 6 kmph is 2100 kg and field efficiency is 75%. Calculate unit draft, actual power required and area covered per hour.

Ans: Step I: Given data: 1) No. of bottoms=4; (2) Bottom spacing=40 cm; 3) Speed=6 kmph
(4) Depth of furrow=22 cm; 5) Field efficiency = 75%; (6) Total draft=2100 kg
(7) unit draft, actual Power and area covered=?
Step II: Width of ploughing = 40x4 = 160 cm
Furrow cross section = 160x22 = 3520 cm^2,

$$Unit\ draft = \frac{Total\ draft}{Furrow\ cross\ sectional\ area} = \frac{2100}{3520} = 0.597\ {}^{kg}/_{cm^2}$$

Step III: Actual power required $Power = \frac{Draft(kg) \times Speed(\frac{m}{s})}{75} = \frac{2100 \times 6 \times 1000}{75 \times 3600} = \mathbf{46.66 \approx 47\ hp}$
Step IV: Area covered/h = width x speed = [160/100] x [6000/10000] = 0.96 ha.
Considering 75% field efficiency, Actual area covered = 0.96 x 75/100 = **0.72 ha/h**.

Problem 5: Two bullocks, weighing 400 kg each are pulling a implement with a speed of 3 kmph. Find the power to be developed by the bullocks.

Ans: Step I: Given data – 1) No. of bullocks =2; (2) Weight of bullocks=400 kg each;
(3) Speed=3 kmph; (4) Power developed = ?
Step II: Load pulled by two bullocks = 400 x 2/10 = 80 kg
Step III: Power to be developed by bullocks can be calculated by using the formula

$$Power = \frac{Draft(kg) \times Speed(\frac{m}{s})}{75} = \frac{80 \times 3 \times 1000}{75 \times 3600} = \mathbf{0.888 \approx 0.9\ hp}$$

Problem 6: A four bottom 40 cm MB plough has a working depth of 15 cm and draft of 1600 kg. It is working at a speed of 4.5 kmph with field efficiency of 70%. Calculate (i) unit draft draft (ii) Drawbar power and (iii) Actual field capacity.

Ans: Step I: Given data: 1) No. of bottoms=4; (2) Bottom spacing = 40 cm;
3) Depth of furrow=15 cm; (4) Speed=4.5 kmph
5) Field efficiency = 70%; (6) Draft = 1600 kg;
(7) Unit draft draft=? (8) Drawbar power =?(9) Actual field capacity = ?

Step II: Furrow cross-section = 4 x 40 x 15 = **2400 cm²**

Step III: $$Unit\ draft = \frac{Total\ draft}{Furrow\ cross\ sectional\ area} = \frac{1600}{2400} = 0.667 \approx \mathbf{0.67}\ {}^{kg}/_{cm^2}$$

$$Drawbar\ Power = \frac{Draft(kg) \times Speed(\frac{m}{s})}{75} = \frac{1600 \times 4500}{75 \times 3600} = \mathbf{26.67\ hp}$$

Step IV: Theoretical area covered = 4x40/100 x [4.5 x 1000]/10000 = 0.72 ha

Actual field capacity = 0.72 x 70/100 = **0.504 ha/h**

Lecture No. 10

Secondary Tillage Implements

Definition: Lighter or finer operations performed on soil after primary tillage operations are called secondary tillage operations and the implements used are called as secondary tillage implements.

After ploughing fields are left with large clodds with some weeds and partially uprooted stubbles. This rough surface needs to be worked out to prepare smooth and fine seedbed. The basic works done by ***secondary tillage implements*** are given below:

- These tillage implements &tools works to sallow depth and remove the weeds,stubbles by cutting. Covered, dragged out from the surface of soil and killed.
- Loosen the soil, kill weeds and facilitate the moisture entry into soil.
- Perform the smoothening and levelling process of the field.
- Break the clods, pulverize soil and make it firm for efficient seed bed preparation.
- Cut the crop residue like straw etc and further mix them with soil for faster decomposition.

Types of Secondary Tillage Implements:

Sometimes, Primary Tillage Implements are used in place of secondary tillage implements like one way plough etc. These implements play an important role in Agriculture.

Major secondary tillage implements are grouped as:

1. Harrows: They are further divided into 2 types:
   a. Disc Harrow
   b. Toothed Harrow – Spring tooth & spike tooth
   c. Blade harrow

   Disc Harrow is sub divided into:
   a. Trailing Type
   b. Mounted Type
2. Pulverizers
3. Cultivators – Spring & rigid tyned
4. Roller pockets & roller harrow
5. Ridgers, bedders & listers
6. Weed control implements

Fig. 10.1 Serrated edge Disc harrow

1. Harrow:A harrow is an implement that cuts the soil to a shallow depth for smoothening and pulverizing the soil as well as to cut the weeds and to mix materials with soil.

Use:

1. To break clods after ploughing,
2. To collect trash from the ploughed land
3. To level the seed bed.
4. To prepare fine seedbed
5. To pulverize the soil or mixing soil thoroughly
6. To aerate soil and kill weeds
7. Used mostly in lighter soil conditions
8. Sometimes used to cover seeds after broadcasting

Fig. 10.2 Plain edge Disc harrow

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

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

1. Disc harrow
2. Triangular harrow
3. Spring tooth harrow
4. Bodela
5. Spike tooth harrow
6. Zig-zag harrow
7. Blade harrow (Bakhar)
8. Bindha
9. Guntaka
10. Other harrows.

Fig. 10.3 Tractor drawn Disc harrow

1. Disc Harrow: It is a harrow which performs the harrowing operations by means of a set (or a number of sets) of rotating steel discs, each set being mounted on a common shaft.

Types of Disc Harrow: These are of two types depending upon the sources of power.

(a)Tractordrawn

(b) Animal drawn

(a) Tractor drawn disc harrow: Disc harrow is found very suitable for hard ground, full of stalks and grasses.It cuts the lumps of soil, clods and roots. Discs are mounted on one, two or more axles which may be set at a variable angle to the line of motion.As the harrow is pulled ahead, the discs rotate on the ground.

Fig. 10.4 Types of Disc harrow

Types: Depending upon disc arrangements, divided into two classes:

(i) Single action

(ii) Double action.

(ii) 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. 10.4a).

(ii) 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, Sets of gangs are arranged in such a way that the front and back gangs throw the soil in opposite directions (Fig. 10.4b).Thus the entire field is worked twice in each trip.

Types: It may be of two types:

(a) Tandem and

(b) Off-set.

a) Tandem disc harrow

It is a disc harrow comprising of four gangs in which each gang can be angled in opposite direction (Fig. 10.5).

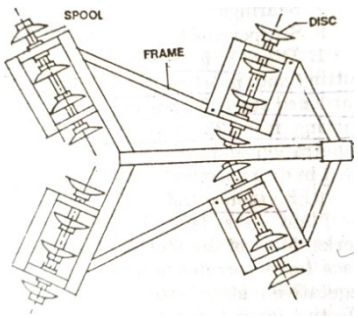


Fig. 10.5 Tandem disc harrow

b) Off-set disc harrow

It is a disc harrow with two gangs in tandem, capable of being off-set to either side of the centre line of pull. Two gangs are fitted one behind the other. The width covered by these types of harrows ranges from 4 to 30 ft. The soil is thrown in both directions because discs of both gangs face in opposite directions. It is very useful for orchards and gardens. It travels left or right of the tractor. The line of pull is not in the middle, that is why it is called off-set disc harrow (Fig.

10.4c & 10.6). Off-set disc harrow is based on the basic principle that side thrust against the front gang is opposed by the side thrust of the rear gang. Hence the gangs are arranged at suitable angles so that both thrusts are counter balanced with each other.

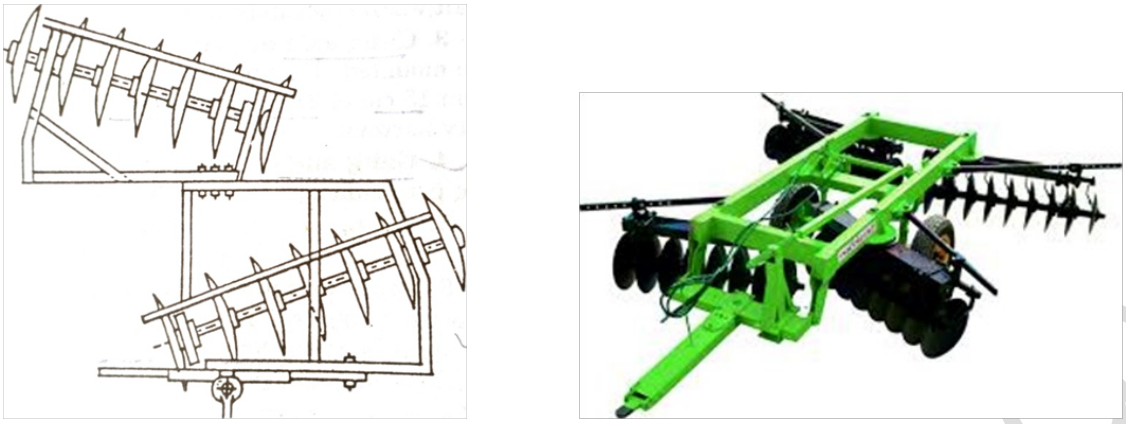


Fig. 10.6 Offset disc harrow

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

i. Disc: It is a circular concave revolving steel plate used for cutting and inverting the soil. Disc is made of high glass heat-treated hardened steel. Tractor drawn disc harrows have concave discs of size varying from 35-70 cm diameter. Concavity of the disc affects penetration and pulverization of soil. Usually two types of discs are used in disc harrows, plain disc and cut away disc. Plain discs have plain edges and are used for all normal works. Most of the harrows are fitted with plain discs only. Cut away discs have serrated edges and cut stalks, grass and other vegetation.

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

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

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

v. Spool or spacer: The flanked tube, mounted on the gang bolt between every two discs to prevent the lateral movement of the disc on the shaft is called the `spool' or `spacer'. It is just a device for keeping the discs at equal spacing on the gang bolt. The standard disk spacing is 7 inches.

vi. Bearing: Bearing is essential to counter at the end thrust of the gang due to soil thrust. The harrow bearings are subjected to heavy radial and thrust loads. Chilled cast iron bearings are used to heavy radial and thrust loads and are also used due to their durability (Fig. 10.7).

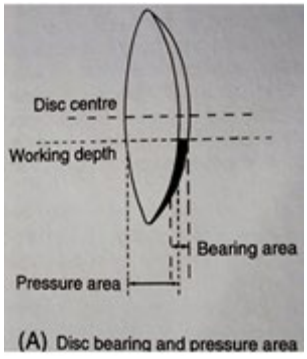


Fig. 10.7 Disc bearing

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

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

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

Adjustments of Disc Harrow: There are several factors which affect the penetration of disc harrow in the field and needs few adjustments for obtaining higher penetration:

1. By increasing the disc angle
2. By adding additional weight in harrow
3. By lowering the hitch point
4. By using the sharp edged discs of small diameter and losser concavity
5. By regulating the optimum speed.

Care and Maintenance of Disc Harrow:

1) Bearings must be thoroughly greased at regular intervals
2) All nuts and bolts must be checked daily before taking the implement to the field
3) Blunt edges of the discs should be sharpened regularly
4) During slack season, the worn parts including bearings should be fully replaced

It is better to coat the outer and inner surfaces of the discs when the harrow is lying without use in slack season.

Animal Drawn Disc Harrow:

Disc harrow is used for breaking clods while preparing seed-beds. It has **6 to 8 discs fixed in two gangs.** It has strong frame **made of mild steel** on which gangs with discs are mounted**.** An operator's seat is also provided on frame. Transport wheels are fitted for easy movement of harrow from place to place (Fig. 10.8). The size of the harrow is determined by the maximum width of cut of the soil. Its weight varies between 80- 100 kg.


Fig. 10.8 Animal drawn disc harrow

Components:

1.Disc	2. Gang frame	3. Beam	4. Gang angle mechanism	5. Scraper
6. Spacer (spool)	7. Clevis	8. Axle	9. Middle tyne	10. Bearings

Other Types of Harrows:

1. Spike Tooth Harrow or Straight tine harrow:

It is a harrow with pegs shaped teeth of diamond cross section to a rectangular frame as working part fitted in a rigid articulated or flexible frame (Fig. 10.9). It is used to

- break the clods,
- stir the soil,
- uproot the weeds,
- level the ground,
- break the soil and cover the seeds.

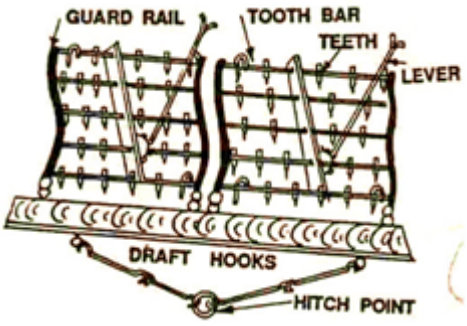


Fig. 10.9 Spike tooth harrow

The peg shaped teeth of diamond cross- section is attached in a rectangular frame. Principal used is to smoothen and level the soil directly after ploughing. Spike tooth harrows are of two types:

i) Rigid Tyne: The animal drawn spike tooth harrows are usually of rigid type. There may or may not be provision for changing the angles of spikes in operating condition (Fig. 10.9).
ii) Flexible Type: Tractor drawn harrows are usually flexible type. It has got advantage of being rolled up for transporting purpose.

This harrow consists of:
1) Teeth: may be square, triangular or circular in section.
2) Tooth Bar: The teeth are so placed on tooth bar that one tooth is behind the other. Tooth bars are made of wood or steel. Steel bars may be round flat or channel shaped.
3) Clamps: used to fasten teeth to the tooth bars tightly so as not to be loose while in operation.
4) Guard:
5) Braces:
6) Lever:
7) Hooks:

2. 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 spring action in working condition. It is used in the soil when obstruction like stone, roots and weeds are hidden below the ground surface. This pulverizes the soil and helps in killing weeds. This type of harrow mainly consists of teeth, tooth bar, clamps, frame, lever and links. Usually the teeth are made of spring steel. Sometimes reversible points are provided so that one end may be used after the other end is worn out. The teeth are fastened to the tooth bar by means of tooth clamps. They are provided to give rigidity and support to the harrow. The levers are provided for setting the teeth for varying the depth of harrowing (Fig. 10.10). For light harrowing, the adjustment is done in slanting position. Draft hooks are there on each corner of everysection for hitching purpose. The depth of ploughing is 7 inches.

