Teaching Materials

Machinery Systems Engineering (ES 2102)

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Dept. of Agric. Eng. & and Soil Science,

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MACHINERY SYSTEMS ENGINEERING

ES 2102 (2/15:30)

TEACHING MATERIALS

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PREFACE

These teaching materials on Machinery Systems Engineering (ES 2102) is prepared by myself, to be submitted to the 219th Faculty Board, Faculty of Agriculture, RUSL on 04th May, 2022. Hereafter, these materials could be used by the undergraduates who are enrolled for the Machinery Systems Engineering (ES 2102) in B.Sc. (Agriculture) Special Degree programme in Rajarata University of Sri Lanka to improve their learning environment.

April, 2022 Dr. G.V.T.V. Weerasooriya

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1. INTRODUCTION

1.1 Course capsule

Soil dynamics for tillage, Farm Production Engineering; Machinery for land Preparation; Primary tillage implements, Secondary tillage implements, Sowing and planting machines; Plant protection machines; Fertilizer distributors; Harvesters and threshers; Water lifting Devices; Safety in agricultural operations; Introduction to Traction

1.2 Course ILOs

On successful completion of the course, the student will be able to

1. describe the dynamics of soil effect for tillage.
2. use the real engineering application for the farm production.
3. select appropriate machinery for land preparation in real time.
4. select appropriate equipment for different farm applications.
5. use safety measures correctly.
6. explain the principles of traction and its application in farm condition

1.3 Lesson outline

Week	**Lesson title**	**Number of hours**			**Method of teaching**	**Method of Assessment**	**Change of attitudes**
		T	**P**	**IL**			
1	Soil dynamics for tillage	1	2		L, TU, Q/A	TU, IR	
2, 3, 4	Machinery for land Preparation	1	2		L,S,DM, Q/A	GR	TW, LS, CU
	Primary tillage implements	1	4	2	L,DM,Q/A	GR	TW, LS, CU
5, 6	Secondary tillage implements	1	5		L,DM,Q/A, PR	PR	CU, CR
7, 8	Sowing and planting machines	1	4	2	L,P,Q/A	PR, QZ	CU, CR
	Fertilizer distributors	1			L, P, Q/A	PR	CU, CR
9, 10	Harvesters and threshers	2	4	2	L, P, Q/A	PR	CU, CR

11, 12	Water lifting Devices	2	4		L, GP, Q/A	PR, QZ	TW, LS, CU
13, 14	Safety in agricultural operations	2	4		L, P, Q/A	IR, PR	TW, LS, CU
15	Introduction to Traction	2	1	2	L, TU, Q/A	QZ	
TOTAL		**15**	**30**	**8**			

Q/A – Questions and answers TU- Tutorials D –Discussions L- Lectures FV – Field Visits PR- Presentations DM- Demonstrations LW – Laboratory Work CS- Case Study V-Videos CS- Community survey P- Practical
CM- Communication CA – Continuous attention LS- Leadership TW –Team work O- Organization/ Care CR- Creativity SA – Situation Analysis
PR- Peer review by students GR – Group Report QZ- Quizzes IR- Individual Report EE – End semester Examination SB- Situational behavior AS- Assignments GP- Group presentation

1.4 Tractor Training Course (vacation programme)

One week training on operation and maintenance of two wheel and four-wheel tractors at any relevant institute in Sri Lanka.

1.5 Assessment Strategy

End Semester Examination (Theory) 50%

End Semester Examination (spot test) 10%

End Semester Examination (Viva) 10%

Continuous Assessment 30%

Continuous Assessments: Assignments, Tutorials, Quizzes, Presentations

2. SOIL DYNAMICS FOR TILLAGE

Preparation of soil for planting, Breaking and loosening soil, Breaking soils in to small particles, Preparation of suitable seed – bed.

2.1 Tillage

Tillage can be defined as the mechanical manipulation of soil for any purpose.

Process of tillage: Converting soil to suitable seed bed by chemical, physical and biological process.

Process of Land Preparation

- Breaking the soil — Soil → Fractured soil
- Loosening the Soil — Fractured soil → Soil aggregates
- Pulverization — Soil aggregates → Tine Soil particles

Soil factors, weather factors and instrument factor are affected on tillage process.

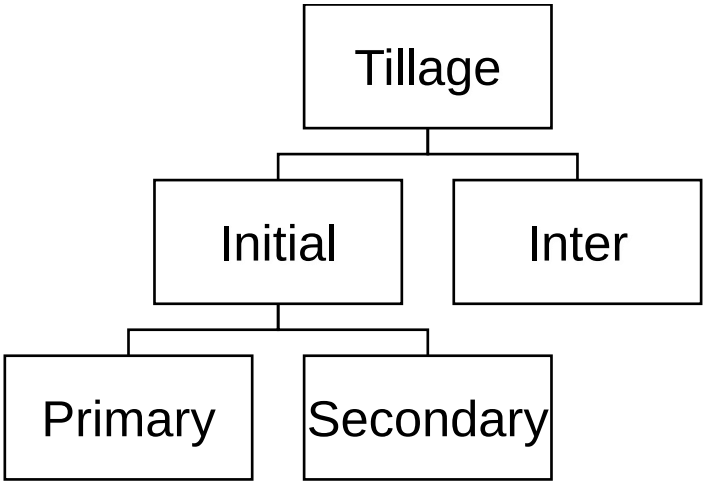
2.1.1 Objectives of Tillage

Followings are the three major objectives of tillage;

- To prepare a suitable seedbed
- To destroy competitive weeds
- To improve the physical condition of the soil.

Apart form that, to develop a granular soil structure for a seed bed or root bed, to control weeds, to manage plant residues, to minimize soil erosion, to mix fertilizer, insecticides etc. into soil, to accomplish segregation (moving soil from one layer to another to remove rocks, foreign objects or root harvesting) also considered as objectives of tillage in agricultural perspectives.

2.1.2 Classification of Tillage



Primary Tillage

1st main tillage procedure, required large amount of energy and heavy implements, normally this is done up to 75cm depth. Soil is broken in to large fragments.

Improve the soil aeration, Improve the soil structure, mixing fertilizer and organic matter with soil, increase water holding capacity, Increase Root growth, Control the weed and pest are the objectives of primary tillage.

Secondary Tillage

Process after primary tillage. Light implements are used. Depth is up to 15cm only (shallow depths), Large fragments are broken in to small fragments.

To improve the seedbed condition, to reduce evaporation & conserve the soil moisture, Control the weeds, and level the floor are the objectives of secondary tillage.

3. FARM PRODUCTION ENGINEERING

3.1 Machinery for Land Preparation

Components of the Plough

Followings are the major components of a plough (Figure 3.1);

- Beam – Hitch the power supplying source
- Handle – Control the plough/Ploughing depth
- Blade (Shoe & share) – cut the soil
- Body – joint above three parts together

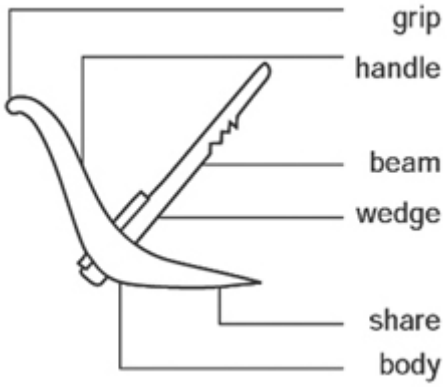


Figure 3.1 Components of a Plough

Development of the Blade

At early-stage used wood/horn as blade. It was Isometric blade. It was easy to produce, not difficult to plough Low power requirement.

Mould Broad: Joined the additional board, Cause to turn over the soil and weed control.

3.1.1 Primary Tillage Implements

Various kind of mould-board ploughs, Disk ploughs, Sub soil plough, Chisel plough and tine tiller, Rotary tiller are the examples for primary tillage implements.

Village Wooden Plough

Consist with wooden made isometric blade. Beam, plough frog, handle & blade can be identified easily (Figure 3.2). Working rate: 0.1 – 0.15 ha/day (6 h). Weight: 12 – 20 kg, Usage: In lowland for seedbed preparation, in up land have to use a metal covered blade. Power requirement: Two buffalos (1 – 1.5 hp)

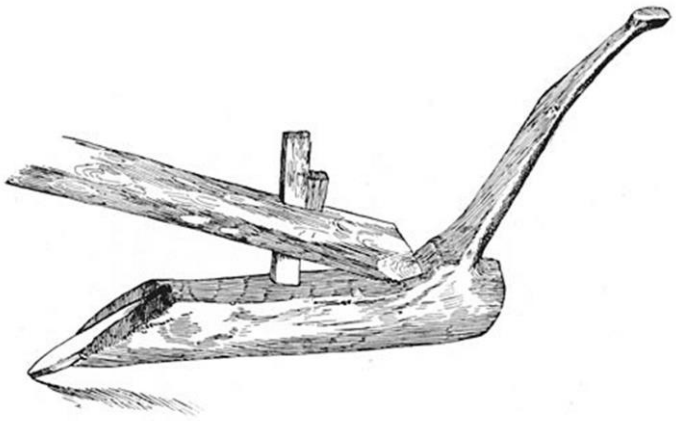


Figure 3.2 Village Wooden Plough

Light Iron Plough

Consist with moldboard plough. Use to loosen and turn over the soil (Figure 3.3). Working rate: 0.15 – 0.25 ha/day (6 h). Weight: 10 – 15 kg. Usage: lowlands & up lands, Depth of Ploughing: 12 cm, Width of Ploughing: 4 – 5 in, Power requirement: Two buffalos (1 – 1.5 hp).

