NATIONAL OPEN UNIVERSITY OF NIGERIA

SCHOOL OF SCIENCE AND TECHNOLOGY

COURSE CODE: 314

COURSE TITLE: INTRODUCTION TO FARM MECHANIZATION

COURSE CODE: **314**

COURSE TITLE: **INTRODUCTION TO FARM MECHANIZATION**

COURSE UNIT: **TWO**

COURSE WRITER: **DR. (ENGR) F.O. ADEGUNLOYE**

DEPARTMENT OF AGRICULTURAL

SCIENCE ADEYEMI COLLEGE OF

EDUCATION, ONDO.

SEPTEMBER 2009

CONTENTS

COURSE OUTLINE

Aims & objectives of agricultural Mechanization

Basic machines

Workshop tools

Principles of ICE

Study of Farm Machinery use for Tillage: Ploughs, Harrows, Cultivators. Farm Power Transmission systems, Harvesting and Processing equipment (sprayers & dusters). Operating Principles of Farm Machinery. Workshop and building materials used on the farm.

1.0 Introduction

Machines are generally used to do work. Various works exist on the farm. For example, land clearing, land preparation for planting, crop planting and crop harvesting. Machines are now used to carry out these works on the farm. The use of machines make such works less tasking and farmers then find farm works interesting and pleasant to do.

Agricultural mechanization is a special field of Agricultural Engineering. It is a way of improving farming operations through the use of machines, equipment and structures to enhance productivity. This unit brings into focus the usefulness of agricultural mechanization.

1.1 Objectives

By the end of this unit, you should be able to

a. define and enumerate the objectives of farm mechanization;
b. know the principles/uses of simple machines and workshop tools;
c. distinguish between petrol and diesel engines as internal combustion engines;
d. study the machinery used for tillage operations,
e. describe the systems of power transmissions;
f. describe the harvesting and crop processing equipment;
g. learn the management and operating principles of farm machinery and
h. itemize the workshop and building materials used on the farm.

I.2 Farm Mechanization

Farm Mechanization is the use of machines for various farm operations to encourage efficiency and guarantee increased productivity.

It is also the application of engineering principles for operating farm machines with a view to increasing farm operations and output.

1.3 Aims & Objectives of Agricultural Mechanization

As indicated in the definition, Agricultural mechanization is aimed at meeting the following objectives:

- To increase efficiency of production
- To reduce farm drudgery
- To encourage farmers to practice large scale farming
- To increase yield of farm produce
- To reduce farm hazards
- To enhance the quality of farm produce
- To ensure that farm work is carried out very fast. i.e to encourage timeliness of farm operations.
- To enable farmers maximize their profits.
- To reduce poverty and facilitate farmers to increase their incomes thus improving their standard of living.
- To save labour through human labour replacement with machines. In doing this, labour is released to other services and industries.
- To make farm work easy, interesting and attractive to youths.
- To bridge the gap between the demand for and the supply of good quality food.
- To supply agro-based industries with adequate and good quality raw materials.
- To encourage investment in agriculture.
- To facilitate the establishment of small scale industries and processing units in the rural areas.

2.0 Basic Machines

A machine is an appliance or piece of equipment that uses power to do a particular job. e.g the raising upward of a heavy load with a relatively small force. Examples of power for doing work are mechanical and electrical.

Machines are used in the production and processing of crops. For instance, mowing machines, threshing machines. In principle, a machine gives a mechanical advantage which facilities the doing of work.

In mowing or threshing machines or other type of machines, they are made up of many simple machines. These simple machines are sometimes called basic machines.

There are six basic machines:

1. The lever
2. The pulley system
3. The wheel and axle
4. The inclined plane
5. The screw and gears
6. The wedge

It is important to note that any basic machine has the capacity to transmit work done upon it to some other body or bodies. Some properties common with basic machines are mechanical advantage, velocity ratio and efficiency.

Mechanical Advantage (M.A.) of a machine is the ratio of the force delivered by the machine to the force applied. The force delivered by the machine is the load (W) while the force which operates the machine is called the applied force (effort).

Thus, $MA = \frac{\text{Load}}{\text{Effort}} = \frac{\mathbf{W}}{\mathbf{F}}$

Mechanical Advantage is a ratio and does not have units.

Velocity Ratio (V.R) = $\frac{\text{Distance moved by effort}}{\text{Distance moved by load}}$

If d_e represents the distance moved by effort and

d_l represents the distance moved by load

Then $V.R. = \frac{d_e}{d_l}$

Efficiency: The efficiency of the machine is the ratio of the work done by the machine to the work done on it.

$$\text{Thus Efficiency} = \frac{\text{Work done on the load}}{\text{Work done by the effort}}$$

$$\text{Efficiency} = \frac{\text{M.A.}}{\text{V.R}} \times \frac{100}{1}$$

Efficiency is always expressed in percentage. It is particularly necessary to note that efficiency of machines is always less than 100%. This is because in machines where there are shafts rotating in bearings, part of the power put into the machine is used in overcoming the resistance of the bearings called friction. If friction is neglected, the work done by the machine (through the load) must be equal to the work done on it (through the effort). Because there is a loss due to friction, the efficiency of the machine is less than 100%.

Let us consider instances of the basic machines.

2.1 The Lever

The lever is the simplest form of machine. For example, a long pole or a rigid bar that is pivoted on a fulcrum to raise heavy objects (fig 2.1). The fixed point at which the straight long pole or rigid bar rotates is the fulcrum. A load of mass 300kg could be easily lifted by a man with the lever in fig 2.1

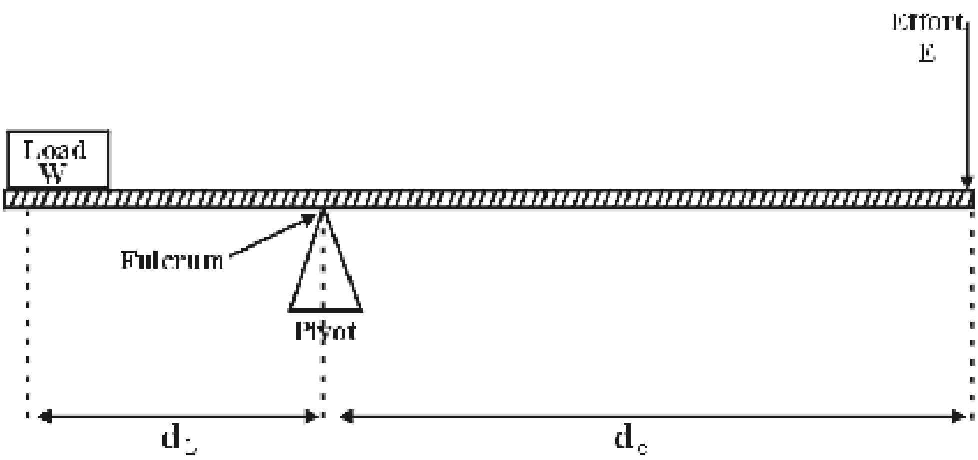


Fig 2.1 A lever for raising a heavy load
Source: Authors Assumption (2009).

Example 2.1

In fig 2.1. Let the effort E acting as a force at A be 245N to lift a load of mass 300kg when the distance of the load from the fulcrum is 2m while the distance of the effort from the fulcrum is 6m. Find

i). the M.A. and
ii). The V.R. of the system

Solution

The mass to be lifted must be expressed in terms of force in Newtons, N. Recall that Force = mass x acceleration due to gravity.

Remember too that acceleration due to gravity $\boldsymbol{g = 9.81m/s^2}$

Thus **W** = 300kg x 9.81m/s^{2-}

= 2943N

i). **M.A.** = $\frac{\text{Load}}{\text{Effort}} = \frac{2943\text{N}}{245\text{N}}$

= 12.01

ii). **V.R**. = $\frac{\text{Distance moved by effort}}{\text{Distance moved by load}}$

= $\frac{6\text{m}}{2\text{m}}$ = 3

2.2 The Pulley System

Let us consider a single fixed pulley as shown in fig 2.2. A rope over the pulley is used to lift the load W at the other end by pulling the rope at one end.

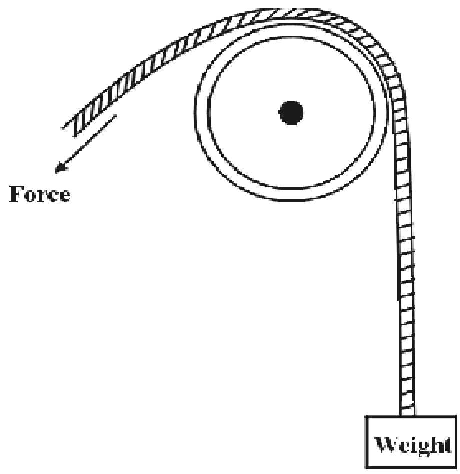


Fig 2.2: Single Pulley
Source: Harris et al (1981)

The pulley is made up of a grooved wheel which can turn easily and freely in a frame referred to as a block. The distance moved by the effort downwards is equal to the distance moved upwards by the load. Thus if the distance moved downwards by the effort is 1.5m, then the distance moved by load is also equal to 1.5m. Hence its Mechanical Advantage (M.A.) must be equal to 1 because the force with which the load is pulled down must be equal to the load being lifted.. On the other hand, when one or more fixed pulleys and one or more movable pulleys are used in combination as shown in fig 2.3, they form the block and tackle.

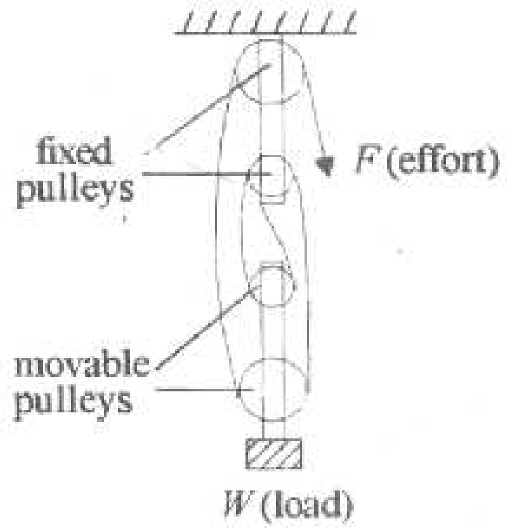


Fig. 2.3: Block and tackle
Source: Claude Culpin (1981)

The distance moved by the effort through the pulling of the rope is equal to twice the distance moved up by the load. The Mechanical Advantage M.A. is 2. The M.A. varies directly as the number of ropes that support the movable pulley and the weight.

Example 2.2

A pulley system has four pulleys, two on the fixed upper block while the other two are on the movable lower block. The effort F is to raise a load W.

i) Draw the diagram of the system

ii) Estimate the Mechanical Advantage of the system.

Solution:

(i) The diagram is shown fig 2.4

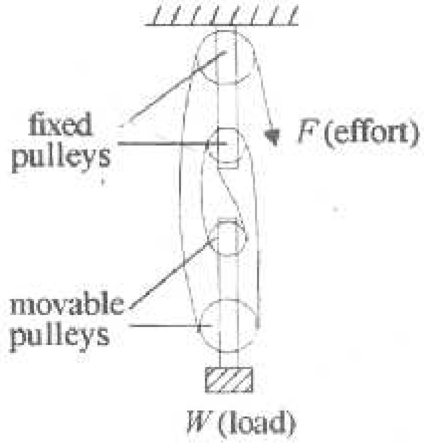


Fig 2.4: Block and tackle with 4 pulleys
Source: Claude Cupin (1981)

(ii) The pull or the tension in all parts of the rope is equal to F.

Then the total upward force on the lower block is 4F while the downward force on the lower block is W.

In order to raise the load.

W = 4F

$$M.A = \frac{Load}{Effort} = \frac{4F}{F} = 4$$

2.3 The Wheel and Axle

The wheel and axle are commonly found in vehicle wheels and bicycle wheels as well as pulleys. The wheel and axle are made up of a wheel of radius R placed or mounted on an axle whose radius is r. the radius of the wheel is bigger than the radius of the axle. The load to carry is borne by the axle while the effort is applied on the wheel (fig 2.5). let the load on the axle be W while the effort applied on the wheel is F. Then the Mechanical Advantage

$$(M.A.) = \frac{Load}{Effort}$$

$$\text{i.e} \quad M.A. = \frac{W}{F}$$

When the wheel rotates once, the distance covered in the revolution is equal to the circumference of the wheel.

i.e $D = 2\pi R$

Similarly, the distance covered in one revolution of the axle, $d = 2\pi r$

Thus the Velocity Ratio $V.R. = \frac{D}{d} = \frac{2\pi R}{2\pi r}$

i.e $V.R. = \frac{R}{r}$

Since Work done = Force x distance

Then Work done on load = $W \times 2\pi r = 2\pi rW$

Work done by effort = $F \times 2\pi R$

$$\text{Efficiency} = \frac{\text{Work done on load}}{\text{Work done by effort}}$$

$$= \frac{2\pi rW}{2\pi RF} = \frac{Wr}{FR}$$

$$\text{i.e Efficiency} = \frac{W/F}{R/r}$$

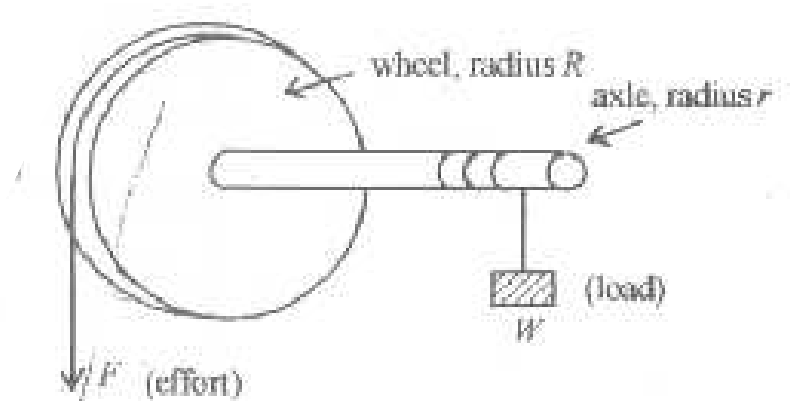


Fig: 2.5: Wheel and axle

Source: Authors Assumption (2009)

The wheel and axle is also found useful in lifting water from deep wells and in raising heavy loads such as anchors of ships.

