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1 INTRODUCTION

CRP 312 is a two (2)-credit unit course on Farm Power and Agric. Mechanization. The topics are important to students of agricultural science. The major topics covered aims and objective of agricultural mechanization, use of some farm machinery and implement for agricultural production and processing. The course covers equipment for livestock production such as automatic feeders for poultry milk and milk handling, Meat and meat processing equipment. Water lifting devices for irrigation were also involved. The student will also have learned various sources of farm power, internal combustion engine, different tractor sub-system such as transmission, electrical, hydraulic and three-point linkage. The student will expose to tillage requirement and implement selection. Planting and forage handling equipment for crop and livestock production. Harvesting and combine harvesters were also discussed. Processing equipment such as drying and drying equipment hammer, burr, and roller mills were introduced to the students. The course guides the student for estimation of cost operating and hiring machinery.

The course is broken into 10 modules. Each module has 1 to 10 units. This course guide defines what the course is all about as well as the course material that you will need to consult to ensure that the course is simple and within your reach. It suggests some general guidelines for the amount of time you are likely to spend studying each unit in order to complete it successfully. It also gives you some guidance on your tutor Marked assignments.

2 WHAT YOU WILL LEARN IN THIS COURSE

Successful students will learn:

1. Aim and objective of agricultural mechanization.
2. Some farm machinery used for land preparation, crop protection, harvesting and processing.
3. Equipment used for livestock management such automatic feed conveyors, automatic drinkers for poultry, feeding and watering equipment; milk and milk handling equipment, and meat processing equipment
4. Water lifting and irrigation equipment.
5. Overview of farm power sources; the internal combustion engine; tractor transmissions, hydraulic and electrical system; tractor chassis, wheel and types; the three-point linkage
6. Tillage requirement and implement selection, row crop planter and grain drills; and earth moving equipment.
7. Equipment used for forage handling such as mowers, rakes and forage.
8. Combine harvesters
9. Processing and size reduction equipment: crop drying and dryers; hammer, burr and roller mills, and their uses in farming operation.
10. Estimation of cost of operating or hiring an agricultural machine for farm operation.

3 COURSE AIMS

The Course aims and objectives are follows:

1. To expose the students to the basic scientific evidence and technical aspects of the different disciplines of farm power and agricultural mechanization (mainly for crops and livestock production).

2. To guide the students of major machineries and equipment involve along the value chain of agricultural production and processing.

4 COURSE OBJECTIVES

For the aims to be achieved, there are set objectives. Each unit of this course also has its specific objectives that are found at the beginning of each unit. You will need to understand these objectives before you start working on each unit. You are encouraged to refer to them periodically to check on your progress in learning and assimilating the content. On completion of a unit, you may re-examine the objectives to ensure that you fully learn what is required. By so doing you can be sure that you have achieved what the unit expects you to acquire. By meeting these objectives, the aims of the course as a whole would have been achieved. These objectives include:

1. Intimate students with farm power and their sources used in crop and livestock production
2. Understand basic farm machineries and their uses

5 WORKING THROUGH THIS COURSE

To complete this course, you are required to read the study units carefully and read other recommended materials. You will be required to answer some questions based on what you have read in the Content to reaffirm the key points. At the end of each unit there are some Tutor- Marked Assignments (TMA) which you are expected to submit for Marking. The TMA forms part of your continuous assignments. At the end of the course is a final examination. The course should take you 12 to 13 weeks to complete. The component of the course is given to you to know what to do and how you should allocate your time to each unit in order to complete the course successfully on time.

6 COURSE MATERIALS

The major components of this course are:
1. Course Guide
2. Study Units/Course Materials
3. Tutor Mark Assessment (TMA)
4. references and further reading

7 COURSE GUIDE

The material you are reading now is called the course guide which introduced you to this course.

8 STUDY UNITS

MODEL 1: AIMS AND OBJECTIVES OF AGRICULTURAL MECHANIZATION
Unit 1: Agricultural Mechanization and its objective
MODE 2: STUDY OF FARM MACHINERY USED
Unit 1: Farm machinery used for tillage
Unit 2: Equipment used for harvesting and processing

Unit 3: Crop protection equipment

MODULE 3: EQUIPMENT USED FOR LIVESTOCK MANAGEMENT
Unit 1: Automatic conveyors
Unit 2: Automatic drinkers for poultry
Unit 3: Feeding and watering equipment
Unit 4: Milk and Milk handling equipment
Unit 5: Meat Processing equipment
MODULE 4: WATER LIFTING AND IRRIGATION EQUIPMENT
Unit 1: Water lifting device and Irrigation equipment
MODULE 5: FARM POWER AND MACHINERY USES
Unit 1: Overview of farm power sources
Unit 2: Internal combustion engine (IC)
Unit 3: Tractor transmission system
Unit 4: Tractor chassis, wheel and type of tractor
Unit 5: Tractor electrical system
Unit 6: Tractor hydraulic system and three-point linkage
Unit 7: Tillage requirement and implement selection
Unit 8: Row crop planter and grain drills

MODULE 6: FORAGE HANDLING
Unit 1: Mowers and Rakes
Unit 2: Forage harvester

MODULE 7: COMBINE HARVESTER
Unit 1: Combine harvester

MODULE 8: FARM STEAD EQUIPMENT
Unit 1: Building equipment

MODULE 9: CROP PROCESSING
Unit 1: Crop drying and dryers
Unit 2: Equipment used for size reduction

MODULE 10: FARM MACHINERY COST
Unit 1: Estimation of farm machinery cost

9 TUTOR-MARKED ASSIGNMENTS (TMA)

There are Tutor Marked assignments and self-assignment in each unit. You would have to do the TMA as a revision of each unit. And there are four Tutor Marked Assignments you are required to do and submit as your assignment for the course. This would help you to have broad view and better understanding of the subject. Your tutorial facilitator would inform you about the particular TMA you are to submit to him for Marking and recording. Make sure your assignment reaches your tutor before the deadline given in the presentation schedule and assignment file. If, for any reason, you cannot complete your work on schedule, contact your tutor before the assignment is due to discuss the possibility of an extension. Extensions will not be granted after the due date unless there are exceptional circumstances. You will be able to complete your assignment questions from the Contents contained in this course material

and References/Further reading; however, it is desirable to search other References/Further reading, which will give you a broader view point and a deeper understanding of the subject.

Contents

10 MODULE 1: AIMS AND OBJECTIVES OF AGRICULTURAL MECHANIZATION

10.1 Unit 1: Agricultural Mechanization and its objective

10.2 Content

1.0 Introduction to agricultural mechanization
2.0 Overview of Agricultural Mechanization
3.0 Aims and Objective of agricultural mechanization
4.0 Types of Agricultural Machinery in Use Conclusion
5.0 Tutor-Marked Assignment
6.0 References/Further Reading

10.3 Aims and Objectives of Agricultural Mechanization

10.4 Introduction to agricultural mechanization

Agriculture provides employment for the majority of Africa's people and generates a good share of GDP. Despite its important role, agriculture is largely underdeveloped in most African countries. There is high potential for expansion of the agricultural sector at all levels. The low levels of input use and mechanization have been cited as main constraints for agricultural development.

Africa is the only region in the world where agricultural productivity has been largely stagnant since 1960s. Average cereal production in Africa stood at 1.5 ton/ha in 2014; the world average was 3.6 ton/ha. Experiences in some developing countries of Asia and Latin America show that agriculture could be transformed into progressive commercial industry. Investment in agricultural machinery has enabled farmers to intensify production and improve their income and quality of life. In countries such as India, China, Brazil and Turkey, the rapid expansion in farm machinery demand has stimulated the growth of local machinery manufacturing. These countries are now major producers and world leaders in farm machinery exports (FAO/UNIDO, 2008). The same development could happen in Africa, if farmers could intensify their activities through greater mechanization. This would lead to increased input use, higher food production, enhanced food security and reduced dependence on imports.

The term "mechanization" is used to describe tools, implements and machinery applied to improving the productivity of farm labour and of land; it may use either human, animal or motorized power, or a combination of these. In practice, therefore, it involves the provision and use of all forms of power sources and mechanical assistance to agriculture, from simple hand tools, to draught animal power and to mechanical power technologies.

Agricultural mechanization can be defined as the economic application of engineering technology to enhance the effectiveness and productivity of human labour.

10.5 Overview of Agricultural Mechanization

In Nigeria Farm power relies to an overwhelming extent on human muscle, based on operations that depend on the hoe and other hand tools. Such tools have implicit limitations in terms of energy and operational output. These methods place severe limitations on the amount of land that can be cultivated per family. They reduce the timeliness of farm operations and limit the efficacy of essential activities such as cultivation and weeding, thereby reducing crop yields

10.6 Aims and Objectives of Agricultural mechanization

FAO and UNIDO (2008) concluded that agricultural mechanization aims at

- Reducing human drudgery,

- Increasing yields through better timeliness of operations because of the availability of more power,
- Bringing more land under cultivation,
- Providing agriculture-led industrialization and markets for rural economic growth, and
- Ultimately improving the standard of living of farmers
- Precision of operation
- Improvement of work environment
- Enhancement of safety
- Reduction of loss of crop and food products
- Increase productivity of land

10.7 Types of Agricultural Machinery in Use

The most commonly used agricultural machinery includes tractors, combine harvester, thresher, manure spreader and fertilizer distributor, plow and cultivating machines, seeder and planters. Figure 1 shows the evolution of agricultural tractors in use in West Africa. Nigeria leads in the total volume, followed by Côte d'Ivoire and Guinea. If we look at tractor usage per hectare, a different pattern emerges (Figure 2). In 2000, Côte d'Ivoire led the field, with about three tractors per 1000 hectares, followed by Guinea. All the other countries had less than one tractor per 1000 ha. It is worth noting that while most countries had increased the level of mechanization over time, Ghana was the reverse. The data for most recent years are unavailable from FAO, however.

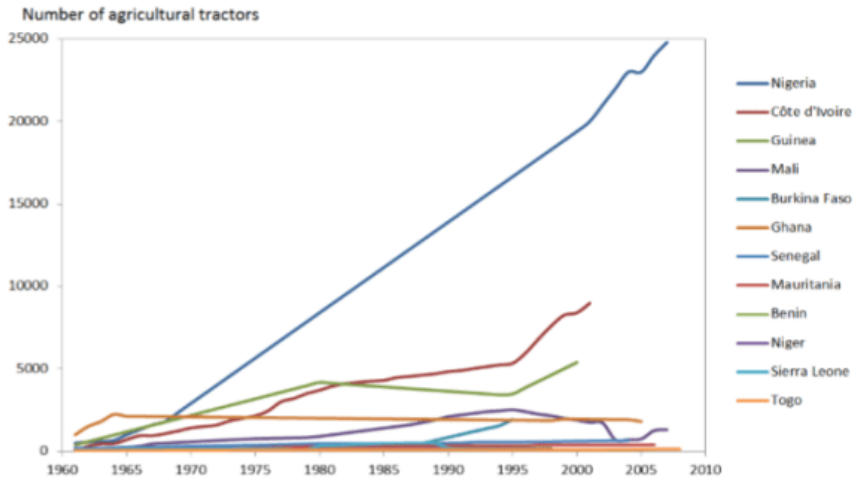

Figure 1 Number of agricultural tractors in use in West Africa, 1961-2008 (Data source: FAOSTAT)

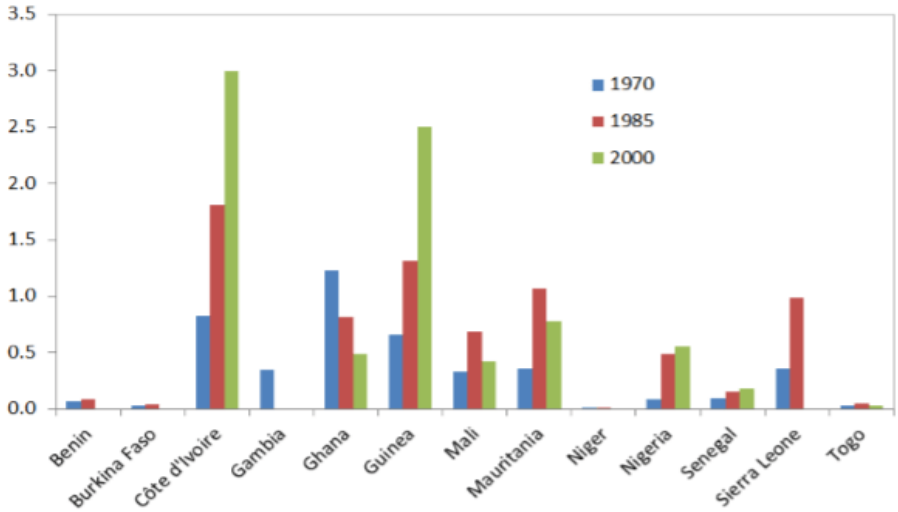

Figure 2 Agricultural tractors per 1000 ha (Data source: FAOSTAT)

More recent country reports show that in Mali in 2010 there were 1,114 threshing machines, 703 mills, 1,286 huskers, 3,878 motor-pumps, 520 multifunctional platforms and 9 mini rice mills. In Burkina Faso, about 40% of farmers were mechanized in 2006, largely with draught animals. There were about 8621 tractors in the country, used on 0.4% of the farms.

10.8 **Conclusion:**

The technology can be applied to aspects of agriculture such as: land preparation, weeding, harvesting, pest control, irrigation and drainage, transportation and crop processing and storage. Tractors of various types and sizes may be involved while animal and human power are also important, as are other forms of internal combustion engines, electric motors, solar power and other methods of energy conversion. Levels and types of technologies need to be compatible with local, agronomic, socio-economic, environmental and industrial conditions.

10.9 **Tutor-Marked Assignment**

1. What do understand by agricultural mechanization?
2. State five (5) Objective of agricultural mechanization?

10.10 **Reference and Further readings**

Yuan Zhou. (2016). Agricultural Mechanization in West Africa. Published by Syngenta Foundation for Sustainable Agriculture

Agricultural Mechanization Research Institute. (2019). Available resources online. http/Mechanization Constraints/Agricultural Mechanization Research Institute.htm

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11 MODULE 2: STUDY OF FARM MACHINERY USED

Unit 1: Farm machinery used for tillage
Unit 2: Equipment used for harvesting and processing
Unit 3: Crop protection equipment

11.1 **Study of farm machinery used for tillage; ploughs harrows, cultivators; harvesting and processing equipment; crop protection equipment (Sprayers and dusters).**

11.1.1 Unit 1: Farm machinery used for tillage

11.1.2 **Contents**

1.0 Introduction
2.0 Tillage

3.0 Primary tillage
4.0 Secondary tillage
5.0 Tutor-Marked Assignment
6.0 References/Further Reading

11.2 **Introduction:**

Crop production requires a number of operations like seedbed preparation, seeding, fertilizing, spraying, dusting, irrigation, harvesting and threshing. Agricultural machines increase productivity of land and labour by meeting timeliness of farm operations and increase work out-put per unit time. Besides its paramount contribution to the multiple cropping and diversification of agriculture. This unit discussed some of the machineries used for these operations

11.3 **Tillage:**

It is a mechanical manipulation of soil to provide favorable condition for crop production. It involves breaking the compacted surface of the earth to a certain depth and to loosen the soil mass, so as to enable the roots of the crops to penetrate and spread into the soil. Tillage operation is most labour consuming and difficult operation, compared to all subsequent operation in the field. It is classified as either primary or secondary. The initial breaking up the soil is generally called primary tillage and subsequent operations carried out to break down the clods and prepare the seedbed ready for planting is called secondary tillage. Implements used for primary tillage comprise mainly ploughs of various types; those used for secondary tillage usually comprise harrows and cultivator's different types of which are available. It is not necessary to have to use primary tillage tools first, followed by secondary tillage implements to obtain a good seedbed. Secondary tillage implements only can be used if the soil conditions are suitable, for example if the ground is not very dry and hard.

11.4 Primary Tillage:

It constitutes the initial major soil working operation. It is normally designed to reduce soil strength, cover plant materials and rearrange aggregates. The operations performed to open up any cultivated land with a view to preparing a seedbed for growing crops is known as primary tillage. Implements may be hand operated tools, tractor-drawn or animal-drawn implements. Animal-drawn implement mostly includes moldboard plough while the tractor-drawn implement includes moldboard plough, disc plough, chisel plough, subsoiler, and another implement.

11.4.1 Plough

The main implement for primary tillage is plough used for ploughing operation. Ploughing is the primary tillage operation which is performed to cut, break and invert the soil partially or completely.

11.4.2 Types of plough

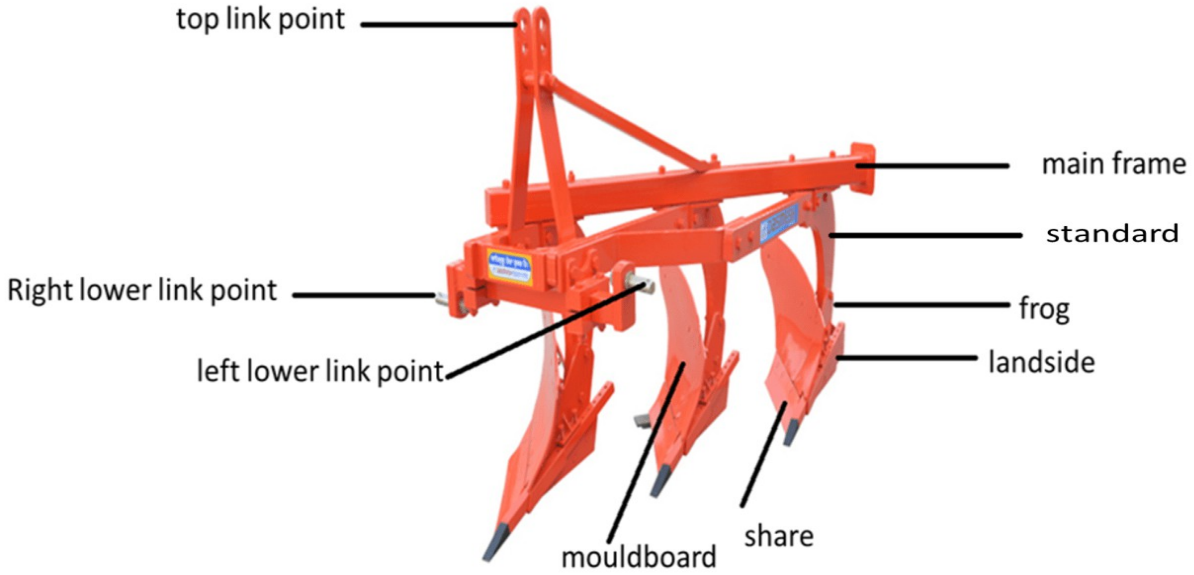
Different types of plough are used in a different place with different soil characteristic. They may be classified as:

1. moldboard plough
2. disc plough
3. chisel plough
4. subsoiler and
5. rotary plough

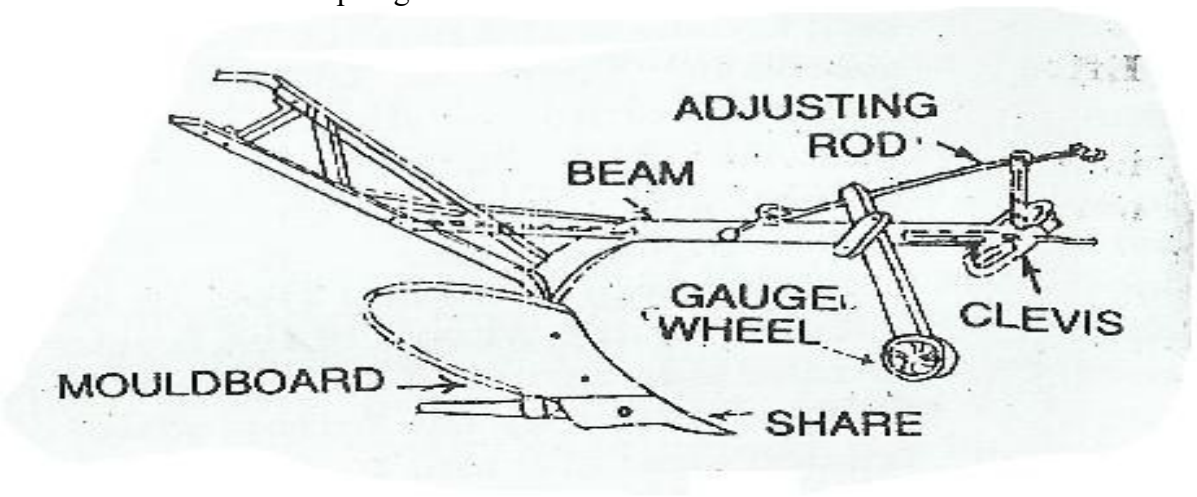
Mouldboard plough: This is one of the oldest of all tillage tools and is primarily intended for use in situations where it is desired to invert the soil in order to bury crop residue. A moldboard consists of the following parts

a. Share;

b. Mouldboard;
c. Landside;
d. Frog;
e. Standard;
f. beam;
g. handle;



Tractor drawn moldboard plough



Animal drawn moldboard plough

Parts a) to e) combined are known as the **plough bottom.** A moldboard plough may have one bottom or several bottoms, depending on the power available to pull it.