Figure 3.3 Light Iron Plough

Single Cattle Plough

Introduced by Philippines. Not popular one, difficult to control the Ploughing depth. Consist with a moldboard plough. Use to loosen and turn over the soil (Figure 3.4). Work rate: 0.15 – 0.25 ha/day (6 h), Usage: lowlands & up lands, Depth of Ploughing: 12 cm, Power requirement: one cattle (0.5 – 0.75 hp).

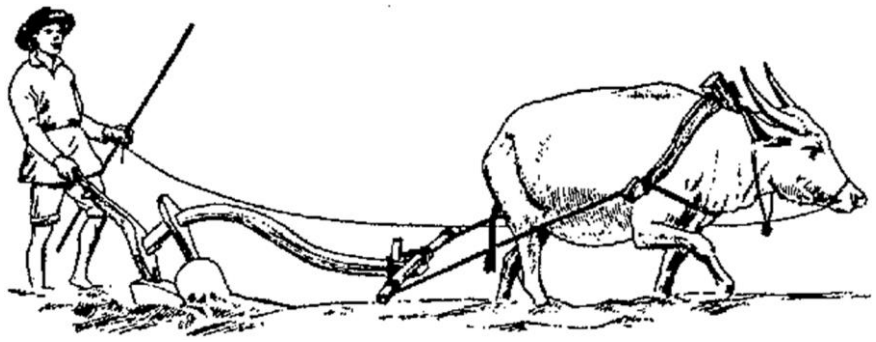


Figure 3.4 Single Cattle Plough

Heavy Duty Moldboard Plough

This is the improved version of single cattle plough. Ploughing depth is controlled by the handle (Figure 3.5). Power requirement - one cattle (0.5 – 0.75 hp).

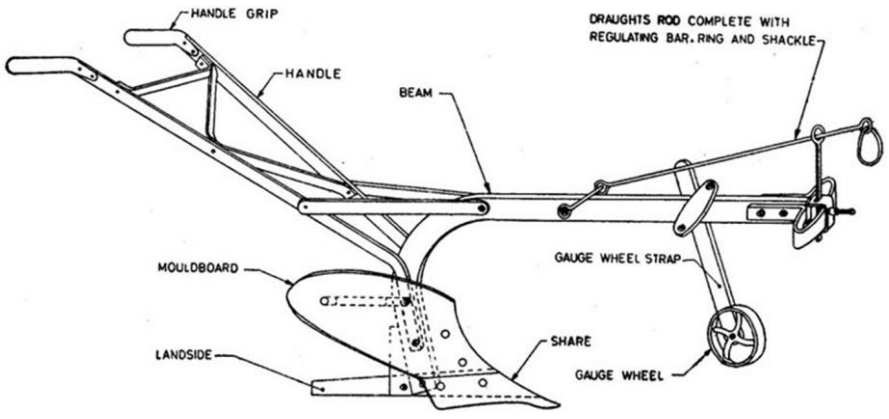


Figure 3.5 Heavy Duty Mould-board Plough

Mould-Board Plough

Mechanical power is used. Cut and turn over the soil. Achieve efficient weed control, Power requirement - four-wheel tractor (Figure 3.6).

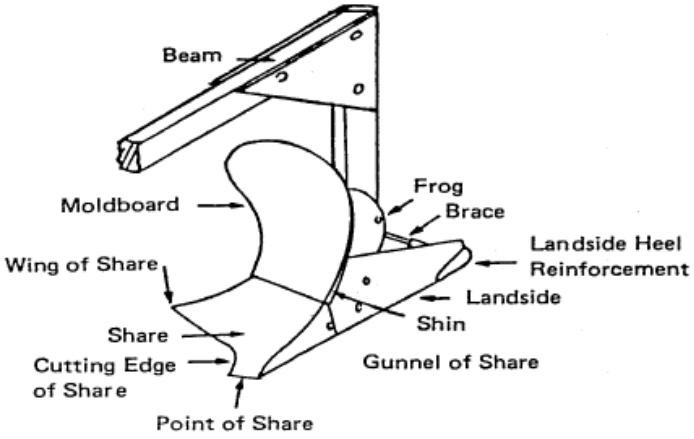
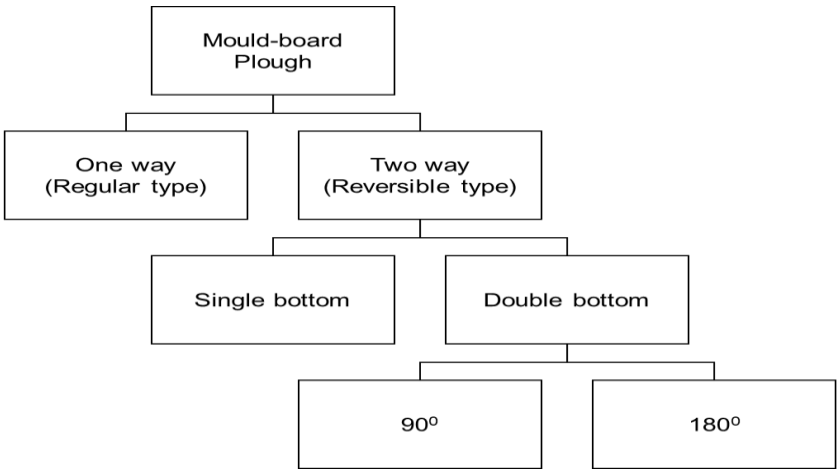


Figure 3.6 Parts of Mould-Board Plough

Classification of Mould-Board Plough



Japanese Reversible Plough

Rear attachment of two-wheel tractor, two-way, single bottom type, Cut, lift and turn the soil (weeds controlling). There are three adjustments for direction controlling, cutting width controlling and cutting depth controlling (Figure 3.7). Working capacity – 1-1.5 acres/day, Maximum plowing width – 20 cm. Maximum plowing depth – 25 cm.

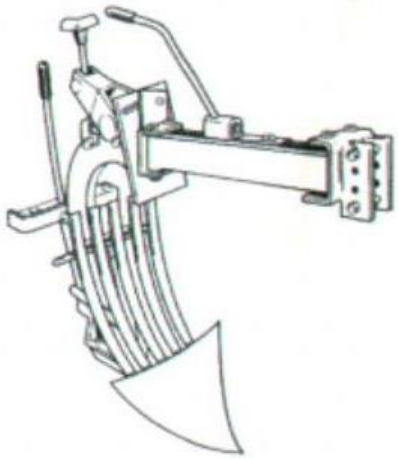
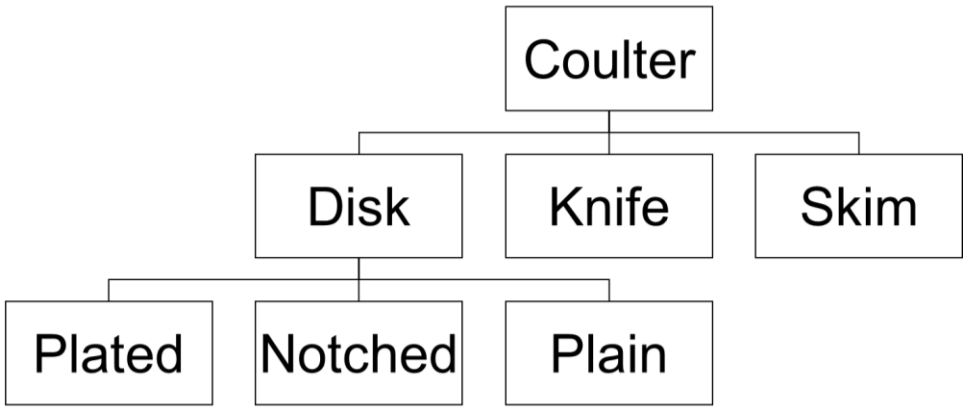


Figure 3.7 Japanese Reversible Plough

List of Accessories of a Mould-Board Plough

Ground wheel / gage wheel / depth wheel, Coulter (additional small plough) and trash covering aids are the major accessories of mould board ploughs. Further coulter can be classified as follows;



Disc Plough

Primary tillage implement. Consists of concave steel discs of 60 to 90 cm diameter. A disc plow is designed with a view to reduce friction by making a rolling plough bottom (Figure 3.8). can be operated with two-wheel tractor or four-wheel tractor. Disc plows are appropriate for; hard soil, soil with stones, roots and debris deep plowing, Power requirement is less than the moldboard plough, turn the soil into one direction. Weeds are controlled by cutting turning and pulverizing.

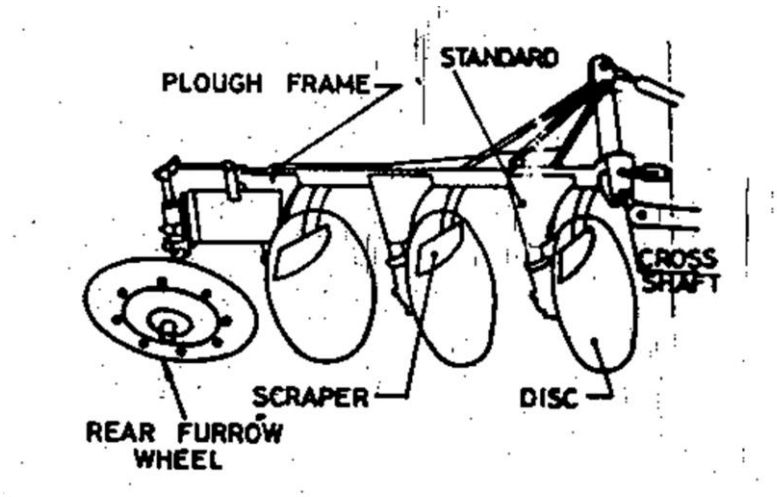


Figure 3.8 Disk Plough

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

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

Furrow wheel – It is a spring-loaded wheel to take the side thrust of the plow. It helps to keep a straight plowing and avoid dragging the plow to a side.

