Agriculture Machinery Operator

(Job Role)

Qualification Pack: Ref. Id. AGR/Q1103

Sector: Agriculture

Textbook for Class XII

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PSS CENTRAL INSTITUTE OF VOCATIONAL EDUCATION, SHYAMLA HILLS, BHOPAL- 462 002, M.P., INDIA

(a constituent unit of NCERT, under MHRD, Government of India)

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FOREWORD

The National Curriculum Framework–2005 (NCF–2005) recommends bringing work and education into the domain of the curricular, infusing it in all areas of learning while giving it an identity of its own at relevant stages. It explains that work transforms knowledge into experience and generates important personal and social values such as self-reliance, creativity and cooperation. Through work one learns to find one's place in the society. It is an educational activity with an inherent potential for inclusion. Therefore, an experience of involvement in productive work in an educational setting will make one appreciate the worth of social life and what is valued and appreciated in society. Work involves interaction with material or other people (mostly both), thus creating a deeper comprehension and increased practical knowledge of natural substances and social relationships.

Through work and education, school knowledge can be easily linked to learners' life outside the school. This also makes a departure from the legacy of bookish learning and bridges the gap between the school, home, community and the workplace. The NCF–2005 also emphasises on Vocational Education and Training (VET) for all those children who wish to acquire additional skills and/or seek livelihood through vocational education after either discontinuing or completing their school education. VET is expected to provide a 'preferred and dignified' choice rather than a terminal or 'last-resort' option.

As a follow-up of this, NCERT has attempted to infuse work across the subject areas and also contributed in the development of the National Skill Qualification Framework (NSQF) for the country, which was notified on 27 December 2013. It is a quality assurance framework that organises all qualifications, according to levels of knowledge, skills and attitude. These levels, graded from one to ten, are defined in terms of learning outcomes, which the learner must possess regardless of whether they are obtained through formal,

non-formal or informal learning. The NSQF sets common principles and guidelines for a nationally recognised qualification system covering schools, vocational education and training institutions, technical education institutions, colleges and universities.

It is under this backdrop that Pandit Sunderlal Sharma Central Institute of Vocational Education (PSSCIVE), Bhopal, a constituent of NCERT has developed learning outcomes based modular curricula for the vocational subjects from Classes IX to XII. This has been developed under the Centrally Sponsored Scheme of Vocationalisation of Secondary and Higher Secondary Education of the Ministry of Education.

This textbook has been developed as per the learning outcomes-based curriculum, keeping in view the National Occupational Standards (NOS) for the job role and to promote experiential learning related to the vocation. This will enable the students to acquire necessary skills, knowledge and attitude.

I acknowledge the contribution of the development team, reviewers and all the institutions and organizations, which have supported in the development of this textbook.

NCERT would welcome suggestions from students, teachers and parents, which would help us to further improve the quality of the material in subsequent editions.

Prof. Dinesh Prasad Saklani
Director
National Council of Educational
Research and Training

New Delhi
May 2022

About the Textbook

An Agriculture Machinery Operator is important Job role in agriculture, for operating agriculture machineries used in different farming processes such as tilling, planting seeds, fertilizing plants, spraying and dusting of plants and harvesting crops and also responsible for carrying out periodical maintenance procedures for the same and making minor adjustments. Agriculture Machinery Operator is responsible for driving, minor repair maintenance and servicing of agriculture farm machinery and other set-ups. The person should be able to work independently on the assignment, be comfortable in performing laborious work, be a good listener, good at following instructions, a cooperative team player and result-oriented, with a positive attitude. Agriculture Machinery Operator is a beginner's level course. On completion of this course, a student can take up an intermediate level course for a job role in the Agriculture sector.

The textbook for the job role of Agriculture Machinery Operator has been developed to impart knowledge and skills through hands-on learning experience, which forms a part of experimental learning. Experimental learning focuses on the learning process for the individual; therefore, the learning activities are student-centered rather than teacher-centred.

The textbook has been developed with the contribution of the subject experts, vocational teachers, industry experts and academicians, for making it a useful and inspiring teaching-learning resource material for the vocational students. Adequate care has been taken to align the contents of the textbook with the National Occupational Standards (NOS) for the job role so that the students acquire the necessary knowledge and skills as per the performance criteria mentioned in the respective NOS of the Qualification Pack (QP). The NOS for the job role of ' Agriculture Machinery operator' covered through this textbook are as follows:

1. AGR/N1123: Prepare for training and demonstration.
2. AGR/N1124: Demonstrate the operation of various farm machineries and

implements.

3. AGR/N1125: Demonstrate and supervise the repair and maintenance of agricultural machineries and implements.
4. AGR/N1107: Prepare power tiller for operation.
5. AGR/N1108: Operate a power tiller for various farm operations.
6. AGR/N1110: Carry out various operations using power tiller attachments.
7. AGR/N1103: Prepare combine harvester machine for operation.
8. AGR/N1104: Operate the combine harvester machine to harvest grain crop.
9. AGR/N1105: Perform repair and maintenance of combine harvester machine.
10. AGR/N1115: Prepare and operate the reaper.
11. AGR/N1116: Prepare and operate the power thresher.
12. AGR/N1101: Operate tractor for farm operations.
13. AGR/N1102: Perform regular maintenance and basic repair of tractor.
14. AGR/N9903: Maintain health and safety at the workplace.

Unit 1 of the textbook gives introduction of use of engine in agriculture machinery. Unit 2 Focusses on land leveling /shaping machine. Unit 3 deals with power tiller. Unit 4 is on new technology and future of agriculture machinery. Unit 5 deals with custom hiring of agricultural machinery.

This textbook could not have been completed without the support of the National Skill Development Agency (NSDA), National Skill Development Corporation (NSDC) and Agriculture Skill Council of India (ASCI).

We extend our gratitude to all the contributors for selflessly sharing their precious knowledge, acclaimed expertise and valuable time, and positively responding to our request for development of the textbook.

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The Council acknowledges the contribution of the members of the Review Committee for sharing their expertise and time. The Council would also like to thank Dr. Deepak Paliwal, *Joint Director*, PSS Central Institute of Vocational Education (PSSCIVE), Bhopal for providing support and guidance in the development of this textbook.

The Council is also grateful to Saroj Yadav, *Professor* and *Dean* (Academic), and Ranjana Arora, *Professor* and *Head*, Department of Curriculum Studies, NCERT, for their sincere efforts in coordinating the review workshops for the finalisation of this book.

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We are thankful to the course coordinator Saurabh Prakash, *Professor and Head*, Department of Engineering and Technology, PSSCIVE, Bhopal, for his untiring efforts towards developing the content for this textbook and also providing photographs used in the textbook. The images used other than these are under Creative Commons License. The contribution of Dr. Satyendra Thakur, Assistant Professor (Contractual), Department of Engineering and Technology, PSSCIVE, Bhopal is also acknowledged.

The Council also acknowledges the copyediting and proof reading Publication Division, NCERT; Vinod Kumar Soni, *Computer Operator Grade-II*; Mohd. Safeeq DTP operator, PSSCIVE, NCERT, are also acknowledged. This textbook would not have been possible without the support of the Agriculture skill council of India, New Delhi.