The size of this type of plough is given by the number of bottoms and width of furrow that each bottom is designed to cut. A3 X 15 cm plough would mean that it has three bottoms, each giving a furrow width of 15 cm. The total width cut by this plough will therefore be 45 cm.

- The **share** is the first part of the plough to enter the soil and cut a furrow slice. The cut soil is lifted upwards to the **moldboard** where it is inverted by the curvature of this component.
- The **landside** assists in making a neat furrow. It presses against the furrow wall, absorbing the sideways thrust of the plough. It may have a detachable heel.

- The **frog** is the component that joins the share, moldboard and landside.
- The **standard** provides the connection with the beam. Sometimes the standard, frog and landside are cast as one component.
- The **beam** provides the connection between the plough and the source of power (tractor or animals).
- **Handles** are provided on animal- drawn ploughs for guidance by the operator.

11.4.3 **Disc plough**

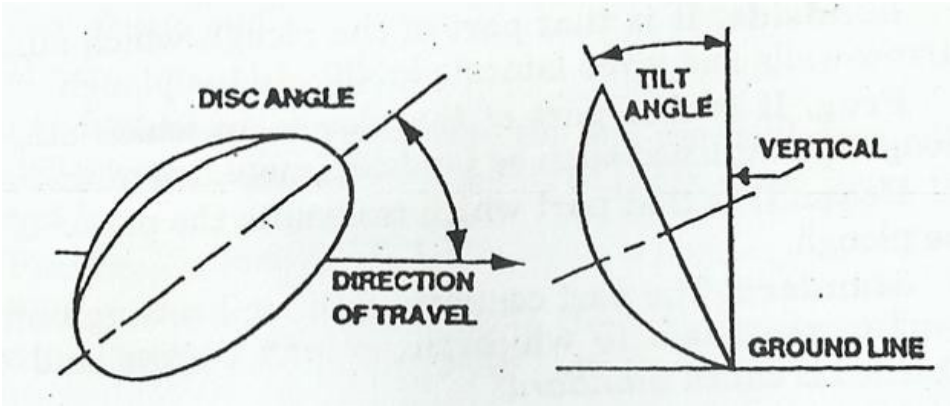
The basic component of this type of plough is a disc of a certain diameter and curvature. The disc is mounted on a frame.

A plough may have several individually-mounted discs, and again, the number depends on the power available to pull the plough. Disc ploughs are preferred in hard dry soils or in sticky soils where the moldboard plough will not work satisfactorily.

A disc plough is pushed into the ground by its own weight rather than by suction, as in the case of the moldboard plough. Disc ploughs are therefore built more heavily than other types and occasionally additional weights are put on to aid penetration.

11.4.4 **Disc and tilt angles**

On a disc plough the discs are tilted at angles relative to two different axes. One tilt is in relation to the vertical and this is called the tilt angle. The other angle of tilt lies between the disc face and the direction of travel and this called the disc angle. The tilt angle is usually of the order of 15 to 250, and the disc angle of the of the order of 42 to 450. Disc angle can influence the width of cut but a greater pull will be required if the angle is too great. Tilt angle affects the penetration of the plough. Penetration is greatest when the tilt angle is closest to the vertical.



Disc and tilt angle

Inversion of the furrow slice does not occur to the same extent as with a moldboard plough. Disc plough work better in tropical countries where the climate is hot and the land is baked hard.

11.4.5 Additional attachments

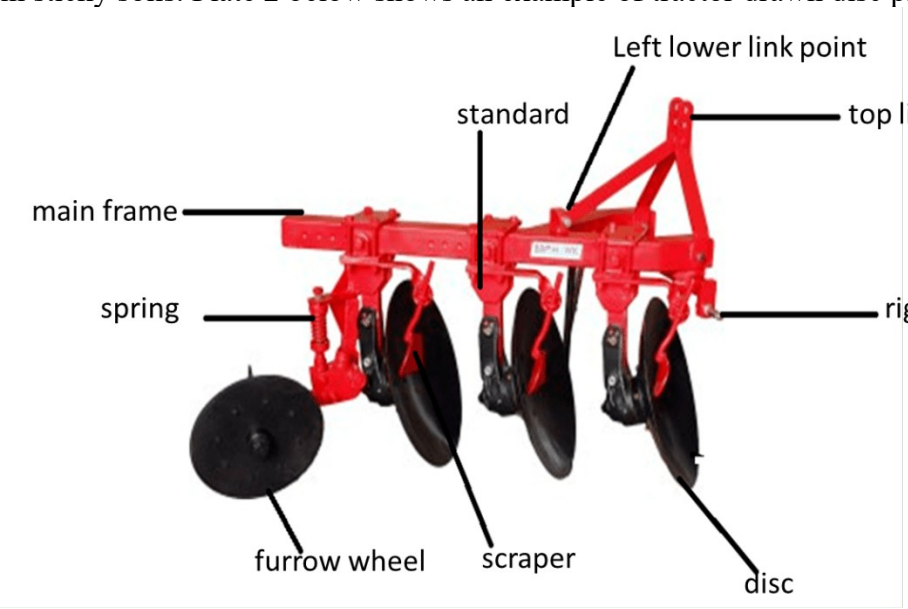
Mouldboard plough

Coulters. These are aids to increase the work efficiency of the plough, and can be either disc or knife-edge types. They are set in such a way that the center –line of the disc falls behind the point of the share.

Jointer. This is a miniature moldboard-shaped part which helps to detach a small slice of soil just in front of the main plough. This facilitates the penetration and soil inversion of the main plough.

Disc plough

Scrapers. These are small plates that help to cover trash and prevent soil built-up on the discs in sticky soils. Plate 2 below shows an example of tractor drawn disc plough



Tractor drawn disc plough

11.4.6 **Chisel Plough**

This type of plough comprises deep tines which operate at a considerable depth to break open the subsoil and thus assist in drainage and pulling out deep –rooted weeds. Because of the depths to which they plough (deeper than the subsoiler), chisel ploughs are sturdy in construction and require considerable power to be pulled through the soil.

Chisel plough

11.4.6.1 ***Subsoiler***

A subsoiler is an implement that is used to break up the hard soil pan (or compacted soil) that can develop as a result of the continuous use of ploughs. The legs of the subsoiler shatter the hard pan, thus improving drainage and aeration, but it requires a highly power tractor, usually of the crawler type to pull it through the soil.

Subsoiler

11.5 **Secondary tillage implements**

Secondary tillage implements can be used either before or after the crop is planted. If they are used before planting it may be either to prepare the seedbed, to mix fertilizer, to break the soil crust, or to break clods left by a primary tillage implement, such as a plough. Secondary tillage implements are used, after a crop is planted, for weeding and for minor earthing-up operations.

Some examples of secondary tillage implements are:

1. harrows
2. cultivators
3. rotary cultivators
4. rollers

These implements may either be mounted or trailed

11.5.1 **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. It is an implement used to break the clods after ploughing, to collect trash from the ploughed land and level the seed bed.

11.5.2 Type of harrow

There are three main types of harrow which are:

a. disc harrow;
b. spike-tooth harrow;
c. chain harrow.

Disc harrow. The basic component of the disc harrow, as in the case of the disc plough, is a disc having a given diameter and curvature. A number of these disc are mounted on an axle to constitute a “gang”, and several gangs may be mounted together to make a disc harrow. Some gang arrangements commonly used are as shown below.

Disc harrow

Unlike the disc plough, the angle of the individual discs on the disc harrow is fixed, but the angle of the gang may be set in relation to the direction of travel. The greater the angle set, the greater the pulverization of the soil.

Spike-tooth harrow. This unit consists basically of a peg or spike, several of which are fixed on to a bar and mounted on a frame. The spike angle, in relation to forward travel, is usually adjustable and can be set to achieve the required amount of soil breakdown. This type of harrow is also useful for collection of weeds.

Spike-tooth harrow

Chain harrow. This type of harrow comprises basically a flexible chain link mat that is pulled behind the tractor. It is very useful for weed collection and manure mixing.

Chain harrow

11.5.2.1 ***Rotary hoe***

Basically, a rotary hoe consists of a revolving shovel that breaks down and pulverizes the soil by impact. The pulverizing action can be controlled by the forward speed of the tractor.

Several of the revolving shovels may be mounded on an axle which is then power by the tractor PTO shaft through gearbox and a sprocket-chain drive system.

In dry, arid conditions such implements have limited use because of lack of penetration and a high degree of wear. In addition, the amount of dust generated may be uncomfortable for operator.

Rotary hoe

11.5.2.2 ***Cultivators***

These implements comprise basically a set of soil working tines or a share, mounted on a robust frame. Depending on the type of tine used, the cultivator can be classified as

a) a rigid-tine cultivator;
b) a spring-tine cultivator

The rigid-tine cultivator has a strong tine with a cutting shovel or sweep. Several tines are mounted in either a single row or several rows, depending on the amount of power available to pull the cultivator. The tines are staggered and spacing can be altered to suit various plant spacing and thus provide effective weed hoeing. The shape of the shovel or sweep may take different forms and some reversible points so that when the cutting edge on one side wears, it may be reversed and the second edge used. The depth of operation may be altered by

1) Changing the position of the shovel on the tines by raising or lowering it;
2) Changing the pitch by means of the top link (in the case of a mounted cultivator);
3) Using the land wheel;
4) Using the hydraulic system of a tractor.

rigid-tine cultivator

Spring-tine cultivator

The spring-tine cultivator has tines made of spring steel, thus enabling them to withstand shocks when they hit an obstruction. As such, this type of cultivator is to be preferred in situation where there are rocks and hard material. The spring action also helps to break down any clods of soil left by the plough. However, this type of cultivator works at a shallower depth than the rigid type.

11.6 Tutor-Marked Assignment

1. Defined the term “tillage”?
2. What are the two type of tillage?
3. List three (3) primary tillage implement?
4. Mention four (4) component of disc plough?
5. Differentiate between primary and secondary tillage implement?

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11.8 Unit 2: Equipment used for harvesting and processing

1.0 Introduction
2.0 Harvesting
3.0 Different type of harvesting equipment
4.0 Threshing
5.0 Different type of threshing equipment
6.0 Tutor-Marked Assignment
7.0 References/Further Reading

11.9 Harvesting and Processing Equipment

11.10 Introduction

Harvesting equipment has to be designed to cope with a wide variety of different crops. Some crops are harvested above the ground, for instance most cereals like wheat, sorghum, millet and so on, while others are harvested below ground, as in the case of groundnut, cassava, yam, potato and so on. For fruit and vegetable picking requires and other specialized equipment. In either case harvesting equipment is design base on the degree of harvesting operation involved. This unit will discuss different harvesting equipment for different crops.

11.11 **Definition:**

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

Harvesting action can be done by four ways:

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

Harvesting can be done by:

1. Manual operated tool
2. Animal drawn machine
3. Mechanically operated machine

11.12 **Different type of harvesting equipment**

a. Sickle. It is a curved steel blade having a hand grip used for harvesting by manual power
b. Mower. It is a machine use to cut herbage crops and leave them in swath
c. Reaper. It is a machine to cut grain crops
d. Binder. It is a reaper which cuts the crops and ties them into neat and uniform sheaves.
e. Windrower. It is a machine to cut crops and deliver them in a uniform manner in a raw.
f. Digger. It is a machine used for harvesting root crops such as ground nut, cassava and potatoes
g. Combine harvester. It is a harvesting machine that are more sophisticated than most other harvesting machines and usually intended for use on large farms, they have the advantage of being able to carry out cutting, threshing, cleaning and bagging in one operation.

11.12.1 **Sickle**

Sickle is the simplest forms of device used for harvesting forage and some cereals crops. The shape and size of the sickle may vary considerably and primarily depends on the tradition in a particular area and the local blacksmith practice.

11.12.2 **Mower**

Mowers are intended primarily for cutting grass but may be adopted for use in harvesting cereals like wheat. Two types of mower are generally used:

1. Cutter bar mowers;
2. Rotary mowers,

11.13 **Reaper**

Reaper is a machine used to cut grain crops. It can be animal drawn, tractor mounted or power tiller operated.

11.14 Animal drawn reaper**:**

It is pulled by a pair of animals and it can harvest nearly 5 to 8 cm above the ground. The machine consists of a frame, cutter bar, knife, wheels, bearings and other attachments. Usually two persons are required to operate the machine. One man guides the animals and another man is engaged in dropping the cut crops from the platform to the ground.

11.15 Tractor mounted reaper:

This type of reaper is mostly used to harvest paddy and wheat. It is front mounted at the tractor which can be lowered and raised by the hydraulic control. It powered through the PTO of the tractor. Crop is guided by the star wheel to the cutter bar and held in vertical position by the springs. The crop is conveyed to the side by the conveyer belt.

11.16 Power tiller operated reaper:

This type of reaper tis similar to tractor mounted but has different arrangement of power source. The power is transmitted from the engine flywheel to the reaper either through belt or by providing gear box and propeller shafts. Crop is guided by the star wheels to the cutter bar and held in vertical position by the springs. The crop is conveyed to the side by the conveyer belt.

11.16.1 **Reaper binder**

This is similar to the conventional reaper and after cutting it binds the crop simultaneously. It cuts the crop at the height of about 10 cm from the ground level.

11.16.2 **Diggers**

These are equipment used for harvesting crop below the ground such as groundnut, cassava, potatoes, etc.

11.16.3 Groundnut digger**:**

It is used for digging of groundnut crop and can be animal drawn or tractor mounted. Tractor mounted has a gigging blade and a spike tooth conveyer. The machine was design for harvesting of both erect or spreading varieties of groundnut crop, grown in all types of soil.

11.16.4 Potatoes digger elevator**:**

It is used for digging and windrowing the potatoes. The is a PTO operated single row machine. The machine consists of cutting blade and elevator roller chain of iron bars. The potatoes are dug by the blade and lifted to a conveyor which is under periodic shaking. The potatoes are delivered at the rear of the machine and collected manually. It is a tractor rear mounted PTO driven machine. of machine and

Cassava digger elevator: The machine has a wedge with two discs at the side which penetrate the soil and cut through the trash. The disc are mounted on the drum which allows the unit to sink to a depth of 300 mm. The blade slices through the ground, lifting soil along with the cassava tubers, and both soil and tubers pass through the bar elevator which shakes out the soil and delivers the tubers behind the machine. Because the elevator speed is faster than the forward speed of the machine, the soil is detached from the tubers as it moves on the elevator bars.

11.16.5 Threshing equipment

Threshing is one of the farm operations after crop harvest. Threshing of agricultural produce involves separation of grains from stalks, straw, chaff and husks. It is usually done along with such post-harvest operations like sieving, winnowing and sorting the grains for packaging. Traditionally, threshing is done manually with sticks for beating or striking repeatedly the harvested crop in order to separate the grain. This traditional approach is usually laborious and thus, requires sizeable number of people to complete in good time. Mechanization of the threshing operation take much of the drudgery out of farm labor. These led to the invention of mechanical thresher that are used to achieve maximum level of cleaning, quality product and reduction in post-harvest losses.

Mechanical thresher: is a machine use to separate grains from the harvested crop and provide clean grain without much loss and damage. During threshing, grain loss in terms of broken grain, un-threshed grain, blown grain, spilled grain etc. should be minimum. The total grain loss should not be more than 5 per cent, in which broken grain should be less than 2 per cent.

11.16.5.1 ***Components of a Thresher***

The basic unit of a threshing machine is a beater, which rubs or hits the crop against a stationary plate. The beater achieves detachment of the grain from the ear head either by impact (beating) or by rubbing action or by the combination of the two.

11.16.5.2 ***The main components of a threshing machine are:***

I. A beater, usually revolving and may have different types of beater heads or pegs on its circumference. It is usually called a threshing cylinder, and depending on whether the threshing action is achieved by beating or rubbing the cylinder

II. A stationary plate, usually with slots or spaces, against which the threshing cylinder beats. This part is called the concave.

III. A feeding hopper or trough to feed the crop to be threshed into the threshing cylinder.

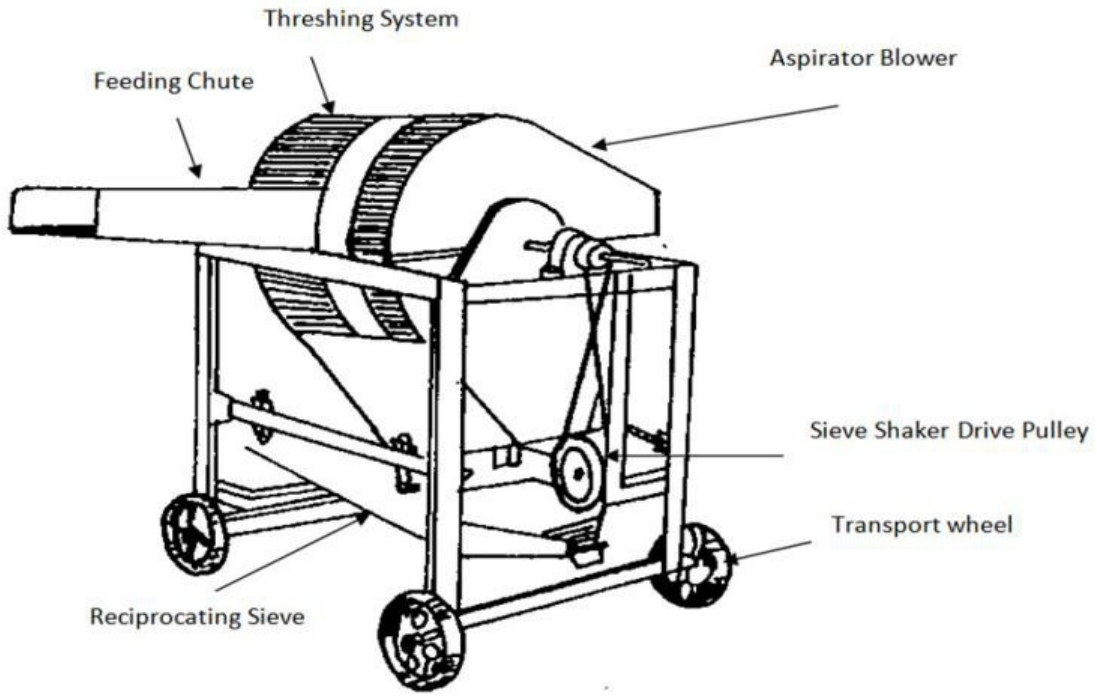
IV. A winnowing device, which is usually a fan to blow the chaff away from threshed material or an aspirator to suck up the unwanted chaff. This part is usually called a blower.

V. A set of sieves, to sort grain from the chaff and other materials. Grains and chaff passed through sieve holes' cross flow the air current, which removed lighter material than the grain particles.

11.16.5.3 ***Working principle of a thresher:***

The crop is fed from the hopper into the threshing area and the grain and chaff fall onto the sieve area. Air Simultaneously passes from the blowers to the mixture of the grain and the chaff. As air passes through, the grain being heavier, falls down to the screen and the chaff and other debris are blown out. In some cases, the blowers are replaced by aspirators, which instead of blowing air into the mixture of grain and chaff in the threshing area, suck the chaff from the mixture. This action may even be continued during sieving. The sieves usually have a reciprocating motion which helps to sort out the grain from unwanted material and also helps to prevent the sieve getting choked/blocked.

The threshing machines are capable of running with electric motor as well as Diesel engine and are compatible with tractor. The power requirement of available threshers ranges from 2 - 50hp. The number of operators required per thresher depend on the thresher make and model. However, 1-4 operators are generally required.