Plough frame – carries all the parts together and provide attachments for the power source.

Adjustment of disk plough

- Horizontal angle ((disc angle) - Control the ploughing width, bolts behind the disk are the adjustments (Figure 3.9)
- Vertical angle (Tilt angle) - Control the ploughing depth (Figure 3.10)

Sub Soil Plough

Heavier equipment. Ploughing depth 1-1.25 m. Brake the compact layers (Hard pan). Higher amount of power is required (Figure 3.11).

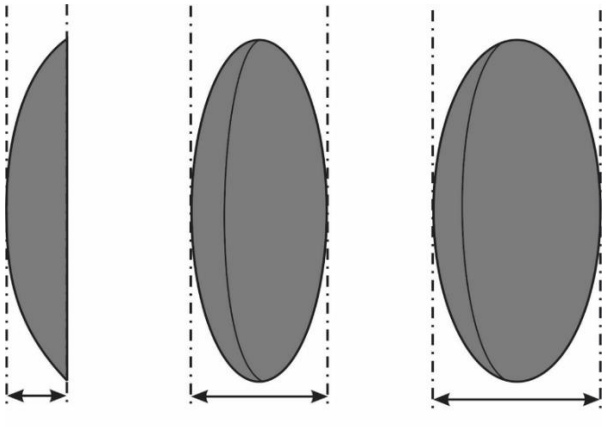


Figure 3.9 Adjustment of Horizontal Angle

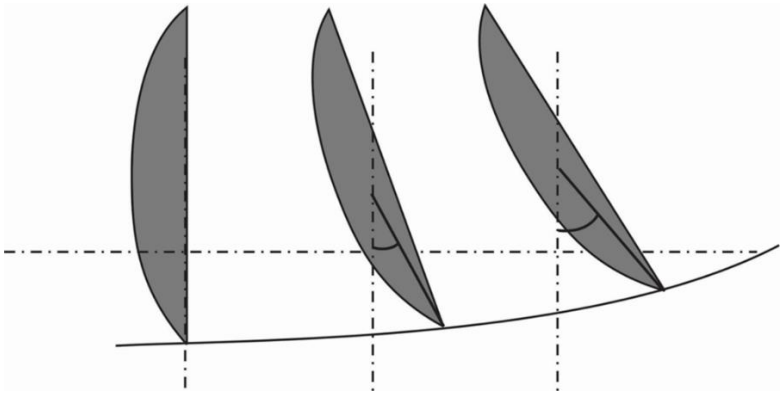


Figure 3.10 Adjustment of Vertical Angle

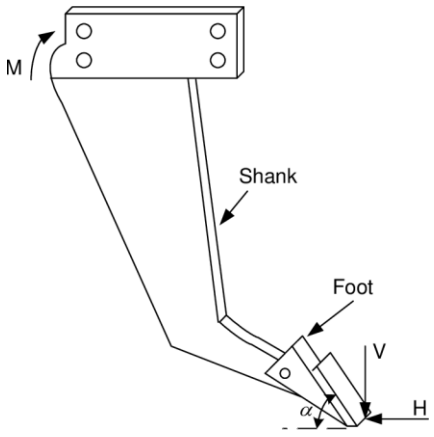


Figure 3.11 Sub Soil Plough

Cultivator/Chisel Plough and Tine Tiller

Suitable for both upland and low land conditions. Light implement. Power requirement is low. Suitable for inter-cultivation too. Working capacity is 2 – 3 acres per day. Plowing width is about 1-2 m. Plowing depth is 15- 20 cm.

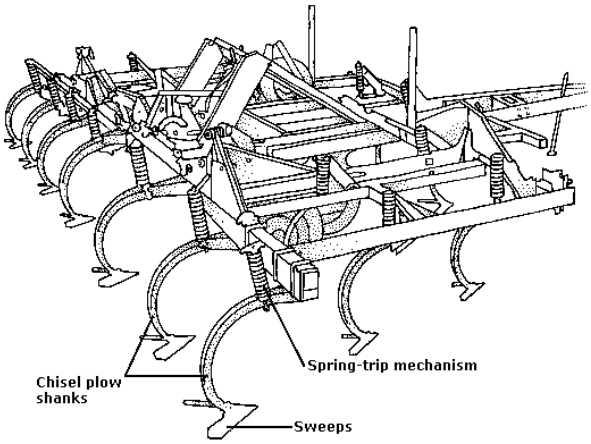
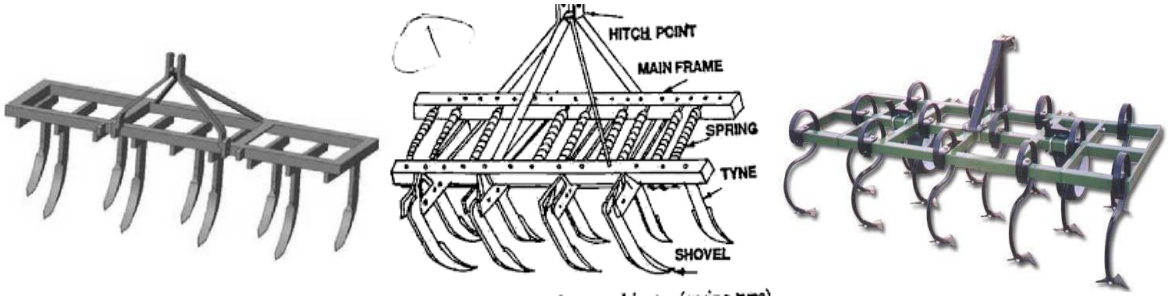


Figure 3.12 Chisel Plough

There are three types of tine tillers; Ridge, Spring loaded and Spring steel (Figure 1.13).



A B C

Figure 3.13 Types of Tine Tillers *(A - Ridge, B - Spring loaded and C- Spring steel)*

Rotary Tiller

PTO power/torque is used. Use as primary and secondary tillage equipment. Operated by 2/4-wheel tractors. Use in upland and lowland, chop and incorporate crop residues (Figure 3.14). Number of blades, rotation speed of blade, speed of tractor and position of the lid are affected on tilled partial size. Supply a drawbar push, use as primary/secondary equipment and use to make ridge and furrows are the advantages of rotary tiller. No efficient weed controlling and

shallow ploughing are the disadvantages of rotary tiller. There are three types of rotaries; Center drive, Single side driven and Double side driven.

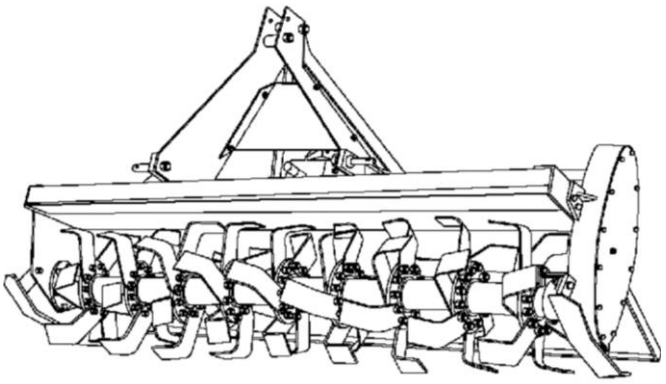


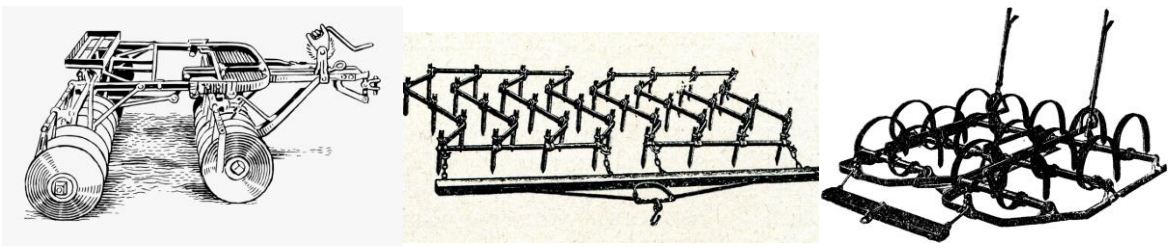
Figure 3.14 Rotary Tiller

3.1.2 Secondary Tillage Implements

Harrows, Pulverizes/rollers, Leveling board, Cultivators and Special tools for surface tillage are the examples for secondary tillage implements.

Harrows

A harrow is an implement with spikes or disks that is used to cultivate the soil by pulverizing and smoothing it. There are three types of harrows; Disk harrow, Spike tooth harrow and Spring tooth harrow (Figure 3.15).



A B C

Figure 3.15 Types of Harrows *(A - Disk harrow, B - Spike tooth harrow and C -Spring tooth harrow)*

Disk Harrow

Consist with number of small disks. Disks are arranged as gangs: Two gang, four gang. Three types of disk harrows; Single action, double action and off set (Figure 3.16).