CONTENTS

UNIT 1: USE OF ENGINE IN AGRICULTURE MACHINERY

1.1: INTRODUCTION

Agriculture is the sole source of income for Indian farmers. Power is required for all agricultural operations, from the farm field to the storage facility. Human, animal, mechanical, electrical, solar, wind, and other biomass sources provide power for farm operations. The mechanical and electrical power sources, on the other hand, are derived indirectly from other sources. In addition to human power, modern agriculture makes extensive use of mechanical and electrical power for motive and stationary uses.

Farmers have a variety of opportunities in the agriculture sector to use new technology, machinery, tools, and equipment to complete their jobs more efficiently. Different types of machinery are utilized in agriculture to fulfill various duties in the field; thus, each portion of the machinery must function well. If it isn't, then it has to be maintained properly. The engine is a critical component of every machine.

SESSION 01: USE OF ENGINE IN AGRICULTURAL APPLICATIONS

1.2: WHAT IS AN ENGINE?

'An engine is a machine that converts one or more forms of energy into mechanical energy.'

A device that turns potential energy into mechanical work is known as an engine. It's a device that transforms energy into useful mechanical motion. It's a machine with moving elements that transform energy into motion. Engines are machines that convert one form of energy into another by moving.

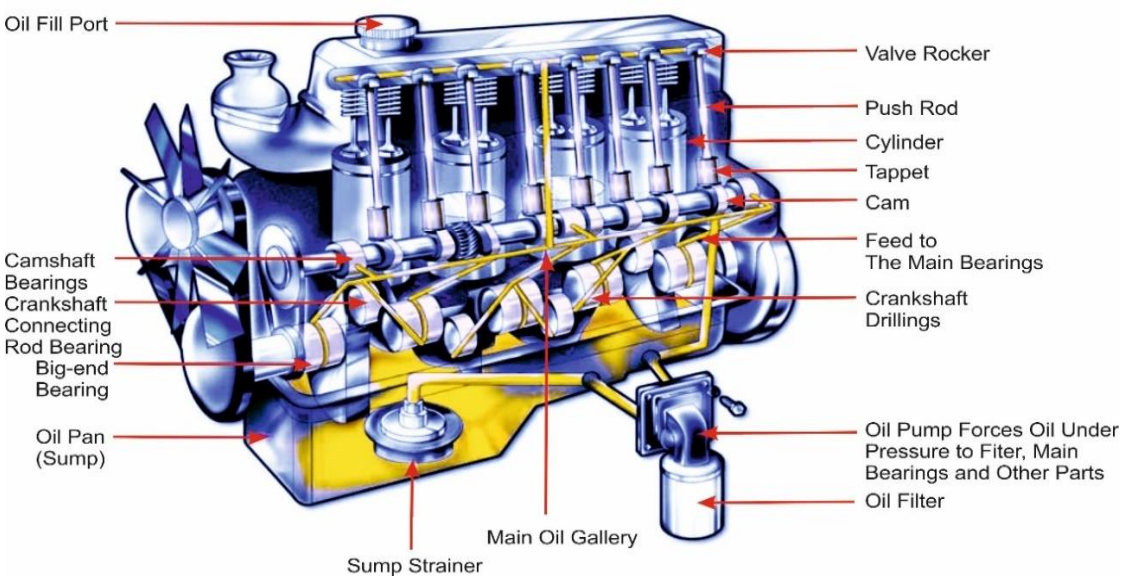


Fig. 1.1: Engine

'An engine or motor is a machine that converts thermal energy into mechanical energy, allowing vehicles to move from one location to another.'

Different types of engines are now used in various agricultural machinery. The application of engines in various agricultural applications is determined by their fieldwork.

1.2.1: BASIC ENGINE TERMINOLOGY

A. **Bore:** The distance across the cylinder (or the diameter).
B. **Bottom Dead Centre (BDC):** The lowest position in the cylinder that the piston reaches.
C. **Combustion chamber:** The space left at the top of the cylinder when the piston is at the top dead centre (TDC). This also includes any space in the cylinder head.
D. **Compression:** The squishing or squeezing of the air/fuel mixture from BDC to TDC.
E. **Compression ratio:** The difference is expressed through a ratio of the space left in the cylinder when the piston is at TDC versus BDC.

F. Cylinder Volume: Cylinder volume is defined as the capacity of the cylinder. The volume of a cylinder can be calculated by radius 'r' and height 'h' of the cylinder. The cylinder volume is measured in cubic centimeters, cubic meters, and so on. The volume of a cylinder is its capacity, which is used to calculate how much material it can store.

G. Clearance Volume: 'The volume which remains in the cylinder when the piston is at the top dead centre'.

When the piston is at the top dead center, the engine's "clearance volume" is the space between the cylinder head and the piston.

H. Engine types: Engines can be classified in many different ways. However, basic engine types are:

- **Petrol Engine**
  - **Two-stroke cycle engine:** It takes two strokes of the piston to complete a cycle.
  - **Four-stroke cycle engine:** It takes four strokes of the piston to complete a cycle.
- **Diesel Engine:** It (two or four-stroke) uses the heat of compression rather than a spark plug to ignite the fuel that is directly injected into the cylinder. Each of these engines can come in several different configurations.

I. Four-stroke cycle: Four movements of the piston equal one cycle.

J. Stroke: The distance the piston travels from TDC to BDC or from BDC to TDC.

K. Stroke length: It can be defined as the distance travel by the piston from TDC to BDC inside the cylinder of an engine.

L. Top Dead Centre (TDC): It is the top position in the cylinder that the piston reaches.

M. Swept Volume: It is the volume swept by the piston in a stroke.

N. Piston area: The area of the flat surface or end of a piston.

1.2.2: COMPONENTS OF ENGINE

- **Engine Block:** The engine block is the foundation and centre of the engine. Blocks come in many different sizes, shapes, and styles. The engine block holds the cylinder, the crankshaft, connecting rods ("con rods"), and pistons. The large round holes in the block, called cylinders, are where the pistons slide up and down
- **Cylinder:** It is the main part of the engine inside where the piston reciprocates to and fro motion. It should have high strength to withstand high pressure above 50 bar and temperature above 2000 ^{o}C. The ordinary engine is made of cast iron and heavy-duty engines are made of steel alloys or aluminum alloys. In the multi-cylinder engine, the cylinders are cast in one block known as a cylinder block.
- **Piston:** A piston slides up and down a cylinder and pushes the crankshaft around. The piston connects to the crankshaft via the connecting rods**.**
- **Piston Rings:** Each piston has two compression rings and one oil control ring to help seal the piston in the cylinder.
- **Connecting Rod:** Connecting rods connect the pistons to the crank. They utilize an I-beam construction for strength.
- **Crankshaft:** The crankshaft is bolted to the bottom of the engine block through bearings so it can rotate freely. It is sometimes referred to as the crank. The crankshaft converts the vertical motion of the pistons and connecting rods to rotational motion. One end of the crankshaft is connected to a flywheel that transfers the engine power to the wheels through a transmission (manual or automatic).
- **Cylinder Head:** The cylinder head is bolted to the top of the cylinder block. It serves as a cover for the cylinders and pistons. The cylinder head helps to create the top part of the combustion chamber. An engine "breathes" through the cylinder head. It lets an air/gas mixture into the engine and exhausts out of the engine. The valves and valve train control the breathing of the engine by opening and closing the valves at the appropriate time.