Multi-crop thresher

*11.16.5.4 **Adjustments***

Various adjustments are required before starting threshing operation. The machine is to be installed on clean level ground and is to be set according to crop and crop conditions. The adjustments necessary to get best performance from the machine are (i) concave clearance, (ii) sieve clearance, (iii) sieve slope, (iv) stroke length and (v) blower suction opening. Besides these, cylinder concave grate, top sieve hole size and cylinder speeds for threshing different crops are important for a multi-crop thresher.

*11.16.5.5 **Different type of thresher and their suitability for crops***

The type of thresher is generally designed according to the type of threshing cylinder fitted with the machine. The major type of threshers commercially available is as follows:

i. **Drummy type:** It consists of beaters mounted on a shaft which rotates inside a closed casing and concave.
ii. **Hammer mill type:** It is similar to dummy type but it is provided with aspirator type blower and sieve shaker assembly for cleaning grains.
iii. **Spike-tooth type:** Spikes are mounted on the periphery of a cylinder that rotates inside a closed casing and concave. It is provided with cleaning sieves and aspirator type blower.
iv. **Rasp bar type:** Corrugated bars are mounted axially on the periphery of the cylinder. It is fitted with an upper casing and an open type concave at the bottom of the cylinder. The cleaning system is provided with blower fan and straw walker.
v. **wire-loop type:** Wire-loops are fitted on the periphery of a closed type cylinder and woven wire mesh type concave is provided at the bottom.
vi. **Axial flow type:** It consists of spike tooth cylinder, woven-wire mesh concave and upper casing provided with helical louvers.
vii. **Syndicator type**: The cylinder consists of a flywheel with corrugation on its periphery and sides, which rotates inside a closed easing and concave. The rims of the flywheel are fitted with chopping blades.

*11.16.5.6 **Factors affecting thresher performance***

The factors which affect the quality and efficiency of threshing are broadly classified in three groups:

i. Crop factors: Variety of crop, Moisture in crop material.
ii. Machine factors: Feeding chute angle, Cylinder type, Cylinder diameter, Spike shape, size, number Concave size, shape and clearance
iii. Operational factors: Cylinder speed, Feed rate, method of feeding, Machine adjustments.

11.17 **Tutor-Marked Assignment**

1. Defined harvesting?
2. Explain Four (4) different type of harvesting equipment?
3. What is mechanical thresher?
4. Mention three component of mechanical thresher?
5. List Four (4) types of threshing equipment?

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11.19 Unit 3: Crop protection equipment

11.20 Contents

11.21 Sprayers and Dusters

11.21.1 Introduction:

Once a seed has successfully germinated in the field there is no guarantee that it will become a mature plant, fruit, be harvested and the crop stored. There is danger that the plant may be lost at several stages in its growth, as a result of damage by birds, weeds, disease, and so on. This danger continues even when the crop has been stored. Fortunately, many of these dangers are now identifiable and control measures are available at different stages of plant growth and later, during crop storage. There is a range of equipment that is available for applying most of these control measures and the study of this equipment is the to pics of this unit.

11.21.2 Sprayers

sprayer is a machine used for chemical application in liquid forms. Water or oil is most commonly used as the carrier for the chemical. The chemical may be in the form of powder or granules that can be mixed in water, or the chemical already be in the form of a liquid and may or may not be diluted with water. Generally, the chemical, when mixed, can form solution, suspension, or emulsion.

11.21.3 Sprayer components

1. **a tank**, which carries and stores the chemical and is usually made of non-corrosive material (plastic or fiberglass)
2. **a nozzle**, which is a device to discharge the chemical at a given rate and in particles or droplets of the correct size,
3. **a pump**, which imparts the correct pressure to the liquid carrier and, with the appropriate nozzle, delivers the liquid at the required rate
4. **a control valve or cut-off device**, which is used to regulate the flow of the liquid chemical.
5. **filters**, are used to ensure free flow by trapping unwanted material, and which are usually located at the tank (filling hole), before the pump, and in the nozzle.

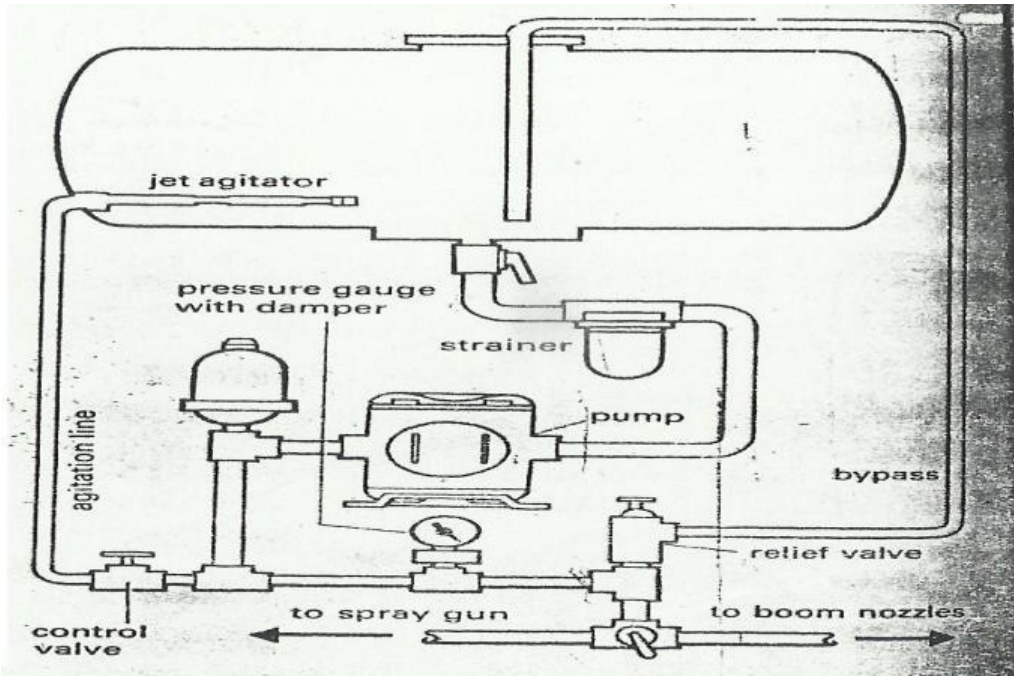

Fig. 4: schematic arrangement of the essential components of a sprayer

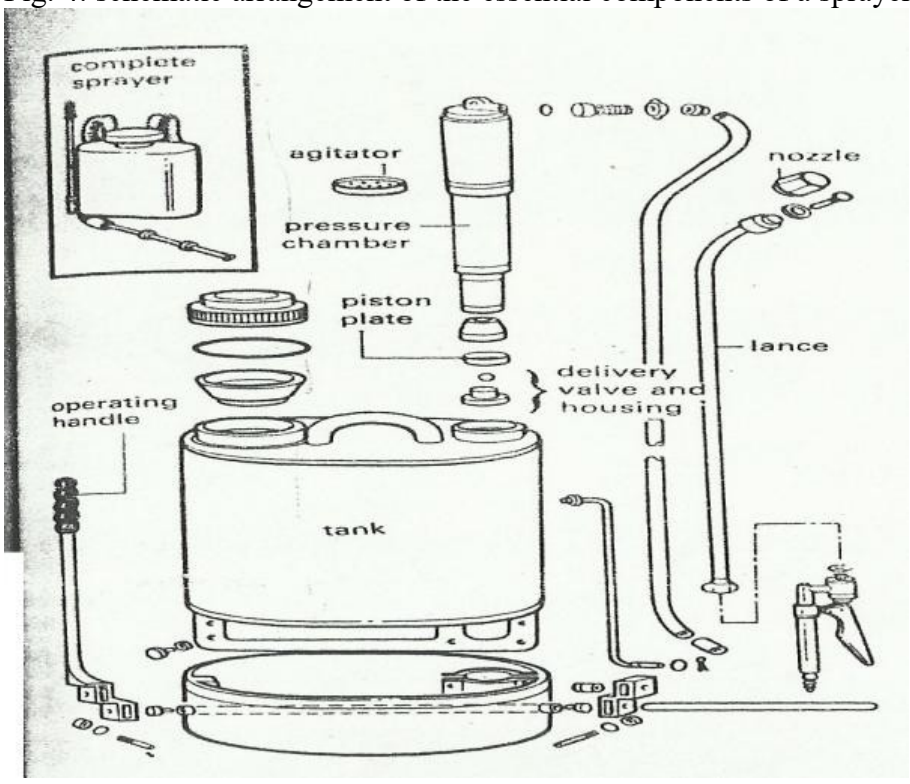

Fig. 5: Schematic arrangement of manually operated knapsack sprayer

11.21.4 **Dusters**

These are machine used to apply dry powder chemicals and air is mostly used as the carrier. The air steams carry the pesticides in finely divided dry form on the target. The duster can be either manually operated or powered. The powered type may be either shoulder mounted or belly-mounted. While dusting is in operation the prevailing wind direction should be used to

carry the dust to the target. The powered duster or dusters that is run from the power take off shaft usually directs a part of the air stream through the hopper to keep the dust moving freely and prevent it caking or it may have a mechanical agitator provided in the hopper.

11.21.5 **Duster components**

1. **a, hopper** for storing the chemical in dust form;
2. **an agitator** which is usually provided within the hopper to keep the duster moving freely and prevent it caking;
3. **a metering mechanism** which is usually an adjustable orifice that allows the rate of discharge to be varied;
4. **a delivery blower** which creates an air steam that is used to carry the powder to the target.

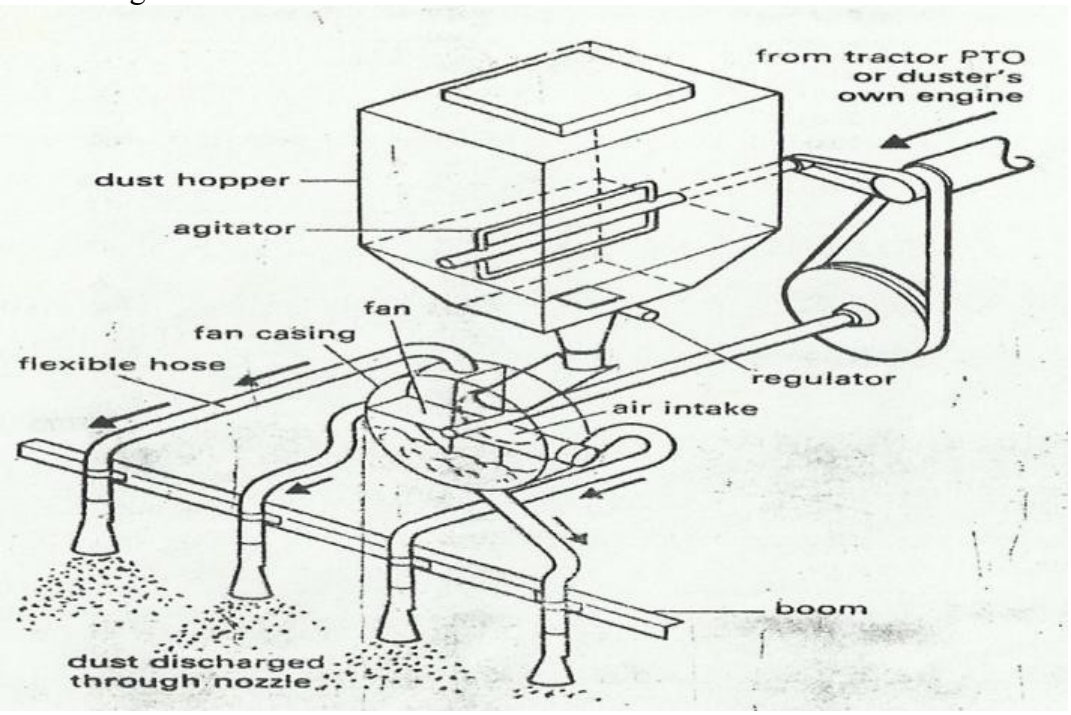

Fig. 5: Schematic arrangement of the main components of a typical power dusters

11.22 **Tutor-Marked Assignment**

1. Differentiate between sprayer and dusters?
2. Mention four components of sprayer?
3. List three component of duster and their functions?

11.23 **Reference/Further readings**

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12 MODULE 3: EQUIPMENT USED FOR LIVESTOCK MANAGEMENT

Unit 1: Automatic conveyors
Unit 2: Automatic drinkers for poultry
Unit 3: Feeding and watering equipment
Unit 4: Milk and Milk handling equipment
Unit 5: Meat Processing equipment

12.1 Unit 1: Automatic conveyors

12.2 Contents

12.3 Conveyors

12.4 Introduction:

Conveyor is a mechanical devices or assemblies that are used for material handling and transporting material from none location to another with minimal effort. Conveyors are mostly useful in applications involving the transportation of heavy or bulky materials from one place to another depending on the speed of handling, height of transportation, nature, quantity, size and weight of materials to be transported. conveyor systems, they usually consist of a frame that supports either rollers, wheels, or a belt, upon which materials move from one place to another. They may be powered by a motor, by gravity, or manually. Many kinds of conveying systems available are used according to the various needs of different industries. It uses a wide range of manual, semi-automated, and automated equipment.

Automated conveyor system: These are conveyor system that works with less human interference and its self-operated.

12.4.1 Objective of automatic conveyor system

- To Increasing in productivity.
- To reduce human efforts.
- To reduce accident with the help of sensor and monitoring.

- To reduce time of material handling.
- To minimize cost of material handling.
- Minimize delays and interruptions by making available the materials at the point of use at right quantity at right time
- Prevention of damage to materials.

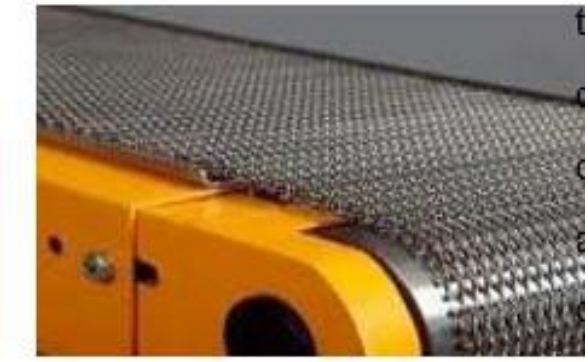
12.4.2 **Types of conveyor**

Belt conveyor: A belt conveyor consists of an endless and flexible belt of high strength with two end pulleys (driver and driven) at fixed positions supported by rollers. In this work, 3 roll idlers are required for adequate support of materials transported and protection of the belt along its length. Pulleys are used for providing the drive to the belt through a drive unit gear box powered by an electric motor. It also helps in maintaining the proper tension to the belt. The move the belt and its loads. Materials are transported over the required distance as a result of friction generated between the roller surface and the moving belt set in motion by a rotating pulley (drive pulley). The other pulley (driven or idler pulley) acts as a wheel around which the material rotates and returns in a continuous process.

Belt conveyor

Plastic belt conveyors: A plastic belt conveyor is a piece of industrial equipment used to transport materials or goods. The system uses a plastic belt on which items can be placed; the belt will then move along a slotted track, thereby facilitating transportation of goods. This belt will revolve around the track so the belt forms a continuous loop. Plastic belt conveyors feature interlocking plastic pieces that allow bending, making the track more versatile and able to move in various directions as needed.

Wire mesh conveyors: Wire mesh belt conveyors can be used in a variety of conditions to conveyor hot, cold, or oily products in oven, cooling, carrying cold items from a freezer, hot food items or other special conditions. A variety of belt types can be used depending on the application. It's designed to interface with existing conveyor systems



Wire mesh conveyor

Bucket Conveyor: The bucket conveyor presents a continuous row of over lapping buckets at the inlets and allows for single or multiple selective discharge stations so the system can be used to either split or recombine production lines. The system is available in a range of specifications to suit the application.

Bucket conveyor

Spiral conveyors: Spiral Conveyors offer substantial immediate and long-term savings in production costs and form an integral solution for optimum use of factory floor space. Contact us for more information on how you can use spiral conveyors effectively for your production space.

Pneumatic conveyors: Pneumatic conveyors are characterized by pressure or vacuum systems, and use either a dilute phase or dense phase technology to transport material. ... In dense phase systems, material is not suspended and low volume, high pressure air is used to move material through the pipeline

Screw conveyor or auger conveyor: A screw conveyor or auger conveyor is a mechanism that uses a rotating helical screw blade, called a "flighting", usually within a tube, to move liquid or granular materials. They are used in many bulk handling industries.
Application today there are different types of conveyor belts that have been created for conveying different kinds of material available in PVC and rubber materials. Material flowing over the belt may be weighed in transit using a belt weighed. Belts with regularly spaced partitions, known as elevator belts, are used for transporting loose materials up steep inclines.

Screw conveyor

12.4.2.1 ***Automatic feed conveyors***

These are conveyors that are used for automatic distribution of basic ration or mixed basic and fodder concentrate to feed the animals. The machine supplies a total mixed ration with a higher frequency and a low labour requirement. The system allows for increasing the frequency of feed distribution, with a consequent optimization of dry matter ingestion by the animals and concurrently assist to maintain a higher stability of ruminal pH with significant advantages in terms of health and production. There are three types of automatic feed conveyors: Belt feeder conveyor, rail-guided or self-propelled feed robots.

Self-propelled feed robots: The robot is controlled by a sensor and an induction wire let 2-3 cm into the floor. The dispensing wagon can be filled automatically from one or more stationary mixing vessels by doctor rolls and can eject the feed either to the right or left. The Multi Feeder is driven by a diesel engine.

Automatic feed conveyor

Rail-guided feed wagons**:** steer a middle course between stationary conveyor belts or chain link tables and mobile self-propelled feeders. Here a feed hopper with a weighing device is suspended from a rail. Power is provided by batteries, trailing cables or a supply voltage rail with continuity contacts. Control (frequency of feed distribution, ration composition etc.) is

mostly carried out by way of a computer directly at the feed hopper. Here filling takes place at stationary storage or mixing vessels near the feeding table. In rail-guided systems a distinction is generally made between distributor wagons and feed mixer wagons

Belt feeder conveyor: The belt feeder is distributing the feed with perfect precision. The machine caries the feed and distribute metre-by-metre to its destination, no matter the path is on the level, or otherwise the system continuous distributing and stopped when it reaches a required amount. The length of the belt feeder can be flexibly adjusted to suit the local conditions and is able to bring its efficient way of working into the barn by the metre. The machine fixed either on a support construction or from the ceiling, the cable guided plough can supply both narrow and wide feed alleys. It can be in forms of V-shaped belt.

Belt feeder conveyor

Different between manual and automatic conveyor

Manually	**Semi-Automatic**	**Automatic**
Manual warehouses" are synonymous with "man-to-goods" warehouses, where workers move to a pick location, pick the goods, and then move to the delivery dock.	this system half manually and half machine operated are known semi- Automatic.	this system are fully automatic systems which are fully machined operated.
It requires more human Effort.	It requires less human effort.	It requires very less human effort.
It requires more time for material handling.	It requires less time for material handling.	It requires very less time for material handling
It is hazardous for human.	It is less Hazardous for human.	Does not hazardous for human.
Man, itself does work.	Man put the job on conveyor.	Machine do itself of pick up job and put on conveyor

12.5 **Tutor-Marked Assignment**

1. What do you understand by conveyor systems?
2. What is the different between manual and automatic conveyor?
3. State five objective of conveyor?
4. Explains three (3) automatic feed conveyor?

12.6 **Reference/Further readings**

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12.7 **Unit 2: Automatic drinkers for poultry**

12.8 **Contents**

12.9 **Introduction**

To achieve the optimum performance from your birds, it is extremely important to provide fresh and clean drinking water. For this, water must be available reliably, free from contamination and within easy reach for the birds. This unit discussed automatic drinkers used for poultry production

12.10 **Drinkers**

The Automatic Drinker is an innovative equipment that providing clean and continuous water supply for poultry with a minimal use of manpower for constant refills. It can provide 24 hours supply of water once connected to a filled overhead tank. As a bird drinks, reduction in

water levels in the cup automatically triggers a mechanism to refill the cup. Once the water gets to a particular level, a negative feedback mechanism adjusts the valve to stop the supply of water to the cup. Some were design in a colored to attract the chicks and birds in general, thus they are ideal for broilers, breeders, layers, pullets, ducks and other similar birds.