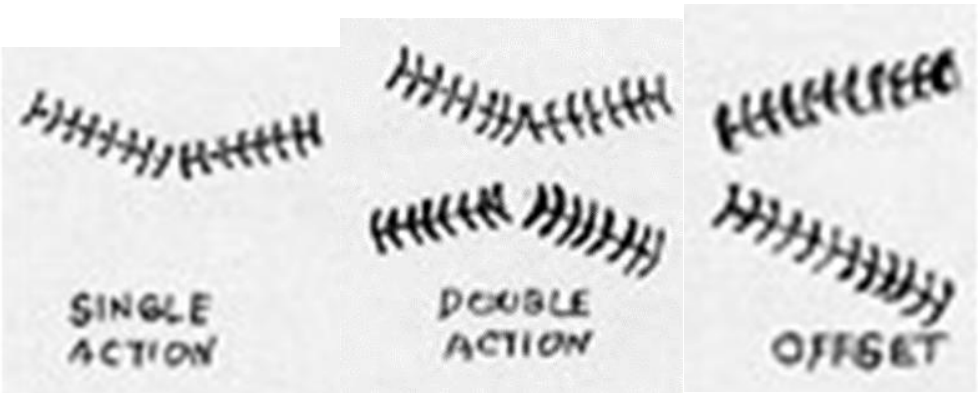


Figure 3.16 Types of Disk Harrows

Disk Bedder

Two gang disk harrow is used to make race beds. Disk size and concaveness are different (Figure 3.17).

Figure 3.17 Disk bedder

Pulverizes/rollers

Large soil clods convert to tiny soil particles. Can achieve good seed bed condition (Figure 3.18).

Figure 3.18 Pulverizer

Leveling Board

Use to level the field/seed bed. Use for irrigation practices. Use to make roads. Working width – 1.5 – 3 m. The suitable forward speed – 3-5 km/h.

Cultivators

Light chisel type ploughs used to loosen the soil and control weeds between rows of growing crops.

Special Tools for Surface Tillage

- Sweeps
- Swiss hoe
- Chopping hoe

Ridger and Furrow Opener

Use to make ridge and furrows.

Ridger: make a furrow in an un-broken soil. Heavy implement.

Furrow opener: make a furrow in a broken soil, light implement, use after rotary tiller.

3.1.2 Equipment for Inter Cultivation

Cultivation operations from planting to harvesting is called as inter cultivation. Earth loosening, earthing up, weed controlling etc. are considers as inter cultivation operations.

Example 3.1: A tractor operates at a speed of 8.8 km/h and use 6x356 mm mould board plow bottom. If plowing depth is 140 mm and unit draft is 5.51x 104 Nm-2. Calculate;

a) Plowing rate (ha/h) b) Total draft requirement.

Example 3.2: Tractor operates at speed of 5.6 km/hr. 4x355 mm wide mould board plow is attached to it and plowing depth is 137.5mm. If the field efficiency is 78%,

a) calculate the plowing capacity per day. (8h)
b) If the soil resistance is 5.51 x 104 Nm-2, calculate the total draft requirement.
c) What is the approximate HP of the tractor?

Example 3.3: A tractor with 4x500mm mould board plow is used to plow 10 ha land. Tractor manipulate the 10 h /day.

a) When the tractor speed is 8 km/h calculate the days that required for finished the work.
b) If the area is increased up to 20 ha and working period per day change up to 9 h, calculate the plowing width when farmer want to finish work at previous time period.

Example 3.4: A farmer has to plow one hectare field at the forward speed of 2.5 km/h using a single cattle plow with a bottom width of 150 mm. If the weight of the draught animal is 500kg and it can pull equivalent pull of 10% of its body weight. Calculate,

a) power developed by the animal b) time taken to plow the field

Example 3.5: A four bottom moldboard plow travels at a forward speed of, 6.5 kmh-1, width of a plow bottom is 320 mm and the depth of working is 140.5 mm. Determine,

a) the field capacity in ha/day, if it works 6 hours per day
b) the total draft, if the soil resistance is 5.62 x 104 Nm^2

Example 3.6: A tractor operates at speed of 6.3 km/h. 4×346 mm wide mould board plough is attached to it and ploughing depth is 126.5 mm.

a) If the field efficiency is 76%, calculate the ploughing capacity per day.
b) If the soil resistance is 5.63Nm-2, calculate the total draft requirement.
c) What is the approximate Horse power of the tractor?

Example 3.7: A farmer has a 10-acre land and he intend to cultivate maize and he is going to use a 350 x 3 mm moldboard plow for primary tillage up to 170 mm. The most suitable forward speed of the tractor for this plow is 6 km/h. The soil resistance and the field efficiency of the tractor are 5 x 104 Nm^{-2} and 65% respectively. Calculate,

a) the total draft of the plow
b) Plowing capacity
c) drawbar power
d) time taken to complete the work
e) If farmer want to finish the work within 1 day (working hours per day is 8 hours), what may be the speed of the tractor?

3.2 Sowing and Planting Machines

Use to place seed or seedlings in the soil. It should be right number of seed/seedlings at proper depth of the soil. Transplanters are used to plant seedlings. Seeders are used to sow seeds. There are four types of seeders; broadcaster, band Sowers, row seeders and seed drillers.

3.2.1 Seeders

Broadcasters

Use to broadcast seeds. Seed rate can be controlled. However, in row & between row spacing and planting depth cannot be controlled. There are several types: Pneumatic, Rotary disk and Belt.

Band Sowers

Use to spread seed as bands. Cannot control: seed rate, in row & between row spacing and planting depth.

Row Seeder

Lays seeds in rows. Between row space can be controlled. Seed rate, in row spacing, and planting depth cannot be controlled.

Seed Planter

Use single SMM. Seed rate, in row & between row spacing and planting depth can be controlled.

Parts of a Seeder

Parts of a seeder are shown in figure 3.19.

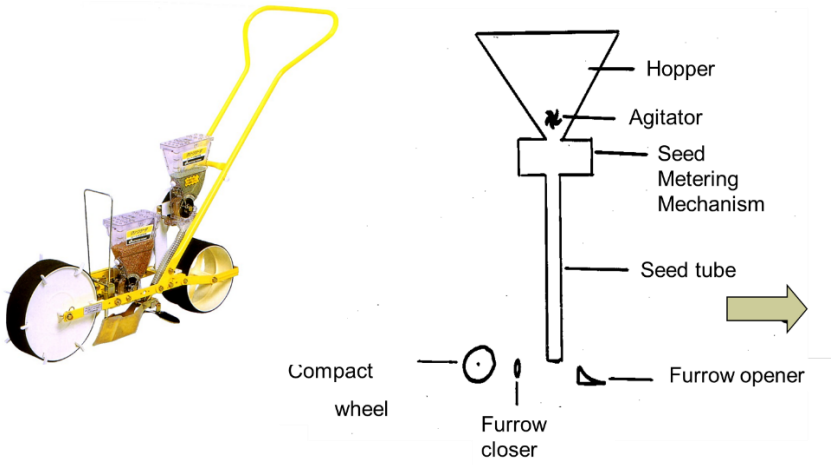


Figure 3.19 Parts of a Seeder

Seed tube: It takes seeds from S.M.M. to furrow opener. Mostly seed tubes are transparent and light weight. There are three types: Bellow, Telescopic and plane.

Furrow opener: Help to open the furrows. There are several types: Sword, Angle iron, Backward, incline knife, concave disk and Double disk.

Furrow closer: Help to close the furrows. There are several types: Chain type, Inverted 'T' closer, Double conical wheels.

Compacting wheels: Help to compact the soil after closing the furrow.

Seed Metering Mechanisms (SMM)

Seed metering has two aspects; (1) Seed rate – number of seeds released per unit time, related to final plant population (2) Singular seed releasing ability – help to placement of seeds at uniform spacing in each row.

There are two types of SMM; (1) Bulk flow mechanisms, (2) Single seed metering mechanisms. Fixed orifice, Variable orifice, Fluted roller, Belt type and Cup feed are the examples for bulk flow SMM. Vertical plate, Inclined plate, Horizontal plate, Seed tape, Pneumatic type, Finger pickup and Brush-Type are the examples for single SMM.

Available Seeders in Sri Lanka

Low land seeders: Johan Pulley seeder, Dias dibber, Wickramasekara seeder and FMRC low-land seeder

Up land seeders: Single row push type seeder, FMRC high-land seeder, Power operated seeder

Johan Pulley seeder

Use to sowing pre-germinate seeds, pull type, one man can operate, weight - 4 kg. Working capacity - 0.05 ha/h, couldn't control the space and planting depth (Figure 3.20)

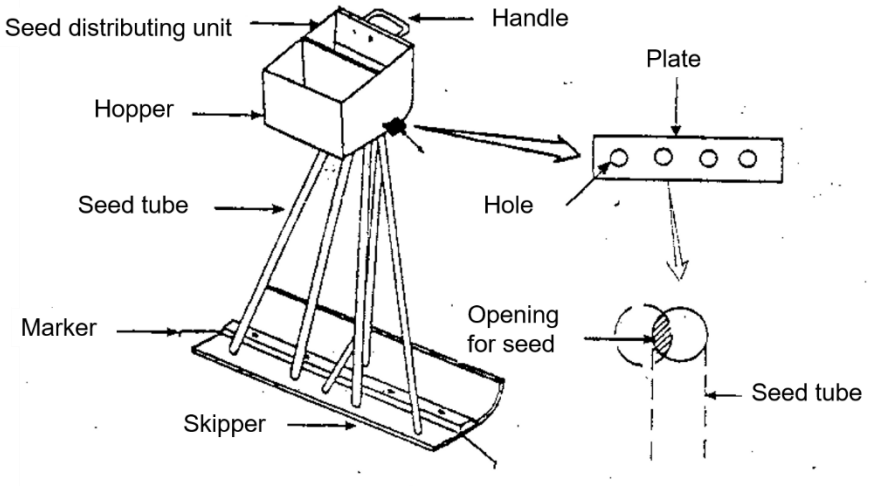


Figure 3.20 Johan Pulley seeder

Dias Dibber

In row space can be controlled. Power requirement - Two men. The seeder is raised by men and put another place.