Example 2.3

A mass of 35kg is to be lifted by a wheel and axle system. The ratio of wheel to radius of axle is 5:1 Given that the system is 84% efficient, determine the effort required to lift the body. Take g = $10m/s^{2.}$

Solution:

Since the mass to be lifted is 35kg, then the Load on it is W=mg where m=35kg, g=$10m/s^2$

Thus W = 35kg x $10m/s^2$ = 350N. The diagram of the system is shown in Fig 2.6

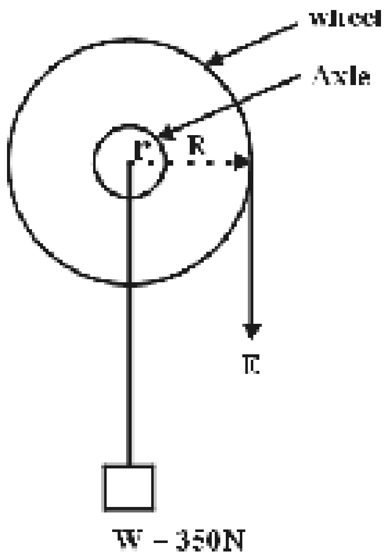


Fig 2.6 Load W, lifted by wheel and axle system
Source: Smith and Wilkes (1984)

Now R to r = 5:1

i.e $\frac{R}{r} = \frac{5}{1}$ = V.R

but M.A = $\frac{\text{Load}}{\text{Effort}} = \frac{W}{E}$

Also Efficiency = $\frac{\text{M.A.}}{\text{V.R.}} \times \frac{100}{1}$

i.e 84 = $\frac{350/E}{5/1} \times 100$

$$\frac{84}{100} = \frac{350}{E} \times \frac{1}{5}$$

84 x E x 5 = 350 x 100

$$E = \frac{350 \times 100}{84 \times 5}$$

$= 83.33N$

2.4 The Inclined Plane

Let us assume that processed palm oil by a farmer was put in a big drum. If the drum of palm oil is to be loaded into the floor of a trailer coupled to a tractor. The heavy drum of palm oil can be lifted into the trailer with the use of a plank placed in an inclined plane at an angle Θ to the horizontal fig 2.7. The inclined plane is therefore serving as a machine to accomplish the rolling of the drum of palm oil into the trailer.

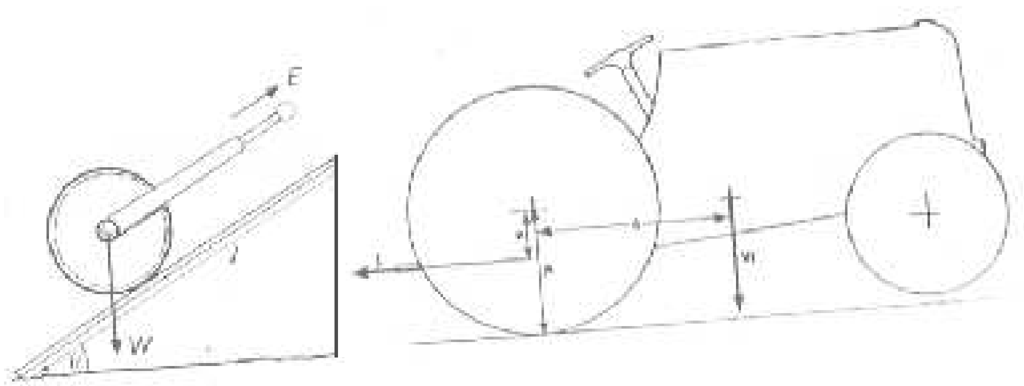


Fig 2.7: Inclined plane for loading heavy drums
Source: Author's Assumption (2009)

The inclined plane section can be magnified into a simple triangle shown in fig 2.8

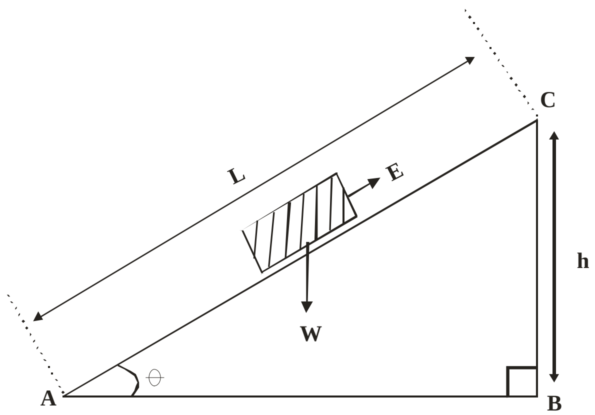


Fig 2.8: Inclined plane simplified
Source: Author's Assumption (2009)

Let L be the length of the inclined plane

Θ = angle of inclination of the plane to the horizontal

H = the height through which the heavy drum of palm oil was lifted.

W = Load or drum of palm oil

E = Effort applied to roll the drum of palm oil on the inclined plane

$$V.R = \frac{\text{distance moved by effort}}{\text{distance moved by load}} = \frac{AC}{BC} = \frac{l}{h}$$

From triangle ABC, $\sin \Theta = \frac{Opp}{Hyp} = \frac{h}{l}$

Thus $V.R = \frac{1}{\sin \Theta} = \frac{l}{h}$

If friction is neglected, $M.A = V.R. = \frac{1}{\sin \Theta}$

Chisel and wedge are other examples of inclined plane.

The **wedge** is a very simple and small triangular block. It is normally driven between two objects to force them apart.

The wedge is a combination of two inclined planes. Fig 2.9

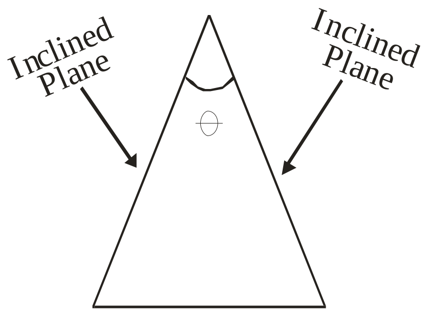


Fig 2.9 Wedge
Source: Smith and Wilkes (1984)

Example 2.4

An inclined plane at an angle of 30^0 to the horizontal is used as a simple machine. A force E is used to push a load of 120N uniformly up the plane at efficiency of 50%. Determine:

i) Its velocity ratio

ii) The magnitude of E

Solution

Since the angle of inclination of the plane is 30^0 (fig 2.10), then

$$V.R = \frac{1}{\sin \Theta} = \frac{1}{\sin 30}$$

But sin 30 = ½

$$V.R. = \frac{1}{½} = 2$$

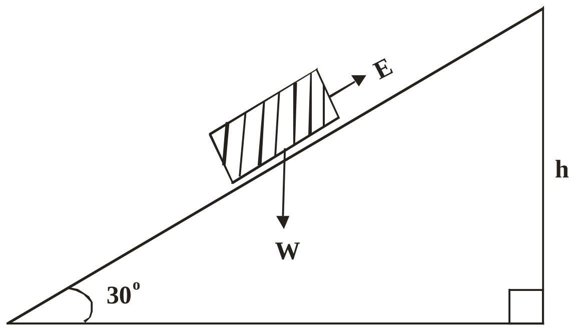


Fig 2.10 inclined plane as a machine

Source: Culpin (1981)

$$\text{Efficiency} = \frac{M.A}{V.R} \times \frac{100}{1}$$

$$\text{i.e Efficiency} = \frac{\text{Load/Effort}}{V.R.} \times \frac{100}{1}$$

$$50 = \frac{120N}{\frac{\text{Effort}}{2}} \times \frac{100}{1}$$

$$\frac{2 \times 50}{100} = \frac{120N}{\text{Effort}}$$

Effort = 120N

2.5 The Screw and Gears

2.5.1 Screw

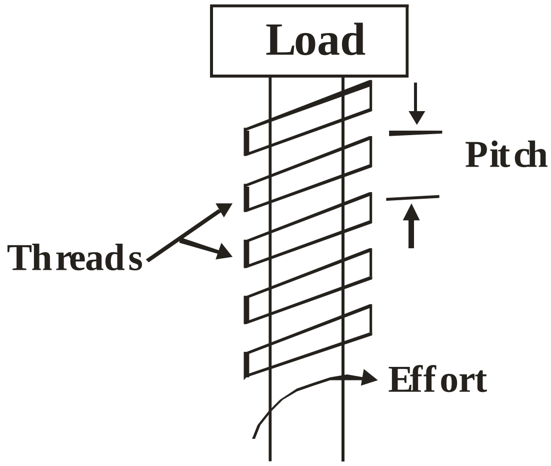


Fig 2.11 Screw Jack
Source: Ashworth (1982)

The screw, also called nut and bolt is a simple machine. It has screw threads. The distance between successive threads is referred to as pitch. Fig 2.11. The screw jack is a good example of this system and is normally used in lifting cars or tractors. During usage, as the screw head is made to turn one complete revolution, the screw (load) travels forward and covers a distance equal to the pitch. In other words, one full turn on the handle makes the threaded vertical part to turn one revolution, thus raising the load the distance between two threads. It is important to note that the screw jack has a long vertical screw which threads into a heavy base. It also has a long rod called 'tommy bar'

$$V.R. = \frac{2\pi l}{Pitch}$$

Where l is the length of the tommy bar. Neglecting frictional forces,

$$\text{then } V.R. = M.A = \frac{2\pi l}{pitch}$$

Example

The tommy bar and pitch of a screw jack are 20cm and 0.5cm respectively. Find its velocity ratio.

Solution

$$V.R. = \frac{2\pi r}{Pitch}$$

Now $\pi = 3.142$, $l = 20cm$, pitch = 0.5cm

$$\text{Then } V.R. = \frac{2 \times 3.142 \times 20cm}{0.5cm}$$

$$= 251.36$$

2.5.2 Gears

Gears are meant to increase or decrease speed. Gears are used in cars, tractors, bicycles and cranes. For instance, in a tractor, gears may be made to change the speed of the rear wheels in spite of the fact that the engine speed may remain constant. The driving gear is called the driver while the gear being driven is called the driven.

Fig 2.12

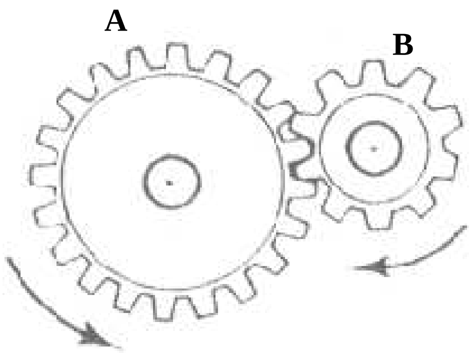


Fig 2.12 Gears

Source: Harris et al (1991)

If A is the driving and B the driven gear, then the speed of gear B is increased relative to the speed of gear A. On the other hand, where B is the driving and A the driven gear, then the speed of gear A is decreased relative to the speed of gear B. It is important to note that for two gears IN MESH, the large gear has a greater number of teeth than the small gear. The smaller gear rotates faster.

$$V.R = \frac{\text{Number of teeth on driven wheel}}{\text{Number of teeth on driving wheel}}$$

V.R. can also be given in terms of angular speed. It is the ratio of the angular speed of one to that of the other.

$$w_l n_l = w_s n_s$$

from this eqn, $\frac{w_l}{w_s} = \frac{n_s}{n_l}$

where w_l = angular speed of large gear

w_s = angular speed of small gear

n_l =number of teeth on large gear

n_s = number of teeth on small gear

Example

Two intermeshing gear wheels have 35 and 105 teeth respectively. What is the rotational speed of the larger wheel if the smaller wheel rotates at 72 rev per second?