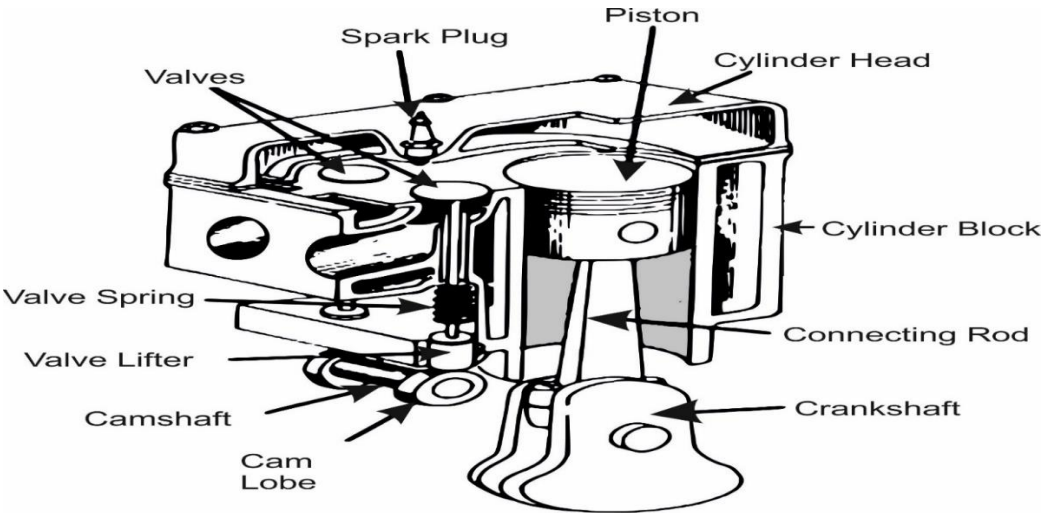


Fig. 1.2: Cylinder head

- **Valves:** Valves can be divided into two groups:
  - Intake valves control the flow of the air/gas mixture into the engine.
  - Exhaust valves control the flow of exhaust out of the engine.
- **Camshaft:** The camshaft controls the opening and closing of the valves. There is one lobe on the camshaft for each valve in the engine. Camshaft lobe design dictates three things:
  - How far the valve opens.
  - How fast the valve opens.
  - How long the valve opens.

  Depending on the engine type, the camshaft can be located either in the engine block or over the head.
- **Lifters (Tappets):** Lifters are the link between the cam and valves. They are so named because they lift as the cam lobe rotates and opens the valves. There are two basic types of lifters:
  - Hydraulic lifter.
  - Solid lifter.

  The valve train includes all the parts that are used to open and close valves. This may include parts like valve springs, keepers, lifters, cam followers, shims, rockers, and pushrods.

- **Flywheel:** The flywheel attaches to the crankshaft, and uses its momentum to power the engine through the three non-power strokes (intake, compression, and exhaust). Because an 8-cylinder car has more power strokes than a four-cylinder car, the flywheel will be smaller and lighter as there is less need for momentum carry capabilities. Flywheels are used in standard transmissions. Flex-plates are used in automatic transmissions. Flywheels and flex-plates have ring gear for the starter.

Engine and its types

Small gas engines are widely employed in agriculture and serve a variety of purposes. Sprayers, brush cutters, garden tillers and mowers, small generators, tree pruners, chainsaws, irrigation pumps, and other items are all powered by engines. The engine is a self-contained heat engine that burns chemical fuel and converts it into mechanical energy in a controlled and regulated manner to provide mechanical energy for practical work. Petrol and diesel, both derived from petroleum are the most prevalent engine fuels.

1.3: WORKING PRINCIPLE OF ENGINE

1.3.1: TWO-STROKE CYCLE ENGINE AND FOUR-STROKE CYCLE ENGINES

A. Two-Stroke Cycle Engine (Petrol Engine): In two-stroke cycle engines, the entire sequence of events, such as suction, compression, power, and exhaust, is accomplished in two strokes of the piston, or one crankshaft revolution. This sort of engine does not have a valve. The cylinder has holes called ports that allow gas to flow through. The engine's crankcase, in which the crankshaft rotates, is airtight. The next procedure is as follows:

1. Upward stroke of the piston (Suction + Compression): When the piston moves upward it covers two of the ports, the exhaust port, and transfer port, which is normally almost opposite to each other. This traps the charge of the air-fuel mixture drawn already into the cylinder. Further upward movement of the piston compresses the charge and also uncovers the suction port. Now the fresh mixture is drawn through this port into the crankcase. Just before the end of this stroke, the mixture in the cylinder is ignited by a spark plug (Fig 1.3). Thus,

during this stroke, both suction and compression events are completed.

2. Downward stroke (Power + Exhaust): Burning of the fuel rises the temperature and pressure of the gases which forces the piston to move down the cylinder. When the piston moves down, it closes the suction port, trapping the fresh charge drawn into the crankcase during the previous upward stroke. Further downward movement of the piston uncovers first the exhaust port and then the transfer port. Now fresh charge in the crankcase moves in to the cylinder through the transfer port driving out the burnt gases through the exhaust port. Special shaped piston crown deflects the incoming mixture up around the cylinder so that it can help in driving out the exhaust gases. During the downward stroke of the piston power and exhaust events are completed.

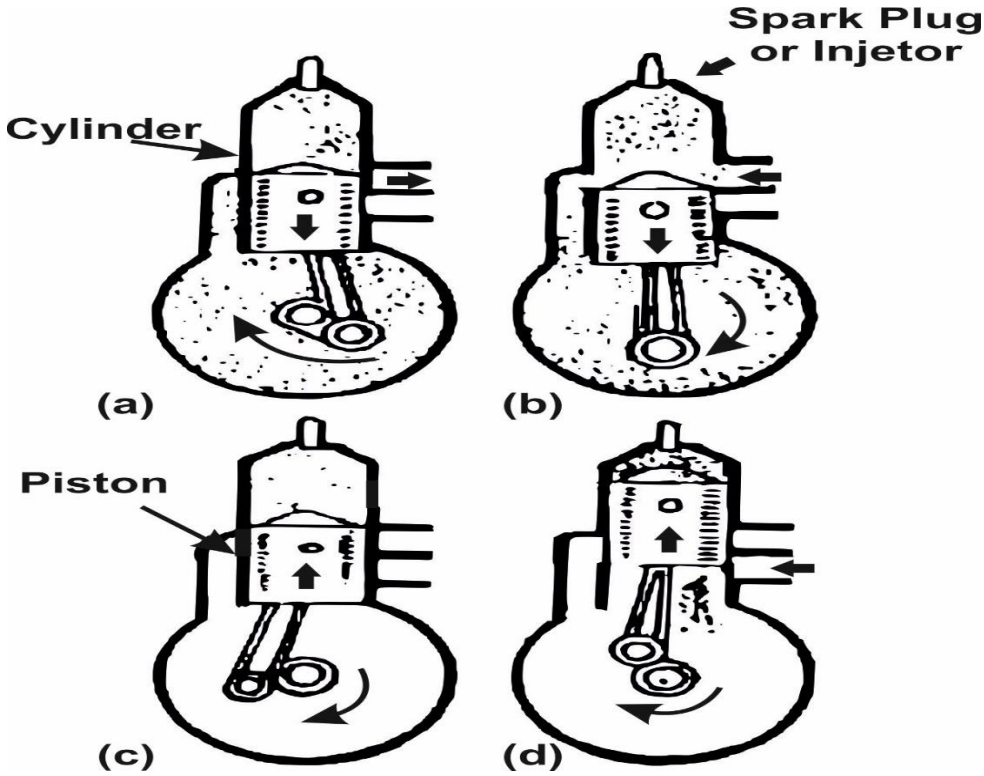


Fig. 1.3: Two-stroke cycle engine

B. FOUR STROKE CYCLE ENGINE (DIESEL/PETROL ENGINE): In four-stroke cycle engines the four events namely suction, compression, power, and exhaust take place inside the engine cylinder. The four events are completed in four strokes of the piston (two revolutions of the crankshaft). This engine has got

valves for controlling the inlet of charge and outlet of exhaust gases. The opening and closing of the valve are controlled by cams, fitted on the camshaft. The camshaft is driven by a crankshaft with the help of suitable gears or chains. The camshaft runs at half the speed of the crankshaft.