Wickramasekara Seeder

Power requirement – 01 man, manual and pulling type, working capacity 0.1ha/h

FMRC Low Land Seeder

Use to sowing pre-germinate seed in rows. No of rows: 04, Seed rate: 30 kg/Ac, Field capacity: 2.5ha/day, Power source: Manual (one man)

FMRC High Land Seeder

Row seeding, pulling type, no of rows: 02, Spacing: variable from 200 to 600 mm, Field capacity: 0.5 – 1.0 ha/day, Power source: manual (one man).

Calibration of Seeder

Due to usage for long time, some parts may tear and wear and it is required be adjusted/replaced. This process is called as calibration of seeder.

To check the accuracy of the SMM (seeding rate) and adjust the seeding rate are the objectives of seeder calibration. There are two calibration method; 1. Stationary and 2. Field.

Stationary calibration: Use for seeder. The number of seed per 10 or 15 rounds of rotation of the ground wheel is counted. Using the circumference of wheel determine the distance of row. Calculate in row space. Distance between adjacent seed tube = between raw space. Then Calculate seed rate and adjust the SMM accordingly.

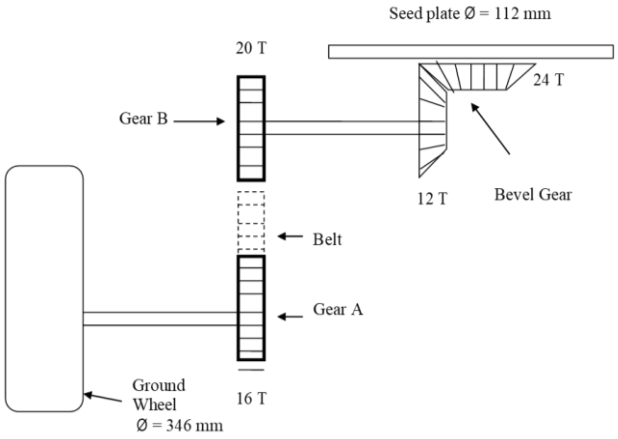
Example 3.8: A three row maize seeder is going to be calibrated before use at the field. The radius of the ground wheel of the seeder is 14.3 cm and the single seed metering mechanism is fitted to the axel of the ground wheel. The expected between and within row spacing of the seeder are 60 cm and 30 cm, respectively. How many seeds should be collected with 15 rotations of the ground wheel?

3.2.2 Transplanters

Mark II Transplanter

Use to Transplant rice seedlings in puddle paddy fields. Power: manual (one man). Field capacity - 0.35 ha/day.

Example 3.8: As shown in the following figure, the ground wheel is connected to the seed plate, which has 72 cells, through a gear mechanism.



1) If the cell-filling rate of the seed plate is 75%, calculate within the row spacing of the seeder.
2) If the average forward speed of the seeder is 3 km/h, calculate the angular velocity of the seed plate in revolution per second.

Example 3.9: A seeder having a single seed metering mechanism was adjusted to release 22 seeds per revolution of the ground wheel. Estimate plant density after one month from planting, using the information given below;

Radius of the ground wheel - 35 cm

Cell filling % - 98

Germination % - 85

Survival % - 80

Row spacing - 1.5 m

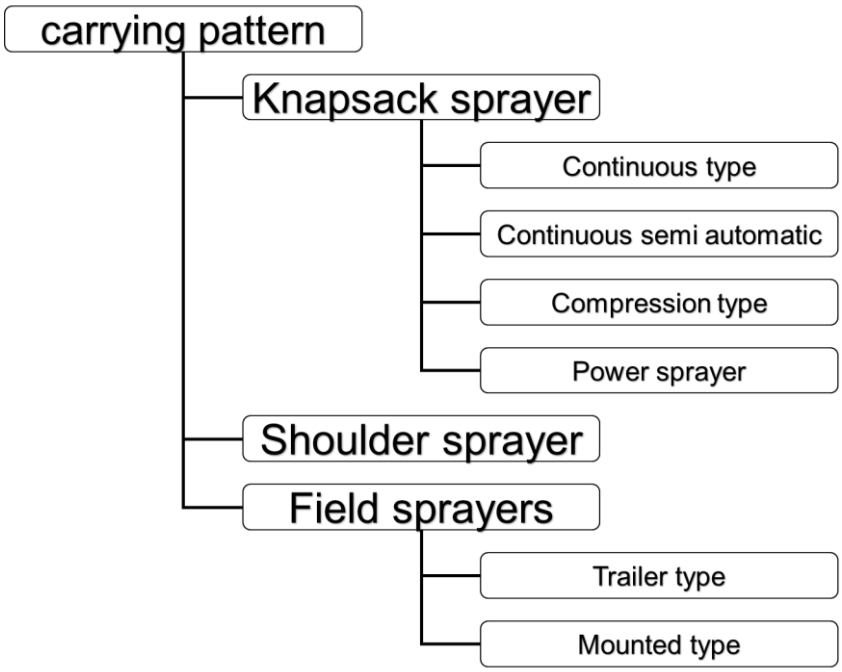
3.3 Plant Protection Machines

3.3.1 Classification of sprayers

Power Source

1. Hand operated
2. Power operated

carrying Pattern



Knapsack sprayer: Carry in the back side of the operator

1. Continuous type knapsack sprayer: Pump should be operated continuously while liquid is discharge, No pressure chamber.

2. Continuous semi-automatic knapsack sprayer: Has pressure chamber, No need of continuous pressure application, Most popular in small scale farmers

3. Compression type knapsack sprayer: Liquid thank works as pressure chamber, Heavy metal bottle, uneven output is the disadvantage.

According to the Volume of Handling

1. Ultra-low volume
2. Low volume
3. High volume

According to the Pressurized Mechanism

1. Piston
2. Diaphragm
3. Plunger

3.3.2 Types of Sprayer Nozzles

- Solid cone type - More concentration in middle
- Hollow cone type - Uniform distribution
- Flat fan type - Not use in agriculture
- Flood type - Use in large scale application, large size drops

3.3.3 Calibration of Knapsack Sprayer

All hand-operated sprayers need to be calibrated at the start of the spray season. This will ensure that the correct rate of chemical is applied to the target plant.

Calibration process: Measure the spray width (swath width) of the nozzle on a dry surface (in meters). Spray a test area at the intended pressure and walking pace. Record distance (in meters) covered in one minute (min). Measure the nozzle output in liters over one minute in a measuring jug (L/min). The spray volume can be calculated by the following formula;

$$\textbf{Application rate (L/ha)} = \frac{\textbf{Nozzle output (L/min) x 10,000}}{\textbf{Spray width (m) x walking speed (m/min)}}$$

Example 3.10: if; Nozzle output in 1 minute is 5 L, spray width is 1 m and walking speed is 100 m/min. calculate Application rate (L/ha).

The following formula can be used to determine the amount of product needed for each tank.

$$\text{Product/tank (L or kg)} = \frac{\text{Recommended rate (L/ha or kg/ha) x tank size (L)}}{\text{application rate (L/ha)}}$$

3.4 Water lifting Devices

Water lifting devices can be classified as in figure 3.21.

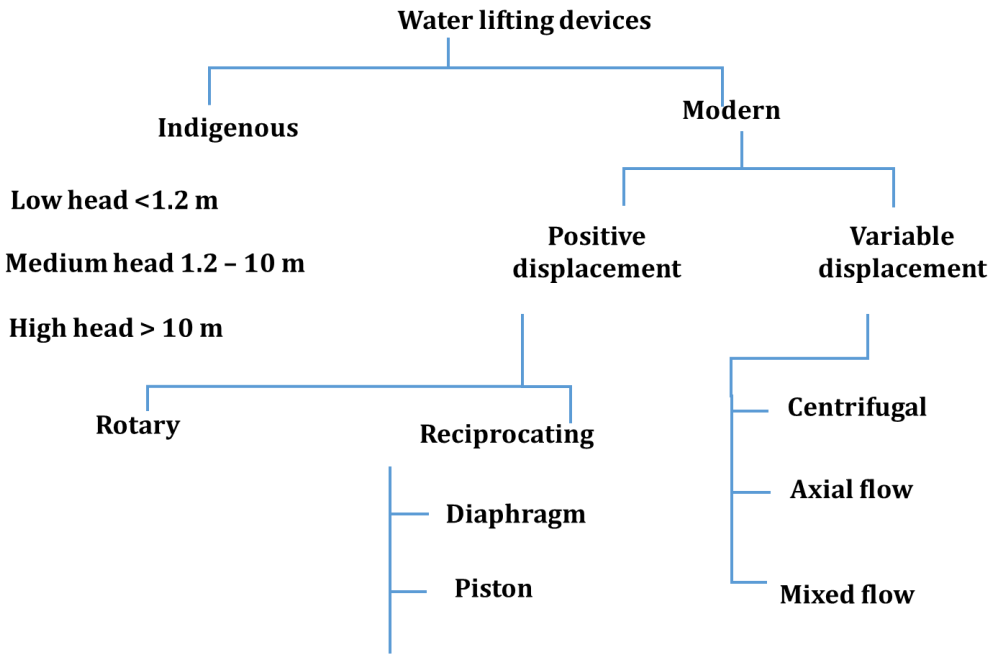


Figure 3.21 Water Lifting Devises

3.4.1 Indigenous Water Lifting Devices

Scoop, swing basket, Counterpoise lift, Dhone, Noria, Open screw pump, Coil pump, Persian wheel, Liberation pump, Paddle-wheel or tread-wheel, water wheel, and Water ladder are the few examples for indigenous water lifting devices.