Solution

w_l = ?, w_s = 72 rev/s, n_l = 105, n_s = 35

$\frac{w_l}{w_s} = \frac{n_s}{n_l}$ i.e $\frac{w_l}{75\text{rev/s}} = \frac{35}{105}$

solving w_l = 24 rev/s

3.0 Workshop Tools

Agricultural engineering workshop embraces wood workshop and metal workshop. Tools that are commonly used in these workshops for various farm machines include:

1. Hand Tools
2. Saw
3. Planes
4. Grinding and sharpening angles

The tools are used for specific purposes

3.1 Hand tools

Among the workshop hand tools are: chisel, files, scriber, odd-leg calipers, divider, punches, screw drivers, Allen key, hack saw, tee squares, steel rule, protractor, inside and outside calipers, vernier caliper and micrometer screw guage. A sketch drawing of each of these hand tools is first given while their uses are indicated on underneath the drawing.

Sketch Drawing

i)

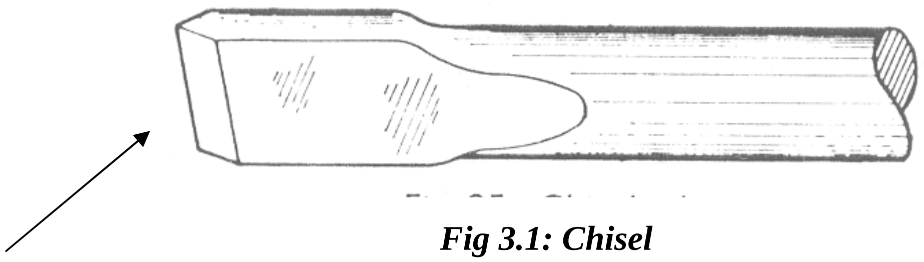


Fig 3.1: Chisel
Sourece: Harris et al (1981)

Cutting Edge

Uses

Useful to cut cold metals for smoothening and chiselling that include cutting grooves, for making keyways, making slots in a shaft etc.

Examples of chisels are: Flat chisel, Half round-nose chisel, cross-cut chisel and diamond-nose chisel.

Note: chisels are made from high carbon steel ii)

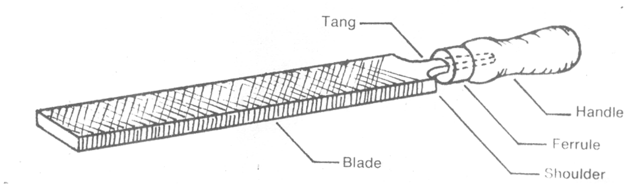
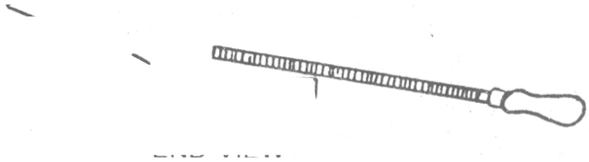


Fig 3.2: Flat file
Source: Grimshaw (1976)



Round File

Flat File

Files are used for sharpening edges of metals. They are also useful for removing small amounts of metal by rubbing with the teeth of the file. Example of files are flat file, round file, square file, triangular file and half-round file.

iii)

Fig 3.3: Scriber
Source: Grimshaw (1976)

Scriber

The scriber is used for making a straight line on metal. It is used in conjunction with the steel rule and try square.

iv)

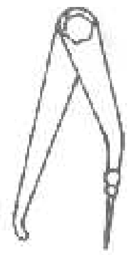


Fig 3.4: Odd Leg Caliper
Source: Elekwa et al (1983)

Odd Leg Caliper

Useful in marking lines parallel to an edge. It is also used in making centerlines. It is particularly useful when finding the centres of round bars.

v)

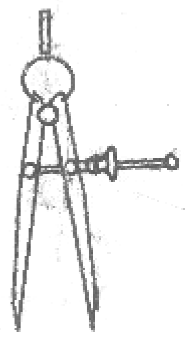


Fig 3.5: Divider
Source: Elekwa et al (1983)

Divider

Divider is used for marking circles and curves. It is useful in transferring measurements.

It can be used for stepping off equal divisions along a line.

vi)

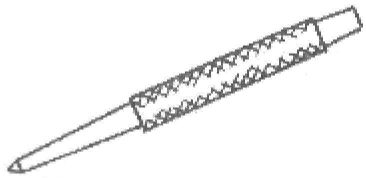


Fig 3.6: Centre Punch
Source: Elekwa et al (1983)

Centre Punch

Punches are useful in removing rivets or split pins. The centre punch is particularly useful for making a mark on a piece of metal where a hole is to be drilled.

vii)

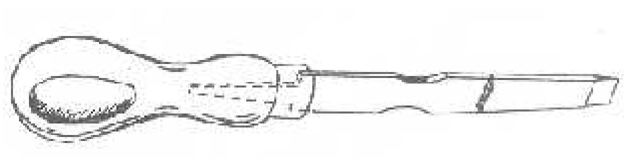


Fig. 3.7: Screw driver
Source: Grimshaw (1976)

Screw driver

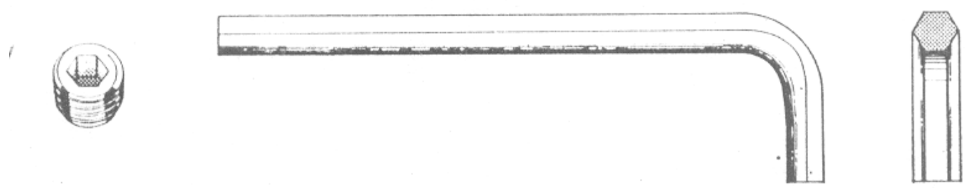


Fig 3.8 Allen key
Source: Harris et al (1981)

Allen key

Screwdrivers are used for driving screws into or out of structured members. They are in two main groups:

(a) General purpose screw drivers and

(b) Electricians screw drivers. The general purpose screw drivers are of three types: flat screwdriver, star screw driver and Allen key. Allen keys are used to tighten or slacken screws that have a hexagonal hole in their heads

viii)

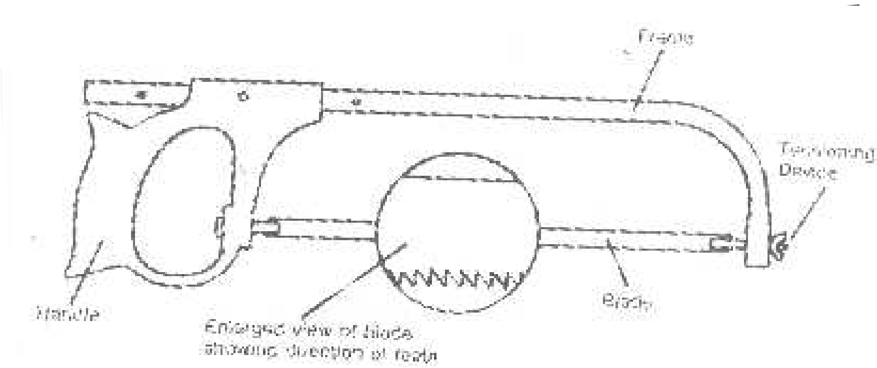


Fig 3.9: Hack Saw
Source: Grimshaw (1976)

Hack Saw

A hacksaw for farm work is used to cut metal with a minimum of waste to ensure that the edge does not bend or distort

ix)

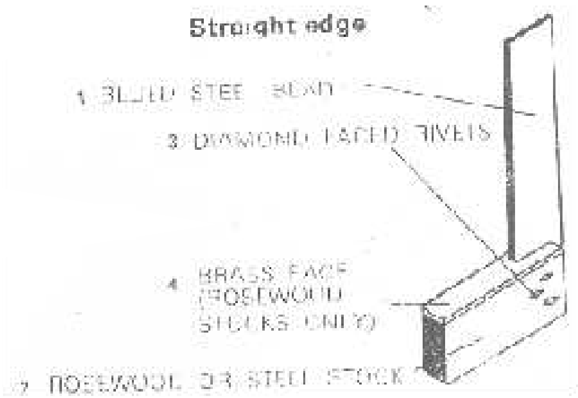


Fig 3.10: Try Square
Source: Grimshaw (1976)

Try Square

When a job is needed to be tested for squareness, the use of Trysquare come into place. It is thus useful in marking lines at right-angles to an edge.

x)

Fig 3.11: Steel Rule
Source: Elekwa et al (1983)

Steel rule

The steel rule is useful for

- ruling straight lines
- testing straight edges
- testing flat surfaces

xi)

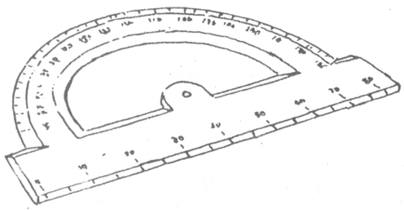


Fig 3.12: Protractor
Source: Elekwa et al (1983)

Protractor

The protractor is a semi-circular piece made from wood or plastic for measuring angles between 0^0 and 180^0

xii)

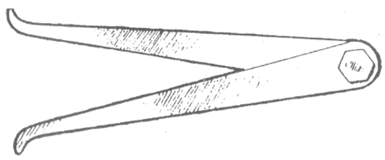


Fig 3.13: Inside
Source: Elekwa et al (1983)

Inside Caliper

The inside caliper is used to measure the inside dimensions of objects e.g the inside diameter of a hole. The dimensions should be within the capacity of the caliper.

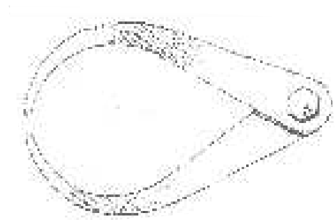


Fig 3.14: Outside Caliper

Source: Elekwa et al (1983)

Outside Caliper

The outside caliper is used to measure the outside dimensions of objects within its capacity e.g the outside diameter of a round bar

xiii)

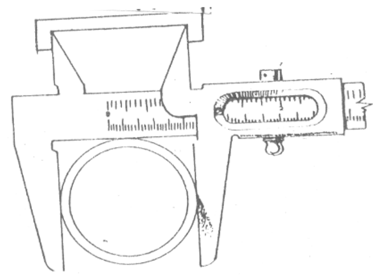


Fig 3.15: Vernier Caliper

Source: Elekwa et al (1983)

Vernier Caliper

The vernier caliper is used to measure small distances such as the diameter of a rod or the inside diameter of a tube. Thus the vernier caliper is useful in measuring both internal and external dimensions of small objects.

xiv)

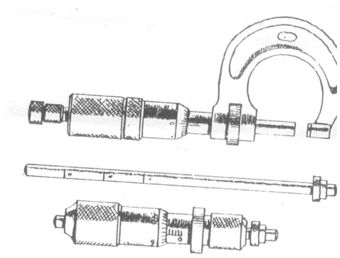


Fig 3.16: Micrometer Screw gauge
Source: Elekwa et al (1983)

Micrometer Screw Gauge

The micrometer screw gauge is used to measure smaller lengths such as the diameter of a wire. Method of use: Take and record the last visible division on the main scale. Next record the reading on the circular scale that coincides with the central horizontal line. The sum of these two numbers give the micrometer screw guage reading.

4.0 Principles of ICE

ICE stands for Internal Combustion Engine. It involves the burning of fuel in a confined system for the generation of heat energy and the liberation of mechanical energy. Combustion itself means the burning of fuel in the presence of air or oxygen. Examples of fuel are kerosene, petrol and diesel. Examples of internal combustion engine are:

i. motor cars (petrol engines)
ii. motor cycle (petrol engines)
iii. tractor (petrol or diesel engines)

iv. generator (petrol or diesel)

Just as we have ICE, so are External Combustion Engines (ECE) where combustion takes place outside a close confinement. Examples of External Combustion Engine are

i) Railway (locomotive engines)
ii) Steam Traction Engine
iii) Gas Turbine Engine

In view of the fact that the tractor obtains its power from an ICE, It has remained one of the most important sources of farm power.

Therefore, the two basic types of ICE commonly used on the farm are petrol and diesel engines. Both engines obtain their power by burning the liquid fuel inside the engine cylinder. The burning fuel generates heat which allows the gas inside the cylinder to increase its pressure and supply power to rotate a shaft connected to the transmission. The petrol engine is also called spark-ignition engine while the Diesel engine is referred to as compression-ignition engine. What are the differences between them?

4.1 Terms used with Engine

To be able to understand the differences between spark-ignition and compression-ignition engines, there is need to know and be familiar with some terms commonly used with the engine.

Burning of fuel takes place in the combustion chamber which is a space above the piston within the cylinder. It is also called clearance volume. Assume a cross-section of a cylinder shown in fig 4.1, the top dead centre (t.d.c.) is the position of the crank and piston when the piston is farther away from the crankshaft.

While moving up, the piston cannot go beyond the t.d.c.

Bottom dead centre (b.d.c.) is the position of the crank and the piston when the piston is nearest to the crankshaft. The piston cannot move down beyond the b.d.c. while going downwards.

Bore represents the internal diameter of the cylinder

Stroke is the distance between the b.d.c. and the t.d.c.