The events taking place in four-stroke engines are as follows:

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

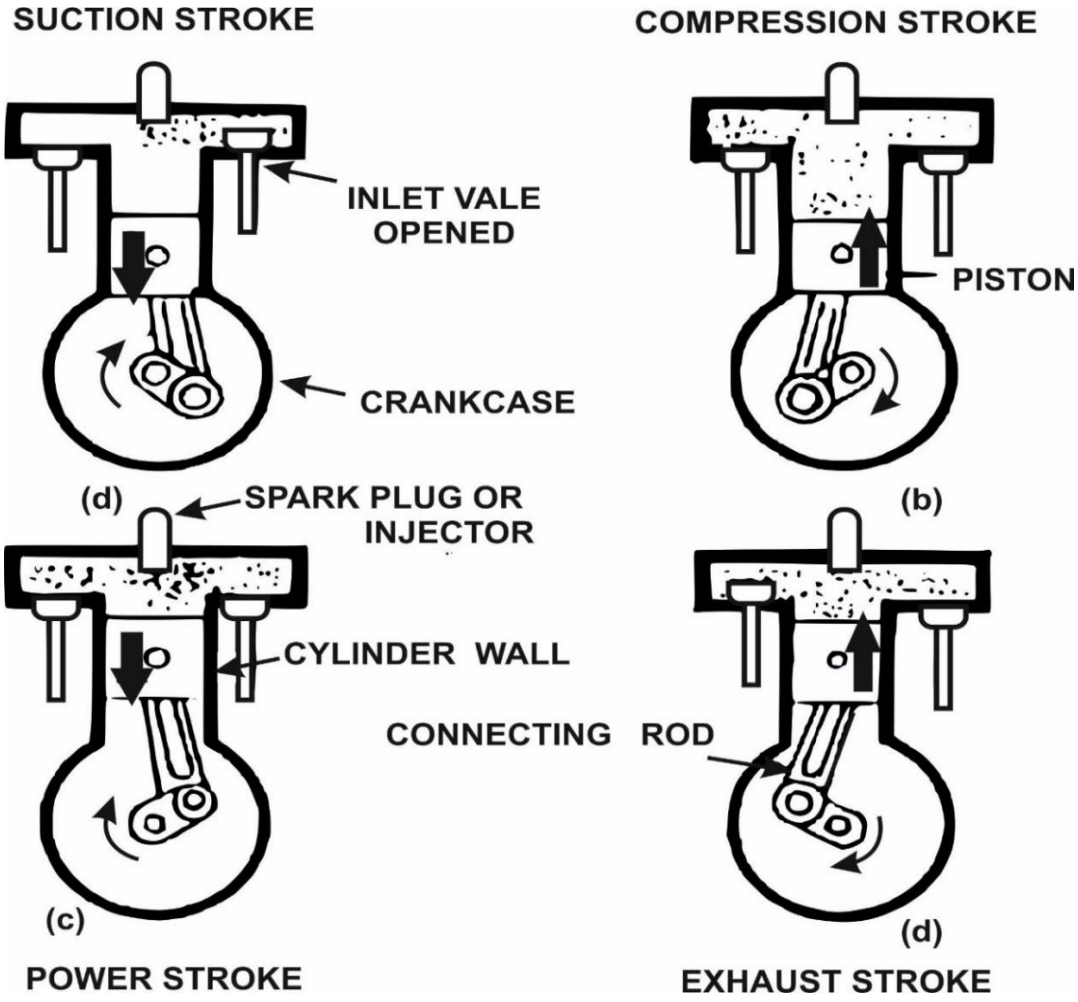


Fig. 1.4: Four-stroke cycle engine

Process of four-stroke cycle engine

1. **Suction stroke:** During suction stroke inlet valve opens and the piston moves downward. Only air or a mixture of air and fuel is drawn inside the cylinder. The exhaust valve remains in the closed position during this

stroke. The pressure in the engine cylinder is less than atmospheric pressure during this stroke (Fig. 1.4 a).

2. **Compression stroke:** During this stroke, the piston moves upward. Both valves are in a closed position. The charge taken in the cylinder is compressed by the upward movement of the piston. If only air is compressed, as in case of a diesel engine, diesel is injected at the end of the compression stroke and ignition of fuel takes place due to the high pressure and temperature of the compressed air. If a mixture of air and fuel is compressed in the cylinder, as in case of the petrol engine, the mixture is ignited by a spark plug.

3. **Power stroke:** After the ignition of the fuel, a tremendous amount of heat is generated, causing very high pressure in the cylinder which pushes the piston downward (Fig.1.4 c). The downward movement of the piston at this instant is called power stroke. The connecting rod transmits the power from the piston to the crankshaft and the crankshaft rotates. Mechanical work can be taped at the rotating crankshaft. Both valves remain closed during the power stroke.

4. **Exhaust stroke:** During this stroke piston moves upward. The exhaust valve opens and exhaust gases go out through the exhaust valve opening. All the burnt gases go out of the engine and the cylinder becomes ready to receive the fresh charge. During this stroke inlet valve remains closed (Fig.1.4 d). Thus, it is found that out of four strokes, there is only one power stroke and three idle strokes in four-stroke cycle engines. The power stroke supplies the necessary momentum for useful work.

1.3.2: SPARK IGNITION ENGINE (SI ENGINE) AND COMBUSTION IGNITION ENGINE (CI ENGINE)

A. SI Engine (Spark Ignition Engine): Spark Ignition (SI) Engine is a type of

engine in which the combustion takes place by the spark generated by the spark plug. It uses petrol as fuel and works on the 'Otto cycle'. In the spark-ignition engine, the air-fuel mixture is inserted into the cylinder with the help of a carburetor. The compression of the fuel takes place but it has a low compression ratio. The fuel is ignited by the spark generated by the spark plug. Spark Ignition engine produces less noise and vibration and their starting is very easy. They are light in weight and have less maintenance cost. They are mostly used in light commercial vehicles such as scooters, motorcycles, cars, etc.

B. CI Engine (Compression Ignition Engine): A Compression Ignition (CI) Engine is an engine in which the combustion of fuel takes place by the heat of the compressed air. It uses diesel as fuel and works on the Diesel cycle. In the compressed ignition engine, only air enters into the cylinder during suction stroke. It has a high compression ratio because of the high ignition temperature of the diesel fuel. The heat of the compressed air ignites the fuel. Due to the high compression ratio, it produces more power. Due to incomplete combustion of the fuel, it produces more hydrocarbons which lead to air pollution. The noise and vibration problems are there in the CI engines. The maintenance cost of the CI engine is more as compared with the SI engines. They are mostly used in heavy-duty vehicles such as buses, trucks, railways, etc.