3.4.2 Modern Water Lifting Devices

positive Displacement vs. Variable Displacement

Positive displacement	Variable displacement
Discharge does not vary with the head	Discharge varies with head
Discharge is not depend on the head	Discharge is inversely proportional to head

Positive Displacement Pumps

A positive displacement pump causes a fluid to move by trapping a fixed amount of it then forcing (displacing) that trapped volume into the discharge pipe. A positive displacement pump has an expanding cavity on the suction side and a decreasing cavity on the discharge side. Liquid flows into the pump as the cavity on the suction side expands and the liquid flows out of the discharge as the cavity collapses. The volume is constant given each cycle of operation.

Centrifugal Pump

A centrifugal pump is any pump that uses centrifugal force to create a pressure differential in a fluid, thus resulting in pumping action (Figure 3.22). Impeller, Casing, Out let and Inlet are the components of centrifugal pump.

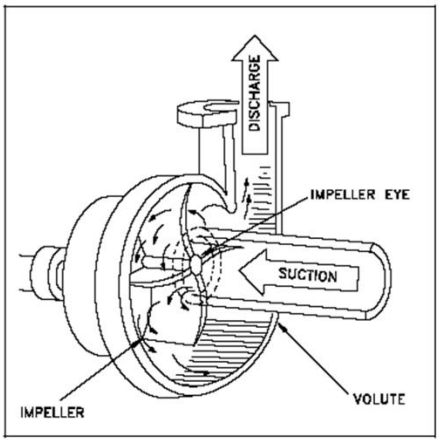
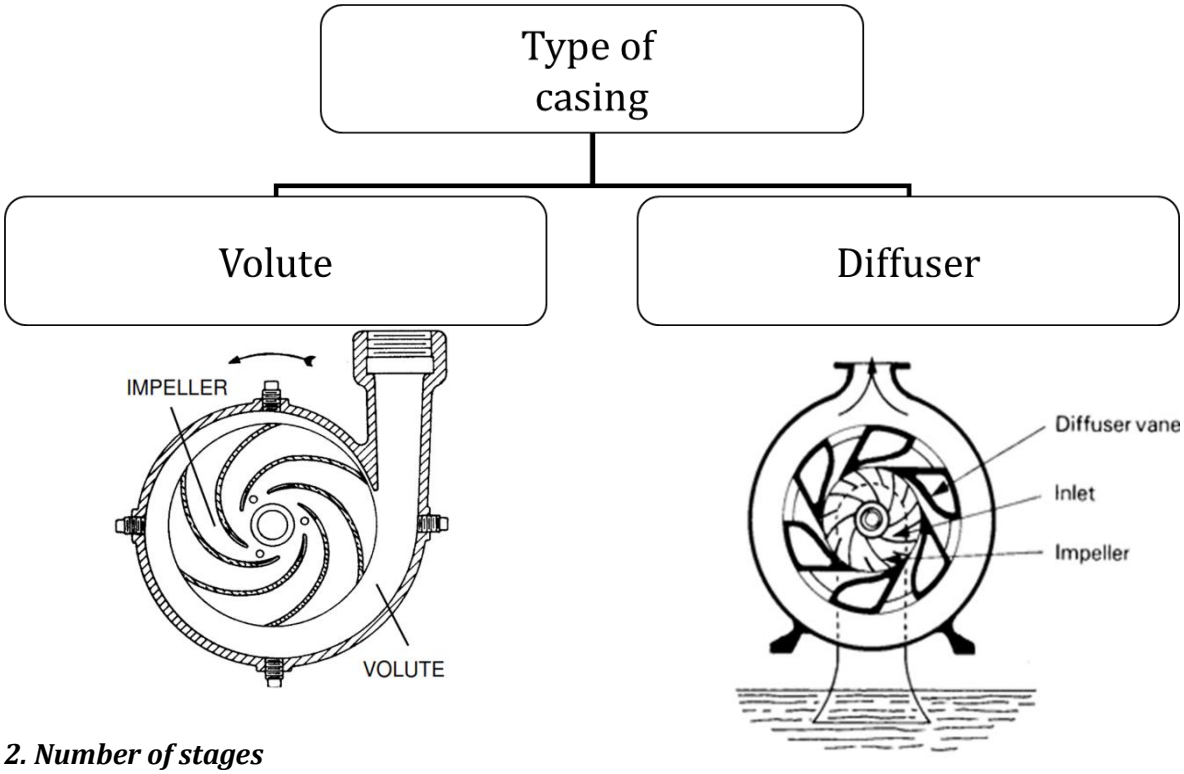