Swept volume: it is the volume of the space between t.d.c. and b.d.c. It is also called piston displacement.

Engine capacity: this is the swept volume of all the cylinders e.g. a four-cylinder car having a capacity of 2.4litres (2400cm^3) has a cylinder swept volume of 600cm^3.

Engine size: this is given by the bore and stroke of the engine. For example, a 120mm by 132mm engine has a bore of 120mm and stroke of 132mm.

Compression ratio: this is the ratio of the total volume to the clearance volume

i.e $C.R = \frac{\text{swept volume + clearance volume}}{\text{Clearance volume}}$

Thus Total Volume = swept volume + clearance volume

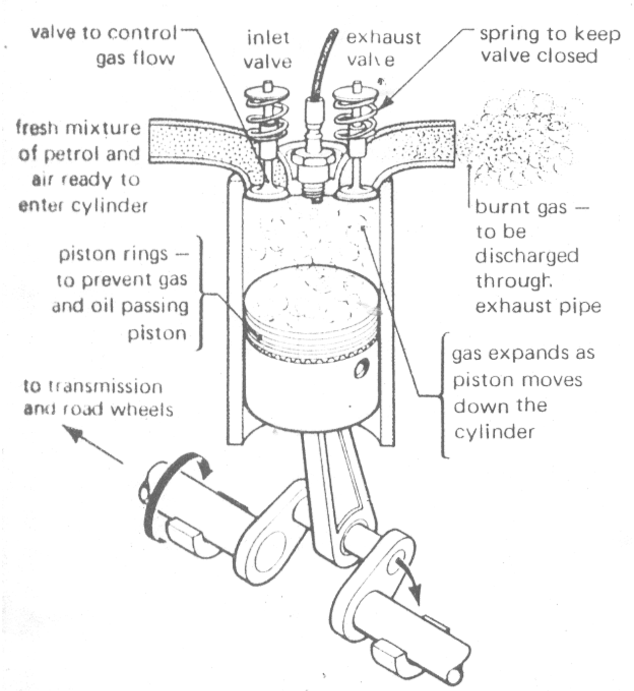


Fig 4.1 x – section of engine cylinder
Source: Hillier 1978

4.2 Cycles of Operation

The moment an internal combustion engine starts working, it operates in either of two ways: (a) Two – Stroke cycle or (b) 4-stroke cycle. A cycle is a series of events which are repeated in regular order or sequence in the operation of an engine. Therefore, in the 2-stroke cycle, a power stroke takes place at every revolution of the crank. In other words, the crankshaft makes one revolution and the piston makes 2 strokes in each cycle.

Similarly, in the 4-stroke cycle, a power stroke occurs at every other revolution of the crank. This translates to the crankshaft making 2 complete revolutions and the pistons four strokes. Here, a stroke is the movement of the piston from one end of the cylinder to the other.

4.3 Operation of the 4-stroke Cycle

The operation of a 4-stroke engine will be described in two forms:
(a) petrol engine and (b) Diesel engine

4.3.1. Principles of 4-stroke Petrol Engine

The 1st Stroke is called **intake stroke**. The inlet valve is opened to allow the mixture of fuel and air enter into the vacuum in the cylinder. At this time, the piston is pushed downwards from the t.d.c. to the b.d.c. It should be noted that the outlet or exhaust valve remains closed.

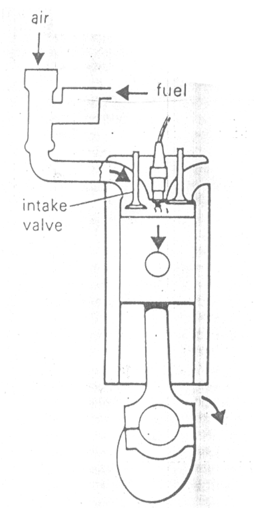


Fig 4.2: Intake stroke
Source: Kaul and Egbo (1985)

The 2nd Stroke is called the **Compression Stroke**. Both the inlet and exhaust valves are closed. The piston is pushed upwards by the connecting rod to compress the mixture of fuel and air into the combustion chamber or clearance volume thus increasing the temperature of the mixture.

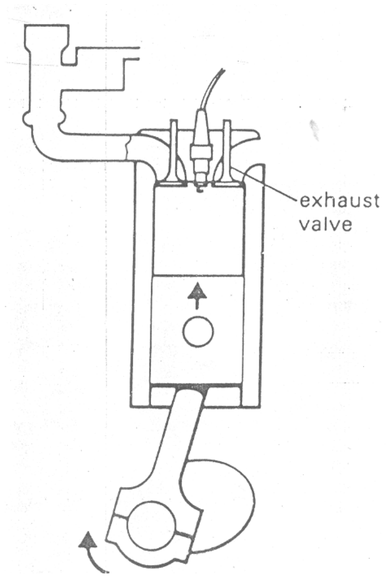


Fig 4.3: Compression Stroke
Source: Kaul and Egbo (1985)

The 3rd Stroke is called the Power Stroke. With the approach of the piston towards the t.d.c. in the 2nd Stroke, the mixture of fuel and air is ignited with a spark arising from the spark plug causing them to burn. The resulting expanded gases push the piston from the t.d.c. to the b.d.c. At this time, both the inlet and exhaust valves are closed.

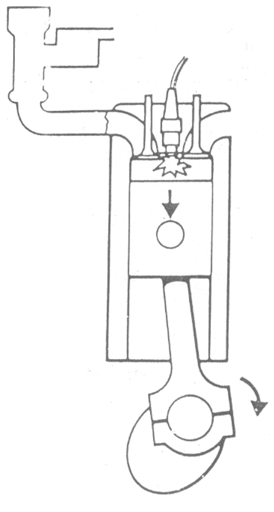


Fig 4.4: Power Stroke

Source: Kaul and Egbo (1985)

The 4th Stroke is called the Exhaust Stroke. The crankshaft rotates to push the connecting rod upward which in turn moves the piston upwards from the b.d.c. to t.d.c. In the process, the product of combustion is pushed out of the cylinder through the opened exhaust valve to the cylinder. It is to be noted that the inlet valve remains closed during the 4th Stroke fig 4.2.

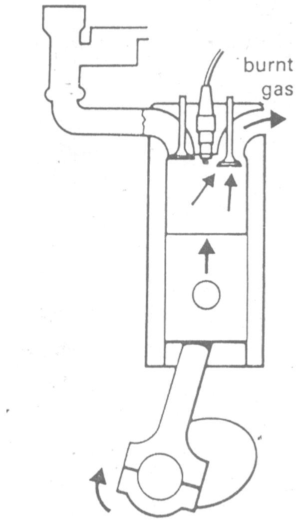


Fig 4.5: Exhaust Stroke

Source: Kaul and Egbo (1985)

The cycle or series of events continue so long as the engine operates. The Power Stroke is the most important stroke needed. However, to permit the operation of the intake, compression and exhaust strokes to continue, there is the provision of a flywheel to give inertia and keep the engine running to supply the required power stroke from one cylinder to another. Thus the intake, compression and exhaust strokes are called idling strokes.

4.3.2 Principles of 4-stroke Diesel Engine

The 4-strokes obtained in petrol engine are obtainable too in diesel engine i.e intake or induction, compression, power and exhaust strokes. The major difference lies in the way the diesel fuel is burnt.

(i). **Intake Stroke**: the inlet valve opens while the exhaust valve closes. Air only is supplied to the cylinder forcing the piston downwards.

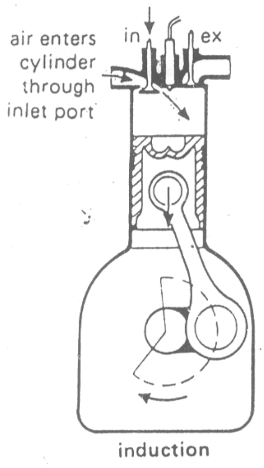


Fig 4.6: Induction
Source Hillier (1978)

(ii) **Compression Stroke**: The piston moves from the b.d.c. to t.d.c. thus compressing the already admitted air and its temperature becomes very high as a result of the compression. Both inlet and exhaust valves are closed during the compression stroke.

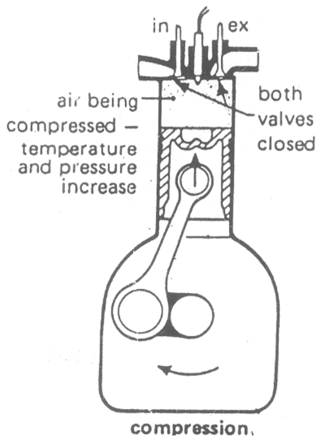


Fig 4.7: Compression
Source Hillier (1978)

(iii) **Power Stroke**: immediately the compression stroke is ended, atomized or fine spray of diesel fuel is injected into the very hot compressed air resulting spontaneously into burning which pushes the piston downwards for the power stroke. Both inlet and exhaust valves are closed. The direct delivery of diesel fuel to the cylinder is accomplished by the injector. Fig 4.3

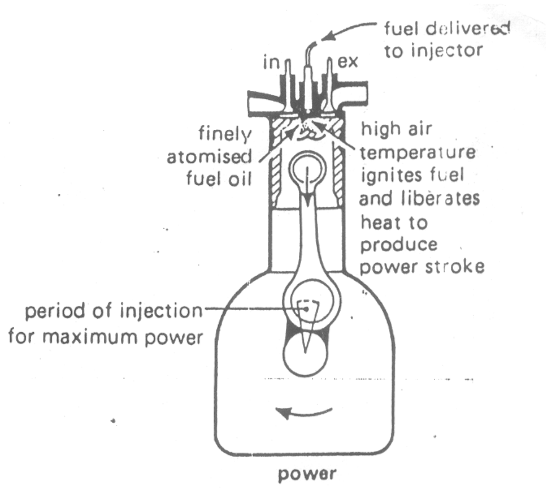


Fig 4.8: Power
Source Hillier (1978)

(iv) **Exhaust Stroke**: The piston moves upwards to push out the product of combustion through the outlet or exhaust valve that is now opened. The inlet valve is closed during the exhaust stroke.

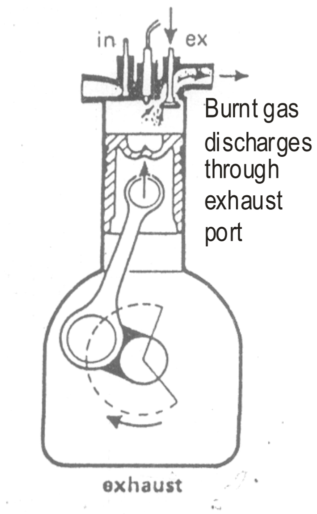


Fig 4.9: Exhaust
Source Hillier (1978)

4.3.3 Differences Between Spark-Ignition Engine and Compression Ignition Engine.

Although it is possible to identify the difference between the two forms of engine from sections 4.3.1 and 4.3.2, this present section assists in its compilation in a compact form as follows:

Stroke	Petrol Engine	Diesel Engine

Intake	A mixture of Air and fuel (petrol) in suitable ratio enters the cylinder on opening of the inlet valve.	Only air is admitted into the cylinder when the inlet valve opens
Compression	The mixture of air and fuel is compressed. The resulting heat is not enough to cause burning on its own	The Air is highly compressed thus increasing the temperature astronomically.
Power	A spark plug ignites the mixture of air and fuel that is already compressed to have the power stroke	The compressed hot air is atomized with diesel by an injector thus resulting into the burning of the mixture of fuel without spark plug. The burning gives the power stroke

Example 4.1

What is the piston displacement of an I.C.E.? Given that the bore of an I.C.E. is 100mm when its piston displacement is 973.4mm^3, estimate its stroke length

Solution:

(i) The piston displacement of an Internal Combustion Engine = the swept volume in one stroke fig 4.10

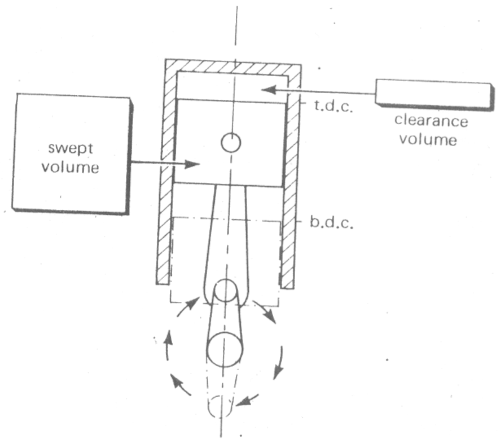


Fig 4.10: Swept volume of an I.C.E.
Source: Hillier (1978)

(ii) Piston Displacement = piston area x stroke length

i.e P.D = $\pi r^2 S$

where r = radius of the piston

S = stroke length

but $r = \frac{\text{Diameter}}{2} = \frac{D}{2}$ (diameter = bore)

$$P.D = \pi\left(D/2\right)^2 S \text{ or } \pi \frac{D^2}{4} S$$

Thus $S = 4\frac{P.D.}{\pi D^2}$

$$= \frac{4 \times 973.4\text{mm}^3}{\pi \times 100\text{mm} \times 100\text{mm}}$$

$= 124$mm

5.0 Study of Farm Machinery used for Tillage

A broad look at the environment confirms that not all the available land can be used for crop production. To enhance the production of crops on parts of the land, the use of machines becomes important for suitable soil conditions for seed germination and plant growth. Therefore, seedbeds preparation with appropriate machines is the focus of this study.