Table 1.1: Difference between CI engine and SI engine

S. No.	Parameter	CI Engine	SI Engine
1.	**Definition**	• In this engine heat of compressed air is used to burn the fuel.	• In this engine, the spark is used to burn the fuel.
2.	**Starting**	• The starting of the CI engine is difficult.	• The starting of the SI engine is easy.
3.	**Operating cycle**	• It operates on the Diesel cycle.	• It operates on the Otto cycle.

4.	**Fuel used**	• Diesel is used as fuel.	• Petrol is used as fuel.
5.	**Method of ignition**	• The heat of compressed air is used for the ignition.	• A spark plug is used to produce a spark for the ignition.
6.	**Fuel supply**	• Injector	• Carburetor
7.	**Intake**	• Only air.	• Air + fuel.
8.	**Engine speed**	• Low-speed engines.	• High-speed engines.
9.	**Compression ratio**	• High compression ratio.	• Low compression ratio.
10.	**Thermal efficiency**	• Less thermal efficiency.	• High thermal efficiency.
11.	**Pressure generated**	• High pressure is generated.	• Low pressure is generated after combustion.
12.	**Weight of engine**	• CI engines are heavier.	• SI engine has less weight.
13.	**Constant parameter during cycle**	• Constant pressure cycle.	• Constant volume cycle.
14.	**Production of hydrocarbon**	• More hydrocarbon is produced.	• Less Hydrocarbon is produced.
15.	**Noise production**	• It produces more noise.	• It produces less noise.
16.	**Vibration problem**	• Very high	• Less
17.	**Volume to**	• High	• Less

	power ratio		
18.	**Cost of engine**	• High cost	• Less cost
19.	**Maintenance cost**	• High	• Low
20.	**Application**	• It is used in heavy-duty vehicles likes bus, trucks, ships, etc.	• It is used in light commercial vehicles like motorcycles, cars, etc.

1.4: COMPONENTS OF ENGINE

The engine consists of several parts which are given below:

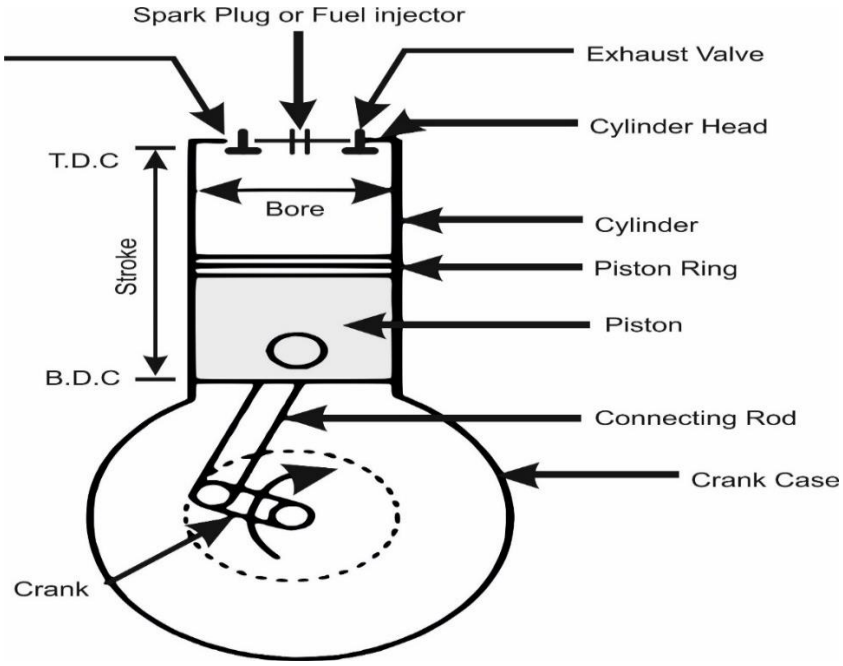


Fig. 1.5 (A): Engine parts

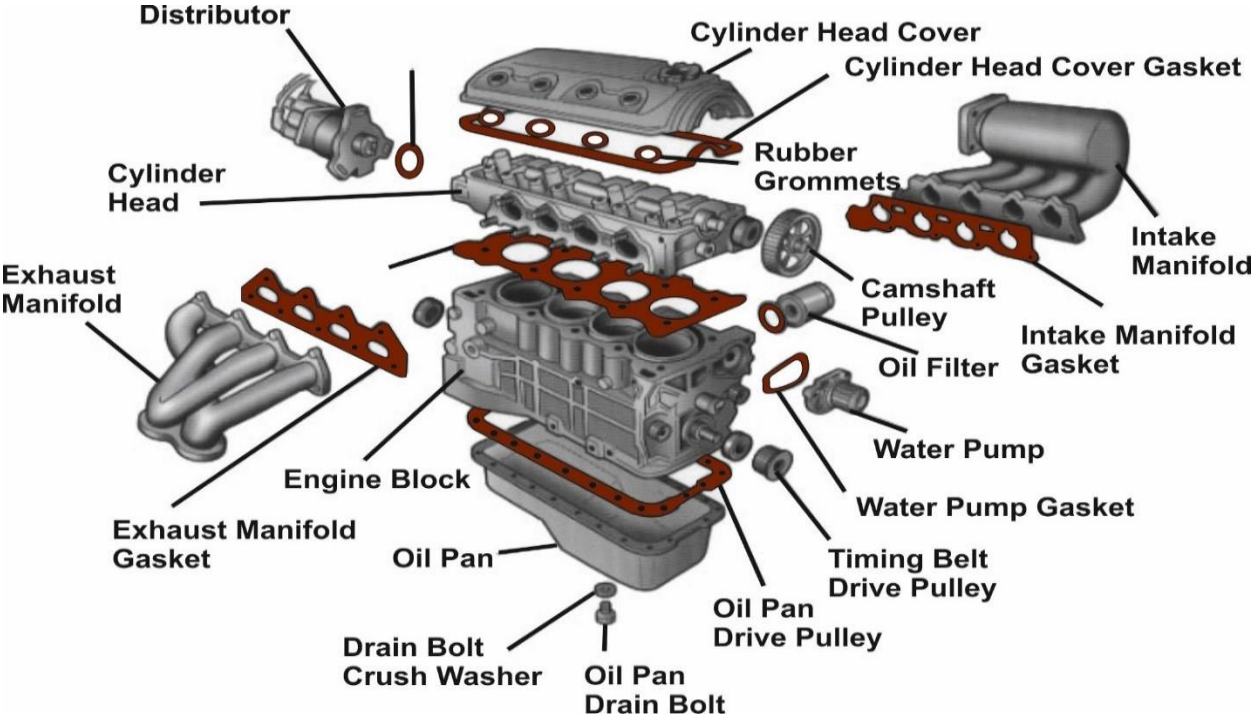


Fig. 1.5 (B): Parts of Engine

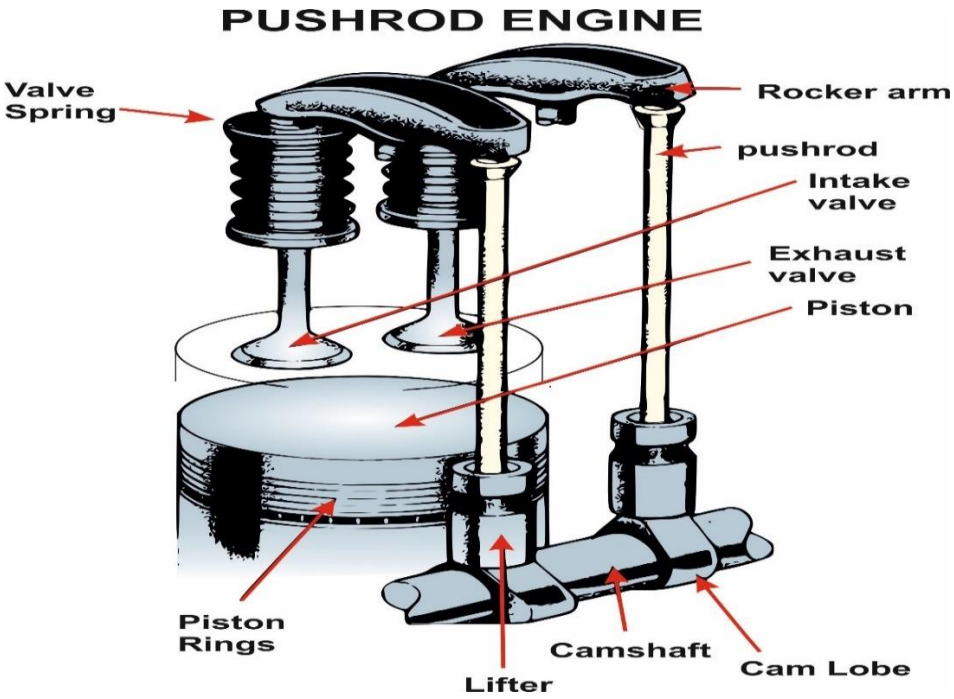


Fig. 1.5 (C): Pushrod and Piston of engine

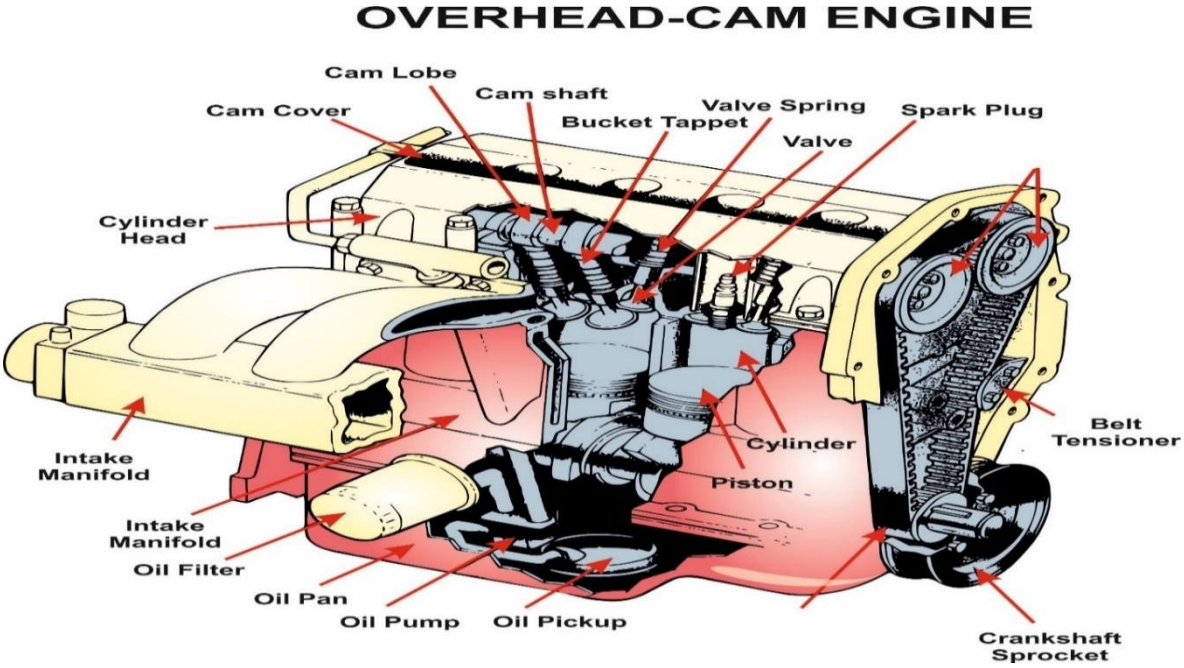


Fig. 1.5 (D): Parts of Engine

I. **Cylinder:** It is a part of the engine which confines the expanding gases and forms the combustion space. It is the basic part of the engine. It provides space in which the piston operates to suck the air or air-fuel mixture. The piston compresses the charge and the gas is allowed to expand in the cylinder, transmitting power for useful work. Cylinders are usually made of high-grade cast iron.

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

III. **Cylinder head:** It is a detachable portion of an engine that covers the cylinder and includes the combustion chamber, spark plugs, or injector and valves.

IV. **Cylinder liner or sleeve:** It is a cylindrical lining either wet or dry type which is inserted in the cylinder block in which the piston slides.

Liners are classified as (1) Dry liner and (2) Wet liner

The dry liner makes metal-to-metal contact with the cylinder block casing. Wet liners come in contact with the cooling water, whereas dry liners do not come in contact with the cooling water.

V. **Piston:** It is a cylindrical part closed at one end which maintains a close sliding fit in the engine cylinder. It is connected to the connecting rod by a piston pin. The force of the expanding gases against the closed end of the piston forces the piston down in the cylinder. This causes the connecting rod to rotate the crankshaft (Fig 1.5 A). Cast iron is chosen due to its high compressive strength. Aluminum and its alloys are preferred mainly due to their lightness.

a. **Head (Crown) of piston**: It is the top of the piston.
b. **Skirt**: It is that portion of the piston below the piston pin which is designed to adsorb the side movements of the piston.

VI. **Piston ring:** It is a split expansion ring, placed in the groove of the piston. They are usually made of cast iron or pressed steel alloy (Fig.1.5 A). The function of the ring are as follows:

A. It forms a gas-tight combustion chamber for all positions of the piston.
B. It reduces the contact area between the cylinder wall and piston wall preventing friction losses and excessive wear.
C. It controls the cylinder lubrication.
D. It transmits the heat away from the piston to the cylinder walls.

Piston rings are of two types: (1) Compression ring and (2) Oil ring

1. **Compression ring:** Compression rings are usually plain, single pieces and are always placed in the grooves of the piston nearest to the piston head. They prevent leakage of gases from the cylinder and help increase compression pressure inside the cylinder.
2. **Oil ring:** Oil rings are grooved or slotted and are located either in the lowest groove above the piston pin or in a groove above the piston skirt. They control the distribution of lubrication oil in the cylinder and the piston.

VII. **Piston Pin:** The piston pin is used to join the connecting rod to the piston.

It is also called a 'wrist pin' or 'gudgeon pin'.

VIII. **Connecting rod:** It is a special type of rod, one end of which is attached to the piston and the other end to the crankshaft. It transmits the power of combustion to the crankshaft and makes it rotate continuously. It is usually made of drop forged steel.

IX. **Crankshaft:** It is the main shaft of an engine that converts the reciprocating motion of the piston into the rotary motion of the flywheel. Usually, the crankshaft is made of drop forged steel or cast steel. The space that supports the crankshaft in the cylinder block is called the main journal, whereas the part to which connecting rod is attached is known as the crank journal. The Crankshaft is provided with counter-weights throughout its length to have counter-balance of the unit.