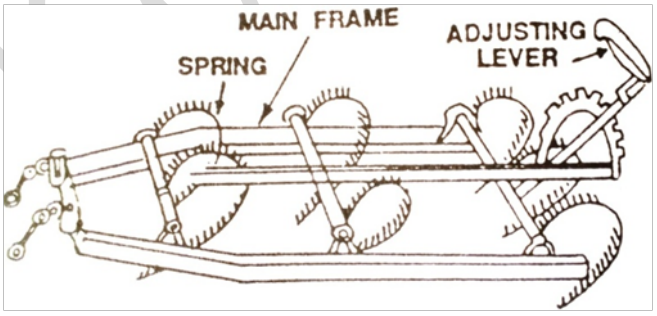


Fig. 10.10 Spring tooth harrow

3. Blade harrow:

It is an implement, which consists of one or more blades attached to the beam or frame, used for shallow working of the soil with minimum soil inversion (Fig.10.11). It works like a sweep which moves into top surface of the soil without inverting it.

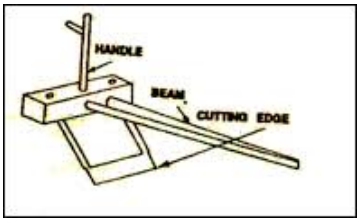


Fig. 10.11 Blade harrow

Cultivators:

Definition: It is an implement for inter-cultivation with laterally adjustable tynes or discs to work between crop rows.
Use: Seedbed preparation and for sowing with seeding attachment.

A cultivator is any of several types of farm implement used for secondary tillage.In One sense the name refers to frames with the teeth(also called shanks) that pierce the soil as they are dragged through it linearly. Another sense refers to machines that use rotary motion of disks or teeth to accomplish a similar result. Example - rotary tiller
Types: The cultivators can be

1. **Disc cultivator:** It is a cultivator fitted with disc.
2. **Rotary cultivator:** It is a cultivator with tines or blades mounted on a power driven horizontal shaft.
3. **Tyne cultivator:** It is a cultivator fitted with tines having shovels.

Depending upon the type of power available for the implements, cultivators can be classified as:

1. Tractor drawn cultivator – i) Trailed type and (ii) Mounted type
2. Animal drawn cultivators

Fig. 10.12 Tyne cultivator

1. Tractor drawn cultivator:
   a) Cultivator with spring loaded tynes
   b) Cultivator with rigid tynes

Cultivators stirs and breaks the clods.The tines fitted on the frame of the cultivator comb deeply in the field. It pulverizes the soil, either before planting or after the crop has begun growing (to kill weeds—controlled disturbance of the topsoil close to the crop plants kills the surrounding weeds by uprooting them, burying their leaves to disrupt their photosynthesis, or a combination of both). A cultivator performs functions intermediate between those of plough and the harrow. Destruction of weeds is the primary function of cultivator. Unlike a harrow, which disturbs the entire surface of the soil, cultivators are designed to disturb the soil in careful patterns, sparing the crop plants but disrupting the weeds.

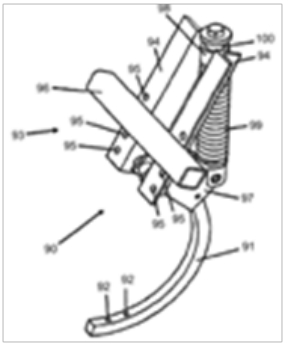


Fig. 10.13 Spring tyne

Important functions of cultivators:

a) Interculture the fields
b) Destroy weeds in the field
c) Aerate the soil for proper growth of crops
d) Conserve moisture by preparing mulch on the surface
e) To sow seeds when it is provided with sowing attachments.
f) Prevents surface evaporation and encourage rapid infiltration of rainwater into soil.

1.Cultivator with spring loaded tynes:

- It is cultivator fitted with tines having shovels
- It stirs soil, breaks the clods
- Tynes hinged to the frame & loaded with spring so that it swings back when obstacle is encountered.
- Each tyne is provided with two heavy coil springs
- On passing over springs tynes are automatically reset and work without interruption (Fig. 10.13).
- This type of cultivator recommended **for soils embedded with stones or stumps**.
- There may be **7, 9, 11, 13 tynes** depending upon requirement.

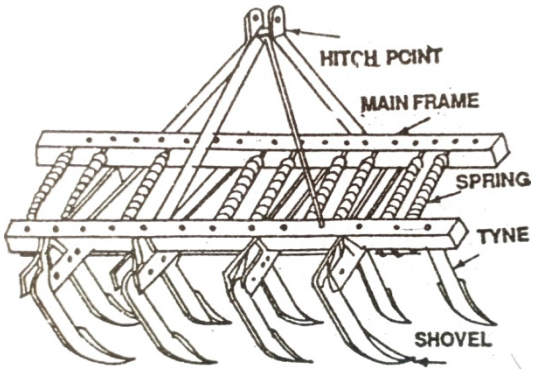


Fig. 10.14 Spring loaded tyne cultivator

- **Construction:** Tines fitted on the frame that enter deeply in soil
- **Function:** performs functions intermediate between those of plough and the harrow.

- Cultivators of the toothed type are often similar in form to chisel ploughs, but their goals are different.
- Cultivator teeth work near the surface, usually for weed control, whereas chisel plow shanks work deep beneath the surface, breaking up hard pan.
- Consequently, cultivating also takes much less power per shank than does chisel plowing.

2. Cultivator with rigid tines:

- Rigid tines of the cultivator are those tines which do not deflect during the work in the field. Tines are bolted between angles braces, fastened to the main bars by sturdy clamps and bolts (Fig. 10.15). The spacing between the tines can be easily adjusted without getting tines choked with crop residues and stubbles.

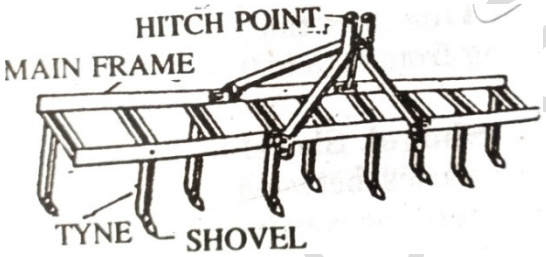


Fig. 10.15 Cultivator with rigid tines

- A pair of gauge wheels is used for controlling the depth of operation.

Solved Examples:

Problem 1: Calculate the energy in kg-metre required to prepare one hectare of seed bed with following implements:

(a) An indigenous plough cuts 10 cm deep and 20 cm wide triangular furrow and unit draft is 0.5 kg/cm^2 of furrow cross section. Two ploughings are required.

(b) Harrowing twice with 60 cm wide blade harrow (bhakhar) having unit draft of 90 kg per meter width of harrow.

(c) Levelling twice with a 3 m long wooden leveler having draft of 40 kg per meter width.

Ans: Given data- (1) depth of furrow=10 cm; (2) Width of furrow=20 cm;
(3) Unit draft=0.5 kg/cm^2; (4) No. of ploughings = 2; (5) Energy required=?

Step II: Area of Triangular furrow cross section = ½[20x10] = 100 cm^2
Width of furrow = 20 cm = 0.2 m
Total draft = 0.5 x 100 = 50 kg

Step III: (a) Ploughing with indigenous plough:

Total length of two ploughings per hectare = [2 x 10000]/0.2 = 100000 m
Energy required = 100000 x 50 = **5000000 kg-meter**.

Step IV: (b) Given data harrowing twice- (1) width of blade = 60 cm;
(2) unit draft = 90 kg per meter width of harrow
Total draft of harrow = 90 x [60/100] = 54 kg
Total length of travel for harrowing (twice) per ha
= [2 x 10000/0.6] = 100000/3 meters
Energy required = [100000/3] x54/1 = **1800000 kg-meter**

Step V: (c) For levelling twice-
Given data- (1) Width of wooden leveller =3 m; (2) draft = 40 kg per meter width
Total draft for levelling = 40 x 3 = 120 kg
Total length of travel per ha = 2 x[10000/3] = 20000/3 m
Energy required =[20000/3] x 120 = **800000 kg-metre**

Therefore, total energy required for all three operations
= 50,00000+1800000+800000 = **7600000 kg.m**

Problem 2: How many acres can be covered by a harrow of 2 m width in a day of 8 hours with tractor power working at a speed of 5.5 kmph? If each spike of harrow is giving soil resistance of 1 kg and there are 70 spikes, what horse power would be required for the tractor to pull the harrow?

Ans: Step I: Given data- (1) Width of harrow=2 m; (2) Speed of tractor = 5.5 kmph; (3) Working hours = 8 hr; (4) Soil resistance = 1kg/spike; (5) No. Of spikes= 70; (6) Area covered =?; (7) Power required=?

Step II: Area covered in 1 hour = width x speed = [2 x 5.5 x 1000]/10,000 = 1.1 ha

Area covered in 8 hours = 1.1 x8 = 8.8 ha.

Step III: Total draft = 70x1 = 70 kg

$$Horse\ power\ required = \frac{Draft \times Speed}{75} = \frac{70 \times 5500}{75 \times 3600} = 1.426\ hp$$

Problem 3: A five tine cultivator having tine spacing 8 cm, working depth of 5 cm and speed is 3 kmph. The time loss in turning is 10%, soil resistance is 0.6 kg/cm^{2}and width of each furrow is 5 cm. Calculate (1) Time to cover 1 ha (2) Maximum draft (3) Required power

Ans: Step I: Given data- (1) No. of tines= 5; (2) Tine spacing= 8 cm; (3) Depth & width of furrow= 5 x 5 cm; (4) Speed = 3 kmph; (5) Turning loss = 10%; (6) Soil resistance= 0.6 kg

Step II: Width of cultivator = 8 x 5 = 40 cm = 0.4 m

Area covered= width x speed = [0.4 x 300/10,000] x [90/100] = 0.108 ha

Time required per ha = 1/0.108 = 9.259 ≈ 9.26 hr

Step III: Cross sectional area of 5 furrows = 8x5x5 = 200 cm^2

Maximum draft = 200 x 0.6 = 120 kg

Power necessary for pulling the harrow will be

$$Horse\ power\ required = \frac{Draft \times Speed}{75} = \frac{120 \times 3000}{75 \times 3600} = \mathbf{1.33\ hp}$$

Problem 4: A tractor is attached with a 9 tyne cultivator. While field testing, drawbar dynamometer shows an average pull of 1428.57 kg. If the speed of the tractor is 6 kmph, find the power of the tractor.

Ans: Step I: Given data- (1) No. Of tines=9; (2) Pull or load=1428.56 kg; (3) Speed of tractor = 6000 m; (4) Tractor power=?

Step II: the horse power of tractor required to create necessary pull is calculated as

$$Horse\ power\ required = \frac{Pull \times Speed}{75} = \frac{1428.56 \times 6000}{75 \times 3600} = 31.7457 \approx \mathbf{32\ hp}$$

Lecture No. 11-12

Implements for Inter-cultural Operations

The main objective of weed control is 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 these weeds.

Types of weeding tools and implements: Weeding devices used by farmers are as follows

1. Traditional hand tools,
2. Traditional and improved hoes
3. Wheel hoes
4. Animal drawn multipurpose hoe
5. Tractor drawn interculture equipment

Traditional hand tools: Among the traditional hand tools, the khurpi and the weeding hooks are the popular tools made by the local artisans for the use on small and marginal farms (Fig. 11.1 & 11.2). Khurpis used in India may vary in its size, shape and weight but these have common basic parts i.e. cutting blade and a small wooden handle for grip. Variation in the size ofcutting blade exists due to its variety of uses. The khurpi with long narrow blade is preferred for weeding around the flower plants, broadcasted crops and vegetable crops. Khurpi with wider blades is used for earthing up operations and for weeding crops sown in lines or rows. A man can weed out about 0.025 ha in a day.

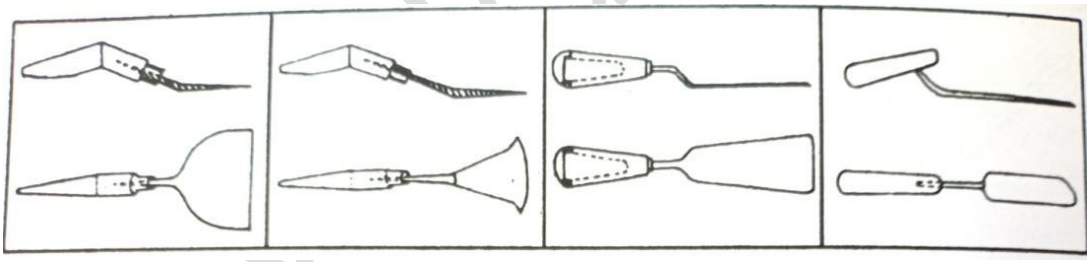


Fig. 11.1 Khurpi

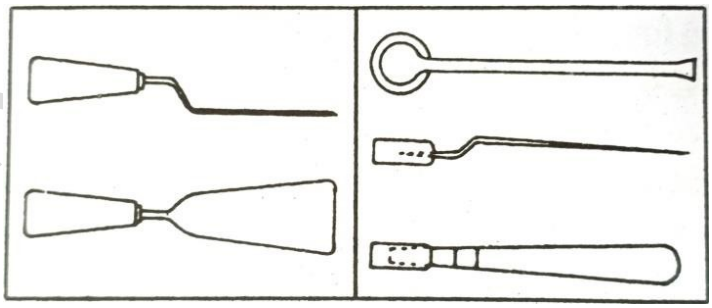


Fig. 11.2 Weeding hooks

1. Traditional and improved hoes: The hoe is a versatile form of implement used for many operations, i.e. seed bed preparation, ridge making, channel shaping and weeding. It is also used for removing plant roots, harvesting root crops and thinning drilled crops. Two common types ofhoes used by farmers are

1. Hand hoes and
2. Animal drawn hoes

1. Hand hoes: Hand hoes are used to cultivate very small area of land by human labour. Amongindigenous type of hand hoes, the *Kodali* (narrow spade) is the most popular one.

Kodali [Fig. 11.3(a)] is similar to *phawara* (broad blade), the difference being that instead of wide thin cutting blade, a narrow long pointed thicker section blade is attached to the handle. The person working with it has to bend his body during operation. It is used for inter cultivating maize and sugarcane crops, earthing up the potato crops and digging trenches in the open land. About 0.04 ha can be covered in a day by one man. An improved hand hoe (Fig. 11.3b) is operated in standing position. It is provided with long handle fitted in the middle of the cutting blade. One end of the blade is about 10 cm wide, sharp edged and the other end is pointednarrow one for making small furrows. It can be used for cultivating and weeding very close tothe individual plant.