5.1 Tillage

Basically, tillage is the preparation of land for planting. It embraces the breaking, loosening, turning or working the soil in preparation for planting. Tillage is done with a view to creating a favourable condition for seed placement and plant growth. Tillage therefore assists in the preparation of a good soil environment for plant growth.

5.2 Purpose of Tillage

Tillage is considered necessary for the following reasons:

(i) To break up soil clods

(ii) To improve soil aeration i.e to facilitate free circulation of air in the soil.

(iii) To enhance water percolation

(iv) To kill pests, destroy insects and their eggs including their larvae and breeding places.

(v) To destroy weeds

(vi) To bury plant residues for the improvement of soil humus condition.

(vii) To facilitate root penetration

(viii) To prevent erosion and promote soil conservation or control of soil moisture

5.3 Classification of Tillage

It is customary to classify tillage as either primary or secondary. Soil management practices have brought about some terms such as zero tillage, minimum and maximum tillage. These soil management terms would be explained as events unfold. Efforts for now are on the two main tillage groups i.e primary and secondary.

Primary Tillage:

Primary tillage is the breaking up of soil large clods or lumps. It is the first stage of opening up the soil up to a depth of 15 to 91cm.

Primary Tillage Equipment

These include ploughs of various types

Mould board

Disc

Chisel

Subsoiler

Features of the moldboard plough are indicated in fig 5.1

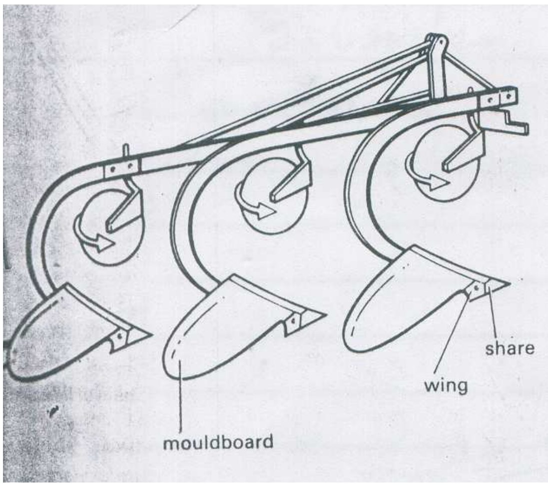


Fig 5.1 Mould board plough
Source: Kaul and Egbo (1985)

While the mould board plough is coupled to the tractor and as the tractor moves on the land to be ploughed, the disc which is flat cuts a vertical slit. The share cuts a horizontal slice and the mould board performs the function of cracking and inverting the sliced soils. The mould board plough is useful for breaking up grassy land and for burying rubbish.

On the other hand, the disc plough contains discs that are mounted on a Frame. The beam has a mast and coupling points to the tractor. It also has a rear or furrow wheel that can be adjusted. The furrow wheel is spring loaded. Fig 5.2

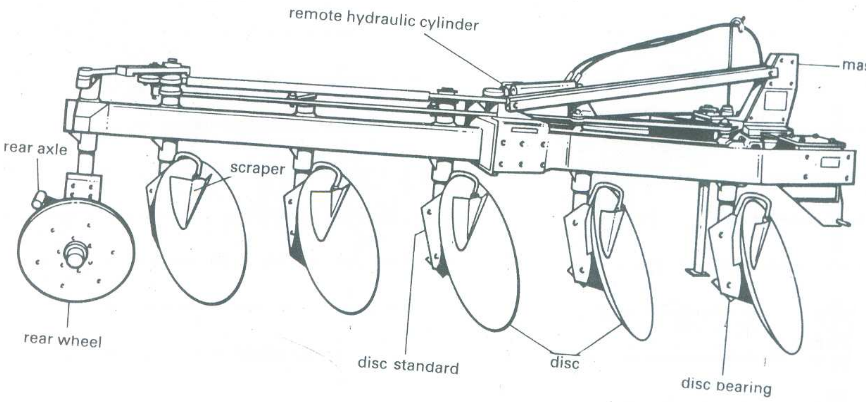


Fig 5.2: Disc Plough

Source: kaul and Egbo (1985)

The disc plough is robust and can work satisfactorily in sticky soils and hard dry soils. It is designed to roll over obstacles. These are the reasons why the disc plough is preferred to the mould board plough particularly in the tropics where the mould board plough would not work satisfactorily.

Chisel plough fig 5.3 is sturdy in construction and is having rigid tines that can easily break open the subsoil. If coupled to the tractor and used for ploughing operation, the chisel plough is capable of removing with relative ease, deep-rooted weeds. The chisel plough is also a heavy duty deep cultivator.

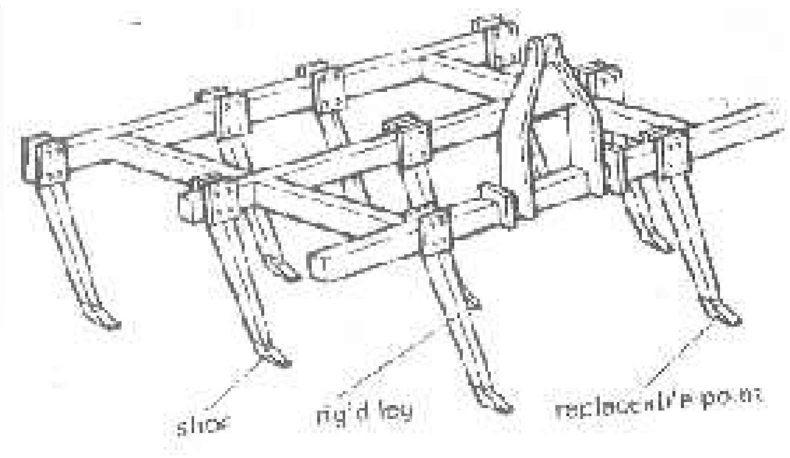


Fig 5.3 Chisel Plough
Source: Kaul and Egbo (1985)

Subsoiler

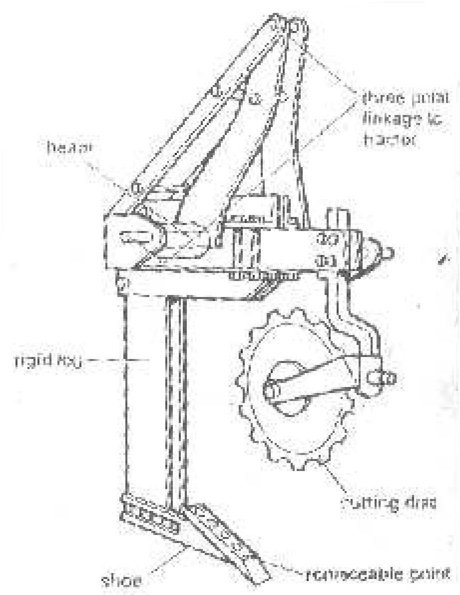


Fig 5.4 Subsoil
Source: Kaul and Egbo (1985)

The subsoiler is a rigid plough that is useful in breaking compacted soil or hard soil pan which could arise due to the continuous use of other ploughs. The hard soil pan is broken into smaller pieces by the rigid legs of the subsoiler thus promoting soil aeration. Because of the sturdy and robust nature of the subsoiler, it is normally coupled to a high-powered tractor such as the crawler type.

Secondary Tillage is the breaking up of the large clods of soil resulting from primary tillage. It involves the pulverization of soil to enhance planting.

Secondary tillage has the following objectives:

(i) pulverization of the soil with a view to improving the seedbed

(ii) conservation of soil moisture

(iii) destruction of weeds

(iv) breaking of large soil clods into smaller pieces and putting them in ridges for seeding and appropriate germination of seeds.

Secondary tillage equipment

The following are secondary tillage implements:

Disc harrows
Cultivators
Spike tooth, tines
Rotary cultivators
Ridgers
Rollers

Among these tillage implements, the most commonly used ones in Nigeria i.e disc harrow and ridgers are further described.

A Disc harrow has discs that are mounted on axles. It is customary to refer to such discs as gang of discs. It is also possible to have more than one gang of discs in a single disc harrow. A harrow is particularly useful to level the ground and break the soil clods, do the stirring and destroy weeds. A gang arrangement of discs in a disc harrow is shown in fig 5.5. Disc harrows can either be trailed or mounted for harrowing work. The trailed disc harrow is hitched to the tractor drawbar and pulled by the tractor for its work. On the other hand, the mounted disc harrow is coupled to the three link arms of the tractor and taken to the field in a mounted position. It is thereafter lowered onto the ground through the hydraulic control and then pulled by the tractor for the performance of the harrowing operation.

Other types of harrow apart from the disc harrow are the spike-tooth harrow and the chain harrow.

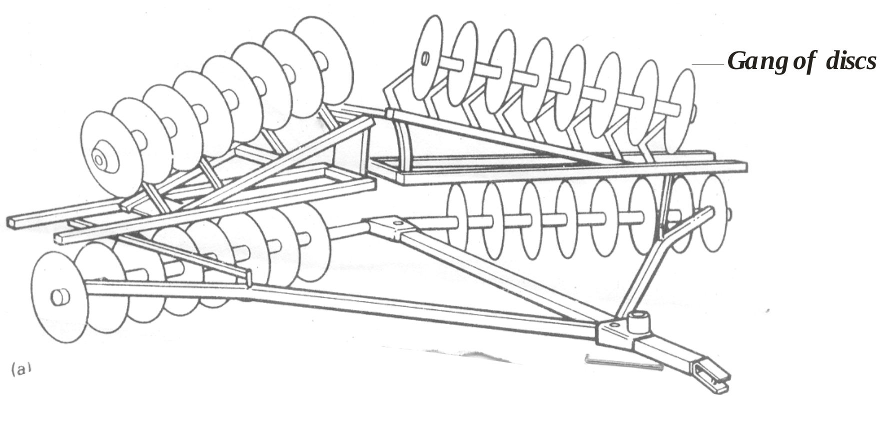


Fig 5.5: Disc Harrow
Source: Kaul and Egbo (1985)

Disc Rigder

The ridger is like a double or two mould board plough which is used to make ridges. A furrow is also made in the process fig 5.6 which assists in moisture conservation. The disc ridger on the other hand has two concave discs that face each other which is found useful in moulding ridges. Weed control is achieved by the ridger as weeds are buried during ridging operation.

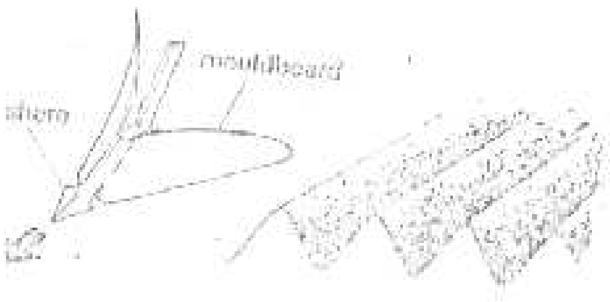


Fig 5.6 Furrow made by a ridger

Source: Adeniji et al (1991)

A disc ridger is shown in fig 5.7

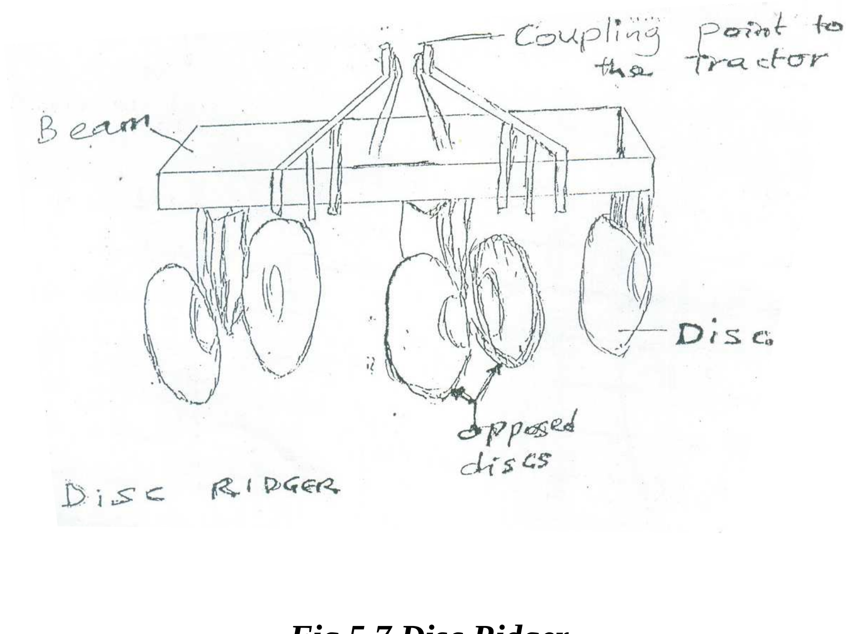


Fig 5.7 Disc Ridger
Source: Adeniji et al (1991)

Soil Management Practices

As earlier highlighted, some soil management terms are zero tillage, minimum tillage and maximum tillage.