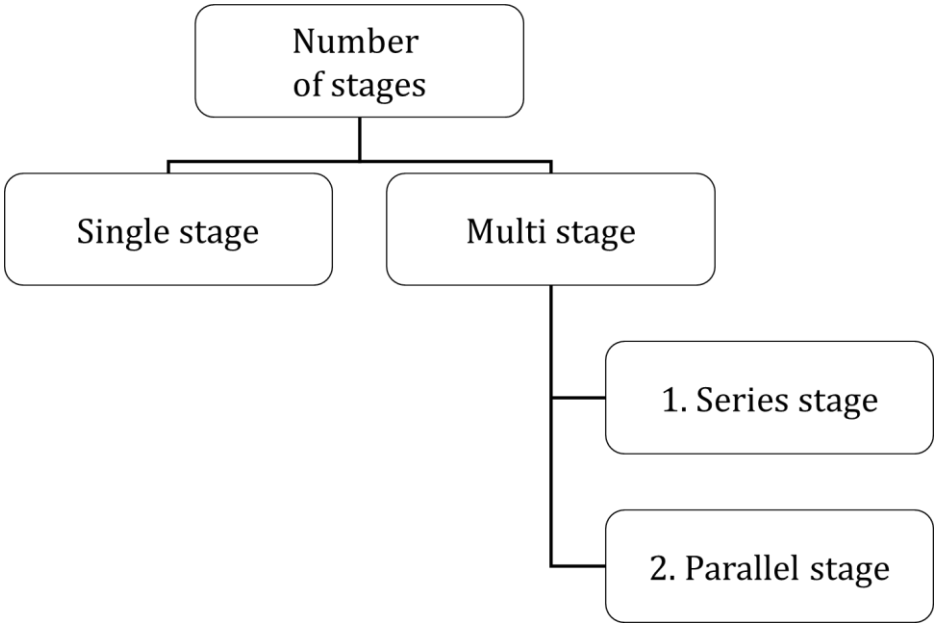
Figure 3.22 Centrifugal Pump

Classification of Centrifugal Pump

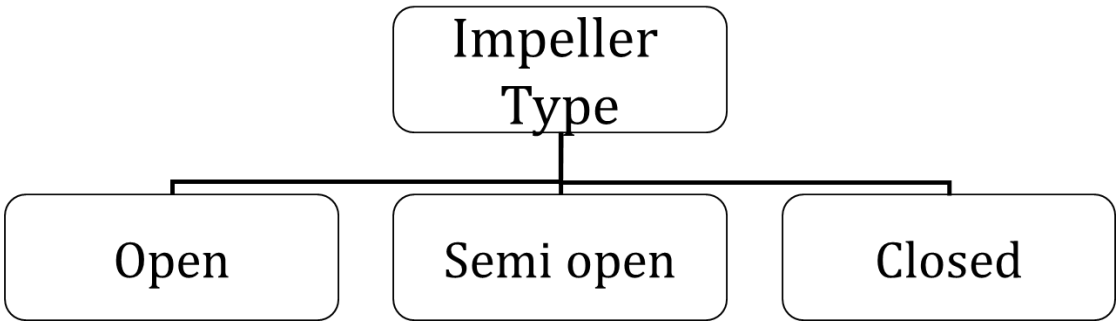
1. Type of casing

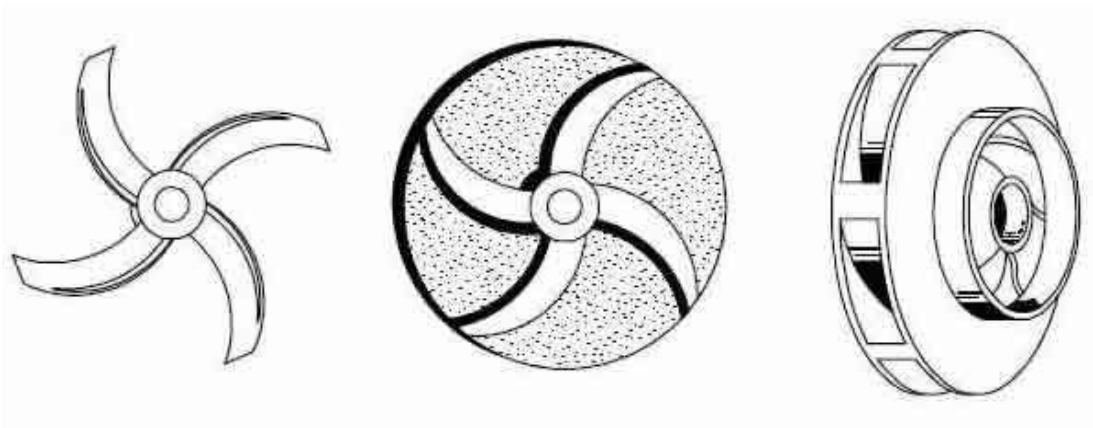


2. Number of stages

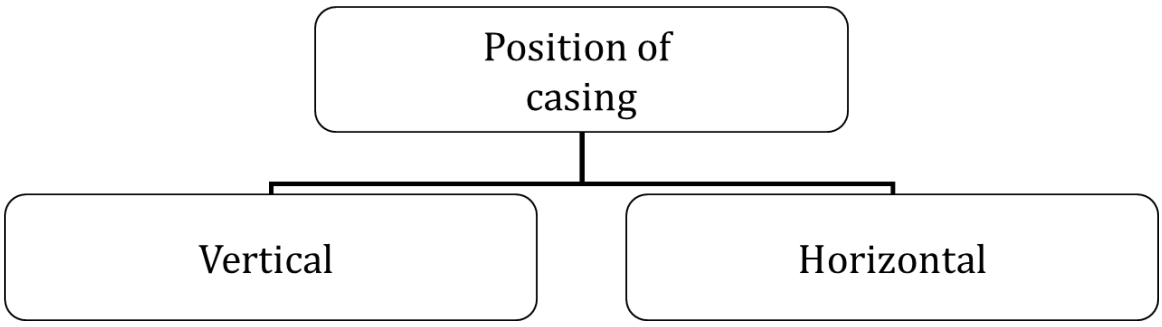


3. Impeller type

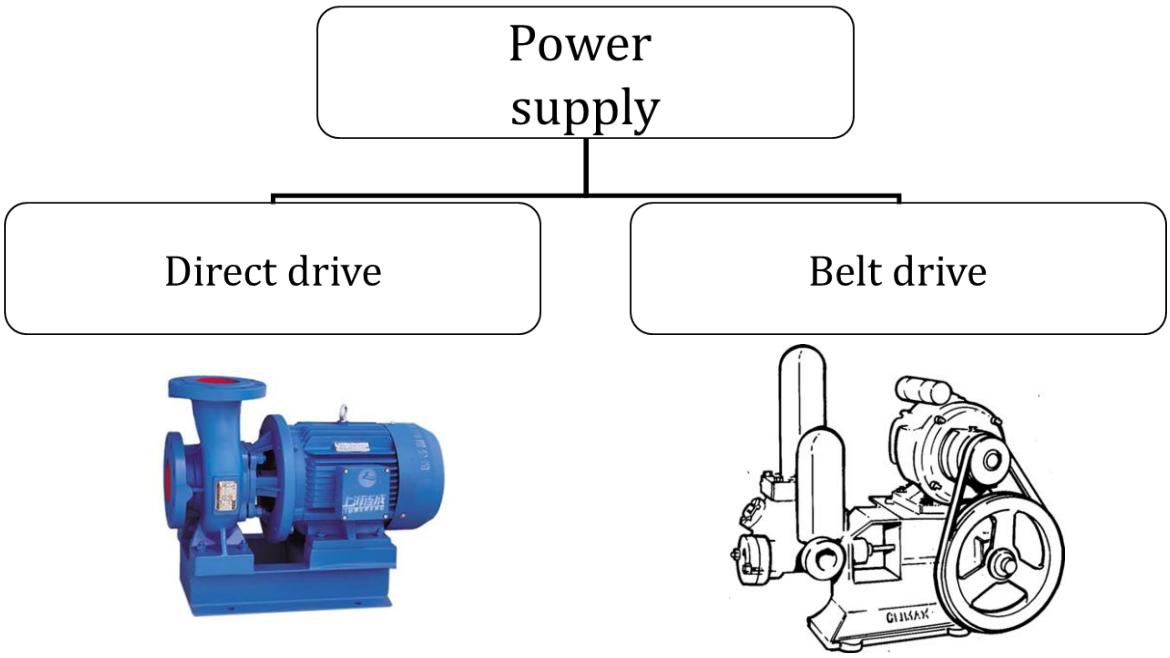




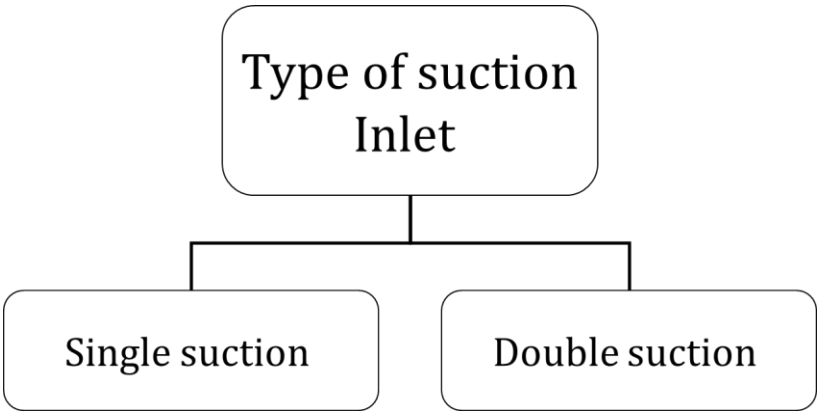
4. Position of Casing



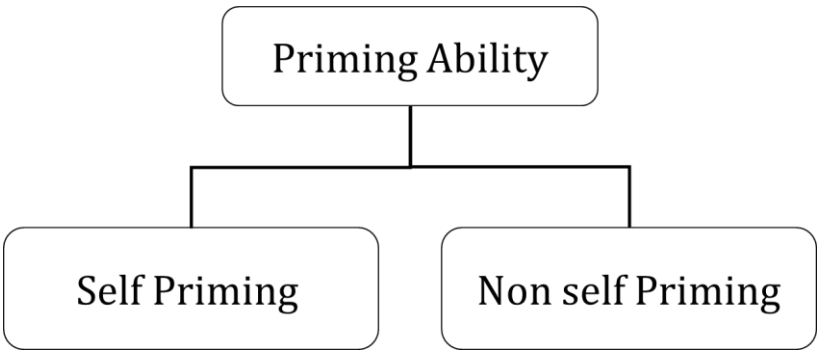
5. Power Supply



6. Type of Suction



7. Priming Ability



Axial flow/Propeller/Turbine pump

Large discharge for low head. Use to flood control (Figure 3.23).

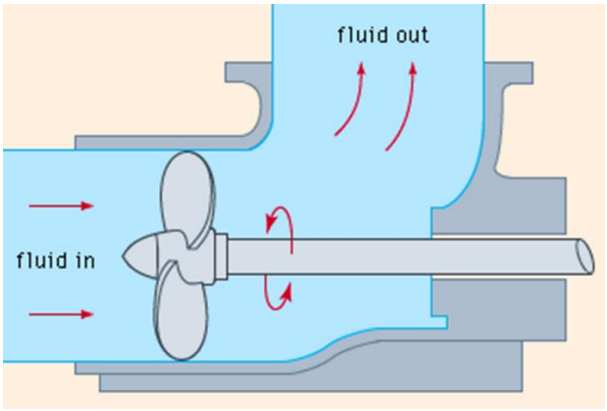


Figure 3.23 Axial Flow Pump

Jet Pump

Not use in now, can get higher suction head > 10 m, having huge casing. All most same to the deep well kit (Figure 3.24).

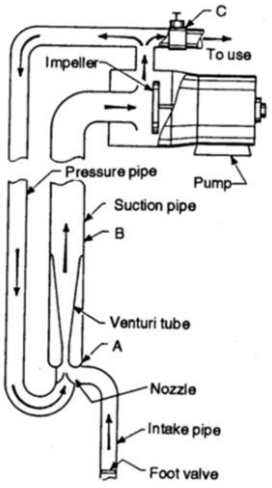


Figure 3.24 Jet Pump

Air Lift Pump

Compressed air is passed though the tube to bottom. Increase the pressure of the bottom and then water pass through discharge tube (Figure 3.25).

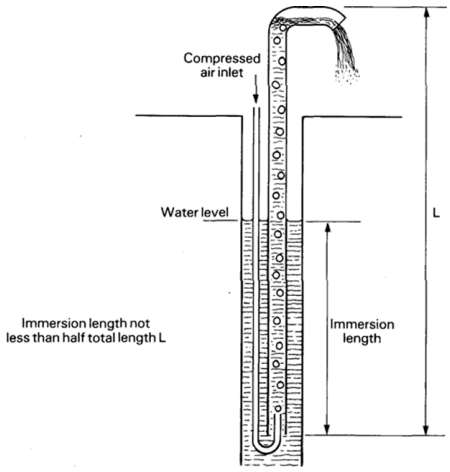


Figure 3.25 Air Lift Pump

3.4.3 Parameters Involved in Pump Selection

1. The nature of the liquid to be transported
2. The required capacity (volume flow rate)
3. The conditions on the suction (inlet) side of the pump
4. The conditions on the discharge (outlet) side of the pump
5. The total head on the pump
6. The type of system to which the pump is delivering the fluid
7. The type of power source (electric motor, diesel engine, steam turbine, etc.)
8. Space, weight, and position limitations
9. Environmental conditions
10. Cost

3.5 Harvesters and Threshers

3.5.1 Harvesting Machinery

- Cutter bar – cutting only
- Paddy reaper – use to cutting and making windrows
- Reaper binder – cutting and making bundles
- Combine harvester – cutting, threshing, cleaning and collecting

Requirements for Mechanical Harvesting

- Large rectangular plots – to reduce the time wastage for turning
- Sort bunds – to move from plot to plot easily
- logging resistance varieties
- Uniform land
- Weeds free conditions
- Favorable moisture content in the plot –water supply should be stopped before 7-10 days
- Height of the plant – The height should be 60 cm – 90 cm

Combine Harvester

There are two types; 1. Full feeding type (whole plants are feeding) and 2. Head feeding (only panicles are feed). Components of the combine harvested is illustrated in figure 3.26.