12.10.1 Type of Automatic drinkers

1) Dome or bell drinkers
2) Little Giant
3) Cup waterers
4) Nipple drinkers

Bell and dome water feeders: Theses feeders look similar, but they are designed for different types of use. Dome feeders sit on the floor; bell feeders need to be placed in the air to work correctly. Bell water feeders need to be hang on air and are better used indoors. If you use them outside the wind can cause them to work improperly. However, the dome water feeders are more suitable for outdoors. The wind and rain won't cause these types of water feeders to leak, or stop them from working correctly. Each bowl has a lip around the base that protrudes up approximately a half inch up. This lip and base hold the water that birds will feed from. Both designs use similar methods to control their water flow. The water holder with the protruding lip at the base is suspended slightly, and this suspended dome (or bell) is connected to a spring valve at the top of the feeder. The valve opens when the water bowl is light, and this allow water to flow into the bowl at the base. As the water flows into the base the weight increases, overcoming the spring's tension and sealing shut – stopping the flow of water. Both of these water feeders do not have a reservoir, or water store. They also won't take mains/household water pressure; therefore, it's best to feed them from a header tank.

Bell drinker

The little Giants: This design has been used for over 60 years in poultry watering, and it's widely used by the large-scale poultry farms. They are inexpensive and can feed a lot of chicks – anything up to 200 per feeder. These feeders use a similar system as a bell waters to control their flow of water. An internal spring opens an internal valve when the drinking cup is empty, allowing water to flow in. And once the drinking cup is full, the weight of the water will overcome the spring tension sealing it shut. These types of waterers need to be suspended in the air to correctly operate. When set correctly these water feeders shows higher efficiency. Incorrect water pressure will make them more likely to fail and leak. Dirt getting into the valve is one of the common causes of malfunction in this type of water feeder. The improved design of this feeder was little Giant pan which consists of a large pan with a float valve in the middle that regulates the water level. The water level is adjustable, and this can be set by altering the float valve. These units also come with a magnetic lid that's designed to

stop muck and debris getting into the bowl. The lid also helps prevent birds from roosting above the water and pooping into it.

Cup waterers: These are very small water feeders. Their drinking bowl is usually a 1-2″ wide and they use a valve to regulate water flow. There are two different design of cup water feeders, each uses a different type of water valve. One design uses a tiny float valve, while the other uses trigger valve. Float valves allow the water to seep into the cup once it goes below a specific level. The trigger valve allows a little water into the cup after it is pecked by a bird.

Cup waterers are designed to be used with low-pressure water systems – you cannot connect them directly to the mains. To get the best out of cup waterers don't place them low and against the floor; this will help keep them clean. The main way these waterers fail is due to muck, and litter, getting into the valve and causing damage. Also, the bowl on these feeders is tiny compared with other types, it doesn't take much muck to fill it stopping them from working. Cup waterers are only really suitable for use on a small number of chickens – rule of thumb is one for every 10 chicks. You will need to set a lot of them up if you want to feed a lot of birds. To mount these water feeders, they need to be screwed in position using the inlet valve on their backs. You can also buy special mounts that fix on the back of the feeder, allowing it to be mounted onto a cage or a wall.

Auto Cup Drinkers

Nipple drinkers: These drinkers can be used both manual and automatic set-ups. These water feeders used heavily in large-scale poultry production. The reason is that there are inexpensive and easy to fit. They can be install by screw them into a water supply, pointing them downwards. In the commercial systems they are screwed into large piping systems placed a few inches off the ground.

12.11 Tutor-Marked Assignment

1. What do you understand by drinkers used in poultry production?
2. List and explain any three automatic drinkers

12.12 Reference/Further readings

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12.13 Unit 3: Feeding and Watering Equipment

1.0 Introduction
2.0 Feeding and Watering equipment for Cattle
3.0 Feeding and Watering equipment for Sheep and Goat
4.0 Feeding equipment for Poultry
5.0 Tutor-Marked Assignment
6.0 References/Further Reading

12.14 Introduction

The means of feed and drink supply are specific to each species. They should be adapted to the height of the animals so that they can satisfy the vital needs of food and drink. The dimensions of the trough must be chosen to conform with the required height, reach and width of the feeding space for the animals to be fed, while providing enough volume for the amount of feed distributed at each feeding time. The equipment should meet the requirements of the economic situation of the farm. This unit will discuss feeding equipment in accordance with animal breed.

12.15 Feeding and Watering equipment for Cattle

12.15.1 Feeding equipment

12.15.1.1 Mangers

Mangers are built-in receptacles for holding feeds from which the animals eat. Their efficiency is measured by the ease in serving, the small amount of space occupied and the reduction of feed waste to a minimum. furthermore, the manger should be accessible and inviting to the animal or herd. For convenience, mangers may be classed as wall manger's and center-feed alley mangers. Wall-mangers are placed along the wall and reached from one side only, while center-alley mangers are accessible from both sides. They can be constructed with either wood or concrete

12.15.1.2 Bunks

Two types of feed bunks (open gain and combination bunks) are used for grain, concentrates and silage and the other for grain and roughage. These bunks are built in convenient lengths of about 12 inch each. The width is about 4 inches for stability.

- **Open grain bunks:** The bunks are constructed with 4X4 posts used with two-inch flooring and sides. Two-inch matched floor in resting on 2X6 inch joint form the bottom of the bunk. Two by eight-inch sides, which give sufficient depth so that the grain is not pushed out. Cross and end bracing of 2X4 inch, which is necessary to strengthen the bunks since they received rough usage.
- **Combination bunks:** The combination bunks are similar to the open bunk, except that a low rack is built over the feed box. Hay, fodder or straw may be placed in this rack in addition to using the feed troughs for grain. Long posts are necessary to support the framing for the rack. Two by fours are used for the rack, spaced ten inches apart. This permits a six inch opening, which allows animals to feed. on roughage without pulling out large bunches and dropping them. The troughs catch the leaves which fall from the roughage and serve for feeding grain.

12.15.1.3 ***Feed racks***

Feed racks are built for holding forage, such as hay, straw and other roughage. They may be built of a small size which is filled daily, or of a large size which will hold several days' supply. Also, the rack may be mounted on a low-down wagon or truck. A good example of feed racks is hay racks.

- **Hay racks:** Hay racks consist of two main compartments: one in which the hay is placed and one in which the animals pull the hay before eating. The two compartments are separated by vertical bars spaced by 140 to 160 cm. A manager at the base of the eating compartment collects the hay dropped by the animals and this is eaten subsequently. The cattle gain access to the feeding compartment through a feed barrier.

Hay rack

12.15.1.4 ***Self-feeder***

Self-feeder has not been generally used in cattle feeding, but research record has shown that some cattle farmers has been used successfully for some years back. It consists of a large hopper-shaped bin with troughs at the sides. The grain flows from bin to troughs by gravity as it is consumed by the animals. There are two different self-feeders. One is built on runners and may be moved about the feedlot, while the other is not movable; it is set on short posts and shed shelters are provided on each side. This latter feeder is filled from the ends while the movable feeder may be filled from the ends or by lifting a section of the roof. self-feeders for cattle should be wide and well braced so they will withstand winds and rough usage. They should be low down and compact to prevent upsetting. The length can be 12 feet and will hold about 200 bushels of small grain.

Movable self-feeder

Stationary self-feeder with affords shelter

Self-feeder

12.15.1.5 ***Automatic concentrate feeders***

A concentrate feeder should not deliver too-small portions, otherwise feeding motivation is reduced. The availability of feed should also be very predictable, to avoid unrewarded visits. If the animals know when they can get concentrates and when not, they will quickly learn the relationship between visiting the feeder and obtaining concentrates. In such systems the concentrate feeder should be located in the feeding area, near the feed barrier, in rows of cubicles, or in an (exterior) exercise yard rather than in the lying area. The advantages of the automatic feeder are the possibility to control the quantity of concentrates taken by animals each day and a decrease of labor.

Automatic concentrate feeder

12.16 **Watering equipment**

Water is very important for animals, and lack of water significantly affects production. Consequently, good-quality water supplied through adequate and accessible drinking facilities must be provided.

The size of a water trough depends on whether the herd is taken for watering periodically or is given water on a continuous basis. If water is limited, the length of the trough should be such that all the cows can drink at the same time. A trough space of between 60 cm and 70 cm should be allowed for each cow. For free choice, the trough should be sized for two to three cows at a time. One trough should be provided for every 50 animals. A well-designed trough made of concrete. The length may be increased if necessary.

Water trough

12.16.1 **Water bowl**

The bowl drinkers used must have a minimum surface area of 0.06 m^2 and a water inlet flow rate of 0.16 L/s. The height of the bowl above the floor is 0.55 times the height of the animal withers. The number of water bowls provided should be equivalent to 15% of the number of animals. The number of water troughs should be equivalent to one per 25 cows. Troughs should be located in passages at least 3m and preferably 3.5 m wide. Several animals may be drinking at the same time, and sufficient space is necessary for others animals to walk behind.

Water bowl

12.16.2 **Automatic drinkers**

Automatic drinkers activated by the animals provide a hygienic means of supplying water for cows and young stock. When used in loose housing systems for cows, the bowl should be placed at a height of 100 cm and be protected by a raised area beneath it (1-metre-wide and 150–200 mm in height). One bowl should be provided for every 10 -15 cows. However, a nipple drinker without a bowl provides the most hygienic means of watering for young stock, but most nipples have a limited flow rate and can therefore not be used for calves older than six months.

Automatic drinkers for cattle

12.16.3 **Feeding and Watering equipment for Sheep and Goat**

Generally, the type of equipment used for sheep and goat is similar to cattle as explained above. Most of the material are made of wood, concrete, metal or plastic and are movable.

Feeding Alleys and Troughs: for sheep and goat when a shed is built for a large herd, a concrete feeding alley makes mechanized distribution of feed easier. The trough may be separated from or included in the alley. With a crate trough the animals eat from the trough from both sides and is usually placed in the middle of the shed. This system is used in older buildings or on permanent pastures for hay.

Mechanical trough: This has several advantages such as saves distribution time and it is cleaned automatically and the food is pushed back when dropped. However, it is still expensive. The system used in sheep sheds consists of a belt conveyor drawn by a cable sliding along a metallic framework. The cable winds up around a pulley, which is driven by electricity. At one end a food bin receives the fodder. Concentrates can be distributed at the same place but separately.

Racks: Racks are used for feeding hay to the animals. Their size must be adapted to the type of bales that are used. A rack can be placed over the trough. It is used only for bulk hay or small bales. In that case, metal is used as building material. Using round bales implies large-size racks. They are round or square in shape, and a fixed yoke is set at the base. The basic principle is the same as for cattle racks.

Hay racks for sheep and goat

12.16.4 Watering equipment for Goats and Sheep

The general requirements for drinking facilities are similar for goats and sheep. Drinking-water requirements according to its physiological state a ewe can drink 3 to 5 L of water per kilogram of ingested dry matter. But it is very important to allow animals to drink easily. Thus three conditions must be respected: the shape of the drinking facility, its location, and its height. For these animals a water bowl is generally used. Manually watering equipment include buckets, troughs, tanks and tubs. In some farms automatic waterers have been used. Whatever type is used cleanliness of the water is very important because sheep are reluctant to drink soiled water which may affect their body system. The drinkers should be cleaned very often.

Water trough for sheep and goat

Automatic drinkers for sheep and goat

12.16.5 Feeding equipment for Poultry

Laying hens in ground-level breeding every 1000 hens should have trays in the starting period and 40 m of chain, that is, 8 cm of auger length per fowl, or 40 trays. Three systems are used: a spiral, a flat chain, or a trolley.

Spiral feeding system: In a spiral system, the auger and the conveying device are one. The spiral lies at the bottom of the auger. It is operated by a clock.

Fat chain feeding system: The flat chain moves along the bottom of the auger. The forwarding speed is12m/min.

Trolley feeding system: There are two types of feeding trolleys, a trolley with only one feeding box placed above the cages, in which a conveyor pushes the feed towards the down ward pipes; and a side trolley with a feed box for each level on each side.

12.16.5.1 Poultry watering equipment

Drinking water requirements poultry should be provided with sufficient cool drinking water without wastage. The drinking trough should be easily reached. The quality of the water should meet the local standards for drinking water.

In cage-breeding systems the **dripping system** is used or the **suckling drinker** into which the water is led by gravity from constant-level tanks located at the end of each battery. In the cage two drippers should be available to each hen. A device for water recovery (cup or gutter) is fitted below each drinker. This contributes to obtaining dry droppings. However, for broilers dripping systems (pipette) fixed on a feeding pipe and hanging inside the building, supplied through gravity, or round drinkers can be used. Height above floor level depends on the size of the fowls and on the period (either starting or breeding).

12.16.6 Other equipment used for feeding in livestock production

Feeding trailers: The equipment has a container for the feed whose bottom is mobile, and a screw or a side conveyor that drops the fodder into the trough.

Mounted silo unloaders: This machine can take the fodder from the silo and distribute it into the troughs. At the bottom of the machine have a chain conveyor and slats throw the fodder sideways. Trailers and silo unloaders can include a system for distribution on both sides. The hay is either cut or torn from the silo. These machines generally can work at heights between 2 and 3 m.

Hydraulic fork: The hydraulic fork is the simplest means for taking and distributing silage. However, it is impossible to spread the feed in the trough. It has to be piled first and spread later.

***Mixer trailers* (Complete Diet)**: This machine has a system of mixing the feed so that a complete diet can be prepared. A weighing system with a gauge constraint allows for

measurement of the quantities of feed put into the trailer. The mixing of feed and concentrates is achieved by one or several screws that move the fodder.

Fixed Feeding Systems: In large breeding units feed distribution can be mechanized with a conveyor. This is a fixed piece of equipment that conveys and distributes the feed into a trough. Distribution is best with short minced feed. Generally, these pieces of equipment are limited in length, especially those with screws.

12.17 **Tutor-Marked Assignment**

1. What do you understand by Mangers in cattle production?
2. List and explain any three-feeding equipment used for cattle production?
3. Mention any four of feeding and watering equipment that are used for sheep and goat production?
4. Highlight two equipment use in poultry feeding?

12.18 **Reference/Further readings**

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12.19 **Unit 4: Milk and Milk handling equipment**

1.0 Introduction
2.0 Milk handling equipment
3.0 Milking machine
4.0 Milk transport vessel
5.0 Bottle filling machine
6.0 Cream separator
7.0 Refrigeration and cool storage of Milk and Milk product
8.0 Tutor-Marked Assignment
9.0 References/Further Reading

12.20 **Introduction:**

Milk is necessary for both infant and child and is a most important food for adults. In fact, it is essential for the welfare of the human race. Since is perishable and an ideal product for bacterial growth, it must be carefully handled, both during production and while processing. Raw milk available for human consumption must be low in bacterial count, free from diseases germs and visible dirt, and have an acceptable flavor. Once the milk has been received at the milk processing centre, or dairy plant, it should be immediately strained, cooled and processed so as to prevent any further bacterial growth. Various operations performed at the milk processing centre include pasteurization, cooling, cream separating, butter churning, ice cream freezing, bottle filling and capping, bottle washing, can washing etc.

12.21 **Milk handling equipment**

Milk handling start from milking operation to milk packaging and involves different equipment along the processing line. The equipment used depend on the quantity of milk to handle and can be small- or large-scale processing equipment.

12.21.1 Milk room

Sanitation is the primary consideration in the handling of milk, whether it is from one or two cows belonging to a smallholder or from a commercial herd supplying milk for the city. In either case, an adequate supply of potable water is essential for cleaning the milking equipment immediately after use. Hot water (85 °C), mixed with a chemical detergent, is required for effective cleaning, and cold water is used for rinsing.

Milk should be handled in a separate area that is easy to clean and is free of insects, birds, rodents and dust. A smallholder producing milk only for the household may be able to process, curdle, or consume the milk within a short time so that cooling is not necessary. Selling milk to the public requires higher standards of sanitation and more elaborate facilities. Whether the cows are hand- or machine-milked, a separate milk room adjacent to the milking stalls or milking parlour is needed. This room should be well ventilated and designed with a concrete floor with a slope of 20 mm/m to a drain and masonry walls with a smooth, water-resistant surface that can be easily and thoroughly cleaned

12.21.2 Milking machine:

is the first equipment used in milk handling. The machine is used for collecting the milk from animal. The machine gives good quality and operates with a uniform vacuum of 275-350 mm of mercury, provides a massaging effect on the teats, and is easy to clean. The milking machine simulates nursing by the calf. Two vacuum lines lead to the teat cups. A pulsator supplies an intermittent vacuum to one line at the rate of 45-60 pulses per minute. The line, connected to the shell of the teat cup, causes the teat inflation (rubber liner) to alternately expand and collapse. This massaging action promotes normal blood circulation in the teat. The second line maintains a continuous vacuum on the teat and carries the milk either to a stainless steel bucket or through a pipeline directly to the milk cooler. A milking machine as shown Figure below. This type of system is often chosen for the small- and medium-size herd.

The labour of carrying the milk to the cooler has reduce through the use of pump transfer system. This consists of a 30-litre receiving tank, including a built-in filter, mounted on wheels so that it can be moved around the stable. It is connected to the cooler with a plastic hose and the milk is drawn to the cooler by vacuum from the milker pump. The hose is reeled in or out as necessary as the cart is moved around the stable.

In a large-scale system pipeline milking system are usually installed in milking parlours, where the operator stands below the level of the cows. Although they are expensive, they reduce the back-breaking tasks and are usually designed to be cleaned in place.

Milking machine

Coolers: These are equipment used for chilling the milk to about 4° C. This is done to check the multiplication of bacteria and to preserve the quality of milk till it is subjected to pasteurization process.

Pasteurizers: This machine used for heating the milk to at least 61 C and holding it at that temperature for 3o minutes, or heating to a aleast 70 C and holding it at that temperature for at least 15 seconds. This process destroys most of the bacteria in milk and particularly all disease producing organisms. It also improves the quality and test of the milk. There are two basic types of pasteurizers batch type and high temperature short time type

12.21.3 Milk transport vessel:

These are equipment used for transporting and store milk from the farm to collection centers or milk processing plant. The equipment are categorized into two milk cans and tanks

- **Milk cans:** these equipment used to stored milk for a short time and transporting it over the short distances. The material was not usually insulated therefore may lead to poor milk quality. Since the cans are not insulated, the transport to the factory must be efficient enough to enable milk reach the factory in acceptable condition.
- **Milk tanks:** Thank are usually made in rectangular and horizontal or circular and vertical. The shell of these tank made from stainless steels and surrounded by jacketed spaced for circulation of refrigerated water or coolant. The tank is insulated with non-toxic material and is used to transport milk in bulk over long distance.

Bottle filling machine: These are machines used for packaging the processed milk into a bottle. There are two type of mechanical bottle fillers: gravity type filler and vacuum type filler. Sachet type milk fillers also exist.

Bottle Capping machine: This machine used to cap a bottle filled with a milk. The machine can be manually operated or automated.

Cream separator: This equipment is primarily used for the purpose of separating milk into cream and skim milk. Separator works on the principle that milk fat, being lighter than other constituents, remains in the centre of the bowl when the bowl is rotate at very high speed. The heavier portion of the milk is thrown to the outer rim of the bowl. By means of the special construction of the disks, the skim milk and the cream are conducted to separated outlets.

12.21.4 Refrigeration and cool storage of Milk and Milk product

Refrigeration Systems is used to preserved the milk the system works on the same principle as a home refrigerator. A cold-generating fluid in liquid form is distended into an evaporator and produces cold. The heat created by the compression-condensation system is evacuated by means of a ventilator. The cooling level is regulated at the beginning by the mass of milk and then by a thermostat that stops the compressor when the milk has reached the desired temperature.

12.22 Tutor-Marked Assignment

1. What are the milk handling equipment?
2. Write a short note of the following:
   a. Milk room
   b. Coolers
   c. Milking machine
3. What is pasteurizers?
4. Mention any two Milk transport vessel?
5. Explain the method of milk storage?

12.23 Reference/Further readings

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12.24 Unit 5: Meat Processing equipment

1.0 Introduction

2.0 Type of meat processing equipment
3.0 Types of cutting systems
4.0 Tutor-Marked Assignment
5.0 References/Further Reading

12.25 **Introduction:**

Meat is the general term used to explain the edible part of the animal tissue and several processed or manufactured products that ready from these tissues. The meat is also processed by meat processing techniques and machines. There are various types of meat processing machines available in the market that is useful to processed meat.

12.26 **Type of meat processing equipment**

1. Meat grinder
2. Meat Diameter
3. Meat Mixer
4. Meat Timber
5. Meat Poor
6. Meat Hamburger dose
7. Meat Steppers (filling)

12.26.1 **Meat grinder**

The meat grinder is also known as meat mincer that is a kitchen appliance. It is used for fine chopping or mincing and mixing of raw or cooked meat, vegetables, fish and some similar food. The meat grinder is available on 150-800 kg that comes in various models.