Zero tillage is the practice of growing crops on unploughed or undisturbed land with no seedbed preparation. Zero tillage enhances soil conservation.

Minimum tillage is the minimum soil manipulation necessary for crop production. For instance, the planting of crops may be done by the farmer once ploughing operation has been accomplished.

Maximum tillage is the practice whereby primary and secondary tillage implements are used to loosen the soil for seed germination and plant growth, for instance, disc plough or mouldboard plough, harrows and ridgers. Maximum tillage does not enhance soil conservation.

6.0 Farm Power Transmission Systems

Various works are taking place in and outside the farm which are agricultural related. Some of them are: Land clearing, ploughing, cultivation of land, harrowing, ridging, planting, crop harvesting, crop processing and packaging. In almost all these variety of works, machines are used to accomplish the tasks. In the process, power is utilized in many ways. Transmission of power in the machines from one rotating shaft to another then occur. There are different methods in practice for transmitting power from one rotating shaft to another. Among the methods are the use of

i. Belts (flat and Vee)

ii. Chains

iii. Gears

6.1 Power Transmission through Belting

Belts can be used to drive machines. For example, if the source of power is a motor to drive a mainshaft, a belt may be used to drive the pulley on the mainshaft. The two pulleys are linked with the belt. The first pulley is mounted on the shaft of the motor while the second pulley is mounted on the shaft of the machine to be driven. Thus the pulley on the motor shaft is the driver while the pulley on the machine shaft is the driven. Two systems of drive are possible for this arrangement. They are: Open drive and crossed drive.

With the open drive system, the driven and the driver revolve in the same direction Fig 6.1 while the driver and the driven rotate in opposite directions Fig 6.2. for the crossed drive systems. It should be noted that the power that can be transmitted by belting depends on the strength of the belt and the friction between the belt and pulleys. In other words, the grip between the belt and pulleys, upon which the driving depends, is caused by friction between the belt and pulleys. Obviously, the grip varies according to the amount of friction, and the total angle by which the belt laps the pulley. When compared together, the grip in a crossed drive is greater than that of the open drive.

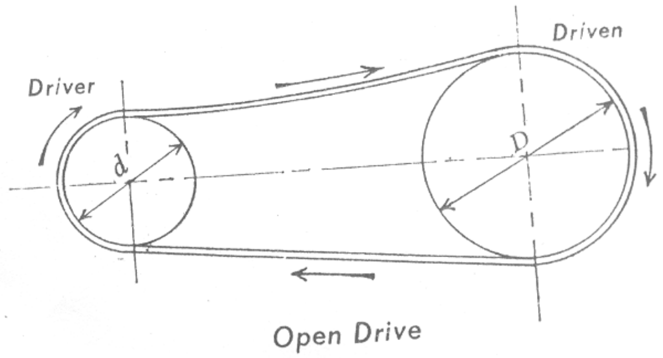


Fig. 6.1 Open Drive System

Source: Chapman (1975)

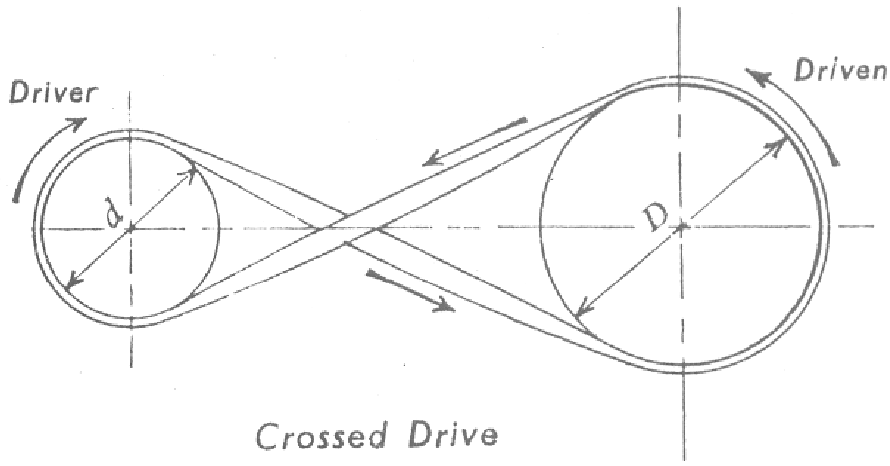


Fig. 6.2 Crossed Drive System

Source: Chapman (1975)

Speed Ratio Expression

For belt driving, the speed ratio for the two pulleys on the shaft of motor and machine to be driven is given by

$$\frac{\text{Speed of Driver}}{\text{Speed of Driven}} = \frac{\text{Diameter of Driven}}{\text{Diameter of Driver}}$$

This condition holds if there is neither slip nor creep between the belt and pulleys. Remembering that diameter = 2 x radius,

Then for the driver = d/2 or d = 2r

And for the driven, R = D/2 or D = 2R

Therefore, $$\frac{\text{Speed of Driver}}{\text{Speed of Driven}} = \frac{\text{Diameter of Driven}}{\text{Diameter of Driver}} = \frac{D}{d}$$

Example

The pulley on a machine is 230mm diameter. It is to be driven at 183rev/min. A mainshaft to drive the machine has a pulley of diameter 140mm. what is the speed of the running shaft to drive the machine?

Solution

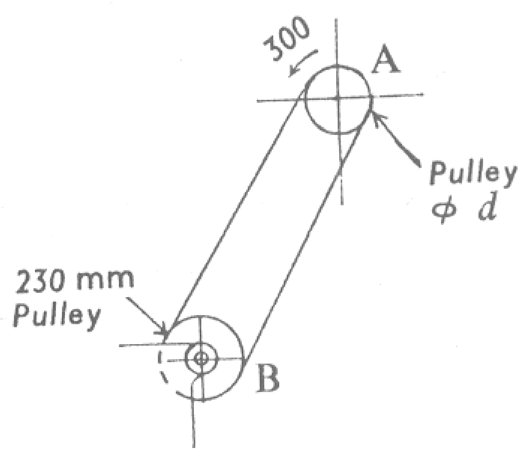


Fig.6.3: Flat belt on Machine and mainshaft pulleys
Source: Chapman (1975)

$$\frac{\text{Speed of mainshaft}}{\text{Speed of Machine}} = \frac{\text{Diameter of Machine}}{\text{Diameter of mainshaft}} = \frac{D}{d}$$

i.e $$\frac{\text{Speed of mainshaft}}{183 \text{ rev/min}} = \frac{230\text{mm}}{140}$$

Therefore, Speed of Mainshaft $= \frac{230}{140} \times 183\text{rev/min}$

$= 300.6\text{rev/min}$

Vee Belt

V-belt drives are found useful in situations where shafts are very close together. For instance, in the development of individual driving of machines and the need for short compact drives, the use of V-belt is favoured.

V-belt often runs on split pulleys which can be adjusted to take up slacks. V-belts are made to run in grooves turned in the pulleys Fig. 6.4. v-belts have greater contact area per unit of belt width than flat belts.

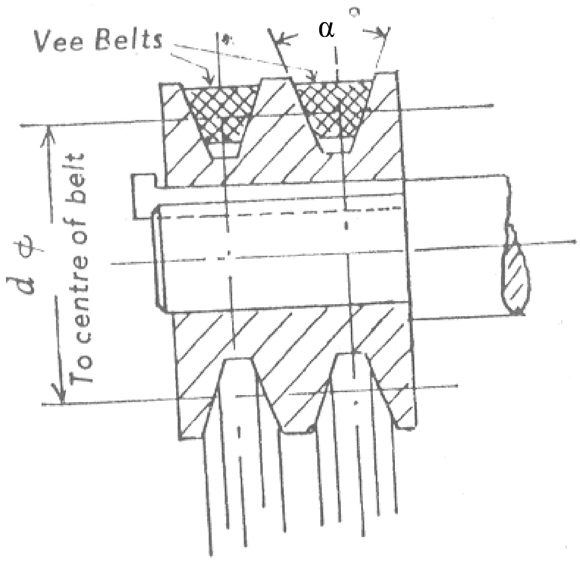


Fig 6.4 v-belt

Source: Chapman (1975)

Another advantage of the V-belt is that it has a reduced space requirement.

In estimating the speed ratios for drives employing standard vee belts, it is important to take the diameters to the centre of the belt. For the wedge belt, the outside diameters of the pulleys should be used.

Power Transmitted by a Belt

The transmission of power by a belt becomes possible because of the frictional grip between the belt and the pulley. Consider a small pulley Fig. 6.5 driving a large pulley. For power to be transmitted, the tension on the belt on the driving side must be greater than that on the slack side. The tensions cannot be the same, if otherwise, there would be none left over.

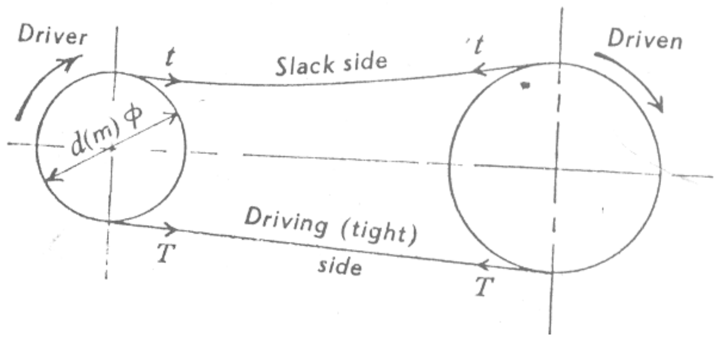


***Fig. 6.5 Tension in Belt for a Driving Tension*.**

Source: Chapman (1975)

Let the tension on the tight driving side be T Newton's. The tension on the slack side be t Newtons. Force available for driving = (T – t) Newtons.

Work done by this force in 1 minute = Force x speed of belt

i.e Work done = (T – t) x Speed of belt.

But speed of belt = circum of small pulley x rev/min of small pulley

$= \pi d \times N$

Thus $W = (T - t) \pi dN$

Since power = Rate of doing work i.e $P = \dfrac{W}{\text{Time}}$

Therefore, $P = \frac{\pi dN (T - t)}{60}$

t, the slack side tension is generally found for an average drive that t = ½T

This implies that (T – t) = T – ½T = ½T

Driving tension is half the tension in the tight side.

Therefore, if the belt width and its thickness are known and with a classical allowable or safe tension, the slack side tension can be estimated.

Example

A flat leather belt is 70mm wide and 7mm thick. Given that the safe tension per cm of width of the belt is 140N and the belt is used in driving a 360mm pulley at 300rev/min.

Determine:

i. the allowable tension

ii. the driving tension

iii. the power transmitted by the belt.

Solution

The belt is 70mm or 7cm wide.

Since the safe tension is 140N/cm then the

i. Allowable tension for 7cm wide belt is 140N x 7 = 980N

ii. The driving tension (T – t) = ½T

= ½ x 980N

= 470N

iii. Belt speed = πDN

Where π = 22/7, D = $\frac{360m}{1000}$, N = 300 rev/min.

Thus, Belt speed = $\frac{22}{7} \times \frac{360}{1000} \times 300$ m/min

= 339.43m/min

Now, work done per min = speed x driving Tension

= 339.43 x 470N

and Power = $\frac{\text{work done}}{\text{second}} = \frac{339.43 \times 470}{60} = 2658.86\text{watts}$

6. Power Transmission through Chains

The two types of chain commonly used in transmitting power on farm equipment are hook-link and roller. Sprocket wheels are designed to fit each type of chain. Chains can be used to change the speed of a drive. The expression in use is

$$\frac{\text{Diameter of the driving sprocket}}{\text{Diameter of the driven sprocket}} = \frac{\text{Speed of the driven sprocket}}{\text{speed of the driving sprocket}}$$

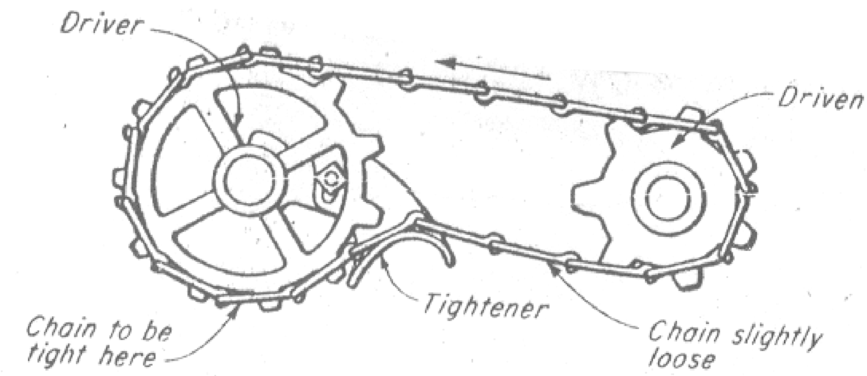


Fig 6.6: Hook Chain on sprocket
Source: Smith and Wilkes (1984)

The hook-link chains can be used in planters for example, where the power requirements are low and the speed is relatively slow.