X. **Flywheel:** The flywheel is made of cast iron. Its main functions are as follows:

A. It stores energy during the power stroke and returns back the energy during the idle strokes, providing a uniform rotary motion the flywheel.
B. The rear surface of the flywheel serves as one of the pressure surfaces for the clutch plate.
C. Engine timing marks are usually stamped on the flywheel, which helps in adjusting the timing of the engine.
D. Sometimes the flywheel serves the purpose of a pulley for transmitting power.

XI. **Crankcase:** The crankcase is a part of the engine which supports and encloses the crankshaft and camshaft. It provides a reservoir for lubricating oil. It also serves as a mounting unit for such accessories as the oil pump, oil filter, starting motor, and ignition components. The upper portion of the crankcase is usually integral with the cylinder block. The lower part of the crankcase is commonly called an oil-pan and is usually made of cast iron or cast aluminum.

XII. **Camshaft:** It is a shaft that raises and lowers the inlet and exhaust valves at proper times. The camshaft is driven a by crankshaft by means of gears, chains or sprockets. The speed of the camshaft is exactly half the speed of the crankshaft in four-stroke engines. Camshaft operates the ignition timing mechanism, lubricating oil pump, and fuel pump. It is mounted in the crankcase, parallel to the crankshaft.

XIII. **Timing gear:** Timing gear is a combination of gears, one gear of which is mounted at one end of the camshaft and the other gear at the crankshaft. Camshaft gear is bigger in size than that of the crankshaft gear and it has twice as many teeth as that of the crankshaft gear. For this reason, this gear is commonly called half-time gear. Timing gear controls the timing of ignition, timing of opening and closing of valve as well as fuel injection timing.

XIV. **Inlet manifold:** It is a part of the engine through which air or air-fuel mixture enters into the engine cylinder. It is fitted by the side of the cylinder head.

XV. **Exhaust manifold:** It is a part of the engine through which exhaust gases go out of the engine cylinder. It is capable of withstanding high temperature of burnt gases. It is fitted by the side of the cylinder head.

XVI. **Top dead centre:** When the piston is at the top of its stroke, it is said to be at the top dead centre (TDC).

XVII. **Bottom dead centre:** When the piston is at the bottom of its stroke, it is said to be at its bottom dead centre (BDC). In two-stroke cycle engines both the sides of the piston are effective which is not in the case of four-stroke cycle engines.

XVIII. **Scavenging:** The process of removal of burnt or exhaust gases from the engine cylinder is known as scavenging. Entire burnt gases do not go out in normal stroke; hence some type of blower or compressor is used to remove the exhaust gases in two-stroke cycle engines.

Practical Exercise

Activity 01: Make a list of different types of engines used for agriculture machinery.

Material required:

1. Pen
2. Notebook
3. Pencil
4. Eraser
5. Sharpener

Procedure:

1. First, take permission from the owner/dealer/Auto mechanics of the agriculture machinery shop.
2. Now identify the different types of engines fitted in the agriculture machineries/equipment's available in the shop.
3. Make a list of each engine type.
4. Write down their name and specification
5. Draw a figure of selected types of engines.
6. Then, read the manual of each engine type.
7. Prepare a report for the same.

Activity 02: Make a list of the components of an engine.

Material required:

1. Pen
2. Notebook

Procedure:

1. First, take permission from owner of the shop.
2. Then, identify the engine available in the shop.
3. Make a list of components of selected engine.
4. Write down their name and specification.

Check Your Progress

A. Answer the following question

1. What is an engine?
2. What is role of engine in agriculture machinery?
3. Write the difference between two and four stroke engines.
4. Explain the CI and SI engine.
5. Describe the various component of engine.

B. Fill in the blank

1. The crankcase of the engine is …… tight in which the crankshaft rotates.
2. The pressure in the engine cylinder is …… atmospheric pressure during this stroke.
3. The camshaft is driven by ……. with the help of suitable gears or chains.
4. Spark Ignition (SI) Engine is a type of engine in which the combustion takes place by the spark generated by …….
5. Compression Ignition (CI) Engine is an engine in which the combustion of fuel takes place by the heat of the compressed air.

C. Match the following

Column A	**Column B**
1. It is a part of the engine which confines the expanding gases and forms the combustion space.	**A. Scavenging**
2. It is a split expansion ring, placed in the groove of the piston.	**B. Cylinder block**
3. The process of removal of burnt or exhaust gases from the engine cylinder.	**C. Cylinder**
4. It is the solid casting body that includes the cylinder and water jackets.	**D. Piston ring**

SESSION 2: VARIOUS SYSTEM OF ENGINE

In any machinery, will require different of types power for proper work. Therefore, engines have different systems to run properly. Here's is the details of various system of engine:

The engine is a very important parts of any vehicle. Every system of the engine must work properly.

1.5: Various systems of an engine: The various systems in an engine are as follows:

1. Intake & Exhaust System
2. Cooling System
3. Fuel supply System
4. Lubrication System
5. Ignition System
6. Governing system

1. INTAKE & EXHAUST SYSTEM: These systems are used for the intake and exhaust of gas and fuel.

I. **Intake System:** It is a system that supplies oxygenated air into an engine's combustion chambers, which is a necessary component for combustion. A well-functioning air intake system feeds the engine with a steady supply of clean air. An air intake system consists of pre-cleaners, air cleaners, intake manifold, and hoses.

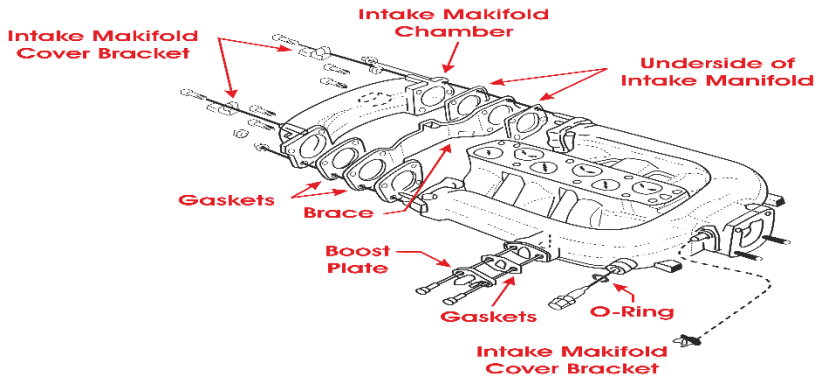


Fig. 1.6: Intake Manifold

An air intake system has following three main parts:

A. **Air Filter:** To run, an engine needs a perfect mixture of fuel and air, and all of the air enters the system through the air filter first. The purpose of the air filter is to filter dirt and other foreign particles out of the air, keeping them from entering the system and potentially damaging the engine.

There are three types of air filters:

- Paper Air Filter
- Gauze Air Filter
- Foam Air Filter

B. **Mass Flow Sensor:** The mass of air entering a fuel-injected internal combustion engine is measured using a mass air flow sensor. It then travels to the throttle body from the mass flow sensor.

The two types of mass airflow sensors in use on engine:

- Vane Meter
- Hot Wire

C. **Throttle Body:** It is used to regulate the amount of air that enters the combustion chamber of an engine. The throttle plate opens when the accelerator pedal is applied, allowing air into the engine. The throttle plate closes when the accelerator is withdrawn, thereby cutting off air passage into the combustion chamber. This procedure successfully regulates the rate of combustion and, as a result, the vehicle's speed.