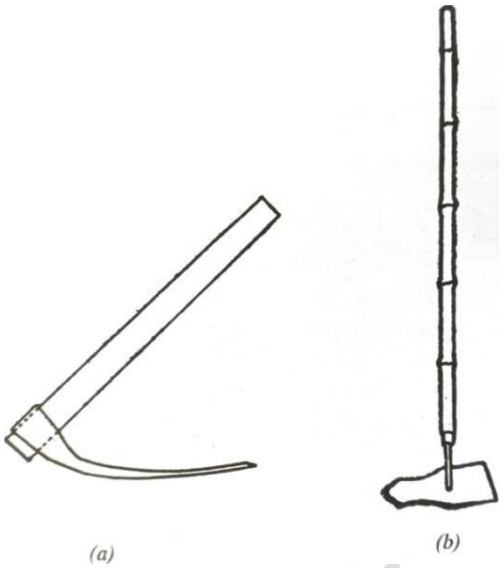


Fig. 11.3 Hand hoe

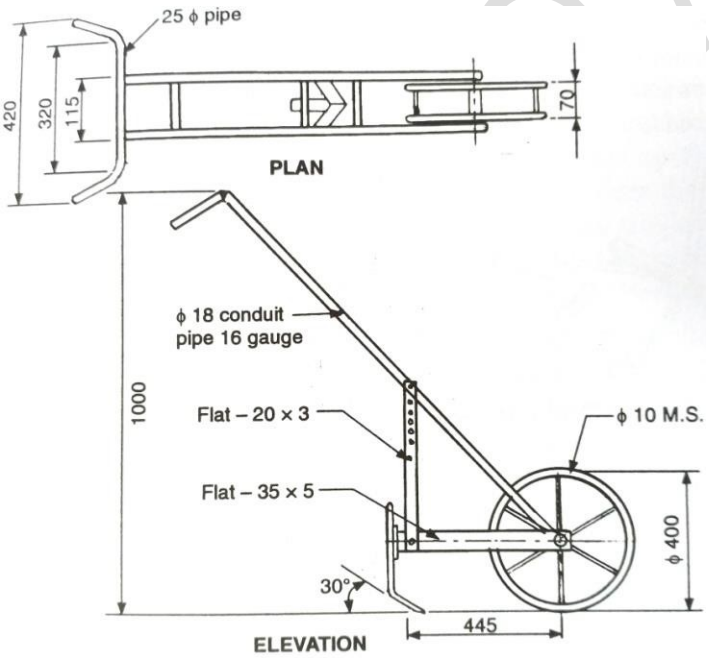


Fig. 11.4 Wheel hand hoe

The wheel hand hoe is used for cultivating the land between rows (Fig. 11.5). It consists of a wheel, two handles and a tyne to place the cutting tool on. The cutting tool may be a reversible shovel or a three prong fork or rake or a sweep depending upon the weeds and moisture condition. A man operates the hoe in standing position by pushing through a short length each time. A single man can cover about 0.04 ha in a day.

The 'Grubber' (Fig. 11.4) is a manual pull type hoe suitable for weeding and inter culture of upland row crops in black soil regions. It is provided with three blades and the working field capacity is 0.005 (1/200) ha per hour.

Rotary paddy weeder (Fig. 11.6) is best suited for uprooting the weeds and burying them into soil. The operator moves the tool forward and backward in narrow rows of paddy crop. It gives higher output and drudgery of the operator is considerably reduced.

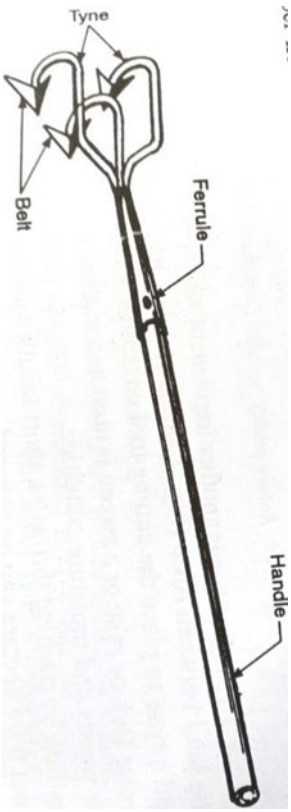


Fig. 11.5 Three tyne Grubber

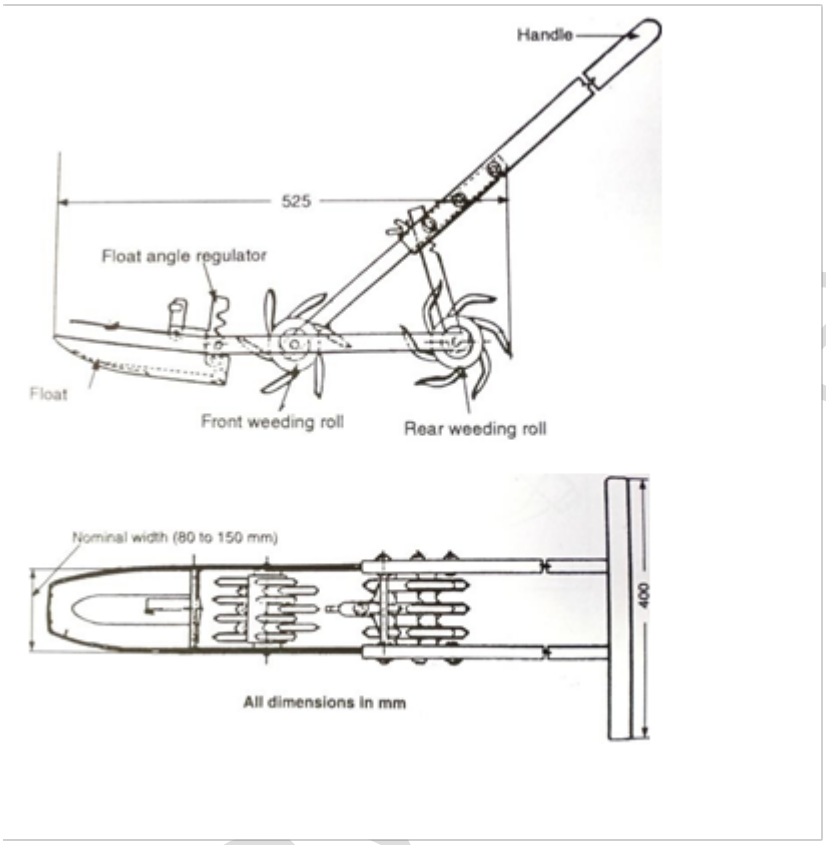


Fig. 11.6 Rotary paddy weeder (Japanese type)

2. Animal drawn hoes:

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 (Fig. 11.7). The tyne cultivator or 'Triphali', Akola hoe, Bardole hoe or two 'Blade hoe' are the most popular implements in different regions for row crop interculture operations. If animal drawn weeders are to be used, it is essential to provide wider spacing (above 30 cm) for movement of animals and implement.

The main parts of the blade hoe are –

(i) head piece (ii) prong, (iii) blade, (iv) handle and (v) beam.

The number of cutting blades on these hoes may be one or more. The prongs make an angle of about 45° downward with the horizontal plane. At the end of each prong the blade is attached. It loosens the upper surface of the soil and is generally used for inter-culturing sorghum, cotton, groundnut and other *kharif* crops. The hoe width is maintained between 25 and 75 cm depending upon the size of bullocks and type of soil.

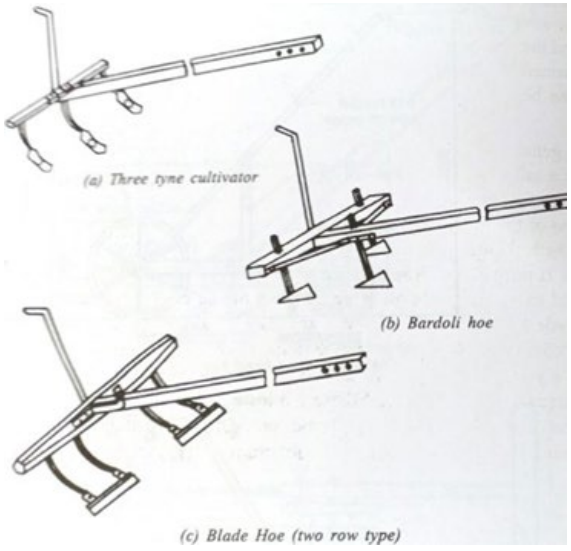


Fig. 11.7 Different types of animal drawn weeders

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Lecture No. 13

Study of Sowing Methods & Seed Drill

Sowing: It is the art of placing seeds in the soil to have good germination in the field.

Perfect Seeding:

1. Correct amount of seed per unit area
2. Correct depth at which seed is placed in soil
3. Correct spacing between row to row and plant to plant

Methods of Sowing: The sowing method is determined by the crop to be sown. There are 6 sowing methods which differ in their merits, demerits and adoption. Those are:

1. Broad casting
2. Dibbling
3. Drilling
4. Seed dripping behind the plough
5. Transplanting
6. Hill dropping
7. Check row planting.

Fig. 13.1 Broadcasting

Broad casting: It is the process of random scattering of seeds by hand all over the prepared field followed by covering with wooden plank or harrow for contact of seed with soil.

Manual broadcasting- uniformity of seed depends on skill of man & higher seed rates are required (Fig. 13.1).

Mechanical broadcasting- used for large scale work

After broadcasting seeds are covered by planking/ suitable device. Crops like wheat, paddy, Sesame, methi, coriander, etc. are sown by this method.

Advantages:1) Quickest & cheapest method, 2) Skilled labour is not required, 3) Implement is not required, 4) Followed in moist condition.

Disadvantages: 1) Seed requirement is more, 2) Crop stand is not uniform, 3) Result in uneven germination & defective wherever the adequate moisture is not present in the soil, 4) Spacing is not maintained within rows & lines, hence inter-culturing is difficult.

2. Dibbling: It is the placing or dibbling of seeds at cross marks (+) made in the field with the help of marker as per the requirement of the crop in both the directions.

Dibbling is the process of placing of seeds in holes made in seedbed and covering them.

In this method, seeds are placed in holes made at definite depth at fixed spacing. The equipment used for dibbling is called dibbler.

It is a conical instrument used to make proper holes in the field. Small hand dibblers are made with several conical projections made in a frame. This is very time consuming process, so it is not suitable for small seeds. Mostly vegetables are sown in this way. This method is followed in crops like Groundnut, Castor, and Hy. Cotton, etc. which are having bold size and high value.

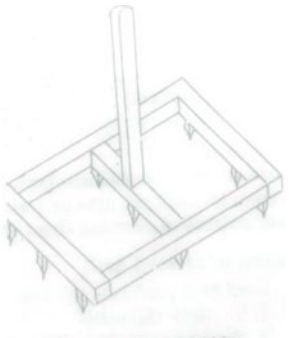


Fig. 14.1. Hand dibbler

Advantages:

1. Spacing between rows & plants is maintained,
2. Seeds can be dibbled at desired depth in the moisture zone,
3. Optimum plant population can be maintained,
4. Seed requirement is less than other method,
5. Implement is not required for sowing,
6. An intercrop can be taken in wider spaced crops,
7. Cross wise inter-cultivation is possible.

Fig. 13.2 Hand dibbling

3. Drilling or Line sowing: It is the dropping of seeds into the soil with the help of implement such as *mogha*, seed drill, seed-cum-ferti driller or mechanical seed drill and then seeds are covered by wooden plank or harrow to have contact between seed & soil.

Crops like Jowar, wheat Bajara, etc. are sown by this method.

Advantages:

1. Seeds are placed at proper & uniform depths,
2. Along the rows, inter-culturing can be done,
3. Uniform row to row spacing is maintained,
4. Seed requirement is less than 'broad casting'
5. Sowing is done at proper moisture level.

Fig. 13.3 Drilling method

Disadvantages:

1. Require implement for sowing,
2. Wapsa condition is must.
3. Plant to plant (Intra row) spacing is not maintained,
4. Skilled person is required for sowing.

4. Putting seeds behind the plough: It is dropping of seeds behind the plough in the furrow with the help of manual labour by hand. This method is followed for crops like wal or gram in some areas for better utilization of soil moisture. The seeds are covered by successive furrow opened by the plough. This method is not commonly followed for sowing of the crops.

5. Transplanting: It is the raising of seedlings on nursery beds and transplanting of seedlings in the laid out field. For this, seedlings are allowed to grow on nursery beds for about 3-5 weeks. Beds are watered one day before the transplanting of nursery to prevent jerk to the roots. The field is irrigated before actual transplanting to get the seedlings established early & quickly which reduce the mortality.

Fig. 13.4 Transplanting

Advantages: disadvantages of dibbling method, initial cost of cultivation of crop can be saved but requires due care in the nursery.

Followed in crops like paddy, fruit, vegetable, crops, tobacco, etc.

6. Hill dropping: In this method seeds are dropped at fixed spacing and not in continuous stream. Spacing between plant to plant in a row is constant. In case of drills, the seeds are dropped in continuous stream & spacing between plant to plant in a row is not constant.

7. Check Row Planting: It is a method of planting, in which row to row & plant to plant distance is uniform. Seed are planted precisely along parallel furrows. The rows are always in two perpendicular directions. A machine used for check planting is called check row planter.

Fig. 13.5 Check row planting

8. Planting: It is the placing of vegetative part of crops which are vegetatively propagated in the laid out field.

Examples: Tubers of Potato, mother sets of ginger & turmeric, cuttings of sweet potato & grapes, sets of sugarcane.

Seed Drill:

The seed drill sows the seeds at equal distances and proper depth, ensuring that the seeds get covered with soil and are saved from being eaten by birds.

Before introduction of seed drill, common practice was to plant seeds by hand. That leads to wastage of seeds, imprecise planting and poor distribution of seeds, leading to low productivity.

The use of a seed drill can improve the ratio of crop yield (seeds harvested per seed planted) by as much as nine times.

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

Functions of seed drill: Seed drill performs the following functions

1. To carry the seeds.
2. To open furrow to an uniform depth
3. To meter the seeds
4. To place the seed in furrows in an acceptable pattern
5. To cover the seeds and compact the soil around the seed.