Manual meat grinder

Power operated meat grinder

Meat grinding machines

12.26.1.1 ***Types of cutting systems***

1. Enterprise System
2. Unger System

Enterprise System: is mainly used in smaller meat grinders with orifice diameters up to 98 mm and consists of one-star knife, sharpened only on the side facing the disc, and one grinder plate. Hole diameters can vary from 13 to 5 mm.

Unger System: Is used in meat grinders with orifice diameters up to 440 mm and consists of the kidney plate, one- or two-star knives sharpened on both edges and one or two grinder plates. For a final particle size above 8 mm the recommended setting is kidney plate-star knife-grinder plate.

Bowl cutter (bowl chopper): The bowl cutter is the commonly used meat chopping equipment designed to produce small or very small meat and fat particles. The machine consists of a horizontally revolving bowl and a set of curved knives rotating vertically on a horizontal axle. Many types and sizes exist with bowl volumes ranging from 10 to 2000 litres.

Bowl cutter filled with meat for chopping

Filling machine (sausage stuffer): These machines are used for filling all types of meat in containers such as casings, glass jars, cans etc. The most common type of filling machine in small and medium size operations is the piston type. A piston is moved inside a cylinder forcing the meat material through the filling nozzle (funnel, stuffing horn) into the containers. Piston stuffers are either attached to the filling table or designed as floor models. In small-scale operations manual stuffers are usually sufficient, sometimes even simple hand-held funnels are used to push meat mixes into casings.

Manual piston stuffer

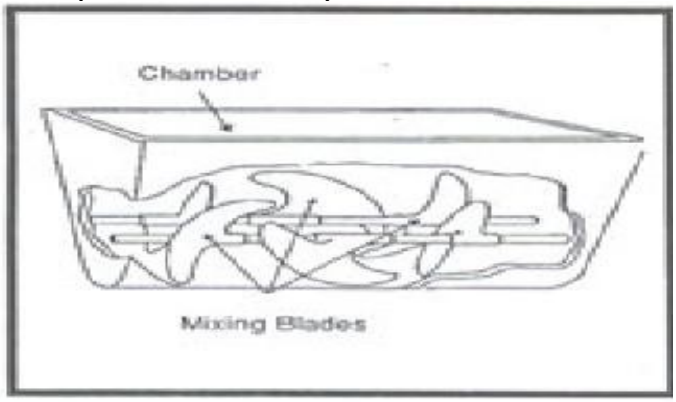
Clipping machine: Clipping machines place small aluminum sealing clips on the sausage ends and replace the manual tying of sausages. When using shirred casings, the time consuming loading of pre-cut casings is no longer necessary. Wastage of casings can be reduced to a minimum by tight filling and leaving only as much casing for the sausage end as needed for the placing of the clips.

Vacuum packaging machine: For vacuum packaging the meat product has to be placed into a vacuum bag (multi-layer synthetic bag). Air is removed from the bag by means of the vacuum packaging machine and the bag then sealed. Special vacuum packaging machines

can operate with gas-flushing, where a mixture of gas is injected after evacuating the air. Such protective gas atmospheres inside the product package inhibit bacterial growth and stabilize the meat colour. The gas mixtures usually contain CO_2 and N_2.

Vacuum packaging machine

Mixer/blender Mixers: Are used to blend meat and spices, or coarse and finely chopped meat. The machine generally consists of a rectangular or round bottom vessel through which two parallel shafts operate. Various paddles are mounted on those shafts to mix the meat. The mixer is discharged through tilting by 90 degrees. Some mixers are designed as vacuum mixers, as the mixing under vacuum (exclusion of oxygen) has advantages for the development of desirable product colour and texture.



Mixer

Emulsifying machine (colloid mill): The emulsifier serves for the preparation of very fine meat emulsions. Its functional parts are a perforated plate, attached to which two edged blades are rotating (rotor blade). Next to the blades there is a centrifugal pump that forces the pre-ground meat through the perforated plate. Most emulsifiers are vertical units. Compared to the bowl cutter the emulsifier operates at much higher speed, producing a finer emulsion-like mix. The emulsifier is also perfectly suited to produce semi-processed products such as pig skin emulsions.

Top view

Plate and rotating blade

Emulsifying machine

Frozen meat cutter: This machine is use to cut the frozen meat into pieces prior to grinding or bowl cutting. There are two types of these machines which worked with knives cutting or using rotating drums with attached sharp knives.

Rotating knife frozen meat cutter

Meat Diameter: The meat diameter is meat cutting machine and designed by a system which works with only piece of meat. This machine is available in 9-25 kg with different range of models.

Meat Timber: Meat timber is a well-known meat processor that processes naturally. It comes in a variety of models with different features.

Meat Poor: Meat Poor is also a meat processor which is used in meat processing. Meat Poor comes in different types of models with excellent features.

Meat Hamburger dose: Meat Hamburger dose comes in a variety of models that is useful for processed meat.

12.27 Tutor-Marked Assignment

1. Define meat?
2. List and explain any five-meat processing equipment?
3. List any two type of cutting systems in meat industries?
4. Differentiate between bowl cutter and clipping machine?

12.28 Reference/Further readings

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13 MODULE 4: WATER LIFTING AND IRRIGATION EQUIPMENT

13.1 Unit 1: Water lifting device and Irrigation equipment

13.2 Contents

13.3 Introduction:

Water constitute a vital component to sustain plant growth, and it may need to be collected from various sources (like canals, wells and pond), so that it may be applied to the plants in the field as required. In this unit the important devices used to lift water from various sources are discussed briefly.

13.4 Classification of water lifting devices

According to power sources water lifts can be classified as manual, animal and power operated devices. The brief description of these devices is here below:

Human Powered Devices: Man has a limited physical power output, which may be in the range of 0.08 to 0.1 hp. This power can be used to lift water from shallow depths for irrigation. The common man powered devices are:

1. Swing basket. The device consists of a basket made from the cheap materials like woven bamboo strips, leather, or iron sheet to which four ropes are attached. Two persons hold the basket facing towards each other's, dip the basket in water source and by swinging, the basket is lifted and filled in water course from where the water flows to the fields. The device ~s useful up to a depth of O. 15m and discharge may vary from 3500 to 5000 l/h.

2. Counterpoise lift. It is generally used for lifting of water from unlined wells, stream or pond for irrigating small fields. It consists of a lever rod supported at a suitable point on a vertical post about which it can swing in vertical direction. About 2000 1itres of water can be lifted from the depth of2 to 3 meters in one hour.

3. Don. The principle of operation of don is similar to counterpoise lift. The don consists of a trough made from wooden log or iron sheet; closed at one end and open at the other. The open end of the trough is connected to a hinged pole with a counter weight through rope. For operation the trough is lowered by exerting pressure on it by pulling the rope and also by foot of the operator till the closed end is submerged in water. Upon releasing pressure, the trough comes to its original position due to action of counter weight along with water. Water can be lifted from this device from a depth of 0.8 to 1.2m.

4. Archimedean screw. It consists of a helical screw mounted on spindle, which is rotated inside a wooden or metallic cylinder. One end of the cylinder remains submerged in water and is placed in inclined position at an angle of 30 degrees. It is used for lifting of water from a depth of 0.6 to 1.2 meters and may discharge 1600 1itres per hour.

5. Paddle wheel. Is mostly used in coastal regions for irrigating paddy fields. It consists of small paddles mounted radially to a horizontal shaft, which moves in close fitting concave trough, thereby pushing water ahead of them. The number of blades depends on the size of

wheel, which may be 8 for 1.2m and up to 24 for 3 to3.6m diameters. The wheel having 12 blades may lift about 18000 litres per hour from a depth of 0.45 to 0.6m.

13.4.1 ANIMAL POWERED DEVICES

Animal power is abundantly available in India. They are used for lifting of water, besides other field operations and processing works. A pair of bullocks may develop approximately0.80 horsepower. They can lift water from the depth of 30m or more. Of course the rate of discharge will go down with increase in lift. Some of the devices used for irrigation operated by animal power are as under.

1. Rope-and-bucket lift: Also known as Mote. Charsa or Pur it is used to lift water from lined wells up to a depth of 30m. The device consists of a bucket or bag made of GI sheet or leather, and pulley arrangement. A rope is attached to the bucket-or bag, which passes over a pulley and finally fixed to the yoke of bullocks. The bullocks walk down on an earthen ramp sloped at an angle of 5-10 degrees to lift the water. About 9000 1itres of water can be lifted per hour with two pairs of bullocks with this device from a depth of 15m.

2. Self-emptying bucket: The arrangement is similar to rope and bucket lift device. The system consists of a leather container shaped like a funnel which has a spout on the lower end and the upper portion resembles to a conical cylinder. The container is open from both ends. The capacity of container may range from 100 to 150 litres. The device is suitable when the lift does not exceed 9m at which discharge is about 8000 litres per hour.

3. Two bucket lift: In this device two buckets are raised and lowered alternately. The bullocks move in a circular path and with the help of central rotating lever, rope and pulley arrangement the buckets move up and down. Each bucket may have carrying capacity up to 70litres. The buckets are provided with hinged flap at the bottom, which acts as a valve. Guide rods are provided in the well for the movement of buckets. The buckets are automatically filled and emptied during operation. The device is suitable for lift up to 5m at which discharge may be 14000 litres per hour.

4. Persian wheel: It is also known as Raha. It is used to lift water from a depth up to 20m.The efficiency of the device is considerably reduced after 7.5m. The device consists of endless chain of buckets made of GI sheet having capacity from 8-15 litres. The chain of bucket is mounted on a drum and is submerged in the water to sufficient depth. The drum is connected to a toothed wheel held in vertical plane by a long shaft, which is usually kept below the ground level. The vertical toothed wheel is geared with a large toothed horizontal wheel connected to a horizontal beam. This beam is yoked to a pair of animals. For operation the animals move in rotary mode that rotates the buckets carrying water through the gear system. The water IS released when the bucket reaches the top. Average discharge of Persian wheel is about 10,000 litres per hour from a depth of9m with one pair of bullocks.

5. Chain pump: The chain pump is used to lift water from shallow wells and works most satisfactorily when the lift is about 6m. The pump consists of an endless chain on which discs are mounted at the interval of about 25cm. The endless chain usually passes over two drums. The upper drum is above the top of well to which axle and handle is attached for operation. The chain with disc passes through a pipe, which is about 10cm in diameter and extends downward from the top of well to about 0.6 to 0.9 m below the surface of water. The discs on rotation of chain entrap the water and carry it to the top, which is discharged into the trough. The pump can be operated either manually or by animals having the system as that of Persian wheel.

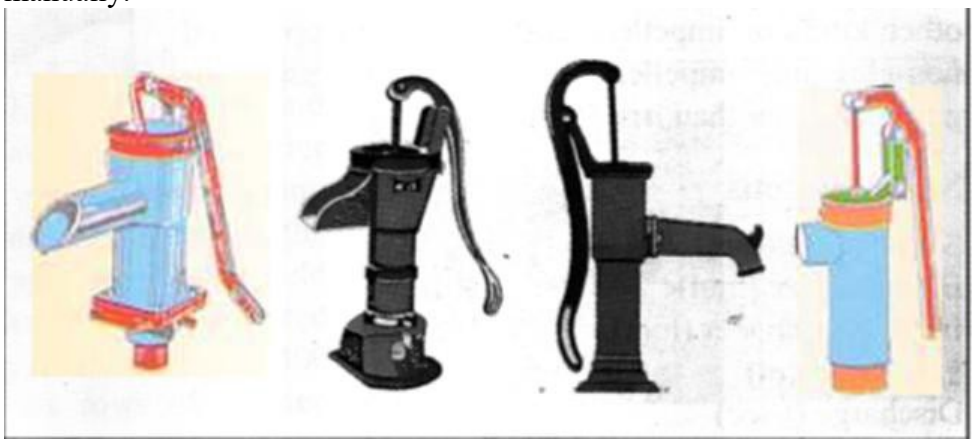
13.4.2 MECHANICALLY- POWERED WATER LIFTING DEVICES

Mechanically powered water lifting devices are usually termed as pumps, which are operated with the help of auxiliary power sources such as engine or electric motor. These pumps are capable of lifting large quantity of water to higher heads and are usually employed for the

irrigation of horticultural crops. Basically, there are four principles involved in pumping water
(1) atmospheric pressure
(2) centrifugal force
(3) positive displacement and
(4) movement of column of fluid caused by difference in specific gravity. Pumps are usually classified on the basis of operation, which may employ one or more of the above principles.
The pump can be classified as:

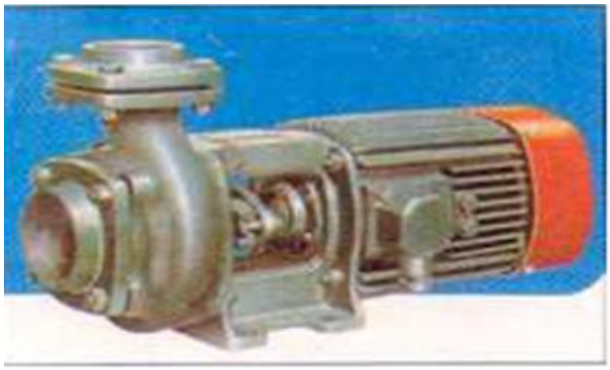
Displacement pumps: Reciprocating and rotary
Centrifugal pumps: Volute, diffuser, turbine, propeller
Airlift pumps.

Reciprocating pumps: Theses type of pump are normally used for drinking water supply in addition to irrigation. The main parts of the reciprocating pumps are the pump cylinder in which an airtight piston or plunger moves up and down with the help of pump rod, handle for operation of pump, valves, pipe and strainer. As the plunger rises, water is drawn through anon-return valve at the bottom of cylinder into the cylinder, and on the downward stroke the water is released to the upper side of plunger. On the next upward movement of plunger water is raised to pump head and discharged through the spout. By changing either the frequency of reciprocation or stroke length of the piston the discharge rate can be varied. The reciprocating pumps are available in various designs and models, which can be operated manually.



Reciprocating pump.

Monoblock centrifugal pump: It is one of the most common types of centrifugal pumps employed for irrigation. It consists of impeller or rotor and progressively widening spiral or volute casing. The pump is directly connected to the prime mover, which may be electric motor or engine. The direct coupling feature reduces transmission. losses. Upon rotation of the impeller, the water enters at the eye, which is thrown radially outward to the periphery. Such an action causes vacuum at the eye and thus more water enters the suction pipe to maintain the continuous flow. The impeller accelerates the water to a high velocity and the casing converts this velocity head into pressure head due to volute design.



Monoblock centrifugal pump

End suction centrifugal pumps: End suction type centrifugal pumps are most commonly used pumps for irrigation in agriculture. The pump can be coupled with electric motor or engine. The pump consists of casing, impeller, high tensile shaft, bearing pedestal, stuffing box, flanges and coupling. Upon rotation of the impeller, the water enters at the eye, which is thrown radially outward to the periphery. Such an action causes vacuum at the eye and thus more water enters the suction pipe to maintain the continuous flow. The impeller, accelerates the water to a high velocity and the casing converts this velocity head into pressure head due to volute design.

End suction centrifugal pump

Self-priming centrifugal pump: The self-priming pumps are available in stationary and portable models. These pumps are primarily used where low discharge is needed at higher heads. Due to self-priming features, pump can handle air and gases entrained in water.

Self-priming centrifugal pump

Turbine pump: These pumps are used in tube wells or in open wells where the water level is below the practical limit of centrifugal pump. The vertical turbine pump consists of a driving motor with discharge connection and the bottom suction centrifugal pump to which one or more impellers are attached. The pump unit remains submerged in water where as the prime mover (motor or engine) is kept above the ground level.

Turbine pump

***Submersible pumps*:** Submersible pumps are also similar to turbine pumps where long vertical shaft connecting the motor and pump unit is replaced by a short shaft and the prime mover and pump become closely coupled and submerged in water. Submersible pumps are suitable for tube wells having a bore of 100 mm or more. Impeller of the pump may be closed; semi open or open. The pumps consume less power for the same output and also require less space. The pump is used for lifting of water from tube wells for irrigation, domestic and industrial applications.

Submersible pumps

Jet pump: A jet pump is a diffuser pump that is used to lift water from both shallow and deep wells. During working, the output of the diffuser is split, and half to three-fourths of the water is sent back down the well through the pressure pipe. At the end of the pressure pipe water is accelerated through a cone-shaped nozzle. The water goes through a venturi in the suction pipe. The venturi speeds up the water causing a pressure drop which sucks in more water through the intake at the very base of the unit. The water goes up the suction pipe and through the impeller, the jet pump is used for lifting of water from shallow and deep wells for irrigation and domestic applications.

Jet pump

13.4.2.1 ***Sprinkler irrigation system***

Irrigation by sprinkler is nearest to natural rainfall, where water is sprayed into air in the form coarse droplets. Because of its ease of operation, sprinkler irrigation is used extensively all over the world. Water can be applied uniformly with this method. The water is subjected to pressure by pumping and discharged through small orifices called nozzles, which break the liquid into coarse droplets. The nozzles are mounted on a rotating head; therefore, each head covers a circular pattern. Sprinkler system is suitable to all vegetable crops.

Sprinkler in operation

Sprinkler system is broadly classified as rotating head system and perforated pipe system.

Rotating head system may be portable, semi portable, semi-permanent, solid set and permanent system. Usually portable system is more popular which can be moved after applying one irrigation to the crop to another area and also requires less initial investment.

Perforated system has holes perforated in the lateral irrigation pipes, which are operated under low pressure (0.5-2.5kg/cm2). This system can be operated by overhead tank. Perforated system is suitable for lawns, vegetables field, and gardens and to the crop where height is below 60 cm.

13.4.3 **Major components of sprinkler system**

(i) **Pump:** which lifts the water from source and sends it under pressure in the system.

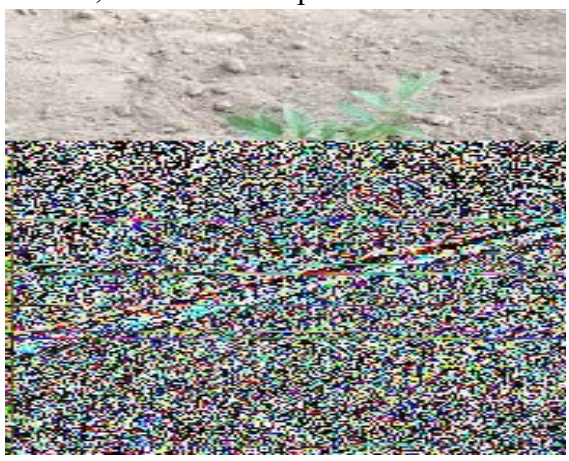
(ii) **Main lines:** which may be permanent or portable; portable lines are usually made of aluminum where as permanent lines may be of steel, asbestos cement or PVC. Mainlines receive water from pump and discharge into laterals.

(iii) **Lateral lines**: which are usually made from aluminum and are portable; however, in some orchards and nurseries permanent laterals are buried,

(iv) **Riser pipes**: which are attached to the laterals. The height of the riser depends on the height of the crop,
(v) **Sprinkler head**: which convert the water stream into coarse droplets and also throw the droplets to a distance, since the sprinkler head rotates while in operation, a circular pattern is achieved. The diameter of water application area depends on the pressure of water and type of sprinkler head. The sprinkler head may have a single or two nozzles.

13.4.4 Drip irrigation system

It is one of the efficient ways of applying irrigation water to the horticultural crops. More than 90% water application efficiency can be achieved by this method. Water is applied in the form of drops or very fine stream. The application is almost equivalent to consumptive use of plants; therefore, the losses due to deep percolation, runoff and evaporation are minimized.



Drip irrigation

13.4.4.1 Major components of drip irrigation system

The system consists of mainline, sublines, supply lines, laterals and emitters. The water is discharged either through emitters or micro-tubes. The pipe lines are made from black PVC to avoid growth of algae in the lines. The water being used should be clean and free from any debris to avoid plugging of pipes, emitters or micro tubes. The system operates under low pressure 0.15 to 0.2 kg/cm^2 and as high as 1 to 1.75 kg/cm^2

13.5 Tutor-Marked Assignment

1. List two classes of water lifting devices?
2. Explains any four manual water lifting devices?
3. Highlight any three animal power water lifting equipment?
4. Differentiate between reciprocating and Monoblock pump?
5. State any four (4) sprinkler components?
6. What are the major component of drip irrigation system What do you understand by conveyor systems?