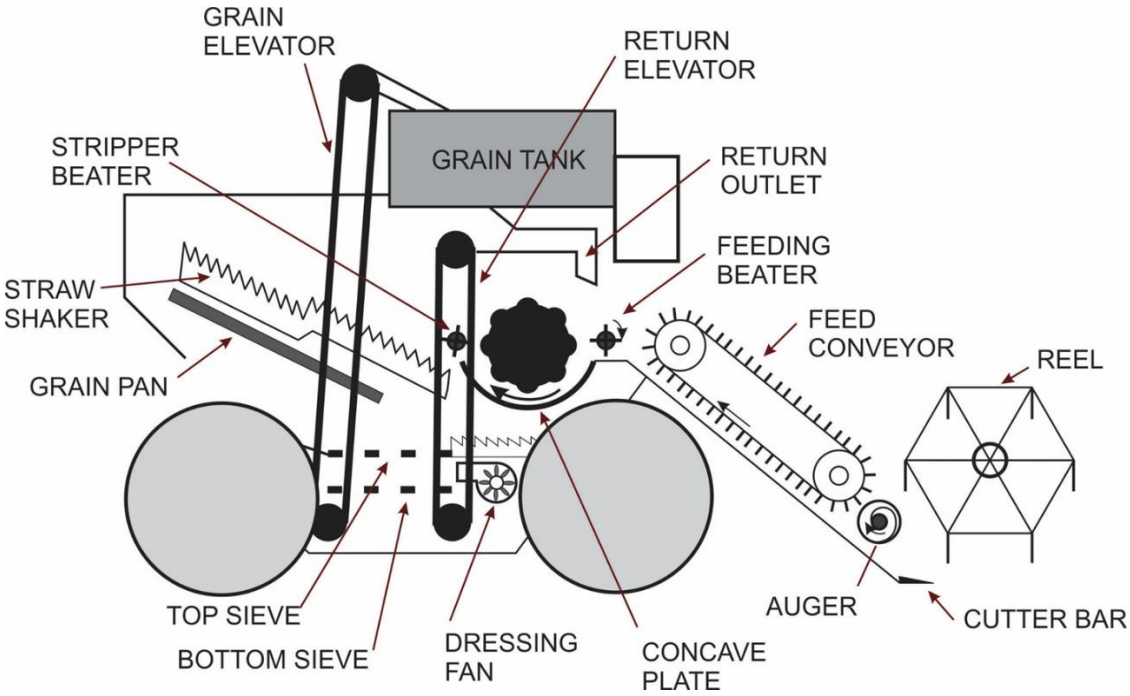


Figure 3.26 Components of Combine Harvester

Cutter Bar: Its' series of fingers are spaced at equal intervals. In some combine harvesters, the fingers are longer, as also are the knife sections. This increased length of section influences the angle of the cutting edges, giving a slightly greater shearing, as opposed slicing action

Reel: Positioned above the knife, where it rotates & gathers the crop into the machine as the cut is made. It is chain or belt driven & its position is adjustable to accommodate different straw lengths & crop conditions.

Auger: Only on combines harvesters. Width is equal to the cutter bar width and substantially greater than the threshing cylinder width.

Feed conveyor: Carries the crop upwards & backwards to the feeder, beater & threshing-cylinder. On machines with auger, it is usually of the chain & slat type. On machines without an auger, it takes the form of a rubber or canvas conveyor fitted with wood or metal cross salts.

Header: The header is the complete assembling which embodies all the above-mentioned components namely the cutter bar, the reel, the auger & the feed conveyor.

Feeder beater: Is positioned between the top of the feed conveyor & the front of the threshing mechanism. It rotates in the same direction as cylinder, speeding up the flow of the crop.

Cylinder (Drum) & concave: They are two vital components, comprising the threshing mechanism of the machine, & are sometimes referred to as the heart of the combine. They perform two functions: The extraction of grains from the ear and Separation of grains from straw.

Stripper beater: Similar to feeder beater. It is behind and slightly above the cylinder; it controls the transfer of the threshed straw from the concave to the straw shakers. Without the beaker, straw would be thrown clear of the front of the shakers & receive inadequate agitation. Helps to prevent straw wrapping around cylinder a tendency which can arise in certain crop conditions.

Controllers of Threshing Intensity

- Cylinder speed
- Concave/beater bar clearance

3.5.2 Post Harvest Machinery

- Threshers
- Combined threshers

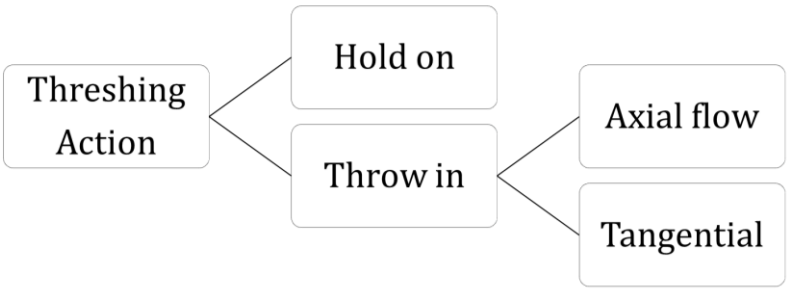
Threshing

Detachment of paddy grains from the panicles. This can be achieved from three actions:

1. **Ribbing action** - By trampling with man, animal or tractor, not efficient method
2. **Impact action** - Beating of small hand-held bundles of paddy stalks against a solid object, 4 - 6 bellows are required, Used primarily in mechanical threshers
3. **Stripping action** - Drawing small bundles of panicles across forked spikes

Thresher Classification

Threshers can be classified as follows;



There are several types of threshing drum cylinders (Figure 3.27).

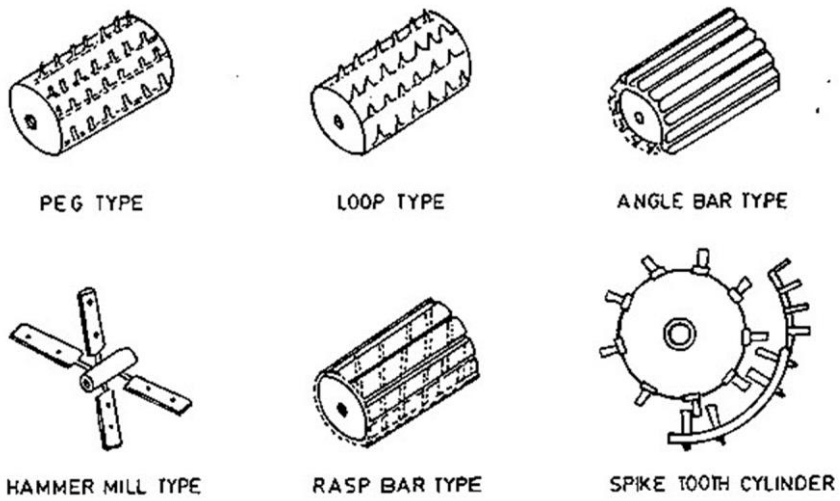


Figure 3.27 Different Types of Threshing Drum Cylinders

Main frame, feeding tray, threshing drum, cover and straw outlet are the major components of a thresher.

Combine Thresher

Combining operations of threshing, cleaning and bagging. Recently More popular, high capacity, low number of losses, Straw is thrown to the field.

Factors Effecting for Threshing Performances

- **Crop factors** - Variety of crop, Moisture content of grains, Drying of crops
- **Machine or mechanical factors** - Type or model of the machine, Manufacturing quality, type of mechanism, operating quality of the machine, care and maintenance of the machine
- **Miscellaneous factors** - Safety factors

4. INTRODUCTION TO TRACTION

Traction is the term applied to the driving force developed by a wheel, track or any other traction device. Transmission losses, slope losses, rolling losses and wheel slip losses are the traction losses (Figure 4.1)

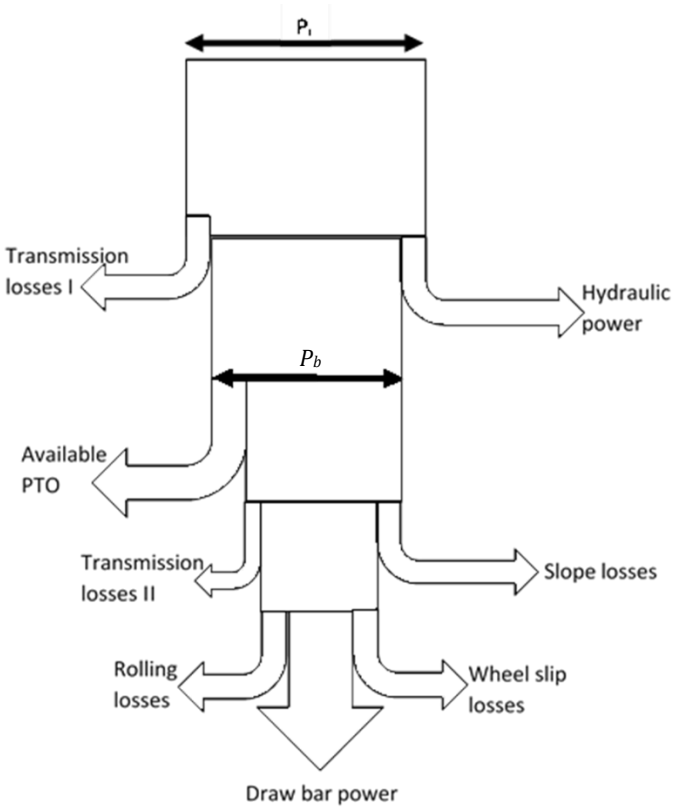


Figure 4.1 Traction Losses

4.1 Travel Reduction

Travel reduction is calculated by following equation;

$$\text{Travel Reduction} = \frac{D_T - D_A}{D_T} \times 100$$

D_T – Theoretical Distance D_A – Actual Distance

4.2 Traction Aids

Traction aids are used to increase the tractive power of the vehicle. Mud wheel, Lug design, Chain, Air pressure, Tracks and Tire filled with water are the few traction aids.

4.3 Factors Affecting for Lower Tactile Efficiencies

- Steering
- Rolling resistance
- Wheel slip
- Deflection of the traction device

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