Components of Seed Drill: A seed drill with mechanical seed metering device consists of :

1. Frame
2. Seed box

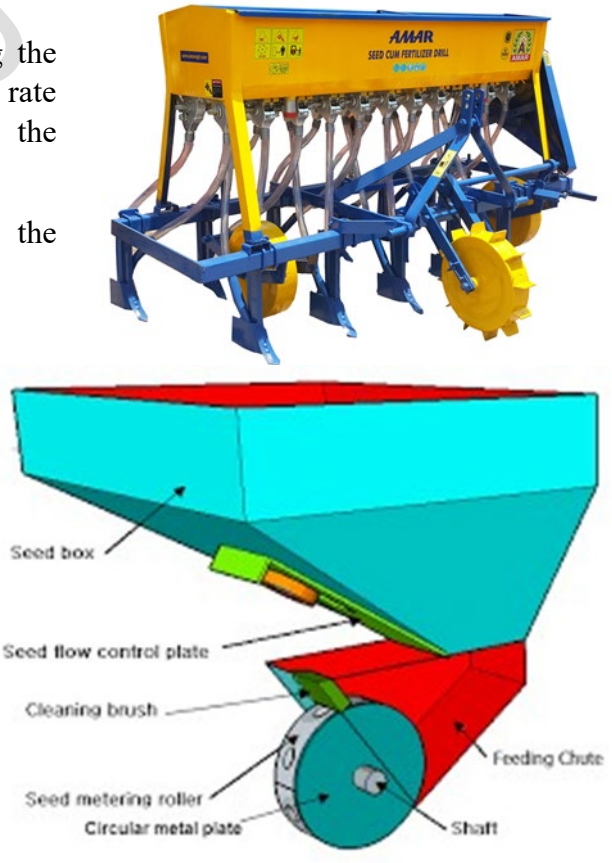


Fig. 13.6 Seed drill

3. Seed metering mechanism
4. Furrow openers
5. Covering device
6. Transport wheels.

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

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

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

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

5. Agitator: This is a stirring device in the seed box, driven by the transport wheels of the drill and which by its mixing effect allows the seeds to flow freely.

6. Drive Mechanism: It transmits power from the transport wheels to the seed delivery system either by chain and sprocket or by a V-belt drive and at times a combination of both.

Seed cum fertilizer drill:

Seed drills, fitted with fertilizer dropping attachment, distribute the fertilizer uniformly on the ground. It is called seed cum fertilizer drill. Such a drill has a large seed box (Fig. 13.7) which is dividend lengthwise into two compartments, one for seed and another for fertilizers.

Fig. 13.7 Seed cum fertilizer drill.

Classification: Seed drill may be classified as

1. Bullock drawn
2. Tractor drawn

Seed Metering Mechanism: The mechanism of a seed drill or fertilizer distributor which delivers seeds or fertilizers from the hopper at selected rates 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 (Fig. 13.8)
(d) Cell feed mechanism
(e) Brush feed mechanism
(f) Auger feed mechanism
(g) Picker wheel mechanism
(h) Star wheel mechanism.

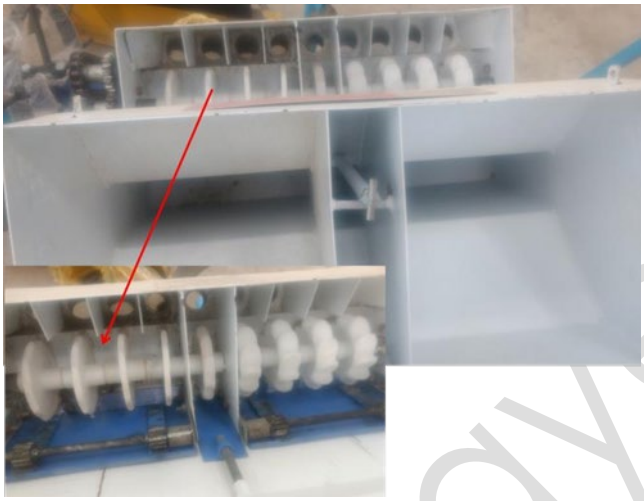


Fig. 13.8 Seed metering mechanism

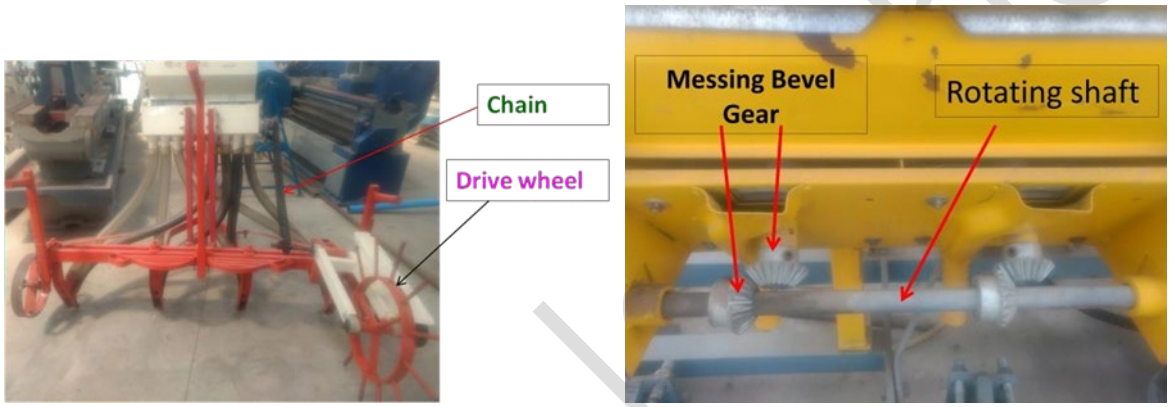


Fig. 13.9 Seed metering mechanism drive

1. Fluted Roller with Seed Hopper:

A) Fluted feed type- It is a seed metering device with adjustable fluted roller (wheel) to collect and deliver the seeds into the seed tube. Fluted feed type mechanism consists of a fluted wheel, feed roller, feed cut-off and adjustable gate for different sizes of grains. (Fig.13.10). The feed roller and the feed cut-off device are mounted on a square shaft, running through the feed cups. The roller carries grooves throughout its periphery.

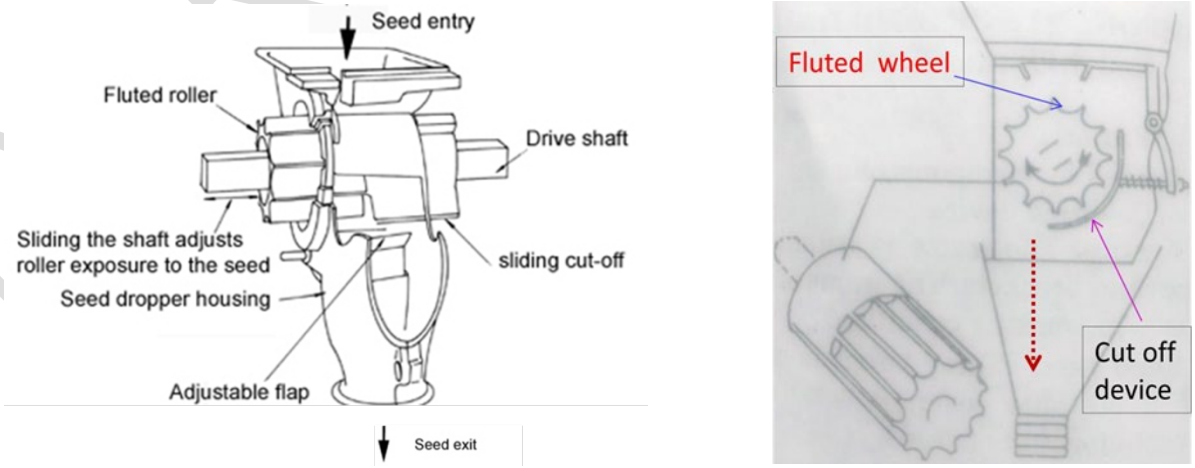


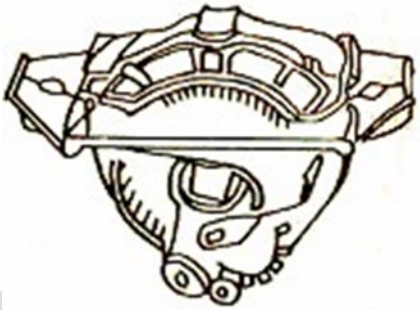
Fig. 13.10 Fluted roller feed type

It rotates with the axle over which it is mounted & throws the grains out on the adjustable gate from where it falls into the seed tube. Fluted rollers mounted at bottom of the seed box, receive seeds into longitudinal grooves and pass on to the seed tube. It is a bulk flow metering device which delivers more or less a continuous flow of seeds.

Adjustments: By shifting the fluted wheel side way, the length of the grooves exposed to the seed can be increased or decreased and hence the amount of seed is controlled.

(B) Internal double run type- It is a seed metering device in which the feed wheel is provided with fine and coarse ribbed flanges.

Construction: It consists of discs, mounted on a spindle and housed in a casing fitted below the seed box (Fig. 13.11). It has double faced wheel, one face has a larger opening for larger seeds and the other face has smaller opening for smaller seeds. A gate is provided in the bottom-of the box to cover the opening not in use.



Adjustments: The rate of seeding is varied by adjusting the speed of the spindle which carries the discs.

Fig. 13.11 Internal double run type

Plate type seed metering device: In this mechanism there is a rotating pate at the bottom of seed hopper. The most common type is horizontal seed plate (Fig. 13.12). The plate consists of cells or notches on its periphery to accommodate the seed, carry and drop in the tube below.

Types of cell: Depending upon the type of notches on plates, there are three types.

(i) Edge drop (ii) Flat drop and (iii) Hill drop.

The edge drop carries the seed on edge in the cell of the plate. The flat drop carries the seed on a flat in the cell of the plate. In hill drop, the cells round the edge of the plate are large enough to admit several seeds at a time.

Use: It is used in Planters for sowing larger seeds which cannot be sown by normal seed drill.

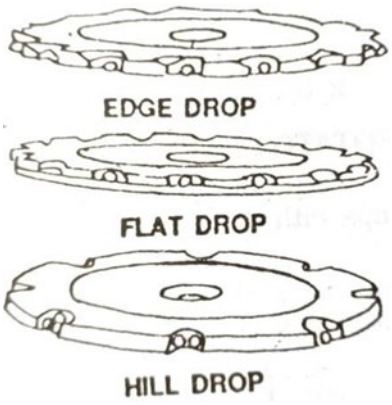


Fig. 13.12 Plate type

Furrow Openers:

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

1. Uniformly open a furrow of stipulated depth.
2. Minimize mixing of soil layers to prevent loss of moisture.
3. Compact the furrow bottom.
4. Minimize disturbance to seed flow. Leave an adequate soil layer between seeds & fertilizer.

Types of furrow openers: Different types of furrow openers are as follows (Fig. 13.13):

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

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

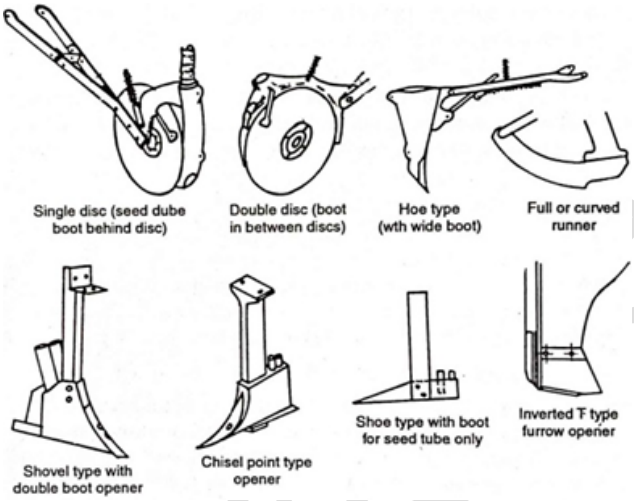


Fig. 13.13 Types of furrow openers

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

Calibration of seed drill:

The procedure of testing the seed drill for correct seed rate is called calibration of seed drill.

Necessity: to calibrate the seed drill before putting it in actual use to find the desired seed rate.

It is done to get the pre-determined seed/ fertilizer rate of the machine (Fig. 13.14). The following steps are followed for calibration of seed drill.

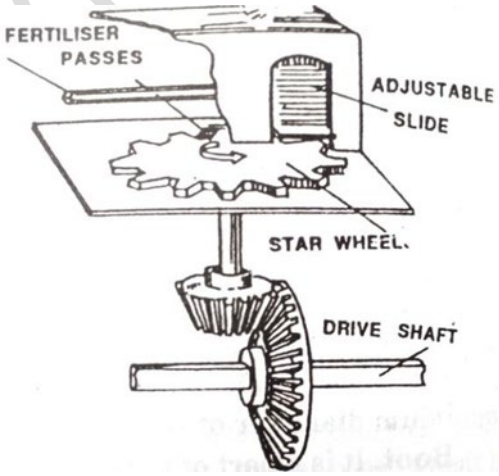


Fig. 13.14 Fertilizer metering unit

Procedure:

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

$$W = M \times S$$

Where, M = Number of furrow openers, S = Spacing between the openers, m

2. Find the length of the strip (L) having nominal width (W) necessary to cover 1/25 ha (1/25 x10000 m^2)

$$\boldsymbol{L = \frac{10000}{W} \times \frac{1}{25} = \frac{400}{W}\ meters}$$

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

$$L = \pi \times D \times N$$

$$\pi \times D \times N = \frac{10000}{W} \times \frac{1}{25}$$

$$N = \frac{10000}{\pi \times D \times W} \times \frac{1}{25} = \frac{400}{\pi \times D \times W}\ RPM$$

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

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

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

7. Engage the clutch and rotate the ground wheel for

$$N = \frac{400}{\pi \times D \times W}\ RPM$$

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

9. Calculate the seed rate in kg/ha

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

Solved Examples:

Problem 1: Calculate the cost of seeding one hectare of land with bullock drawn seed drill of 5x22 cm size. The speed of bullocks is 3 kmph. The hire charges of bullocks are Rs. 300/- per pair, hire charges of seed drill are Rs. 100/- per day and wages of operator are Rs. 300/- per day of 8 hours.

Ans: Step I: Given data-

1) Area to be sown = 1 ha = 10000 m^2.
2) Width of seed drill = 5x22 cm = 110 cm = 1.1 m
3) Speed of bullock = 3 kmph = 3000 m per hour
4) Hire charges: bullock= Rs.300, seed drill= Rs.100 and operator=Rs. 300/-per day of 8 hrs

Step II: Area covered /hr = width x speed = 1.1x3000/ 10,000 = **0.33 ha**

Step III: Time taken to cover 1 ha area = 1/0.33 = **3.03 hrs**

Step IV: Cost of seeding per hour = (300+100+300)/8 = **87.5 Rs/hr**

Cost of seeding one hectare = 87.5x3.03 = **265.12 Rs/ha**.