13.6 Reference/Further readings

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14 MODULE 5: FARM POWER AND MACHINERY USES

Unit 1: Overview of farm power sources
Unit 2: Internal combustion engine (IC)
Unit 3: Tractor transmission system
Unit 4: Tractor chassis, wheel and type of tractor
Unit 5: Tractor electrical system
Unit 6: Tractor hydraulic system and three-point linkage
Unit 7: Tillage requirement and implement selection
Unit 8: Row crop planter and grain drills

14.1 Unit 1: Overview of farm power sources

14.2 Contents

1.0 Introduction
2.0 source of farm power and their uses
3.0 Tutor-Marked Assignment
4.0 References/Further Reading

14.3 Introduction:

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

14.4 Sources of farm power

There are different sources of farm power available which are classified as:

I. Human power
II. Animal power
III. Mechanical power (Tractors + Power tillers + Oil engines)
IV. Electrical power
V. Renewable energy (Biogas + Solar energy + Wind energy)

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

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

Mechanical power: Broadly speaking, mechanical power includes stationary oil engines, tractors, power tillers and self-propelled combines. Internal combustion engine is a good device for converting liquid fuel into useful work (mechanical work). These engines are two types (1) Spark ignition engines (Petrol or Kerosene engine) (2) Compression ignition engines (Diesel engines). The thermal efficiency of diesel engine varies from 32 to 38 per cent whereas that of petrol engine varies from 25 to 32 per cent. In modern days, almost all the tractors and power tillers are operated by diesel engines. Diesel engines are used for operating irrigation pumps, flour mills, cotton gins, chaff cutter, sugarcane crusher, threshers, winnowers etc.

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

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

Solar energy: Most tropical countries are blessed with plentiful sunshine all the year round. Nigeria, for instance, received about 490 W/m2/day. There is thus plenty of potential for the development of solar energy. Solar energy can be used for processing fruits and vegetables and for general drying of crops. Another application is in solar –operated pumps. The sun`s rays are received in a collector and transmitted to a heat engine, which converts the solar energy into mechanical power to run a water or irrigation pump. Solar power can also be converted into electricity directly by semi-conductor devices called cells, or by producing steam to drive power-producing turbines. Others uses includes solar dryers, lantern, cooker, solar still, solar refrigeration, solar lighting etc.

Wind energy: Wind power has been successfully used for raising water. The natural breeze or wind is used to turn the blades of a windmill which in turn operates a pump to lift water. Wind power has also been used to generate electricity for use on the farm.

Water power: The energy available from water falling from one level to a lower level can be harnessed to run a few fam operations, such as feed grinding, or to operate a generating plant to provide electricity.

Biomass energy: Different forms of biomass material can be converted into energy through gasification to produce gas, pyrolysis to produce liquid fuels, anaerobic to produce biogas etc.

14.5 Tutor-Marked Assignment

1. List two and explain any three source of farm power?

2. Explains renewable energy?

14.6 **Reference/Further readings**

R.N. Kaul and C.O. Egbo. (1985). Introduction to agricultural mechanization published by Macmillan Education Ltd.
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14.7 **Unit 2: Internal combustion engine (IC)**

14.8 **Contents**

14.9 **Introduction:**

Heat engine is a machine, which converts heat energy into mechanical energy. The combustion of fuel such as coal, petrol, diesel generates heat. This heat is supplied to a working substance at high temperature. By the expansion of this substance in suitable machines, heat energy is converted into useful work. Heat engines can be further divided into two types:

i. External combustion and
ii. Internal combustion.

In a steam engine the combustion of fuel takes place outside the engine and the steam thus formed is used to run the engine. Thus, it is known as external combustion engine.
In the case of internal combustion engine, the combustion of fuel takes place inside the engine cylinder itself.

14.10 **Internal combustion engines:**

Are devices that generate work using the products of combustion as the working fluid rather than as a heat transfer medium. To produce work, the combustion is carried out in a manner that produces high-pressure combustion products that can be expanded through a turbine or piston. The engineering of these high-pressure systems introduces a number of features that profoundly influence the formation of pollutants. The IC engine can be further classified as:

(i) stationary or mobile,
(ii) horizontal or vertical and
(iii) low, medium or high speed.

The two distinct types of IC engines used for either mobile or stationary operations are: diesel and carburetor.

14.10.1 **Spark Ignition (Carburetor type) IC Engine**

In this engine liquid fuel is atomized, vaporized and mixed with air in correct proportion before being taken to the engine cylinder through the intake manifolds. The ignition of the mixture is caused by an electric spark and is known as spark ignition.

14.10.2 Compression Ignition (Diesel Type) IC Engine

In this only the liquid fuel is injected in the cylinder under high pressure.

14.10.3 Principles of operation of IC engines:

*14.10.3.1 **Four-stroke cycle diesel engine***

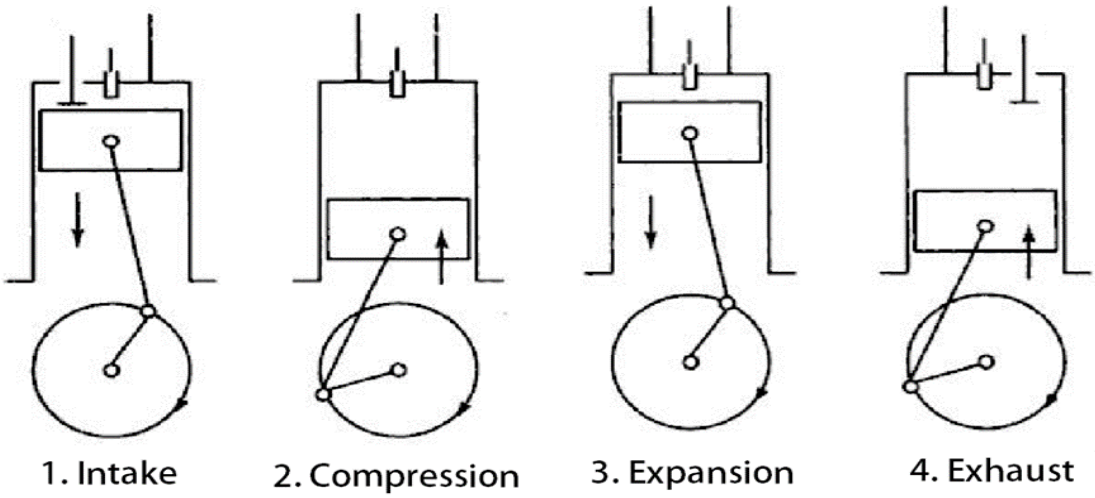
In four-stroke cycle engines there are four strokes completing two revolutions of the crankshaft. These are respectively, the intake, compression, power and exhaust strokes.

- The piston moves down for its intake stroke. Only pure air is drawn into the cylinder during this stroke through the inlet valve, whereas, the exhaust valve is closed. These valves can be operated by the cam, push rod and rocker arm.

- The next stroke is the compression stroke in which the piston moves up with both the valves remaining closed. The air, which has been drawn into the cylinder during the intake stroke, is progressively compressed as the piston ascends. The compression ratio usually varies from 14:1 to 22:1. The pressure at the end of the compression stroke ranges from 30 to 45 kg/cm^2. As the air is progressively compressed in the cylinder, its temperature increases, until when near the end of the compression stroke, it becomes sufficiently high (650-800 ^{o}C) to instantly ignite any fuel that is injected into the cylinder. When the piston is near the top of its compression stroke, a liquid hydrocarbon fuel, such as diesel oil, is sprayed into the combustion chamber under high pressure (140-160 kg/cm^2), higher than that existing in the cylinder itself. This fuel then ignites, being burnt with the oxygen of the highly compressed air. During the fuel injection period, the piston reaches the end of its compression stroke and commences to return on its third consecutive stroke

- Power stroke. During this stroke the hot products of combustion consisting chiefly of carbon dioxide, together with the nitrogen left from the compressed air expand, thus forcing the piston downward. This is only the working stroke of the cylinder. During the power stroke the pressure falls from its maximum combustion value (47-55 kg/cm^2), which is usually higher than the greater value of the compression pressure (45 kg/cm^2), to about 3.5-5 kg/cm^2 near the end of the stroke. The exhaust valve then opens, usually a little earlier than when the piston reaches its lowest point of travel.

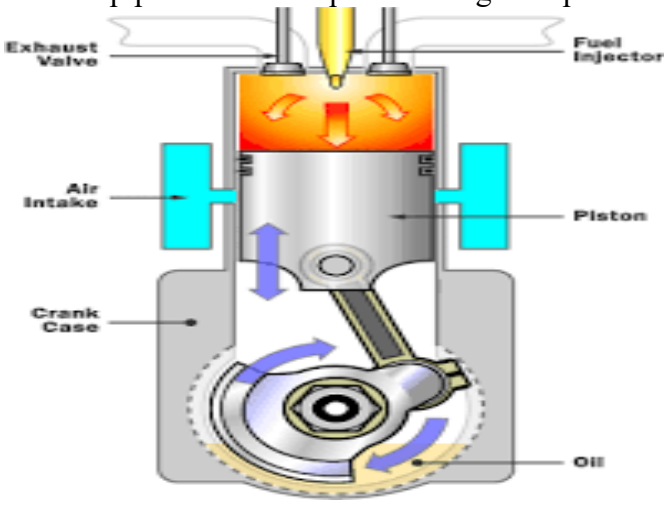
- Exhaust stroke. In this stroke exhaust gases are swept out on the following upward stroke of the piston. The exhaust valve remains open throughout the whole stroke and closes at the top of the stroke. The reciprocating motion of the piston is converted into the rotary motion of the crankshaft by means of a connecting rod and crankshaft. The crankshaft rotates in the main bearings, which are set in the crankcase. The flywheel is fitted on the crankshaft in order to smoothen out the uneven torque that is generated in the reciprocating engine.



Four stroke cycle engine

14.10.3.2 ***Two-stroke cycle diesel engine:***

The cycle of the four-stroke of the piston (the intake, compression, power and exhaust strokes) is completed only in two strokes in the case of a two-stroke engine. The air is drawn into the crankcase due to the suction created by the upward stroke of the piston. On the down stroke of the piston it is compressed in the crankcase. The compression pressure is usually very low, being just sufficient to enable the air to flow into the cylinder through the transfer port when the piston reaches near the bottom of its down stroke. The air thus flows into the cylinder, where the piston compresses it as it ascends, till the piston is nearly at the top of its stroke. The compression pressure is increased sufficiently high to raise the temperature of the air above the self-ignition point of the fuel used. The fuel is injected into the cylinder head just before the completion of the compression stroke and only for a short period. The burnt gases expand during the next downward stroke of the piston. These gases escape into the exhaust pipe to the atmosphere through the piston uncovering the exhaust port.



Two stroke cycle engine

14.10.4 **Major component of IC engine**

Cylinder: The cylinder of an IC engine constitutes the basic and supporting portion of the engine power unit. Its major function is to provide space in which the piston can operate to draw in the fuel mixture or air (depending upon spark ignition or compression ignition),

compress it, allow it to expand and thus generate power. The cylinder is usually made of high-grade cast iron. In some cases, to give greater strength and wear resistance with less weight, chromium, nickel and molybdenum are added to the cast iron.

Piston: The piston of an engine is the first part to begin movement and to transmit power to the crankshaft as a result of the pressure and energy generated by the combustion of the fuel. The piston is closed at one end and open on the other end to permit direct attachment of the connecting rod and its free action.

Piston Rings: These are made of cast iron on account of their ability to retain bearing qualities and elasticity indefinitely. The primary function of the piston rings is to retain compression and at the same time reduce the cylinder wall and piston wall contact area to a minimum, thus reducing friction losses and excessive wear. The other important functions of piston rings are the control of the lubricating oil, cylinder lubrication, and transmission of heat away from the piston and from the cylinder walls. Piston rings are classed as compression rings and oil rings depending on their function and location on the piston.

Compression rings are usually plain one-piece rings and are always placed in the grooves nearest the piston head. Oil rings are grooved or slotted and are located either in the lowest groove above the piston pin or in a groove near the piston skirt. Their function is to control the distribution of the lubricating oil to the cylinder and piston surface in order to prevent unnecessary or excessive oil consumption ion.

Piston Pin: The connecting rod is connected to the piston through the piston pin. It is made of case-hardened alloy steel with precision finish. There are three different methods to connect the piston to the connecting rod.

Connecting Rod: This is the connection between the piston and crankshaft. The end connecting the piston is known as small end and the other end is known as big end. The big end has two halves of a bearing bolted together. The connecting rod is made of drop forged steel and the section is of the I-beam type.

Crankshaft: This is connected to the piston through the connecting rod and converts the linear motion of the piston into the rotational motion of the flywheel. The journals of the crankshaft are supported on main bearings, housed in the crankcase. Counter-weights and the flywheel bolted to the crankshaft help in the smooth running of the engine.

Engine Bearings: The crankshaft and camshaft are supported on anti-friction bearings. These bearings must be capable of withstanding high speed, heavy load and high temperatures. Normally, cadmium, silver or copper lead is coated on a steel back to give the above characteristics. For single cylinder vertical/horizontal engines, the present trend is to use ball bearings in place of main bearings of the thin shell type.

Valves: To allow the air to enter into the cylinder or the exhaust, gases to escape from the cylinder, valves are provided, known as inlet and exhaust valves respectively. The valves are mounted either on the cylinder head or on the cylinder block.

Camshaft: The valves are operated by the action of the camshaft, which has separate cams for the inlet, and exhaust valves. The cam lifts the valve against the pressure of the spring and as soon as it changes position the spring closes the valve. The cam gets drive through either the gear or sprocket and chain system from the crankshaft. It rotates at half the speed of the camshaft.

Flywheel This is usually made of cast iron and its primary function is to maintain uniform engine speed by carrying the crankshaft through the intervals when it is not receiving power from a piston. The size of the flywheel varies with the number of cylinders and the type and size of the engine. It also helps in balancing rotating masses.

14.11 **Tutor-Marked Assignment**

1. What is an IC engine?
2. Give two classes of an IC engine?
3. Differentiate between two stroke and Four stroke engine?
4. List Five (5) major part of an IC engine?

14.12 **Reference/Further readings**

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14.13 **Unit 3: Tractor transmission system**

14.14 **Contents**

1.0 Introduction
2.0 transmission system
3.0 Clutch and fluid coupling clutch
4.0 Types of clutch
5.0 Transmission gears and torque converter gear
6.0 Differential unit and final drive
7.0 Tutor-Marked Assignment
8.0 References/Further Reading

14.15 **Introduction:**

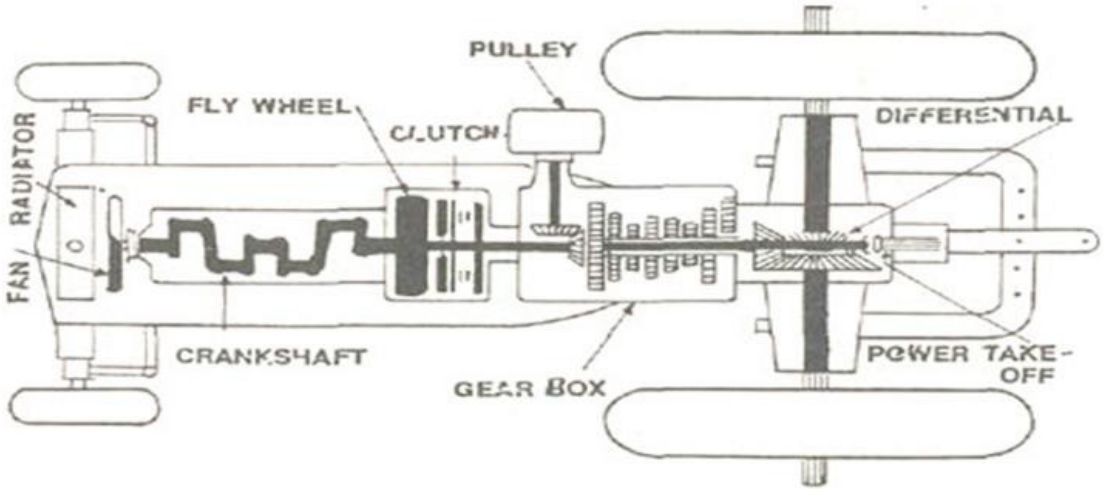
Power transmission system is the next and final stage of the engine generated power before it hits the wheels. The whole system is responsible to couple engine and wheels, driving and adapting the output shaft rotation to a desired speed/torque ratio, allowing a wider range of speed and better performance as the engine.

Transmission is a speed reducing mechanism, equipped with several gears. It may be called a sequence of gears and shafts, through which the engine power is transmitted to the tractor

wheels. The system consists of various devices that cause forward and backward movement of tractor to suit different field condition. The complete path of power from the engine to the wheels is called power train.

14.15.1 **Function of power transmission system:**

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



14.15.2 **Tractor power transmission line**

The major components of a transmission system are:

a) Clutch
b) Transmission gears
c) Differential
d) Final drive

14.15.2.1 ***Clutch and fluid coupling clutch***

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

Necessity of clutch in a tractor: Clutch in a tractor is essential for the following reasons:

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

14.15.2.2 ***Essential features of a good clutch:***

(i) It should have good ability of taking load without dragging and chattering

(ii) It should have higher capacity to transmit maximum power without slipping
(iii) Friction surface should be highly resistant to heat effect
(iv) The control by hand lever or pedal lever should be easy

*14.15.2.3 **Types of clutch***

(1) Friction clutch
(2) Dog clutch
(3) Fluid coupling.

Friction clutch: Friction clutch produces gripping action, by utilizing the frictional force between two surfaces. These surfaces are pressed together to transmit power. While starting the engine, the clutch pedal is depressed. After the start of the engine, the clutch pedal is slowly released to increase the pressure box for onward transmission to the rear wheels. This pressure is obtained by a set of heavy springs, fitted together in housing. Engagement and disengagement of this type of clutch is very smooth due to larger surface area of friction members.

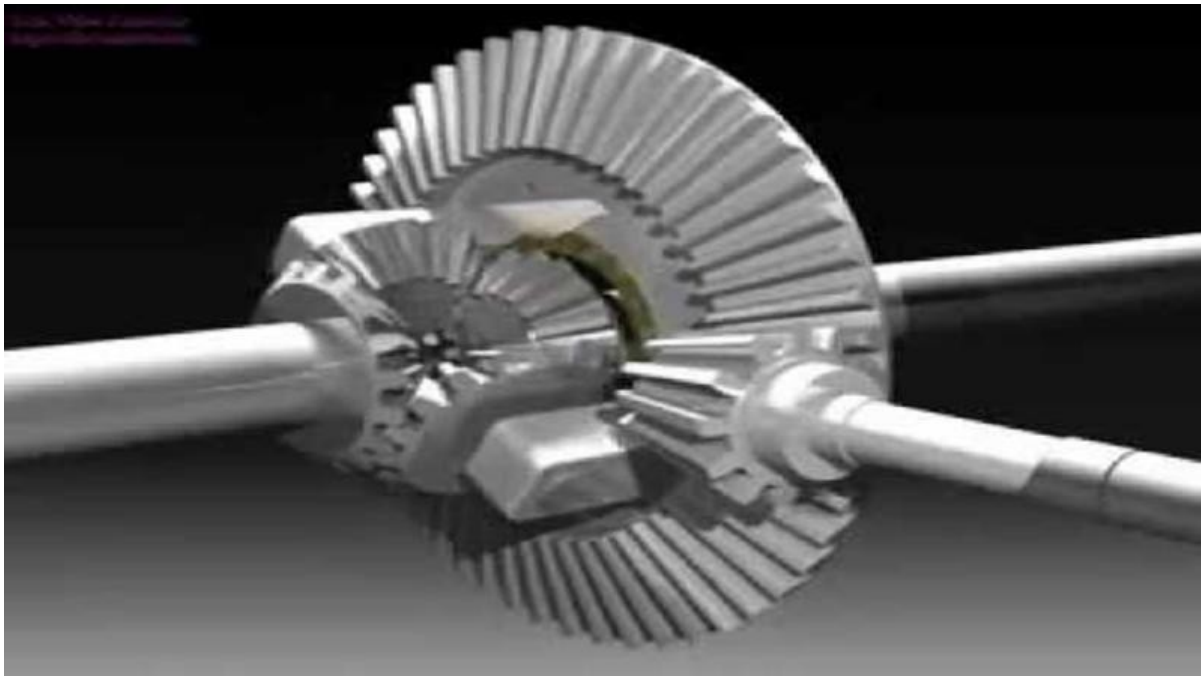
Dog clutch: It is a simple clutch having square jaws, which are used to drive a shaft in either direction. It is mostly used in power tillers.