The hook-link chains are made of either malleable iron or pressed steel. On the other hand, the roller chain is made of special high-grade steel and is used extensively on agricultural machines, manure spreader, cotton picker, combine harvester and so on.

Chains on sprockets must be kept correctly tensioned. The following conditions should be noted in the fixing of chains on sprockets:

i. Chains should not be too tight because tightened chains wear excessively.
ii. Chains should not be too slack because slackened chains jump off the sprockets repeatedly.
iii. Do not put a new chain on a worn sprocket because it is a waste of money to do so.

6. Power Transmission through Gears

When motion and power must be transmitted, the speeds of the two shafts affected or concerned must be preserved to maintain an exact relationship between them. The use of gears solves the problem since they will overcome the problem of slip and creep arising through belt drive system.

Gears are therefore used to increase or decrease the speed and torque of shafts when power is being transmitted. Hence in clear and simple terms, gears are used for changing shaft direction, for changing speeds and for transmitting power. Three kinds of gears commonly used are:

i. the spur gear

ii. the bevel gear and

iii. the worm gear.

The speed ratio for a gear drive depends on the number of teeth in the gears, the one with the less number of teeth revolving the faster.

Consider Fig 6.7. where P is the driving and Q the driven gear, the speed of gear Q is INCREASED relative to the speed of gear P. where Q is the driving and P the driven gear, the speed of gear P is DECREASED relative to the speed of gear Q

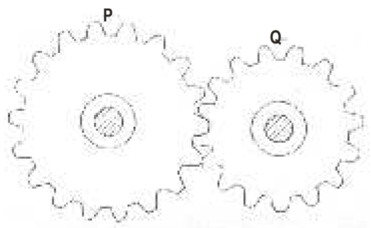


Fig 6.7: Gears
Source: Harris et al (1981)

This is why tractor in bottom gear can pull heavier loads than when the tractor is in top gear. The driver selected in the gearbox has fewer teeth and therefore a greater Mechanical Advantage (M.A) than when the tractor is in top gear. Thus, the lower the gear, the wider the velocity ratio, and therefore the slower the tractor moves forward at a constant engine speed. It is also worth noting that, when using two gears meshed together, the direction of drive is reversed.

The speed ratio for gears is given as

$$\frac{\text{Rev of Q}}{\text{Rev. of P}} = \frac{\text{Teeth in P}}{\text{Teeth in Q}}$$

7.0 Harvesting and Processing Equipment

Several mature crops are still harvested manually in Nigeria with the use of simple tools such as cutlasses, hoes, diggers and sickles. However, due to increase in productivity and cost of labour, the awareness for the use of machines to harvest crops is on the increase. Similarly, after crops are harvested, they have to be processed into forms for preservation and storage before consumption. This is because not all crops harvested are consumed as soon as they are harvested.

7.1 Harvesting Equipment

Harvesting machines may be classified on the basis of the crops that they harvest.

(1) Feed item for farm animals: This is in the area of grass (forage). Grass is a major component of farm animal feed. There are three forms of grass as feed for animals:

- Fresh grass
- Dried grass or hay
- Processed and fermented grass (silage)

Fresh grass can be harvested with mowers which are of two types namely cutter bar mowers and rotary mowers.

Dried grass or hay can be harvested with the forage harvester or conventional hay baler.

Silage equipment with the forage harvester (cylinder and flywheel type) and the flail-type forage harvester driven by the tractor. Fig 7.1

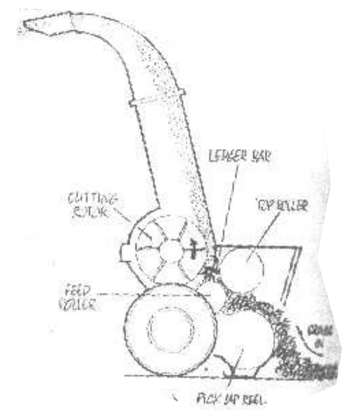


Fig 7.1: Harvesting Equipment
Source: Smith and Wilkes (1984)

(2) Cereal harvesting machines
These include: Reaper, Binder and combine Harvester.

(3) Root Crop Harvest equipment:
These include potato diggers: elevator digger and the spinner.
Cassava lifter
Groundnut combine

(4) Sugar beet harvester

7.2 *Combine Harvester*

The Combine harvester is a useful machine that does the work of a harvester and a processing machine for grains. The processing aspect involves the threshing of grains, cleaning of the grains. Thus the machine that harvest the standing crops directly on the field and simultaneously function to obtain the grain is called combined harvester-thresher. Such machines are therefore referred to as combines. In summary, the functions of a combine are as follows:

i) cutting the standing grain
ii) feeding the cut grain to the cylinder
iii) threshing the grain from the straw
iv) separating the grain from the straw
v) cleaning the grain by removing chaff and other foreign matter, and
vi) making the grain available for collection Fig 7.2

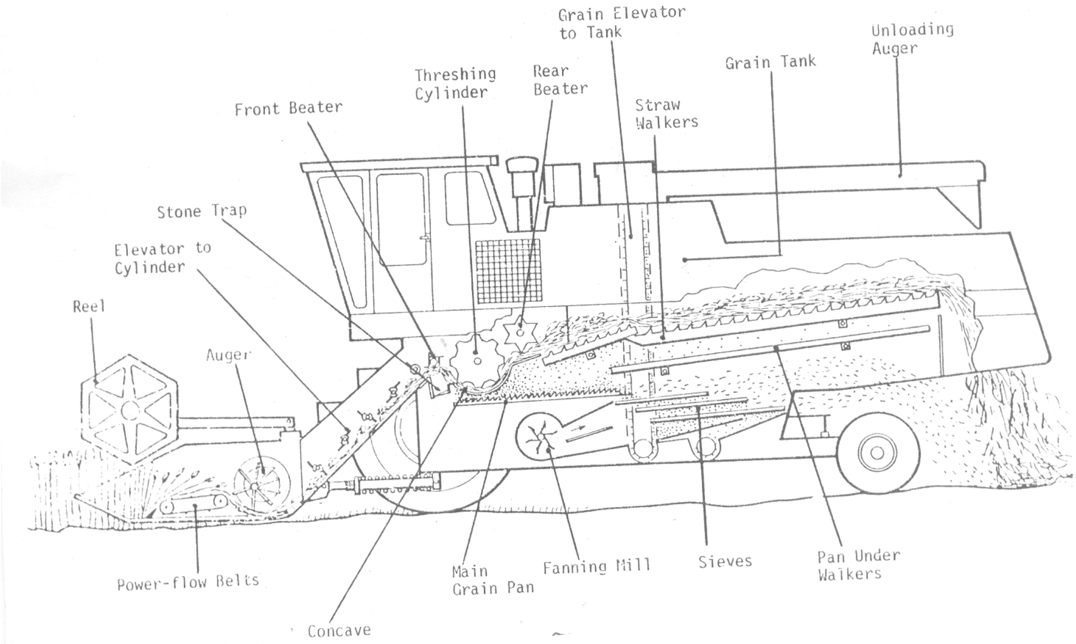


Fig ***7.2:Combine Harvester***
Source: Culpin (1981)

5) Cotton Harvesting Equipment

 i) cotton stripper

 ii) cotton picker

7.3 Processing Equipment

As highlighted in 7.0, crops or farm products harvested need to be treated and preserved before utilization or consumption. Such processing or treatments embrace changing the forms or characteristics. Examples of such processing are: size reduction of crop, threshing grains, milling; preparation of feed for animals through grain grinding and so on.

Size reduction equipment are

i) burr (plate) mill

ii) hammer mill

iii) roller crushing mill

Note: In reducing the harvested crop to a flour, the process is called milling. When food materials are reduced in sizes, they may require mixing them with other food items or ingredients. The machine that performs this feat is called a mixer. (Fig. 7.3).

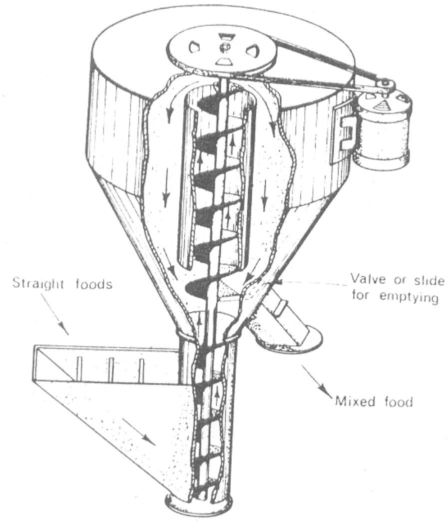


Fig 7.3: Mixer
Source: Harris et al (1981)

Threshing operation is meant to involve the detachment of grain from cobs or earhead; removal of husk from the cobs, shelling the grains; cleaning or separating the grain from foreign materials such as chaff, shell, pod etc. These various operations embedded in threshing are carried out by different machines spelt out as follows:

a) Threshing - It is meant to detach grain from ear head

b) Winnower - It functions for the separation of chaff, pieces of straw from threshed grain.

c) Dehusker - This is for the removal of husk or sheet covering maize cobs or the outer layer of paddy grain.

d) Sheller - It is for the removal of seeds from cobs e.g. maize.

e) Decorticator - This machine works for the breaking and removal of shell from crops like groundnut.

f) Some machines can combine two functions e.g
   i) Dehusker-cum-sheller
   ii) Thresher-cum-winnower

7.4 Spraying Equipment

Farmers do not enjoy insect pests and plant diseases on their crops. They are therefore willing to control the pests and diseases. Machines for applying either dust or liquid insecticides and fungicides are desirable for use by the farmers. Such machines are **sprayers** and **dusters**. A sprayer performs the following functions.

- It breaks the liquid into droplets of effective size.
- It distributes the droplets of liquid uniformly over the surface to be protected.
- It regulates the quantity of insectide so that wastage that could arise as a result of excessive application is avoided.

Sprayer Types

i) **Knapsack Sprayer**:

It is a manually operated equipment having a pump, a large air chamber with a tank. The sprayer is mounted on the shoulder by the operator. The operator pumps with one hand. The knapsack sprayer is useful for spraying small trees, shrubs and row crops.

ii) **Mist blowers:**

These machines are carried on the shoulders by means of straps in a similar manner with knapsack, but they have engines which provide power. The engine replaces the hand and assists in generating a fast flow of air for carrying the dust or liquid insecticide to the tip of the nozzle. Mist blowers are also found useful in spraying shrubs and row crops.

iii) **Tractor Operated Boom Sprayer**

A boom is operated with the tractor. It has a tank that consists of a pump for the provision of sufficient pressure for the sprayer. The pump is operated through the tractor PTO shaft. When the tank is filled with liquid insecticide, it is pressurized with the pump and the liquid is transferred to the long boom having nozzles at adjustable distances for spraying.

iv) **Aircraft Sprayers**

Pesticides could be sprayed onto crops with the use of specially designed air-craft. Spraying principles are similar with the boom sprayer except that much greater quantities of pesticides, distances are involved. Specialists operate the system

Dusters

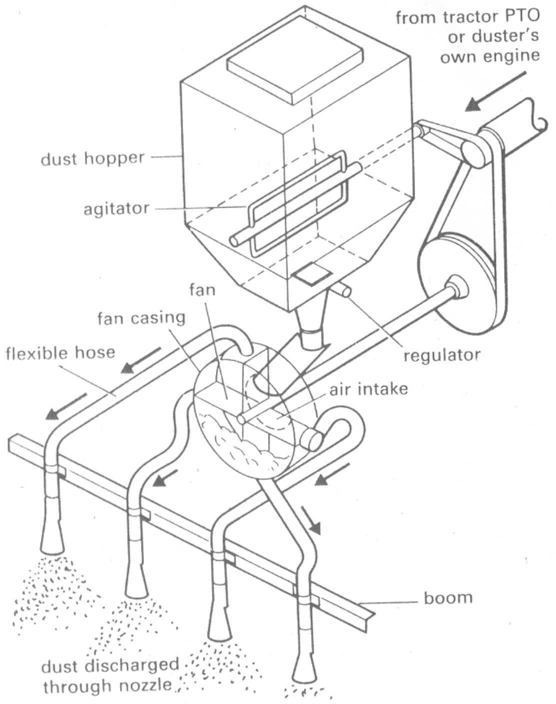
Dusters are machines for blowing powder dust to crops for protection against insects and pests. Dusters usually have cylindrical container for the powder, blower to agitate the dust in the container and a flexible hose pipe through which the dust is blown up.

Available dusters are of three types

i) Plunger Type Hand Duster

ii) Rotary Type Hand and Power Duster Fig 7.4

iii) Air Plane Duster



7.4: Schematic arrangement of the main component of a typical power duster
Source: Kaul and Egbo (1985)

8.0 Operating Principles of Farm Machinery

One of the most important capital inputs in farm production is machinery. Decisions need to be taken on ownership and use of machinery. The farmer is faced with the challenges of decision making on the number of tractor, trucks, implements, sprayers and combines to own, rent or hire as the case may be. An issue of interest is the output. The adoption of machinery frequently results in greater output.