Problem 2: Calculate the time required for sowing 2 hectares of land by five furrow seed drill going 12.5 cm deep. The speed of seed drill is 3.5 kmph and pressure exerted by the soil on the seed drill is 0.42 kg/cm^2. The space between furrow openers is 22 cm and loss in turning is 10%.

Ans: Step I: Given data-

1) Area to be sown = 2 ha = 20000 m^2.
2) Width of seed drill = 5x22 cm = 110 cm = 1.1 m
3) Speed of bullock = 3.5 kmph = 3500 m per hour

4) Soil resistance =0.42 kg/cm^2.
5) Loss in turning = 10%

Step II: Theoretical area covered per hour $A_{Th} = \frac{110 \times 3500}{100 \times 10000} = 0.385\ ha$

Actual area covered per hour, $A_{Act} = \frac{0.385 \times 90}{100} = 0.3465\ ha$ [Considering 10% time loss]

Step III: Time for sowing 2 ha land = 2/0.3465 = **5.772 hrs**.

Problem 3: The following results were obtained while calibrating a seed drill. Calculate the seed rate per hectare.

(a) No. of furrows = 10
(b) Spacing between furrows = 20 cm
(c) Diameter of drive wheel = 1.5 m
(d) Speed of wheel = 500 rpm
(e) Seed collected = 20 kg

Ans: Effective width of seed drill = 10x20 cm = 2 m.
Circumference of drive wheel = π x D
Area covered in one revolution = π x D x Width of seed drill (W)
Area covered in 500 revolutions = π x D x W x rpm
= [22/7] x 1.5 x 2 x 500
= 4714.28 m^2.

Seed dropped for 4714.28 m2 = 20 kg

$Seed\ dropped\ per\ hectare = \frac{20 \times 10000}{4714.28} = 42.42\ kg$

Lecture No. 14

Study of Planters

Planters are normally used for those seeds which are larger in size and cannot be sown by usual seed drills. Planters are used for row drilling (hill dropping) or check row planting of larger seeds. They give more accurate results with larger seeds. Rows are far apart to allow inter-cultivation Planter are provided with seed hopper for each row & may be separate hopper for fertilizer like seed drill, furrow openers (called runners) are provided on planters. On most planters pack wheel is provided for covering seed with soil and compacting it. Tractor drawn maize planter use lister plough bottom to open furrows & two small shovels for covering seeds.

Functions of Planter: Planter is usually used for those seeds which are required to be sown at equal intervals

1. To open furrow,
2. To meter the seed,
3. To deposit the seed in furrows,
4. To cover the seeds with soil and compact it.

Components of planter: (Fig. 14.1)

1. Seed hopper (*A planter has seed hopper for each row)*
2. Fertilizer hopper
3. Frame
4. Ground wheel
5. Furrow opener
6. Beam
7. Seed metering device
8. Knock out arrangement
9. Cut-off mechanism
10. Other accessories

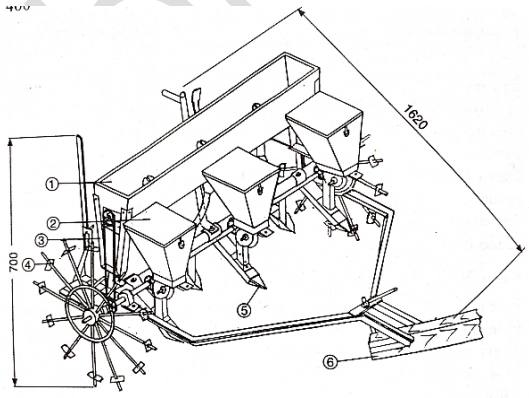
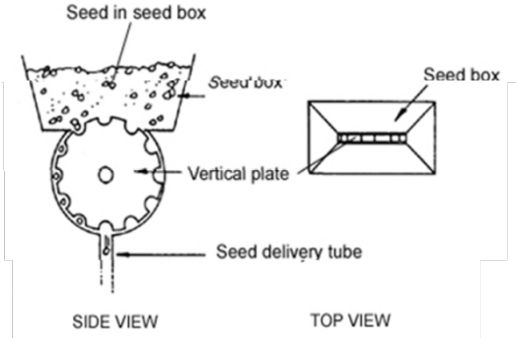


Fig. 14.1 Animal drawn multi-crop planter

Seed metering devices in a planter:

There are number of seed metering devices but the most common device consists of horizontal rotating plate at the bottom of seed hopper. In some planters vertical rotor or inclined rotor is also used. The horizontal rotating plates have got suitable *notches* or holes called *cell*. These are arranged in a number of ways to receive seeds either flat or on edge. The full hill drop receives in each cell 3-4 seeds at a time. After receiving the seeds the plate moves under a cut off device. The cut off allows only the seeds in the plate cell to travel with the plate. There is usually a knock out device to push the seeds out of the plate in case they tend to stick. These seeds usually drop on a valve and wait until the valve is tripped like a trap door to drop the seeds into the furrow or hill. Most of the planters can be set to plant 2, 3 or 4 seeds per hill. A wide range of spacing can be obtained by using plates with varying number of seed cells or by drive chain and sprockets. Depending upon the type of notches on the plates, it is of three types.

1. Edge drop
2. Flat drop
3. Hill drip



1. Edge drop: The edge drop carries the seed on edge in the cell

of the plate.

2. Flat drop: The flat drop carries the seed on a flat in the cell of the plate. Only one seed is allowed in the cell at each time.

3. Hill drip: In hill drop, the cells round the edge of the plate are large enough to admit several seeds at a time.

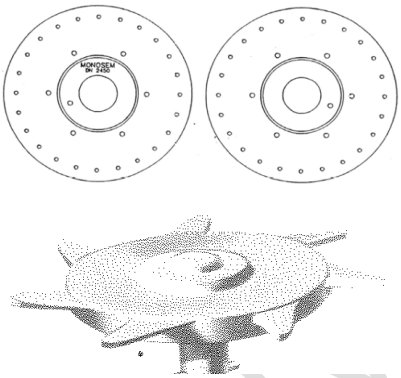


Fig. 14.2 Seed metering devices

Seed Metering Mechanism:

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

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

The accuracy of the planter depends upon following factors:

i) Speed of seed plant
ii) Shape and size of cells
iii) Shape of hopper bottom and
iv) Uniformity of seed size.

Types of Planters:

1. Jyoti Multi-crop planter:

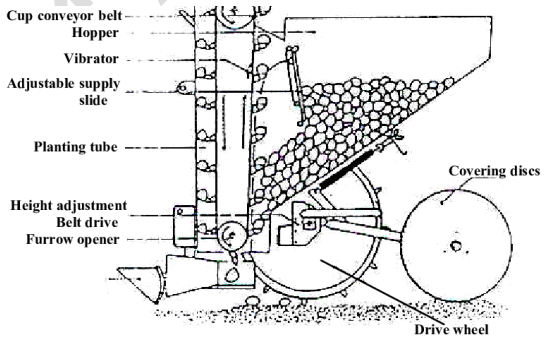


Fig. 14.3 Automatic potato planter

2. Rice transplanters: classified on the basis of type of nursery required, type of planting fingers and power source.

On the basis of type of planting fingers transplanters are classified as:
a) fixed fork type, b) tweezer type,
c) fixed fork and knock out lever type, d) pair of moving fingers type,
e) rotating pincet type

3. Sugarcane planter:

4. Potato planter,

5. Drill for germinated seeds,

6. Pneumatic seed drill.

Lecture No. 15

Plant Protection Equipment

Insects, pests and weeds cause considerable damage to the commercial cops. In a properly organized system, crop protection is one of the most important means of increasing crop productivity.

Among the important methods of weed control and plant protection systems, the following methods have been recognized as effective and economical.

1. Mechanical control
2. Chemical control
3. Biological control
4. Agronomical methods
5. Bio-physical methods
6. Fire as control

The mechanical control of weeds is most widely used in India and many developing countries. The chemical method of plant protection has been universally accepted due to saving of time, labour and its effectiveness with relatively low expenditure. The combination of chemical and mechanical method of weed control has been successfully accepted in developing countries. A large number of herbicides and insecticides are now available in the market for control of wide varieties of weeds and insects. The chemicals for protecting the plants from various injurious organisms need to be applied on plant surfaces in the form of sprays, dusts, mist, etc.

Classification: Different types of spraying and dusting machines are available to meet requirements of farmers in controlling pests, insects and weeds.

Spraying & dusting machines: apply chemical in liquid or dust form. Based on source of power, pressure & area coverage broadly classified into:

1. Hand operated machines- suitable for small holdings, operating pressure = 1 – 7 kg/cm^2.
2. Power operated machines- for treating large area, operating pressure = 20 – 55 kg/cm^2.
3. Air planes- suitable for large scale work.

The chemical preparations in the form of fine liquid droplets are applied to the plants, insects by using the above machines. Chemicals may be used in the form of solution, suspension or emulsion. Usually, liquid fillers are added to the main chemical to facilitate better dispersal. Sometimes, wetting and spreading agents are added to the bulk material to achieve greater effectiveness of chemicals. For effective control of weeds and pests, proper selection of equipment, identification of correct pesticide, its application at correct time in correct dose is very important.

A. Types of Sprayers: Apply chemicals in liquid form. These are categorized on the basis of way of construction as:

1. Bucket type sprayer
2. Knapsack sprayer
3. Hand Compression sprayer

4. Hand Atomizer
5. Engine powered sprayer
6. Air plane sprayers
7. Electro Dyne sprayer

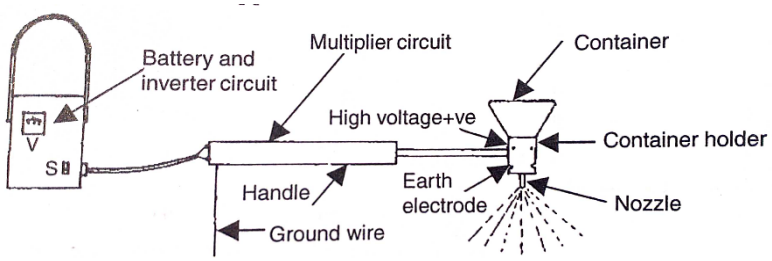


Fig. 15.1 Electro Dyne sprayer

B. Types of Dusters: apply chemical in dust form. These are categorized as:

1. Plunger type hand duster
2. Knapsack type duster
3. Rotary type hand and power duster
4. Air plane duster

C. Other types of chemicals applying machines:

1. Seed dresser: it is machine to apply coating of protective chemicals to seed
2. Fumigator: a machine to generate & distribute gases or smoke
3. Flame gun: it is an apparatus to kill weeds by flame
4. Power Sprayer cum Gun: it is power operated sprayer, which can be converted as duster when desired.

In the initial periods of development of pesticide formulations, the application of liquid pesticides on affected crops and vegetables was done by means of brooms and brushes in the form of sprays. At the turn of 20th century, considerable advances have been made in pesticide application technologies. The pesticides may be applied as sprays (very coarse, coarse sprays, medium sprays or fine sprays), mists, aerosols and fogs, smokes, vapours, dusts or granules. In case of sprays, mists, aerosols and fogs, the pesticide is in the droplets of water or other fluid. Pesticides in solid particle form are carried by air as smokes created by combustion. In case of dusts and granules, the pesticides are mixed with an inert material and carried or coated on the particles of powder of inert material.

Types of Sprays: Droplets in the form of fine sprays, mists or aerosols are required to be used at the Ultra Low Volume (ULV) spray rates. The distribution of such droplets depends on gravity and air movement. According to USSDA, different sprays are defined as:

1. Full cover spray- total volume is expected to thoroughly cover the crop to the point of run off or drip.

2. Low volume (LV) spray- known as concentrate spray. Liquid should be adequate in volume to cover total crop area uniformly but not as full cover treatment to the point of run off or drip.

3. Ultra-Low volume (ULV) spray- plant protection operation in which liquid applied is 5.6 L/ha or less and is to be applied undiluted (Fig. 15.2).

4. Foam spraying- foam agent is added to spraying solution. This system is economical.

The selection of technique depends on type of vegetation, kind of pests and approach to field. Accuracy of application is an important criterion of applying the sprays. Use of water as carrier of pesticide is completely eliminated in ULV spraying. Due to low volume fluid handling in ULV spraying, wear & tear of machine and its components are minimized.

Sprayers:

Definition: Sprayer is a machine to apply fluids in the form of droplets.

It atomizes the spray fluid (which may be a suspension, an emulsion or a solution) into small droplets and ejects it with little force for distributing it properly. It also regulates the amount of pesticide to avoid excessive application that might prove wasteful or harmful.

Purposes for use of sprayers: for application of

1. Herbicides to remove weeds
2. Fungicides to minimize fungal diseases
3. Insecticides to control insect pests
4. Micronutrients on plants

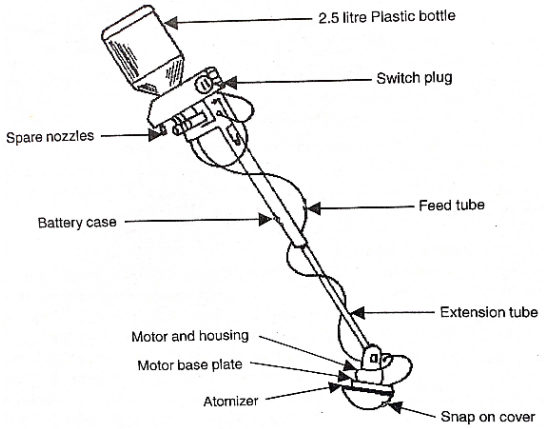


Fig. 15.2 ULV sprayer

Main functions of sprayers:

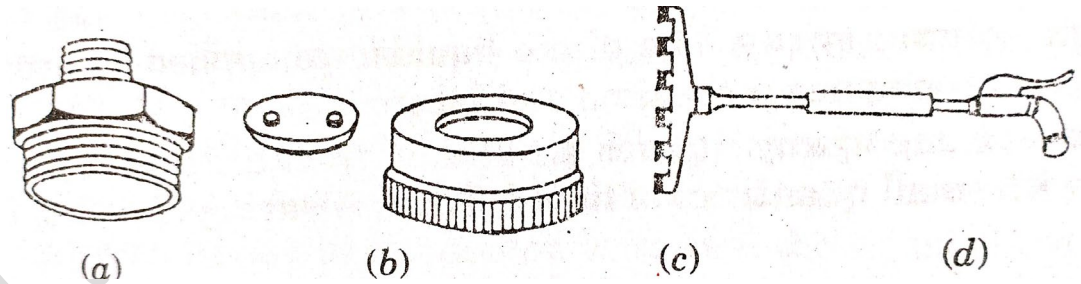
1. To break liquid into droplets of effective size
2. To distribute droplets uniformly over plants
3. To regulate amount of liquid to avoid excessive application

Desirable qualities of sprayers:

1. It should produce steady stream of spray materials in desired fineness of particles so as to cover plant uniformly
2. It should deliver liquid at sufficient pressure so to reach all foliage
3. It should be light in weight, sufficiently strong, easily workable and repairable

Basic components of Sprayers: (Fig. 15.3)

1. Nozzle body: main component on which other components of nozzle fitted



(a) Nozzle body, (b) Swirl plate (c) Nozzle cap (d) Spray boom

Fig. 15.3 Basic components of nozzle.