14.15.3 Transmission gears

A tractor engine runs at high speed, but the rear wheel of the tractor requires power at low speed and high torque. That's why it becomes essential to reduce the engine speed and increase the torque available at the rear wheels of the tractor it is obvious that for higher torque at wheels, low speed is required and vice versa. So the gearbox is fitted between engine and rear wheel for variable torque and speed. This is done by suitable design of gear and shafts. Speed varies according to the field requirements and so a number of gear ratios are provided to suit the varying conditions.

14.15.4 Differential unit and final drive

Differential unit is a special arrangement of gears to permit one of the rear wheels of the tractor to rotate slower or faster than the other. While turning the tractor on a curved path, the inner wheel has to travel lesser the tractor to move faster than the other at the turning point. The output shaft coming from the gear box is provided with a bevel pinion at the end of the shaft.



Differential drive

Differential lock: Differential lock is a device to join both half axles of the tractor so that even if one wheel is under less resistance, the tractor comes out from the mud etc. as both wheels move with the same speed and apply equal traction.
Final drive: Final drive is a gear reduction unit in the power trains between the differential and the drive wheels. Final drive transmits the power finally to the rear axle and the wheels.

14.16 **Tutor-Marked Assignment**

1. What is transmission system of a tractor?
2. State any three function of transmission system?
3. What is clutch and why it's necessary for a tractor?
4. Explain differential and final drive of a tractor?

14.17 **Reference/Further readings**

R.N. Kaul and C.O. Egbo. (1985). Introduction to agricultural mechanization published by Macmillan Education Ltd.
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14.18 **Unit 5: Tractor electrical system**

14.19 **Contents**

14.20 **Introduction:**

Electrical and electronic systems have evolved over the years to become an essential element of modern off-road vehicles. A modern off-road vehicle typically incorporates an electrical system having its own power generation, storage, and distribution. Vehicle controls and diagnostics may have dozens of electronic computer-based controllers integrated into its system. Electrical system of all the tractors is almost same except one or two alterations. In some of the makes of the tractors, alternator has been introduced instead of dynamo for the recharging of a battery.

14.21 **Functions of electrical system for a conventional off-road vehicle are:**

- Engine starting
- Lighting (work and safety)
- Sensing, display, and control
- Air conditioning/Ventilation
- Accessory may include windscreen wiping, entertainment systems, radio, etc.

14.22 **Components of an electrical system**

An electrical system of a tractor consists of the following parts/system below:

1. Battery
2. Charging System
3. Regulating systems
4. Starting system
5. Relays and fuses

Battery: A battery is an electrochemical device which converts chemical energy into electrical energy. Tractors use "lead-acid" batteries. A lead-acid battery uses a series of lead dioxide plates for its positive (+) terminal and porous, soft lead for its negative plates. All the plates are arranged alternately and submerged in a solution of sulfuric acid and water. Chemically, when a battery is connected to an external load (a device which uses electricity) it begins to discharge. As that happens, the lead in the positive plate combines with the sulfate of the acid, forming lead sulfate ($PBSO_4$) in the positive plate. Oxygen in the positive plate combines with hydrogen from the acid to form water (H_2O), which reduces the concentration of the acid in the electrolyte. To know the capacity of battery two methods are adopted. Ampere Hour efficiency or Watt Hour efficiency

14.22.1.1 ***Battery Testing:***

A battery can be tested to ascertain its condition by the following tests.

- Specific gravity test
- Open Volt test
- High discharge test
- Cadmium tip test

Specific gravity test: While the chemical reaction taking place in the battery during discharge, the electrolyte becomes dilute to form water. The proportion of water goes on increasing as the discharging continues. The relative amounts of water and acid is determined by the specific gravity test. This is done by Hydrometer.

Open Volt test: The Open circuit voltage of a fully charged battery cell is about 2.1 volts. This can be measured with the help of a voltmeter. It can be observed that a charge of 0.01 Volt of open circuit voltage is equivalent to a charge of 0.010 in the specific gravity of the electrolyte.

High discharge test: High Voltage of current is required for cranking the starting motor. To satisfy this condition, high discharge test is done with the help of cell voltage tester.

Cadmium Test: The test is done to ascertain whether the battery plates are defective or not. It is done with help of cadmium rod enclosed in a perforated ebonite tube. The rod is immersed in the electrolyte and connected to the negative terminal of a Voltmeter. Its positive terminal is connected alternately to the positive and negative terminals of a battery cell. When connected with positive terminals, the voltage reading should not be less than 2.5 Volts. If it is less it indicates defective positive plates. When connected with negative plates, if it is more than 2.5 Volts, it indicates defective negative plates.

Charging System (Dynamos or Alternators): How the battery gets charged? In older vehicles this was done with a dynamo. After that time all switched to alternators.

Dynamo: This is a device that supplied electricity for lights on the tractor and charge the battery. Essentially an armature rotates between magnetic poles produced by field windings. This generate electricity using the principles of electromagnetic induction and the induced current is picked by commutator. The dynamo is driven by a fan belt from the crankshaft pulley of the engine. Adequate tension in the belt driving the dynamo keeps the battery charged. An automatic device, called a cut-out, is inserted in the circuit to ensure that the battery is disconnected when the engine has stopped or is running at slow speeds, to prevent it discharging to the dynamo. A voltage and current regulator automatically balance the output of the dynamo to meet the needs of the battery.

Dynamo

Alternator: Basically, is similar in principle to the dynamo but whereas a dynamo uses a moving coil to cut a magnetic field, an alternator uses a rotating field coil called the rotor coil, rotating in a stationary stator coil. The alternator also produces alternative current but this is converted to direct current by means of a device called a diode, which allows flow of current in one direction only. Alternator has a higher output at lower engine speeds compared to a dynamo, which is valuable when charging the battery.

Alternator

14.22.2 Regulating system

As, there is no system of internally controlling the output of an alternator or in other words, the faster it spins the more voltage goes into the electrical system. If this weren't controlled the generator would damage the battery and burn out the lights. Also, if the generator weren't cut out from the tractor's circuitry when not running, the battery would discharge through its case.

That's where the **REGULATOR** comes in. Regulators have seen many design improvements over the decades, but the most commonly used electro-mechanical regulator is the three-control units in one box type. These are explained below:

(a) Cut-out relay

Sometimes called the circuit breaker, this device is a magnetic "make-and-break" switch. It connects the generator to the battery (and therefore the rest of the tractor) circuit when the generator's voltage builds up to the desired value. It disconnects the generator when it slows down or stops.

(b) Voltage regulator

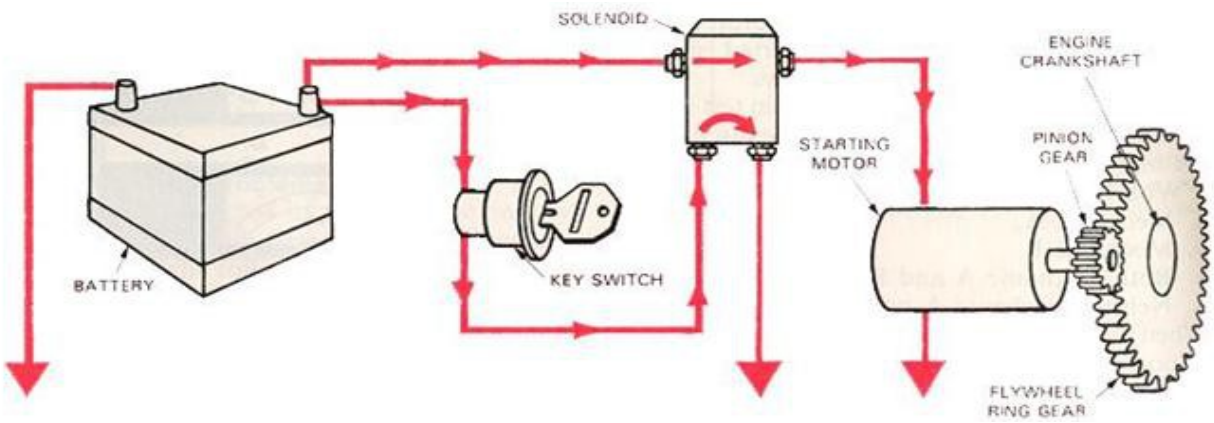
A voltage regulator is used to regulate voltage level. When a steady, reliable voltage is needed, then voltage regulator is the preferred device. It generates a fixed output voltage that remains constant for any changes in an input voltage or load conditions. It acts as a buffer for protecting components from damages. A voltage regulator is a device with a simple feed-forward design and it uses negative feedback control loops.

(c) Current regulator

Even though the generator's voltage is controlled it is possible for its current to run too high. This would overheat the generator, so a current regulator is incorporated to prevent premature failure. Similar in appearance to the voltage regulator.

(d) Starting System:

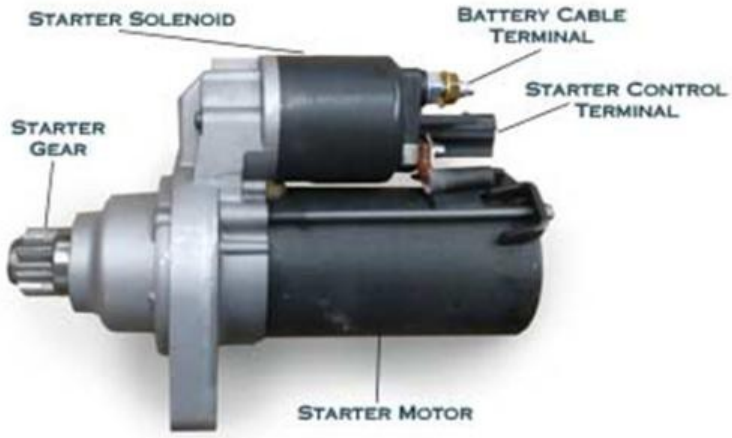
Electrical system only needs 80 to 100 amps of current for general running, even when all accessories are operating. Then, why battery does have a rating of 450 to 740 amps or even more. The main reason for the battery's storage capacity is to operate the starter, and turn the engine to start.



Starting system of a tractor

Flywheel ring gear: This is a toothed ring that is fitted to the outside of the engine's flywheel. Matching teeth on the starter motor mesh with this gear in order to spin the crankshaft.

Starter: A starter is an electric motor that turns over or cranks the engine to start it. It consists of a powerful DC (Direct Current) electric motor and the starter solenoid that is attached to the motor.



Starter

14.22.3 **Relays and fuses:**

All tractors are wired so that the battery's main cable connects to the starter motor windings. This wire must be switched on and off, and it would be costly and inefficient to route it through the ignition switch. Hence a relay is necessary.

Relay: A relay is an electrically operated or electromechanical switch composed of an electromagnet, an armature, a spring and a set of electrical contacts. The electromagnetic switch is operated by a small electric current that turns a larger current on or off by either releasing or retracting the armature contact, thereby cutting or completing the circuit. Relays are necessary when there must be electrical isolation between controlled and control circuits, or when multiple circuits need to be controlled. Relays are used for horns, electric fans, air conditioning clutches, etc. and the most important one is the starter solenoid.

Relay

Fuses are designed to fail when too much current is drawn through the device. This prevents heating of the wires and subsequent melting of the insulation, followed usually by fire! Fuses are simple in design. Inside a fuse is a soft wire with a specific cross-sectional thickness. This dimension dictates how many amps can be carried before the wire melts. Too many amps cause the fuse to fails and saving rest of the circuit from damage.

Fuses

14.23 **Tutor-Marked Assignment**

1. List any Four (4) function of electrical system in a tractor?
2. Identify any Five (5) component of an electrical system?
3. What is the different between generator and alternator?
4. Differentiate between relay and fuses?

14.24 **Reference/Further readings**

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14.25 Unit 6: Tractor hydraulic system and three-point linkage

14.26 Contents

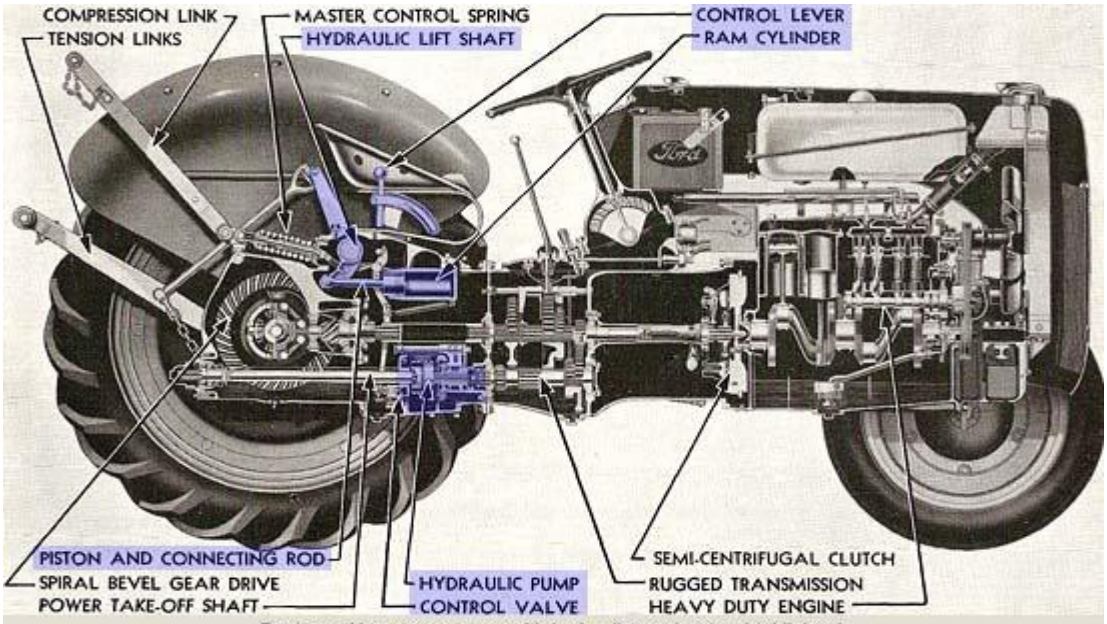
14.27 Introduction:

Hydraulic system is a mechanism in a tractor to raise, hold or lower the implement or equipment. All tractors are equipped with hydraulic control system for operating three-point hitch of the tractor.

Working Principle: The working Principle of hydraulic system is based on Pascal's law. This law states that the pressure applied to an enclosed fluid is transmitted equally in all directions. Small force acting on a small area can produce higher force surface of larger area.

Operation: The hydraulic pump draws up oil from the oil reservoir and sends it to the control valve under high pressure. From the control valve, the oil goes to the hydraulic cylinder to

operate the piston, which in turn, raises the lifting arms. The lifting arms are attached with implements. The hydraulic pump is operated by suitable gears, connected with engine. There are two types of arrangements for storing hydraulic oil in the system



Fordson 9N tractor cutaway with hydraulic mechanism highlighted.

Tractor hydraulic system

14.28 **Basic component of hydraulic system**

The basic components are:

1. Hydraulic pump
2. Hydraulic cylinder and piston
3. Hydraulic tank
4. Control valve
5. Safety valve
6. Hose pipe and fittings and
7. Lifting arms

1**. Hydraulic pump.** There are several types of hydraulic pump such as gear pump, plunger pump, vane pump, and screw. Gear pump is widely used in tractors. Gear pump can flow a bigger amount of oil, compared to plunger pump. The oil pressure in the pump varies from 150 to 200 kg/cm^2.

2. Hydraulic cylinder. It is a bigger size cylinder, fitted with a piston and a connecting rod. It is also called Ram cylinder. The connecting rod transmits power from the piston to the lifting arms. Piston moves in the hydraulic cylinder and causes reciprocating motion in the cylinder. The lifting arms are raised by the hydraulic pressure while raising the implement but it is lowered, by its own weight.

3. **Hydraulic tank**. Hydraulic tank is used for storing hydraulic oil for the system. In some tractors, transmission chamber itself works as a hydraulic tank and same oil is used for transmission system well as hydraulic system. In some tractors separate tank is there for hydraulic oil.

4. Control valve. Control valve is a type of valve, which controls the movement of hydraulic oil to have desired direction, magnitude and speed of lifting. Thus control valve is to perform three functions:

1. To change the direction of lifting

2. To change the power of lifting
3. To change the speed of lifting

Control valve is operated by hand lever and it is of two types: Manual type and Automatic Type Manual type valve is used mostly for small tractors and there are only three positions in this case: up, down and neutral. In Automatic type, there are more than three positions. Any of the positions inside the quadrant can be chosen for operation.

Oil filter: It is small filter, located at a convenient position in the passage of the oil.

14.29 Types of hydraulic system

There are three important methods in hydraulic control system:

Position control. In this system, constant depth, of ploughing is maintained by automatic adjustment of draft of tractor. The control valve can be operated directly by the driver to raise, lower or hold an implement, mounted on the linkage at any chosen height.

Draft control. In this system, the working depth of any implement can be controlled continuously without the need for a depth wheel on the implement. The hydraulic control valve reacts to changes in the loading in either the top or lower links which are due to changes in the draft or pull required by the implement. If any implement goes too deep its draft increases. This increase is sensed through the top link or lower links. The control system then raises the implement until the draft is back to the present level and the implement is at the original depth again using the draft control system.

Mixed Control. It is a combination of Position control and Draft control.

14.30 Three-point linkage

In the three-point linkage the implement is connected to the tractor hydraulic system at two bottom links and one top link. Both the bottom links are connected to two lift arms through lift links. The lift arms are directly mounted on a rock shaft which is further connected to the piston rod. Any movement of the piston is transferred to the bottom links. The top link is used for connecting the third hitch point of the implement and is adjustable for maintaining the implement level and suction angle. Load sensing for the draft control can also be done through the top link which is spring loaded. In some tractors the lower links are spring loaded for draft sensing. Depending upon the soil condition and type of operation the mounted implement can be controlled either by Position control or Draft control.

14.31 Tutor-Marked Assignment

1. Define hydraulic system of a tractor?
2. List and explains any Five (5) hydraulic components?
3. What are the types of hydraulic systems?
4. Explain three-point-linkage?

14.32 Reference/Further readings

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14.33 **Unit 7: Tillage requirement and implement selection**

14.34 **Contents**

14.35 **Introduction**

Tillage of soil is considered to be one of the most difficult farm operations and therefore selection of tillage implements for seed bed preparation and weed control depends on soil type and condition, type of crop, previous soil treatments, crops residues and weed type.

Tillage operation requires the most energy and power spent on farms. Therefore, draft and power requirements are important in order to determine the size of the tractor that could be used for a specific implement. The draft required for a given implement is also be affected by the soil conditions and the geometry of the tillage implement. The unit discussed basic requirement and selection of implement.

Requirement for tillage equipment and selection: Plows and chisel plows have the highest energy requirements among the various tillage machines. Reducing the intensity of tillage will considerably reduce the energy required per m tillage width. In addition, soil type and moisture are important for the actual energy requirement and must be taken into account. The numbers given are only relevant for the tractor power requirement caused by the tillage implement. The tractor itself needs further power to overcome rolling and slope resistance.

In selecting suitable tillage implements for a particular farm situation, draft power requirement data is an important factor. Draft power requirement of each soil types differs; hence operational implement tests should be conducted on each soil type. Farm managers and consultants can only make informed and sound decision on selection of tractors and implements based on their performance parameters. Proper selection and matching of implement onto the tractor is essential to reduce operational cost and this will also ensure efficient farm machinery use.

Implement specifications, such as effective working width, working depth and operational forward speed affect draft power requirements significantly. Draft is affected by soil conditions such as the soil moisture content, clay content and soil hardness. Instrumentation such as a three point hitched dynamometer for measuring draft, a GPS for measuring forward speed and a fuel meter for measuring fuel consumption are used to determine drawbar power on implements. A telemetry communication systems are used to communicate between the data logger on the tractor and a base station along the field where the computer is connected. However, draft can also be calculated manually from unit draft.