The following principles are found useful in operating farm machinery

a) **Sole Ownership** may be considered suitable where the farmer takes it to be a worthwhile investment particularly when the intention is to expand production sufficiently.

b) **Hiring** of machines may become the choice where the jobs require a small amount of time and where the sole ownership of machinery is expensive for the farmer.

c) **Joint Ownership** is another efficient method of the use of capital resources on machinery. Two farmers may buy an expensive piece of equipment if the volume on any one farm is insufficient to justify sole ownership. Necessary guidelines for joint machinery ownership are:

   i) Mutual trust between the partners must exist

   ii) Agreement must be established at the outset as to priority, should the use of equipment about the same time come up.

   iii) Equally necessary is a pre-arranged procedure for dissolving partnership in an orderly manner if future circumstances arise.

d) The option of Co-operative Rotations is another way of achieving efficiency in the use of farm machines. Expensive machinery is more nearly utilized to capacity with this method.

8.1 Cost of Owning and Operating Farm machinery

Machinery costs are classified into two groups:

i) Fixed costs and

ii) Variable costs

8.1.1 Components of Fixed Costs

Fixed costs are made up of the following:

- Depreciation
- Interest on investment
- Taxes
- Shelter or Housing
- Insurance

It is necessary to know that **Fixed Costs** are independent of machine use, and occur whether the machine is used or not. Fixed costs are also referred to as the cost of owning the machine.

Depreciation is the loss in value of a machine with passage of time, whether used or not. Thus, depreciation is the same thing as the amount of money that should be saved each year as a machine is used so that, at the end of its useful life, this money along with the remaining value of a machine could be used to replace it. Depreciation can be estimated by several methods. One of them is the straight line method. It is as follows:

$$\text{Annual Depreciation} = \frac{\text{New cost of machine} - \text{salvage value}}{\text{Assumed life of machine}}$$

Note: 10% of the cost of the New machine is usually regarded as the salvage value.

Interest on Investment: Interest is part of a machine cost because the money that is tied up in buying equipment is not available for investment elsewhere, where it could be earning an investment return.

Taxes: Any sales taxes paid on equipment

Shelter: The cost of housing the equipment should be borne by the equipment

Insurance: Provision should be made for the charge for insurance on equipment

8.1.2 Components of Variable Costs.

Variable costs are associated with the operation of a machine and takes place only when the machine is in operation. Variable costs are made up of the following:

- Repairs and maintenance
- Fuel

- Oil
- Labour

Repairs and maintenance costs of machinery could be very high and are taken into consideration in the operating cost.

Fuel and Oil are used very frequently to keep the engine in good working conditions.

Labour costs are the wages paid to the operators of the machine.

9.0 Workshop and Building Materials Used on the farm

The equipment available in the farm for various farm work will determine the workshop on the repair and maintenance of farm equipment for their storage. Thus an ideal farm workshop has various sections such as service area including a pit, welding unit, electrical unit, battery charging unit and store for keeping tools and spare parts. Building for farm workshop must have iron columns, walls and roof. Buildings are needed on the farm

i) for the farmer as his dwelling place

ii) for livestock e.g. poultry house
house for pigs
house for goats
house for cattle

iii) for crop production e.g screen house
career house

iv) for crops storage e.g silo
warehouse

Farm workshop and building materials are classified as metals and non-metals.

9.1 Metals

Building materials that are metallic are mainly categorized into two groups namely ferrous and non-ferrous metals

Examples of ferrous metals are cast iron, malleable cast iron, wrought iron and steel including alloy steel. The properties of these materials are not considered here but attention is given to their uses. Ferrous metals are useful in building and workshop as frames for doors, windows. Structural steels are shaped into angles, channels, I-beams, Z bars, U bars, tee bars and hollow squares. There are also solid bars in different shapes e.g round, square, hexagon, half-round etc. Structural steel are useful in the construction of roof as well as stanchion barn.

Examples of non-ferrous metals are copper, brass, bronze, aluminum, zinc and solder.

Copper is useful in electrical installation in workshop and farm buildings. Brass is used for making pipes, instrument parts and fittings.

Bronze is an alloy of copper and tin which is useful in bearings, springs and pipe fittings.

Aluminum or white metal is useful for coating chemical tank and for light castings. It is also found useful in high speed bearings.

Zinc is used mostly as a coating on sheet iron and die castings as a protection against corrosion.

9.2 Non-Metals.

Examples of non-metals are: wood, rubber, leather, vegetable fibres and plastics.

Wood is particularly useful in building construction as frame for doors, windows and roofing planks. Wood used for structural purposes is called lumber.

Rubber is useful in V belts and insulation of wires. V belts are useful in power transmission of electric motors mounted in workshop buildings for various purposes. Leather is largely a belting material. Vegetable fibres are useful as upholstery padding. Plastics are used for seed hoppers, chemical tanks and water storage tanks in farm buildings.

9.3 Other Materials

Some other workshop and building materials are concrete, reinforced concrete, mortar and paints.

Concrete is a mixture of cement with a quantity of inert materials which, when mixed with water, will harden to form an artificial stone. Concrete is useful in the floor construction of a building. Concrete can be shaped into blocks used in the construction of walls.

Cement is a pulverized material made up of silica, aluminum and lime.

Mortar is a mixture of cement, sand and water. It is used as a plaster to make rough surfaces smooth. In making concrete, the inert materials may be sand, pebbles or broken stone. Aggregate is the general term applied to these materials.

Hence, coarse aggregate is gravel or broken stone while fine aggregate is sand.

Instances of mixtures are

i) 1 part cement: 1½ parts sand: 3 parts coarse aggregate. This mixture is useful for making columns.

ii) 1 part cement: 2 parts sand: 4 parts coarse aggregate. This mixture is useful for engine foundation in workshops and for reinforced floors.

Reinforced Concrete

Concrete has great strength in compression. Concrete is mainly fairly strong in shear. Cement is however weak in tension.

To make the concrete material to be able to withstand a required tension, steel is reinforced with it and the resulting composite material is called reinforced concrete. It is useful in beam construction.

Paints

Paint is a form of liquid material such that when it is applied, it dries thereafter to form a hard thin film. Paint is used as finishing to a building. Paint add colour to the building to beautify it. Paint is also useful for coating metal surfaces.

10.0 Self-Assessment Exercises

1. What is farm mechanization?
2. State 5 objectives of agricultural mechanization.
3. What is the main function of a machine?
4. Mention six simple machines that you are familiar with.
5. What are the properties common with the simple machines?
6. Determine the velocity ratio of a screw jack when its tommy bar and pitch are respectively 24cm and 0.6cm. (Ans = 80).
7. State the main function of gears.
8. Distinguish between driver and driven gears.
9. What are the uses of the following tools? (i) Allen key (ii) Odd leg caliper and (iii) center punch.
10. Describe the principles of operation of a 4-stroke compression-ignition engine

11. What are the objectives of tillage?
12. Mention the implements for carrying out each of the two main categories of tillage.
13. Enumerate the methods of transmitting farm power.
14. On what basis are the harvesting machines classified?
15. What are the functions of a combine harvester?
16. How are spraying machines different from dusters?
17. Briefly describe the operating principles of farm machinery.
18. What are the factors that constitute the variable costs of operating a farm machine?
19. Why are buildings necessary on the farm?
20. Of what use are the following materials in farm workshop: Rubber, mortar, reinforced concrete and paints?

11.0 Summary

In this unit we have learnt that:

- Farm mechanization assists farmers to practice large scale farming with the use of machines, thereby saving labour, increasing yield and enabling the farmer to make more profits.
- Machines are useful in the production and processing of crops. There are six simple machines in use. Machines are not 100% efficient due to friction.
- Speed of cars, tractors, etc can be changed in form of speed decreasing or increasing by means of gears.
- Metal and wood workshops constitute agricultural engineering workshop. Some useful basic tools in the workshop include chisel, files, scriber, odd-leg calipers, divider, punches, screw drivers, Allen key, hack saw, tee square, steel rule, protractor, calipers, vernier caliper and micrometer screw gauge.
- Internal combustion engines are those engines in which burning of fuel occur in a closed system for the generation of heat energy and liberation of useful mechanical energy.
- Spark-Ignition engines and compression-Ignition engines are the two forms of operation of a 4-stroke engine. The four strokes are the intake or induction, compression, power and exhaust.
- Tillage is the suitable preparation of land for crop planting. Primary and secondary tillage are the main forms of tillage accomplishable with plough, subsoiler, cultivators, harrows and ridgers.
- Flat and Vee-belts, chains and gears are means of transmitting power in machines from one rotating shaft to another.
- Harvesting and processing equipment encourage crops to be harvested with relative ease and to reduce crop spoilage and wastage through their processing. Combine harvester and crop size reduction equipment were studied.
- Crops can be protected from insect infestation, pests and diseases attack through the use of spraying equipment and dusters.
- Operating principles of farm machinery include ownership method, cost of owning and operating them (fixed and variable costs).
- Workshop and building materials used in the farm are ferrous and non-ferrous metals; non-metals, concrete, cement, mortar, reinforced concrete and paints.

12.0 Tutor Marked Assignments

1. Discuss the benefits of farm mechanization.
2. Mention the use of wedge as simple farm machine. Estimate the velocity ratio and the magnitude of a force to push a 25kg bag of rice through an inclined plane at angle 30^0 to the horizontal when its efficiency is 60%.

   (Ans: V.R. = 2, E = 208.3N)
3. What is the usefulness of gears in farm machines. Mention 3 types of gears known to you. Two gear wheels have 40 and 110 teeth respectively. If the gear wheel rotates at 30 rev/s, determine the speed of the smaller wheel.

   (Ans w_s = 82.5 rev/s)
4. With suitable diagrams, explain the uses of the following workshop tools

   (i) Hack saw (ii) Steel rule (iii) Outside caliper (iv) centre punch and (v) Chisel
5. Explain the following engine terms:

   Engine Capacity

   Bottom dead centre

   Swept volume

   Compression ratio and

   Stroke.

   Determine the swept volume of an I.C.E. having a bore radius of 50mm and a stroke length of 124mm.

   (Ans = 973.4mm^3)
6. Mention 5 objectives of tillage.

   Name the implements used for (a) Primary tillage

   (b) Secondary tillage

   Sketch a disc plough and label the main parts.

   State the reason(s) in support of the preference of the disc plough to the mouldboard plough in the tropics.
7. Explain the operating principles of transmitting power through the use of belt.

   Illustrate with suitable labeled diagrams.

   What is the diameter of a pulley on a machine to the driven at 183 rev/min when the speed of the running shaft to drive the machine of a diameter 140mm is 300.6 rev/min?

   (Ans = 230mm)
8. Describe the functions of a combine harvester.

   Itemize the various machines embedded in crop threshing. State the function of each of them.

Give a description of the knapsack sprayer.

If a farmer owns a knapsack sprayer, what benefits can he derive from having it?

9. Distinguish between the fixed and variable costs of owning and operating farm machinery.

10. Describe the categories of workshop and building materials used on the farm.

13.0 Further Reading and Other Resources (References)

Adeniyi, M.O; Udeogalanya A.C.C; Okeke G.C; Abdullahi. Y and Iheukwumere, C.A (1991). Countdown to SSCE Agricultural Science. Evans publishers Nig Ltd.

Ashworth, A.E (1982) Physics for WAEC. Cassell, London.

Chapman, W.A.J (1975) Elementary Workshop calculations. ELBS and Edward Arnold Publishers Ltd. London.

Claude Culpin (1981) Farm Machinery. ELBS and Granada Publishers, London..

Elekwa. I; Bamiro. O.A.; Oluyide. A.O; Ladoye, D.L; Nurudeen. A; Akuru I.O. and Olapade, O.L (1983). Introductory Technology for Schools and Colleges. Evans Brothers, Ibadan, Nigeria.

Grimshaw. S.A (1976). Cassell's Woodwork Notebook. Cassell, London.

Harris, A.G.; Muckle. T.B and Shaw. J.A. (1981). Farm Machinery. Oxford University Press, London 2nd Edition.

Hillier, V.A.W (1978). Motor Vehicle Basic Principles. Hutchinson and Co (Publishers) Ltd. London.

Kaul. R.N and Egbo. C.O (1985). Introduction to Agricultural Mechanization. Macmillan Publishers, London.

Lovegrove, H.T (1978). Crop Production Equipment. A Practical Guide for Farmers, Operator and Trainees. Hutchinson, London.

Mijinyawa, Y; Ogedengbe. K; Ajav. E.A and Aremu. A.K (2000) Stirling-Horden Publishers (Nig) Ltd.

Ojha, T.P and Michael, A.M (2006). Principles of Agricultural Engineering. Reliance Industries (P) Ltd, New Delhi.

Smith, A.E and Wilkes, M.S (1984) Farm Machinery and Equipment. Tata McGraw-Hill Publishing Co Ltd. New Dehli.