2. Nozzle cap: component which retains all the assembled parts in or on a nozzle body

3. Swirl plate: part of cone nozzle which imparts rotation to liquid passing through it

4. Spray gun: it is a spray lance from which spray is readily adjustable

5. Spray boom: it is a spray lance with spray nozzle fitted to a head, mounted at 90° angle

6. Filter: component to remove suspended matter

7. Over-Flow pipe: it is a conduit through which excess fluid from pump is by-passed by action of relief valve or pressure regulator

8. Relief valve: it is an automatic device which opens when pressure of fluid reaches a predetermined value

9. Pressure regulator: automatic device to control fluid pressure within a range of setting

10. Cut-off valve: mechanism between pump & nozzle to control flow of liquid from the sprayer.

11. Nozzle disc: its component containing the final orifice of a nozzle usually a cone nozzle

12. Nozzle boss: it is a lug on spray boom or spray lance to which nozzle body or cap is screwed.

13. Nozzle tip: component containing final orifice of a nozzle usually a fen nozzle

14. Spray lance: hand held pipe through which fluid reaches nozzle mounted at free end

1. Bucket type Sprayer: The bucket sprayer is designed to pump the spray fluid directly from, the open container, usually a bucket. The hydraulic pump will be put inside the bucked and held properly with the help of foot rest (Fig. 15.4).

As the plunger is pulled up, the fluid enters through the suction ball valve assembly and when the

plunger is pressed down, the suction valve closes and the fluid enters the pressure chamber through a ball valve assembly. It is called single barrel stirrup pump.

As the plunger is continuously worked, pressure is built in the pressure chamber and the delivery hose. As soon as the required pressure is built up, the spraying will be done.

A pressure of 4 kg / cm2 is developed in most of the models.

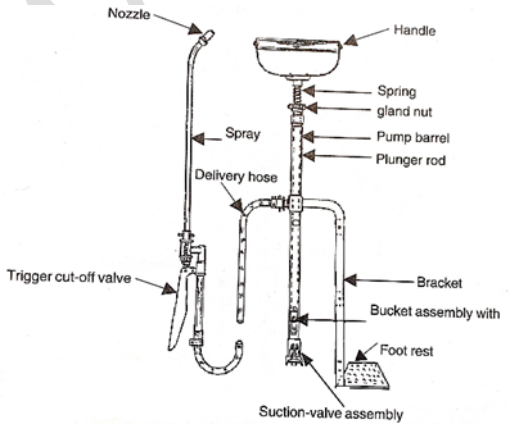
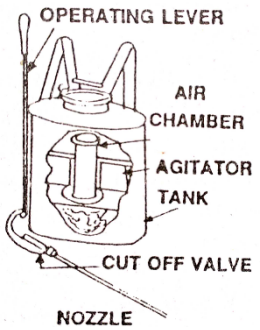


Fig. 15.4 Bucket type sprayer

Use: To spray small gardens and low trees.

2. Knapsack Sprayer: Any sprayer which is carried on the back of the operator is called a knapsack sprayer.

The common type of knapsack sprayer is provided with a hydraulic pump working in a large air chamber permanently mounted in a 9 to 22.5 liters tank or container (Fig.15.5).



The plunger works inside the replacement well attached at the bottom of the container, for easier maintenance.

The pump can be operated through the appropriate linkages by oscillating the handle, with the sprayer carried on the back.

An agitator is also provided with the pressure chamber to agitate the fluid so that the particles in suspension will not be allowed to settle down.

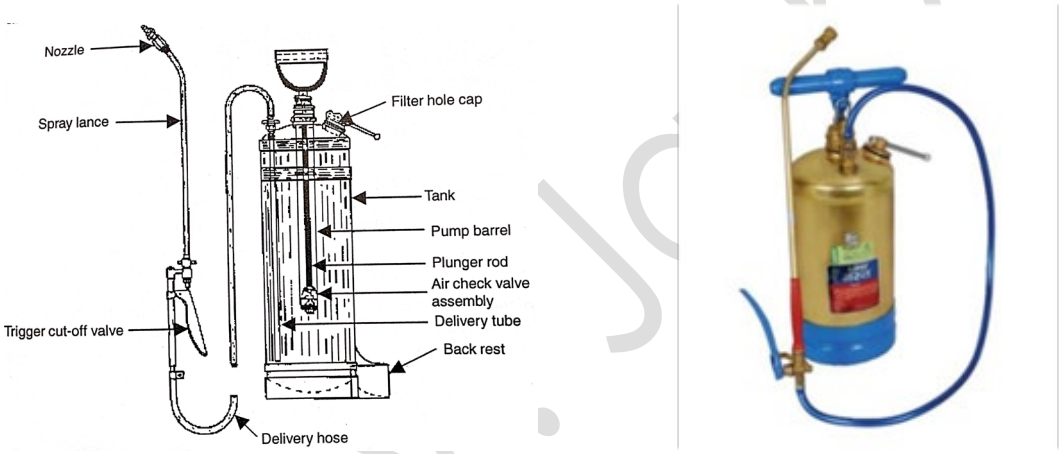
A delivery tube is attached on the other end of the pump which carries the pressurizes fluid to the spray lance.
The flow to the nozzle is controlled by a trigger cut-off valve.

One man can spray about 0.4 ha in a day.

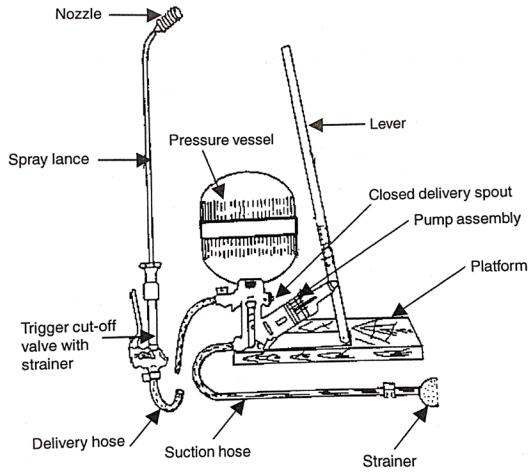
Fig. 15.5 Knapsack sprayer

3. Compression Sprayer: The compressed air sprayer consists of an air pump mounted in an airtight chamber which is filled three quarters full with spraying material (Fig. 15.6). The air pump is used to build air pressure above the free surface of the spray fluid in the container and normally the pumping of the air will be done by keeping the unit on ground and then sprayed till

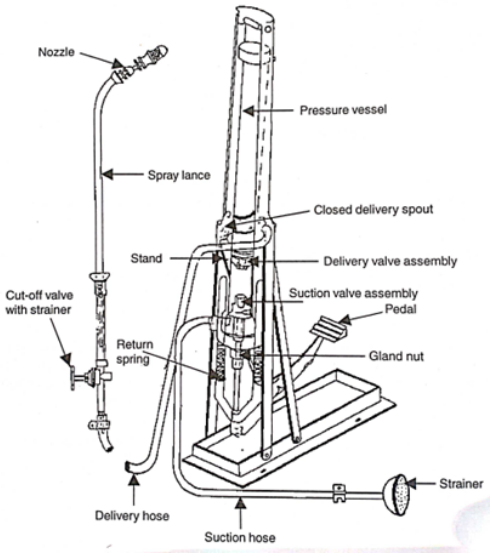
the air pressure comes down. The unit is again brought back to the ground for pumping air and then the spraying is continued as before. The tank capacity is 14 litters. The spray fluid, which does not require any agitation can be sprayed by using this type of sprayers.



(a) Hand operated



(b) Rocker arm operated



(c) Pedal operated

Fig. 15.6 Compression sprayers

4. Hand Atomizer: These sprayers are provided with single action or continuous action air compression pump. The hand sprayer is a small, light and compact unit (Fig. 15.7).
The capacity of the container varies from 500 to 1000 ml.
This is smallest type of hand sprayer & generally used for spraying small areas like kitchen garden or nursery, experimental laboratory plots and apply fly spray in house. It is a hydraulic energy sprayer. It has a hydraulic pump inside the container, with cylinder, plunger and a plunger rod. By operating the plunger up, the spray fluid in the container is sucked into the cylinder through a ball valve assembly and then pressurized during the downward stroke.

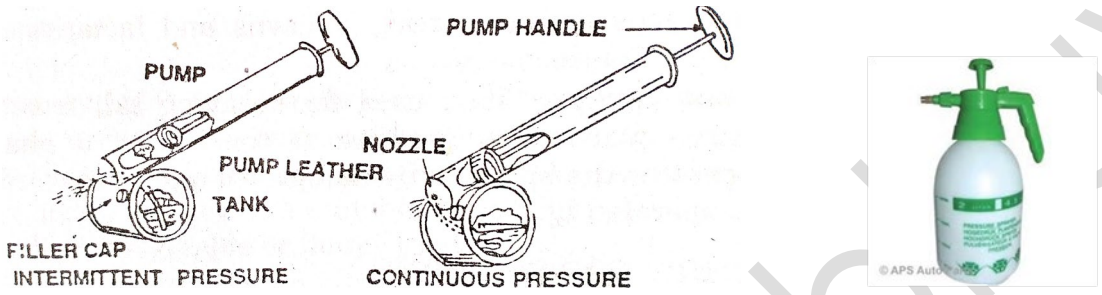


Fig. 15.7 Hand atomizer

5. Engine Powered Sprayers: All the sprayers which impart the mechanical energy developed by an I.C. Engine, on the spray fluid before spraying is called as a power sprayer. The most commonly used type of power sprayer in India is a gaseous energy type knapsack sprayer but now a day portable types are also used for fast spraying (Fig. 15.8). Engine of 1.2 to 3 hp capacity, the spray fluid tank and the petrol tank are fixed rigidly. A flexible hose is attached to the blower elbow to carry the high velocity air and at the end of that a shear nozzle is fixed to allow the spray fluid to trickle from the spray fluid storage tank with a valve control. As the pump is driven by engine, there is no variation in output, pressure and performance of the sprayer. Sometimes power sprayers are operated by power take off (PTO) shaft of the tractor. Tractor mounted PTO operated sprayers are also available. Mostly gear pump is used in these sprayers to pressurize the liquid.

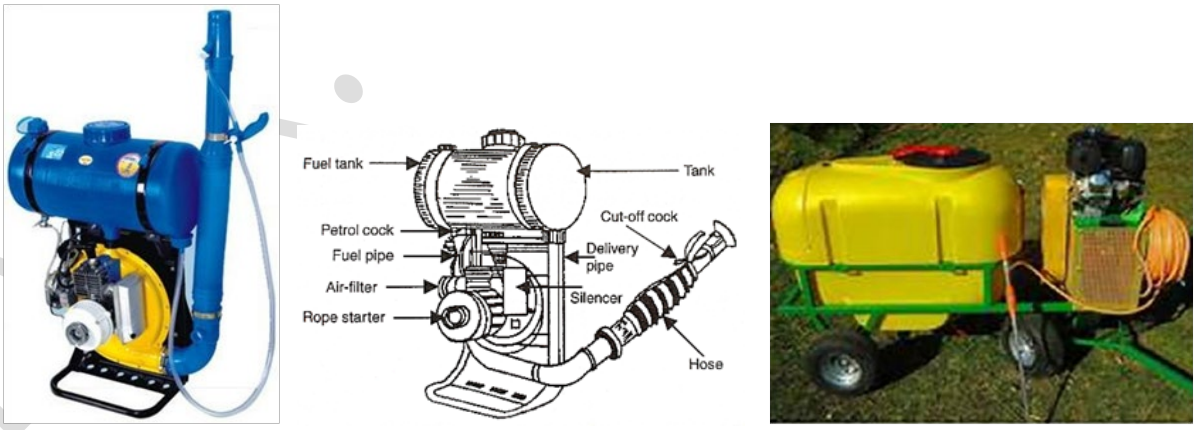


Fig. 15.8 Engine power operated sprayer.

6. Air Plane Sprayers: Arial application of pesticides is done with small aircrafts (Fig. 15.9). Either centrifugal pump or gear pump is used to force spray liquid through the nozzles. The operating pressure of these pumps is about 3.0 to 8.5 kg/cm2. The pump gets its drive from a wind driven propeller having four to six blades. Sometimes the spraying liquid is allowed to flow

by gravity. Aluminum tanks are used to store the liquid in order to reduce the dead load. Depending upon the size of plane, tank capacity may range 450 to 2200 liters.

Fig. 15.9 Air plane sprayer

Dusting Machines: The mechanical appliances that are used for distributing the dust formulations of pesticides are called as dusters.

1. Plunger type hand duster: This machine consists basically of a chamber for 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 outlet. It is suitable for dusting small area (Fig. 15.10).

Fig. 15.10 Plunger type hand duster

2. Rotary type hand duster and power duster: It is provided with an enclosed fan geared to a hand crank and a hopper holding the dust. It is operated by rotating the crank (Fig. 15.11). The

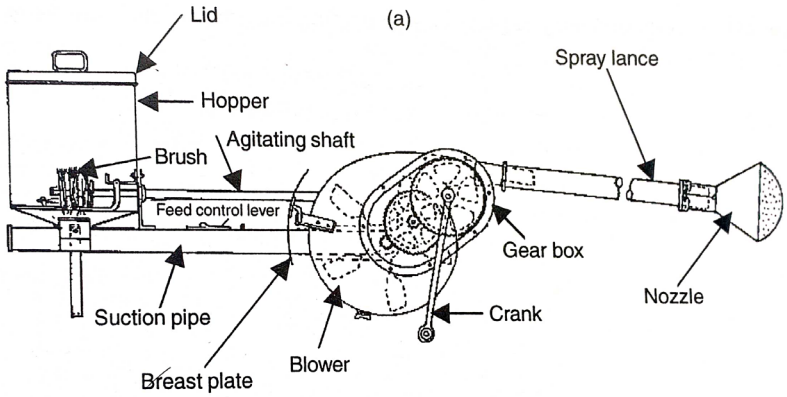


Fig. 15.11 Shoulder mounted Rotary type hand duster

cranking motion is transmitted through the gear box to the blower. A drive is taken for the dust agitator located in the hopper. The rotary duster may be hand carried type or shoulder mounted or belly carried type. The right hand is used for cranking and the left hand to guide the discharge tube. The feed is controlled by a feed control lever, which operates a slide to control the aperture

at the bottom of the hopper. The duster can hold about 3.6 to 4.5 kg dust which can treat 0.4 to 0.6 hectare of cropped area in a day. It is suitable dusting over 3 m height.