Draft = cross-sectional area of cut by the implement (cm^2) X soil resistance (N/cm^2)

matching tractors and implements can increase efficiency of operation and farm profitability. The results of correct matching include reduced power loss, improved operating efficiency, reduced operating costs and optimum use of capital on fixed costs. Poor selection and use of mechanization inputs have led to heavy financial losses and lowered agricultural production. Most often farmers depend very much on their experience to match tractors and implements. This may likely make the system to operate at less than optimum efficiency. It is thus important that both units be selected in such a way that power generated by the tractor is fully utilized of tractor and implements. Therefore, it is necessary to carry out the following:

- Predict the draft and power requirement of the implement taking into consideration factors such as depth and speed of operation, implement width and soil condition.
- Predict the tractive capability and the drawbar that can be available on the tractor by considering factors such as vehicle configuration, weight distribution, ballasting, tractive device type, and terrain conditions.

14.36 **Tutor-Marked Assignment**

1. What are the major parameters in selection of tillage equipment?
2. State the expression for calculating draft?
3. List any three factors that affect draft power requirement?

14.37 **Reference/Further readings**

R.N. Kaul and C.O. Egbo. (1985). Introduction to agricultural mechanization published by Macmillan Education Ltd.

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14.38 **Unit 8: Row crop planter and grain drills**

14.39 **Contents**

14.40 **Introduction:**

Grain drills and planters, regardless of type, operate in the same basic principles. Seed is held in a box (hopper) while a mechanism driven by the ground wheels or disks drops seed at a metered rate. Seed falls to the soil surface where some form of compaction seals it in the ground. Seed boxes come in three configurations, standard, legume, and native grass (fluffy) seed. Each box is designed to handle specific seed and can usually be calibrated independently of one another. This attribute is very helpful when planting mixes of seed to achieve the desired rate of each species. Standard seed boxes are designed to handle large smooth seed similar to corn, soybeans, peas, wheat, oats, etc. They may or may not have agitation to keep seed moving. They generally rely on the smooth nature of the seed and gravity to feed the planting mechanism. These seed boxes will not handle light, fluffy seed.

Seed will bridge on itself and not feed properly; clogging the planter. It is also difficult to calibrate with tiny seed such as clovers. Small seeded species require a smaller delivery mechanism to achieve the correct planting rates. Seed is typically delivered from the seed box through drop tubes to a set of disc shaped "V" openers where it falls into a slice in the soil left by the openers before being covered and sealed with some form of compaction device. The legume box is designed to handle extremely small seed, and is much smaller in size than the standard seed box. Operation is generally the same and relies on gravity to feed the mechanism delivering seed to the drop tubes. The drop tubes deliver seed to the ground surface just in front of a compaction device such as press wheels or a cultipacker. Seed is planted shallower than seed from the standard seed box. Large seed can jam the smaller delivery mechanism of the legume box and should not be used.

The native, or fluffy seed box is similar to the standard seed box, but has some form of aggressive agitation within the box to keep seed moving so it doesn't bridge on itself. Many will have a "pick" wheel mechanism that reaches up into the seed box and pulls seed down into the machine to deliver it to the drop tubes. The drop tubes are much larger in diameter to help prevent seed from bridging.

Row-crop planter: is a machine that has an arrangement that can be used to vary the spacing between plants on the same row or ridge (in addition to being able to vary the spacing between rows).

14.40.1 Planter components

The major planter components are as follows:

I. **Seed hopper**: the seed to be planted are held by the seed hopper. It may be made of sheet metal or plastic, or a combination of materials. Metal hoppers may have a seed-level indicator, which tells the operator when it is time to refill the seed hopper. Plastic hopper is translucent and the seed level can be seen through the side of the hoppers. It may also be in trapezoidal, rectangular or oval shape. The capacity of a hopper may also vary; depending on the size of the machine. Making the hopper trapezoidal helps to ensure free flow of seeds. Seed hoppers are provided for each row and may be a separate hopper for fertilizers.

II. **Seed metering mechanism:** Is the most important part of the planter. This mechanism controls the spacing between seeds dropped on the same row or ridge, as well as to control the spacing between consecutive rows of seeds. It is located at bottom part of the hopper. The metering mechanism exist in different type and size such as: Horizontal plate inclined, vertical rotor, Belt type precision, finger pick up type, pneumatic and fluted feed roller. Although fluted feed rollers are no longer used in most of the manufacture`s because of in accuracy for uniformity when varying a speed of a rotating shaft which causes opening gate to opened wider than expected and more seed is release.

The seed plates metering mechanism has cells or pockets cut into its periphery that receive the seed from hopper, after receiving the seeds the plate move under a cut off. The number of cells depends on the spacing desired and the shape of the cell is best on the type of seed to be planted. Different seed plates of planter exist such as edge-drop plate, flat-drop plate, full-drop plate, etc.

Seed plates

III. **Seed tube**: Is used to carry the seed from the seed metering mechanism to the furrow opener. The tube may be either of the collapsible type or rigid. The length of a collapsible tube can be altered, either by telescopic action or by a spring coil. The seed tube can be made of plastic or metal.

IV. **Furrow openers:** Planters are provided with furrow openers which sometime called runners. Some of the tractor drawn maize planters use a lister plough bottom to open furrow and two small shovels to cover the seeds. This arrangement is common in dry areas where moisture conservation is main aim.

The main types of furrow openers used commonly with fertilizer drills/planters are:

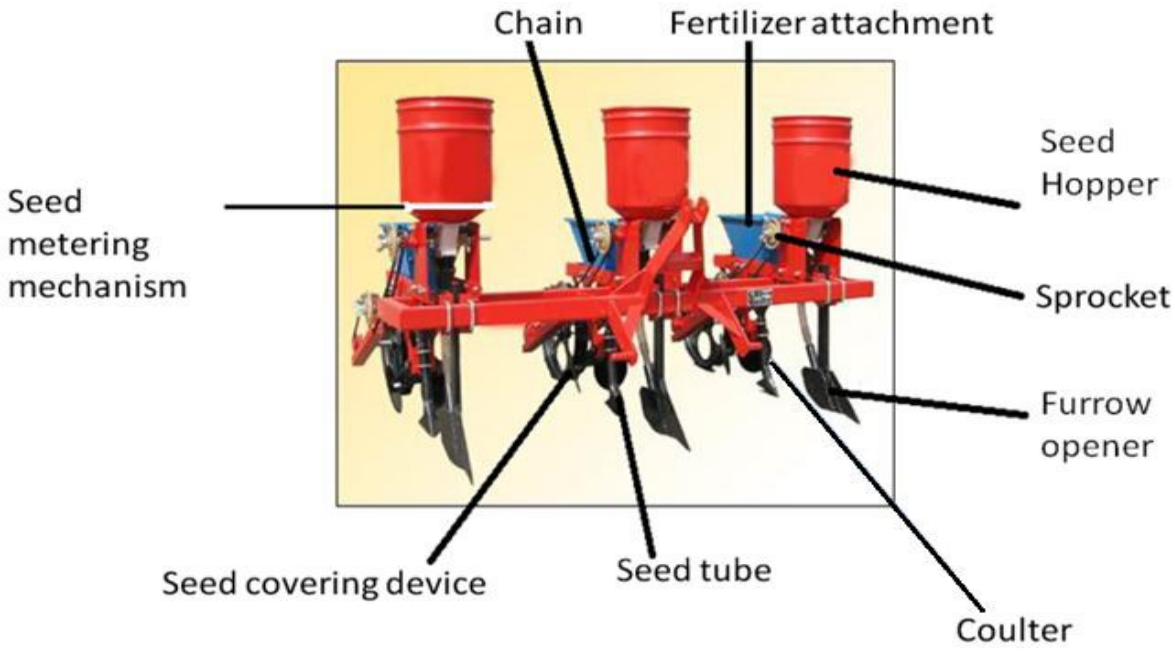
V. **Covering device:** This component has the function of covering the seed that has been planted in the opening made by the furrow opener. Normally when the furrow opener makes a furrow, the soil falls back and covers the seed. However, sometimes the moisture content of the soil and the type of soil may be such that the furrow opened remains uncovered. This can lead to loss of seed (because birds can eat it more easily) or the seed may not germinate because it is not in contact with the soil. Therefore, some form of covering device should be provided. The covering device may take the form of a simple chain which is pulled behind the furrow opener and which throws back the soil over the seed. Another type is the press wheel which is a wheel that follows the furrow opener and gently compact the soil around the seed as it is delivered.

VI. **Fertilizer attachments**. Apply "starter" fertilizer at planting time approximately 5cm below the seed depth and 5cm to the side of the row. Apply herbicide and insecticide in liquid form; or in dry –granular form in small amount over the row, usually at the rate of few kilograms per hectare. Granular applicators are mounted on each row unit and can be driven by the press wheel or by the main drive of the planter.

VII. **Tillage attachments.** No- till planters required more weight and down pressure spring to plant unprepared seedbeds. Two no-till planter attachments that help prepared the seedbed without prior tillage are: fluted coulter and ripple coulters

Fluted coulter prepares a seedbed approximately 7.5cm wide and 10 to 13cm deep
Ripple coulter prepares a seedbed approximately 2 to 4cm wide

VIII. **Seed monitors**. Modern planters are often fitted with seed monitor each time a seed is dropped, using an electric eye. They can also indicate the population being planted in each row.



Tractor mounted row crop planter

Grain Drill: is a planting machine that has an arrangement that can be used to vary the distance between rows of planting (in addition to any other features). This machine placed seeds in a continuous flow in a furrow at uniform rate and at controlled depth with or without the arrangement of covering them with the soil. The machine meter and carried the seed to the opened furrow at the uniform depth. The machine covered the seeds and compacted the soil around the seed. However, some seed drill has a fertilizer attachment and it's called seed cum fertilizer drill. Such drill has a larger seed box which is divided length-wise into two compartment, one for seeds and other for fertilizers. Seed drill may be classified as:

1. Bullock drawn
2. tractor drawn

Depending upon the method of metering the seeds, bullock drawn seed drill can be further divided into two groups: Those in which seeds are dropped by hand, or mechanically. There are a number of bullock drawn implements which are used for sowing seeds in which seeds are dropped by hand. The most popular implement is Three tined cultivator with Seeding attachment. In different parts of the country it is made in different sizes and shapes.

Tractor drawn grain drill

14.40.2 Components of grain drill

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

1. Frame
2. Seed box
3. Seed metering mechanism
4. Furrow openers
5. Covering device
6. Transport wheels

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

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

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

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

Seed metering mechanisms: Is the mechanism of a seed drill or fertilizer distributor which deliver seeds or fertilizers from the hopper at selected rates

14.40.3 Common Problems to Avoid with Planters and Grain Drills

- Planters and seed drills are complex machines that require routine maintenance such as lubrication and cleaning. Store them out of the weather if possible.
- Always clean the seed from the boxes after planting. Seed left in the box could become wet and mold or germinate in the seed box creating oxidation and corrosion of the internal mechanisms and clog the drop tubes. Seed also attracts mice and rats which will chew plastic and create potential health hazards.
- Always inspect the planter or drill before use. Spiders, insects, and mice can clog drop tubes with webs and debris when planters sit idle. Use an air compressor to blowout the drop tubes to make sure they are clear. Check to see that all the tubes are dropping seed when calibrating the planter. Check the planter often when in use to insure all

seed boxes have adequate, evenly distributed seed, and that the drop tubes are putting out seed.

- Never back up with the planter down, especially planters with "V" openers. This pushes rocks and soil into the openers and drop tubes jamming them. "V" openers that cannot rotate freely will not work properly.
- Visually Check the drive mechanism often while in use. This is very important with planters that are driven by disks or coulters. Debris, particularly wood, can get stuck on these and prevent them from rotating or functioning properly. If the drive disk isn't moving the planter is not planting.
- Always check the planting depth by planting a short distance and gently digging down until you find seed. Make adjustments as needed to the planter or the hydraulic setting of the tractor. This is especially critical with no-till drills. May be lengthened or shortened to change the angle of the planter and help with depth adjustments or the depth at which the front coulter cuts on a no-till drill.
- On planters with "V" openers, make sure the press wheels are sealing the opening. Make adjustments as needed to insure a firm seal without excessive packing.
- Avoid planting into soft, unpacked seed beds with drill type planters. The loose soil will sluff off into the tracks left by the press wheels and bury seed too deeply after the first rain.
- When planting native or fluffy seed, always use debearded seed if possible. Add a dry seed lubricant such as powdered graphite to facilitate seed flow and reduce bridging. Check drop tubes often during plantings to insure they are putting out seed. A planter with a picker wheel mechanism will greatly increase reliability.
- Use the appropriate seed boxes. If small seed is mixed with large seed in the standard seed box, vibration from use will settle the majority of it at the bottom of the box. This will more than likely result in a higher than desired rate for the small seed, causing the user to run out of small seed, and non-uniform seed distribution.

14.41 **Tutor-Marked Assignment**

1. Differentiate between planter and grains drill?
2. List and explain Four (4) major component of planter?
3. State any Four (4) factors to considered in operating planter and grain drills?

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15 MODULE 6: FORAGE HANDLING

Unit 1: Mowers and Rakes

Unit 2: Forage harvester

15.1 Unit 1: Mowers and Rakes

15.2 Contents

15.3 Introduction:

Grass constitutes an important feed item for animals but, as human beings consume food that has been processed in different ways, so animals may be fed grass in different forms such as fresh grass, dried grass or processed and fermented grass (silage). The unit discussed some of the equipment used for forage handling in livestock management.

15.4 Mower

Mowers are intended primarily for cutting grass but may be adopted for use in harvesting cereals like wheat. There are two types of mower generally used:

1. Cutter bar mowers;
2. Rotary mowers,

Both types can be either self-propelled or tractor-powered. The rotary mower are generally machines of small size, whereas the larger machines also perform other functions, such as conditioning. Small walking mowers, which represent the first step of agricultural mechanization, are self-propelled; they adopt single action cutter bars no wider than 1–1.5 m.

15.4.1 Cutter bar mowers

The cutter bar mower has two plates, one of which is stationary. The other plate moves backwards and forwards against the stationary plate as the mower passes through the crop by shear action, rather like a pair of scissors. The stationary plate is called the **ledger plate** and movable plate is the **sickle section or knife section**. Usually several units of these (ledger and sickle section) are mounted on a plate or bar called the cutter bar, the number of units depending on the type and amount of power available. Again, as a pair of scissors, for normal cutting action a particular clearance must be provided between the two plates. If there is too little or too much clearance the cutting action will be impaired, so ensure the correct clearance between the two plates the knife section is held against the ledger plate by a component called a **knife clip**. On a cutter bar several such clips are provided.

The sickle section is driven from the tractor power take-off by a gear system. The rotary motion from the power –take-off is converted to reciprocating motion for the sickle by means of a crank and pitman (or connecting rod) attachment. The pitman is attached eccentrically to the crank so that, as it rotates, the rotary motion of the crank is converted to to-and-fro (reciprocating) motions.

The cutter bar unit slides along the ground on a form of skid known as shoes. The shoe closest to the uncut crop is called the outer shoe and the one closest to the tractor is the inner shoe. The outer shoe also acts as a divider for demarcating or separating the crop width to be cut at any time for the uncut crop. Both shoes have removable linings which may be replaced as needed.

Animal-drawn mowers are also commonly used. The principles are the same as for the mower described above, but the power for the cutting mechanism is taken from one of the drive or transport wheels.

Cutter bar mower

15.4.2 **Rotary mower**

A rotary mower has one or more rotating blades mounted either horizontally or vertical, and is generally used for cutting down weeds, stalks and brush. As rotary mowers are low in height they are commonly used to clear weeds under trees in orchard. It has a robust construction and low maintenance requirements, but require more energy than cutter bars

Rotary mower

15.5 **Raking equipment**

Rake: Is an implement that are used for drawing together cut grass or smoothing loose soil or grave. The implement can be manually The or power operated. In livestock production mostly animal or tractor mounted rake are being used. This unit will discuss different rake used livestock management.

15.5.1 **Hay Rakes**

use of hay loaders and pickup balers created a demand for a hay rake that makes a loose, fluffy and continuous windrow. Hay rake is an agricultural rake used to collect cut hay or straw into windrows for later collection. It is also designed to fluff up the hay and turn it over so that it may dry. It May be used in the evening to protect the hay of the dew. The next day a tedder is used to spread it again, so that the hay dries more quickly. A hay rake may be mechanized, drawn by a tractor or draft animals, or it may be a hand tool. The earliest hay rakes were nothing more than tree branches, but wooden hand rakes with wooden teeth, similar in design to a garden rake but larger, were prevalent in the 19th and early 20th centuries, and still are used in some locations around the world.

Hay rakes can be classified as side-delivery and sweep. Side-delivery rakes are further classified according to the types of reel construction such as cylindrical-reel, parallel bar or side stroke and finger wheel. The reel bars are attached to three spiders and the rake teeth are curved forward near the end to aid in picking up the hay. Most teeth are made of spring steel and have a coiled section next to the reel bar. While in contact with hay, the teeth are held at an angle with the points leading. This gives a pushing with a slight lifting action to the hay.

Mechanical rake known as the side delivery rake usually had a gear-driven or chain-driven reel mounted roughly at a 45-degree angle to the windrow, so the hay was gathered and pushed to one side of the rake as it moved across the field as shown below. A side delivery rake could be pulled longitudinally along the windrow by horses or a tractor, eliminating the laborious and inefficient process of raising, lowering, and back-and-forth raking required by a dump rake. This allowed for the continuous spiraling windrows of a farm hayfield. Later versions of the side delivery rake used a more severe transverse angle and a higher frame system, but the basic principles of operation were the same. Later, a variety of wheel rakes or star wheel rakes were developed, with 5, 6, 7 or more spring-tooth encircled wheels mounted on a frame and ground driven by free-wheeling contact as the implement was pulled forward.

Side delivery rake

The type of side delivery rakes are Reel-type units and Finger-wheel units. All reel type rakes were of the cylindrical-reel type. The tooth rotated in parallel positions in planes perpendicular to the reel axis, similar the pickup reel. The reel heads are set at a horizontally acute angle from the reel axis but in parallel planes. The tooth bar ends are shaped so the axes of the tooth-bar bearings are perpendicular to the planes of the reel heads. This arrangement automatically maintains the teeth in parallel positions as the reel rotates. The horizontal path of any tooth is in a plane parallel to the reel-head planes. Thus the horizontal movement of the teeth with respect to the rake can be 85° to 90 ° from the direction of forward motion.

Finger-wheel units: As finger rake has a series of individually floating, ground-driven wheels set at an angle to the direction of motion and overlapping each other. Each wheel is partially counterbalanced with a tension spring and has spring teeth around the periphery that operate in light contact with the ground. The floating feature allows the rake to adjust itself to the contour of surface irregularities such as irrigation levees or terrace channels. Wheel tooth-tip diameters are usually about 1.5 m.

Finger wheel rake

Parallel-bar or side stroke hay rake: May have four to six reel bars attached to two parallel plates or spiders at each end of the reel. The plates are set at right angle to the direction of travel. As the reel revolves, each bar rotates within the bearing mounts to keep the teeth in a vertical position at all times. When a bar approaches its lowest position, teeth come in contact with hay and rakes for a short distance. The next bar follows it.

Sweep rake: Is sometimes called a buck or bull rake. It collects hay from the windrow and transports for short distance to a stationary baler or stack.

15.5.2 **Desirable characteristics of hay rakes:**

The following are the some of the desirable characteristics of hay rakes:

a) The amount of leaf loss due to shattering.

b) The amount of hay missed.

c) The amount of trash, dirt etc. put into windrows.

d) Uniformity and continuity of windrow.

e) Amount of leafy portion in centre of windrow and stems toward the outside.

The amount of leaf loss is affected by the distance the hay is moved from swath into windrow, average hay velocity, type of hay moving action i.e. rolling, lifting or dragging and periodic impact of rake teeth upon the hay. Average hay velocity is affected by forward speed and high forward speed increases the leaf shattering.

15.5.3 **Rake and spreader used in construction**

Rakes are used in road works for raking out vegetation from loose soil. Commercially produced rakes have 10 to 16 teeth, each about 75 – 100 mm long, with an overall length about 400 – 450 mm. Spreaders are useful when forming the camber and when spreading gravel. Spreaders are made of sheet metal (2 - 3mm thick) with ridges on one side, which are used to level the road surface according to set levels and gradients The handles for both tools should be long enough to allow the worker to operate comfortably in a standing position.

15.6 Tutor-Marked Assignment

1. What is mower?
2. List and explains two types of mower?
3. What is hay rake?
4. List any Five (5) characteristic of hay rake?

15.7 Reference/Further readings

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