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 mounted on the crankshaft of the high speed (4000 rpm) air cooled engine. The air pressure from the pump is directed through a tube into the container to agitate the dust in the container and blow it through orifice or flexible hose pipe.

Dusting height- 6 m and capacity – 1 ha/day.

Fig. 15.12 Power operated duster

3. Air plane dusters: It is generally used ro cover large area in short time (Fig. 15.13). The apparatus consists of a hopper with an agitator and a device to feed the dust through a slot into a venture from where the dust is carried by the air. The capacity is the planes ranges from 220 to 900 kg. the slope of the hopper wall is very steep to allow a positive flow of dust material. The agitator and feeding devices are operated by a small wind driven propeller mounted under the wing.

Fig. 15.11 Air plane dusters

Lecture No. 16

Harvesting and Threshing Equipment

Harvesting:

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

The harvesting operation or cutting of a plant is achieved by four different actions:

1. **Slicing** action with a sharp smooth edge,
2. **Tearing** action with a rough, serrated edge,
3. **High velocity** single element impact with **sharp** or **dull edge**, and
4. A two element **scissor** type action.

Principle of Cutting of a Crop: A crop is cut by shearing action of cutting elements. During the process of shearing, some bending and compression also takes place. In practice two opposed elements meet and pass each other with little or no clearance between them. Either one or both of the elements may be moving to produce three types of motion (linear, reciprocating and rotary).

Impact Cutter: An impact cutter has single element moving at high speed and operates by inertia of the material being cut to furnish the opposing force required for shear. Impact cutters are of two types.

1. Rotary cutter: A rotary cutter has knives rotating in a horizontal plane (rotary lawn mowers). Rotary cutters with effective width of 1.0 to 2.1 m have a single rotor with 2 or 4 knives on the ends of radial arms. Wider units have 2 or 3 rotors with total cutting width of about 6.1 m.

2. Flail shredder: It has knives rotating in vertical planes parallel to direction of travel. It has free swinging knives or flails 50 to 150 mm wide attached to the rotor in 3 or 4 rows staggered to the cuts overlap slightly.

Generally, manual harvesting involves slicing and tearing actions that result in plant structure failure due to compression, tension or shear.

Harvesting methods: Harvesting can be done by

1. Manually operated tool
2. Animal drawn machine
3. Mechanical operated machine

Terminologies related to Harvesting: The following terms related to harvesting are used.

1. Mower: It is a machine to cut herbage crops and leave them in swath.
2. Reaper: It is a machine to cut grain crops.
3. Reaper binder: It is a reaper which cuts the crops and ties them into neat and uniform sheaves.
4. Swath: It is the material as left by the harvesting machine.
5. Sickle: It is the curved steel blade having a hand grip used for harvesting by manual power.
6. Windrow: It is a row of material formed by combining two or more swaths.
7. Windrower: It is a machine to cut crops and deliver them in an uniform manner in a row.

Harvesting Tools and Equipments:

Harvesting equipments or machines are classified in different ways.

A. According to crop:

1. Cereal harvesting machines – ex. Sickle, reaper, reaper binder, combine harvester, maize picker, etc.
2. Forage harvesting machines – mower and rotary grass cutter.
3. Root crop harvester – potato digger, groundnut digger, sugar beet harvester, turmeric digger, etc.
4. Miscellaneous – sugarcane harvester, cotton harvester, fruit harvester, etc.

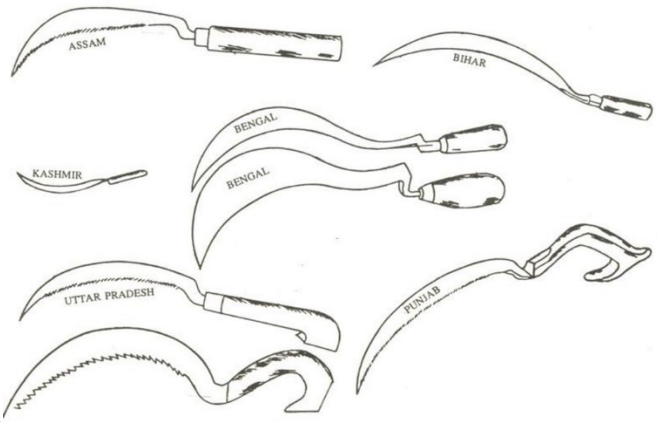
B. Classification according to power source:

1. Manually operated – sickle, scythe, lawn mower, spade, etc.
2. Manual-cum-power operated – knapsack type power reaper, cotton picker, etc.
3. Animal drawn – mower, reaper, etc.
4. Power tiller operated – vertical conveyor reaper.
5. Tractor operated – mower, reaper, reaper binder, combine, digger, etc.

1. Sickle:

It is a simple harvesting tool. It is used for harvesting crops and cutting other vegetations (Fig. 16.1). It is essentially consisting of a metallic blade and a wooden handle. Blade is the main metallic part of the sickle. It is desirable to make the blade of carbon steel. It is made in a curved shape. The tooth of serrated sickle is made sharp for efficient working in the field. The handle of the sickle is made of well-seasoned wood.

- The forged end of the blade for fixing the handle is called tang.
- The plain or serrated edge in the inner side of the blade is called cutting edge.
- Protective metallic bush fitted at the junction of the blade and the handle to keep the tang tight in the handle is called ferrule.
- Harvesting by sickle is very slow and labor consuming practice.



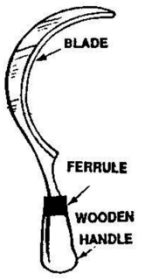


Fig. 16.1 Sickle

2. Mower: Mower is a machine to cut herbage crops and leave them in swath.

Types of mowers:

1. Cylinder mower
2. Reciprocating mower
3. Horizontal rotary mower

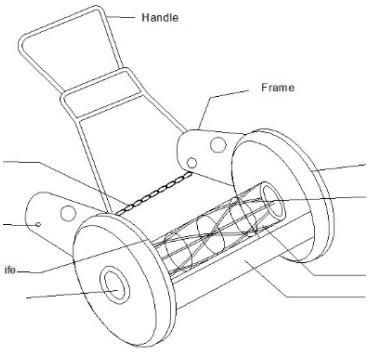


Fig. 16.2 Cylinder mower

4. Gang mower
5. Flail mower

1. Cylinder mower: It has rotating helical blades arranged in horizontal cylindrical form. With the rotation of blades, forage or grasses are cut continuously (Fig. 16.2).

2. Reciprocating mower: It is a mower with a knife having sections that reciprocate against stationary fingers. It is most common type of mower uses everywhere (Fig. 16.3).

3. Horizontal rotary mower: It is a mower with high speed knife rotating in the horizontal plane. Due to rotation of knife, the grasses and forage are cut uniform way.

4. Gang mower: It is assembly of two or more ground driven cylinder mowers.

5. Flail mower: It is a mower with high-speed swinging knives, operating either in a horizontal plane or around a horizontal cylinder.

Out of all these, reciprocating mower is commonly used. Mowers are classified as:

1. Animal drawn
2. Tractor drawn

The main parts of conventional mower: The basic components of these mowers are same but main difference lies in power transmitting unit only.

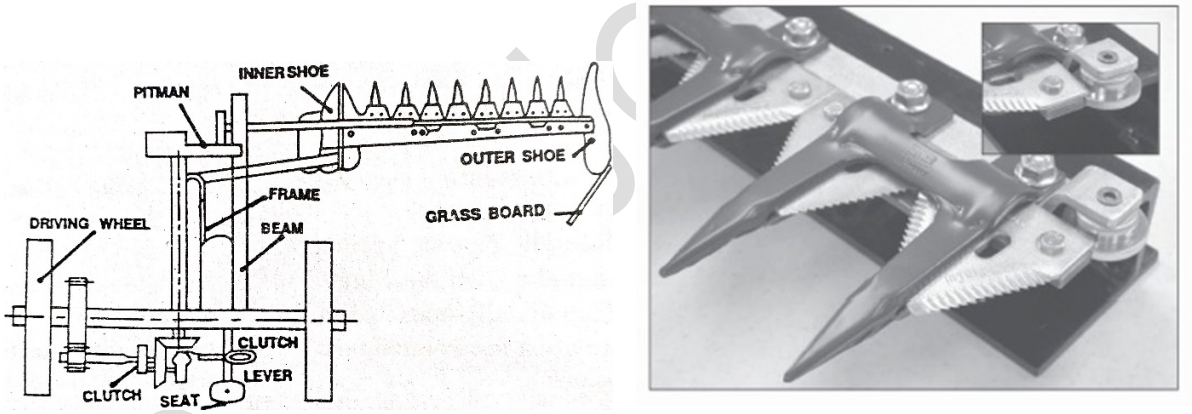
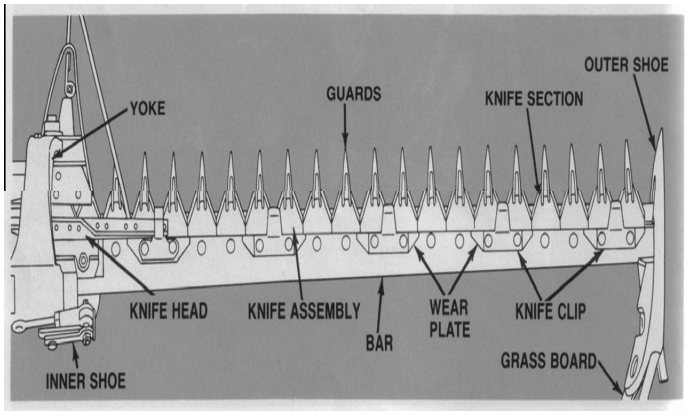


Fig. 16.3 Components of reciprocating type mower

1. **Frame** to support moving parts
2. **Power transmitting unit** to receive and transmit motive force
3. **Cutter bar** to cut crops and separate it from uncut portion (Fig. 16.4).
4. **Shoes:** to regulate the height of cut above the ground (inner and outer shoes).
5. **Ledger plate:** a harden steel plate inserted in a guard (finger) over which knife section moves to a scissor like cutting action.
6. **Wearing plate:** a harden steel plate attached to the finger bar to form a bearing surface for the back of the knife.
7. **Knife:** It is a reciprocating part of the cutter bar, comprising of knife head, knife back and knife section.
8. **Knife head:** It is potion of the knife which connected to the pitman
9. **Knife back:** It is the strip of steel to which knife section are riveted and Knife head is attached.
10. **Grass board:** is provided at the cutter end of the mower which causes the cut plants to fall towards the cut material.

11. **Pitman:** is a type of connecting rod which pinned to the crankshaft with the help of pin. It transmit reciprocating motion to a knife head. Wooden pitman is commonly used for the mowers.
12. **Wheels for transport** and for operating the cutting mechanism
13. **Auxiliary parts** to lift and drop the cutter bar



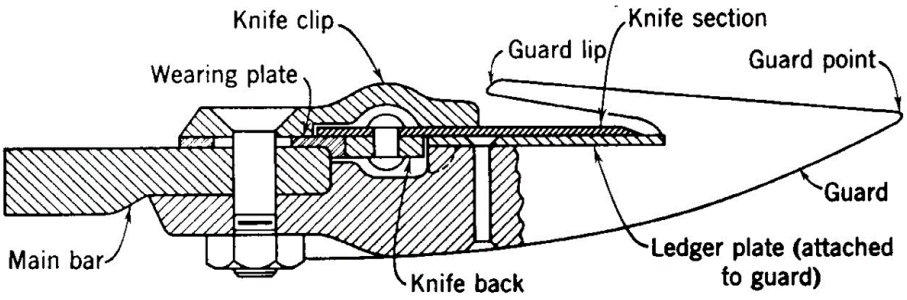


Fig. 16.4 Components of cutter bar

Alignment of mower:

1. Under working condition of mower, the standing crops exert pressure on the cutter bar tending to push it backward.
2. In correct operating position the crankpin, knife head and the outer end of the knife should be in the straight line.
3. This line should be at right angle to the direction of travel of the mower. For achieving this object, the cutter bar is set at about 88° to the direction of motion, i.e., inward lead of 2° is given to it in order to overcome the back pushing action of the crops.

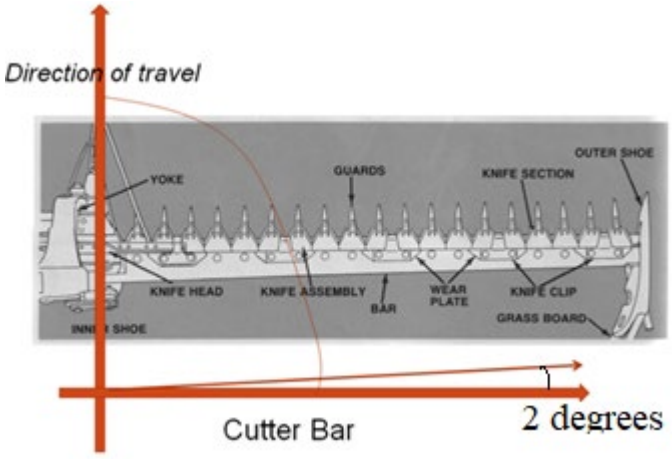


Fig. 16.5 Alignment of mower

4. When the cutter bar is properly aligned, the knife and the pitman run in a straight line.
5. Generally 2 cm lead per metre length of cutter bar is recommended (Fig. 16.5).

Registration of mower:

- A mower knife is said to be in proper registration when the knife section stops in the center of its guard on every stroke i.e. the center of knife is at the center the guard, when it is in operating condition (Fig. 16.6).
- Adjustment is commonly made by moving entire cutter bar in or out with respect to pitman.
- If mower is not well registered, there is unbalanced load, uneven harvesting and excessive clogging of crops on the knife.

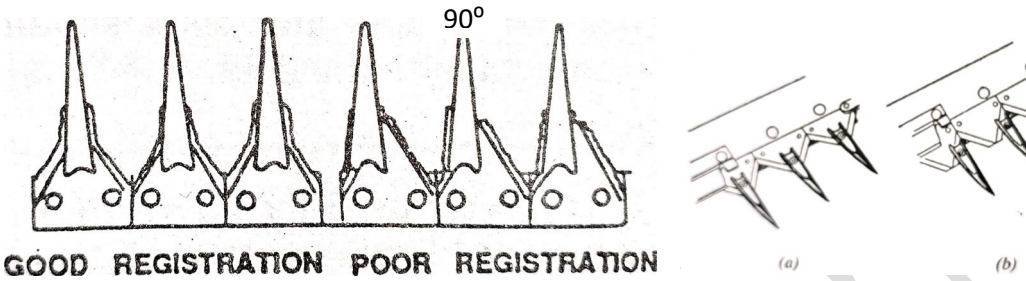


Fig. 16.6 Registration of mower

Combine harvester:

Combine harvester is a machine designed for harvesting, threshing, cleaning and collecting the grain while it moves over the land. All the five operations are carried out in single operation of the harvester. The size of the combine is indicated by the width of cut, it covers in the field (Fig. 16.7).

Functions of combine harvester:

1. Cutting the standing crops
2. Feeding the cut crops to threshing unit
3. Threshing the crops

Fig. 16.7 Combine harvester and its working

4. Cleaning the grains from straw
5. Collecting the grains in a container

Components and working of combine:

1. The reel revolves in front of cutter bar pushes the standing crops towards the cutter bar, operated like mover or reaper cutter bar, which after cutting pushes the crop toward the conveyor (Fig. 16.8).

2. The conveyor feeds the crop to the threshing drum and concave. After threshing threshed material goes to straw rake. These rakes keep on oscillating and separating the grain.
3. The cleaning takes place on number of sieves with the help of fan. The unthreshed grains pass through trailing auger and go for re-threshing.
4. The clean grains pass through grain elevator and finally go to packing unit.
5. The size of the combine is indicted by the width of cut it covers in the field. It ranges from 1.2 to 6.7 meters.
6. The speed of drum ranges from 2000 to 7000 rpm.
7. The field speeds of combine are 2.9 to 6.4 km/h, while road speeds are 4.0 to 20.9 km/hr.

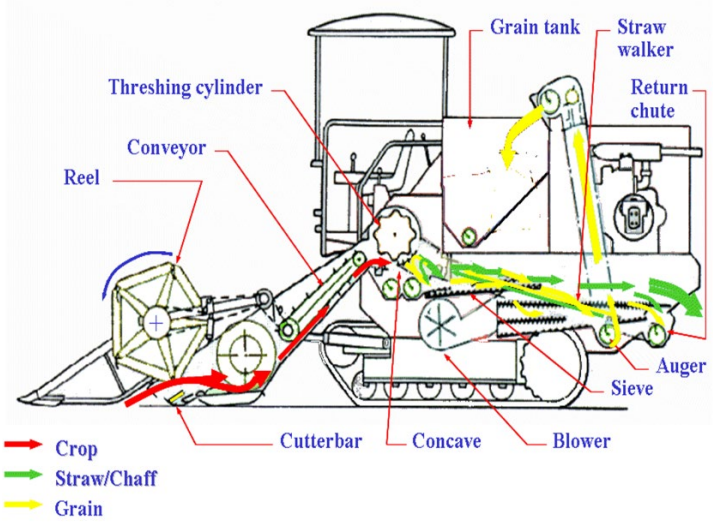


Fig. 16.8 Construction and working of Combine harvester (Material flow).

Advantages of combine harvester thresher:

1. It saves the cost of harvesting and threshing the crops.
2. Reduces labour requirement of the field
3. Grains can be obtained easily from crops and thus reduces risk of fire, rains and other hazards.
4. Cleans farm early and makes available for next crop.
5. Benefit of high prices in the market can be taken.
6. Straw of threshed grains added into the soil as organic matter.

Disadvantages:

1. High initial capital investment.
2. Not adaptable to mixed farming.
3. Cannot be used in fragmented piece of land.
4. Loss of grain to some extent.
5. Operation and maintenance are costly.

Example 1: Calculate the total time required to harvest 8 hectares of grass by means of 2.5 m wide mower operated at 3.5 km/h speed assuming the field efficiency to be 85%.

Ans: Step-I: Given data:

1. Grass land area, A= 8 ha, 2. Width of mower, W= 2.5 m, 3. Time required=?
4. Speed of operation, S= 3.5 km/h=3500 m/h, 5. Field efficiency= 85%

Step II: Theoretical area covered,

$$Theoretical\ field\ capacity = \frac{WxS}{10000} = \frac{2.5x3500}{10000} = 0.875\ \text{ha/h}$$

$$Actual\ field\ capacity = Theoretical\ FC \times Field\ efficiency$$

$$= \frac{0.875 \times 85}{100} = \mathbf{0.743\ ha/h}$$

Step III: Therefore, the total time required at actual field capacity to cover 8 ha area will be

$$Time\ required = \frac{8 \times 1}{0.743} = \mathbf{10.77\ h}$$

Example 2: What power is required to pull 1.2 metre width mower working at a speed of 4.8 km/h, if there is a load of 50 kg per metre length of mower and mechanical efficiency of 80%.

Ans: Step I: Given data:

1. Width of mower, W = 1.2 m,
2. Speed of mower, S = 4.5 km/h=4500 m/hr
3. Load on mower = 50 kg/m
4. Mechanical efficiency, η = 80%
5. Horse power, hp+?

Step II: Total load coming on mower = 50x1.2 = **60 kg**

Therefore, power required to pull the mower can be calculated by relating the total load and speed of mower using the equation,

$$DBHP = \frac{load\ (kg) \times Speed(\frac{m}{s})}{75} = \frac{60 \times 4500}{75 \times 60 \times 60} = 1\ hp$$

The actual power required to pull the mower considering 80% mechanical efficiency,

$$BHP = \frac{DBHP \times 100}{Mech.effic.} = \frac{1 \times 100}{80} = \mathbf{1.25\ hp}$$

Example 3: How many hectares per day of 8 hours can be cut by a combine with 4 metre cutter bar, when it is running at 4 km/h.

Ans: Step I: Given data-

1. Width of cutter bar, W= 4 m,
2. No. of working hours in a day = 8 h,
2. Speed of running = 4 km/h,
4. Area covered in ha, A=?

Step II: Speed of combine = 4x1000 m/h

Area covered per hour, A = Width x Speed = (4x4x1000)/10000 = 1.6 ha

Area covered in 10 hours = 1.6x10 = **16 ha**

Threshing:

Threshing is the process of removal of grain from the ear heads or from the plants by striking, treading or rubbing. Threshing of crop ear heads, comb or pods can be performed by manual labour, animals and by machines.

Principle of threshing:

Threshing separates grains from panicles, cobs and pods. It is based on principles:

1. If some impact or pounding is given on crop, the grains are separated from panicles, cobs and pods.
2. The crop mass passes through a gap between drum and concave, wearing or rubbing action takes place. This separates grain from panicle.

Thus, the rupture of bond between the grains and ears is due to the factors:

1. Impact of beaters or spikes over grains and
2. Wearing or rubbing action.

The strength of bond between the grain and the panicle depends upon:

a) Type of crop
b) Variety of crop
c) Ripening phase of crop
d) Moisture content of grain

The efficiency and quality of threshing depends upon:

Drum speed, Number of beaters, Drum size, Gap between drum and concave, quality and condition of plant mass fed to the thresher, direction of feeding and rate of feeding.

Threshing methods: The common methods of threshing are
1. Manual labour – Its slow and labour consuming process in which grains are separated by beating crop stalk usually on the ground or by sticks.
2. Animal – The combs spread on ground are trampled by animal feet. it is not practiced now.
3. Machines – Different types of threshers are used for grain separation and cleaning.

Olpad thresher:

- It is 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 axles with bearings, on which a seat and a platform are provided.
- It is operated by pair of bullocks.
- 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. 16.9).

It consist of: 1) Frame 2) Disc spacer, 3) Disc axles and 4) Bearing blocks.

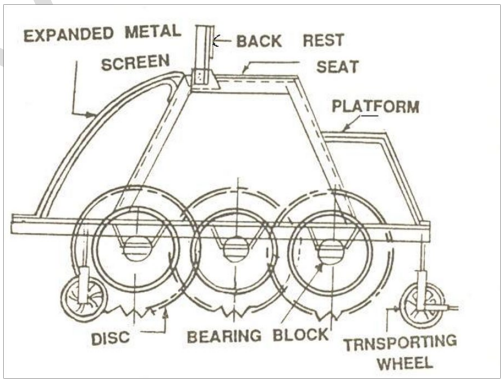


Fig. 16.9 Olpad thresher

Power Thresher: It 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:

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

Working of thresher: 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.

Types of Power Thresher: There are following types of threshers:

1. Hammer mill type
2. Rasp bar type
3. Spike tooth type
4. Syndicator type
5. Drummy type

Components of power thresher: The main components are: concave, cylinder or drum, cleaning unit and elevator (optional).

(i) 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. 16.10).

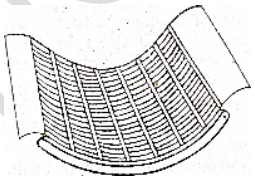
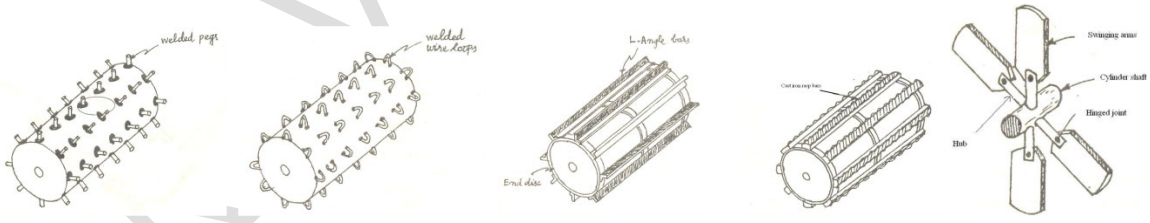


Fig. 16.10 Concave

(ii) Cylinder or drum: It is a balanced rotating assembly, comprising rasp, beater bar or spikes on its periphery and their support for threshing the crop. 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 (Fig. 16.11):

a. Peg tooth or spike tooth cylinder b. Rasp bar cylinder c. Angle bar cylinder
d. Loop type cylinder e. Hammer mill type cylinder



(a) (b) (c) (d) (e)

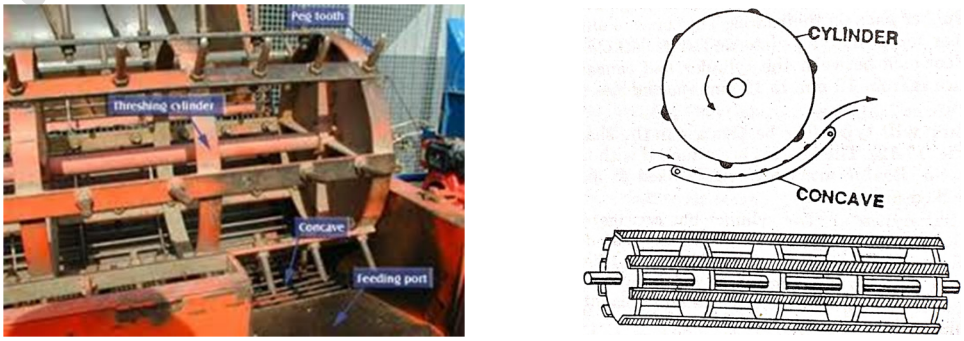


Fig. 16.11 Types of threshing cylinders.

(iii) 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 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.
- Thresher provided with aspirator unit is usually called as **aspirator type of thresher.**
- Those threshers, which are not fitted with aspirator unit, have got only **one blower**, which blows air in horizontal direction. This type of thresher is commonly called **drummy thresher.**
- **Aspirator:** It is a component of the cleaning unit used for cleaning grain by drawing air through the grain mass.
- **Blower:** It is a device to produce air blast (Fig. 16.12).
- **Winnower:** It is a machine with one or two sieves and fan using air stream across falling grain.
- **Winnowing Fan:** It is a machine used for creating air blast mainly for the purpose of winnowing of grains.

Threshing Efficiency: Threshing efficiency depends upon following factors:

1. Peripheral speed of the cylinder,
2. Cylinder concave clearance,
3. Type of crop
4. Moisture content of crop,
5. Weather condition,
6. Feed rate.

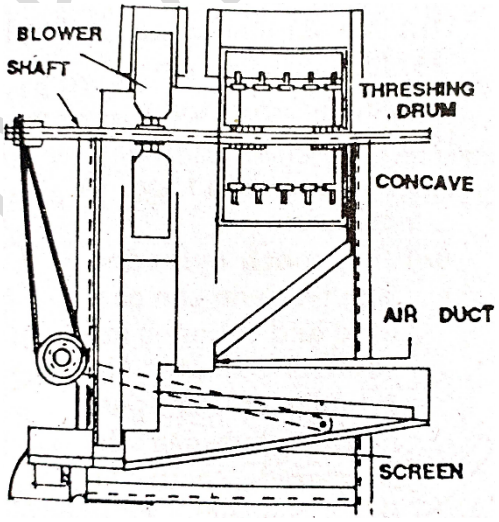


Fig. 16.12 Power Thresher

Terminology connected with power thresher:

1) **Clean grain:** It is the threshed grain, free from foreign matter and broken grain.
2) **Cleaning efficiency:** It is the percentage grain free from all refractions of the total threshed grain mixture obtained from main grain outlet.
3) **Concave clearance:** It is the clearance between beater or cylinder tip and concave.
4) **Feed rate:** It is the quantity of crop fed into the inlet of thresher per unit time.
5) **Threshing efficiency:** The threshed grain received from all outlets with respect to total grain input expressed as percentage by mass.
6) **Blower loss:** The percentage of grains blown by blower along with Chaff (*bhusa*) with respect to total grain input in the thresher by weight is called blower loss.
7) **Sieve loss:** The percentage of healthy grains, dropped from sieve with respect to healthy grains, received from main outlet by weight is known as sieve loss.
8) **Cylinder loss:** The percentage of un-threshed grains from all outlets with respect to total grain input in the thresher by weight is called cylinder loss.
9) **Visible damage loss:** The percentage of broken or cracked grains from all outlets with respect to total grain input in the thresher by weight is known as visible damage loss.