II. **Exhaust System:** Basically, it's responsible for discharging hot exhaust gas produced during the combustion of the air/fuel mixture in the engine to the atmosphere, purifying exhaust gas of harmful chemical components and particulate matter to meet legal requirements, damping exhaust noise to the legal minimum, and shaping it to deliver the sound design desired by customers.

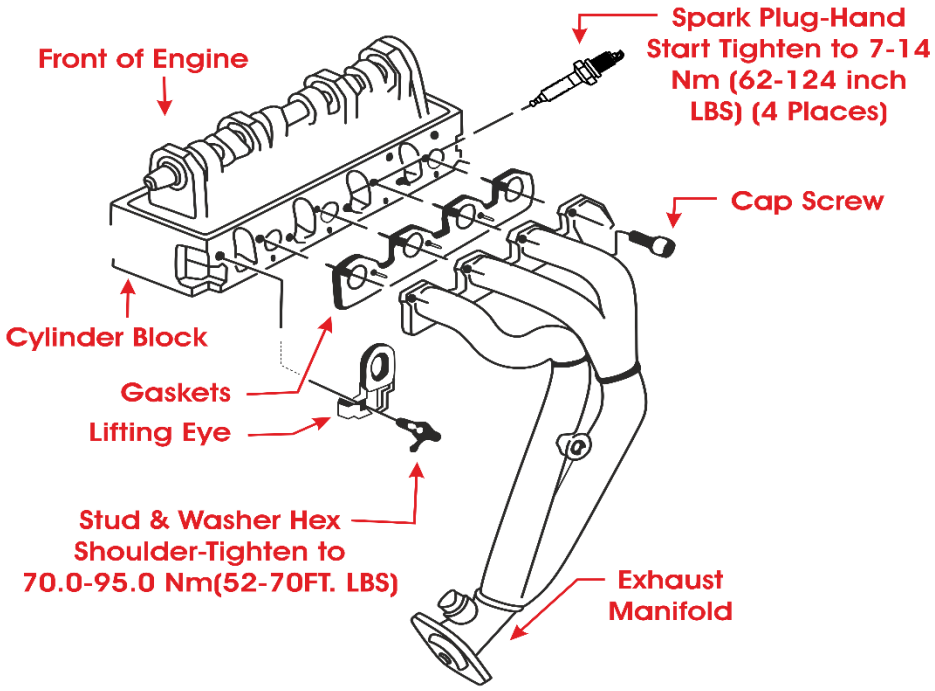


Fig. 1.7: Exhaust Manifold

Air exhaust system has five main parts:

A. **Exhaust Manifold:** It attaches to the cylinder head and collects the exhaust gases from each cylinder into a single pipe.

B. **Oxygen Sensor:** It determines the amount of oxygen in the exhaust. The computer can then add or subtract fuel to achieve the ideal combination for optimal fuel efficiency.

C. **Catalytic Converter:** This part, which looks like a muffler, converts harmful carbon monoxide and hydrocarbon dioxide. Some converters also help to minimise the dangerous nitrogen oxides in the atmosphere.

D. **Muffler/Silencer:** It serves to quiet the exhaust down to acceptable levels. The combustion process is a series of explosions that create allot of noise. Most mufflers use baffles to bounce the exhaust around dissipating the energy and quieting the noise. Some mufflers also use fiberglass packing which absorbs the sound energy as the gases flow through.

E. Resonator: The muffler can't always eliminate all engine noise. A resonator, which is similar to a mini-muffler, is included in many exhaust systems. They're normally straight pipes with sound-absorbing materials within. In the exhaust system, the resonator can be placed either before or after the muffler.

F. Exhaust Pipe: It carries the gas through its journey out your tail pipe.

2. COOLING SYSTEM: The temperature of the engine at the moment of the power stroke burns the air-fuel mixture at 1500-2000°C. This temperature, which is significantly greater than the melting point of cylinder-piston and other material components, necessitates continuous and quick heat dissipation from these metal parts in order to avoid the engine from failing.

The purpose of a cooling system in an engine is to dissipate the surplus heat for the protection of engine components, maintain the optimum temperature of the engine, and maintain the lubricating property of the oil for smooth functioning of the engine. There are two types of cooling systems used in tractors engine- liquid cooling and air cooling.

A. Air cooling system: In air-cooled engine heat is conducted from the working component of the engine to the atmosphere directly. The air-cooled system is used commonly in small engines 1-15 HP used in agricultural machines. In an air-cooling system, the cylinder block is integrated or cylinder casketed with large contact surface fin-shaped protrusions around it. The heat generated due to combustion in the engine cylinder is conducted through the fins and dissipated to the surrounding with air flowing around it.

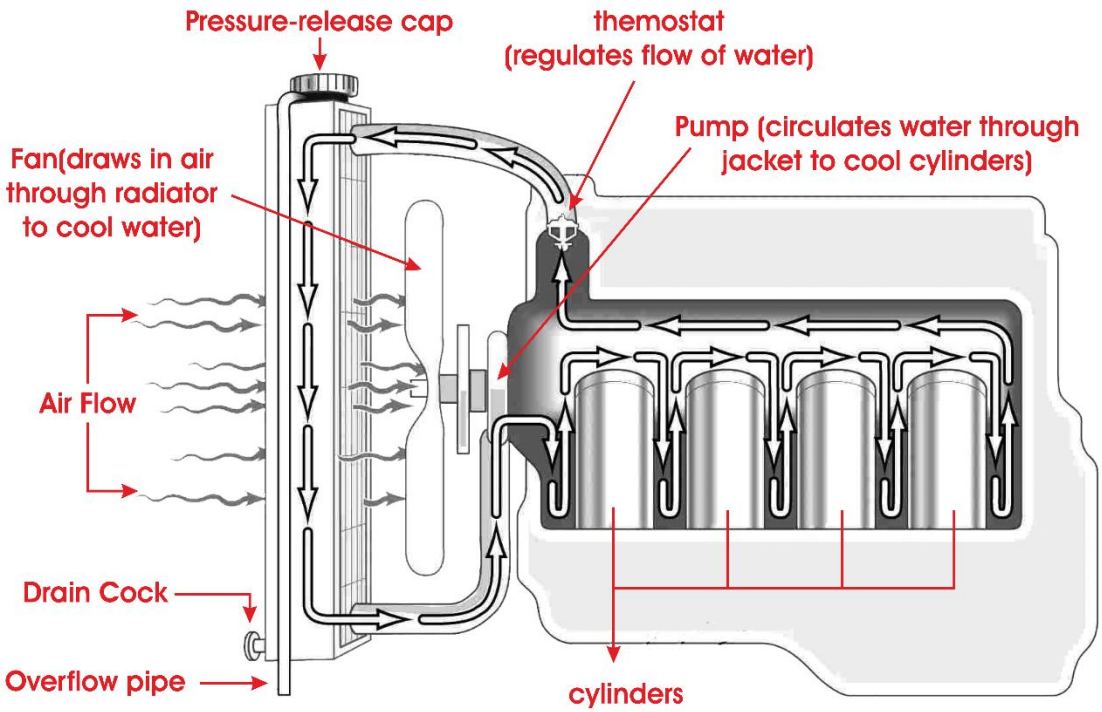


Fig: 1.8: Air cooling system

The amount of heat dissipated to air depends upon:

i. Amount of air flowing through the fins.
ii. Fin surface area.
iii. Thermal conductivity of metal used for fins.

Efficient cooling is achieved with larger space between fins and larger length of fins to facilitate thermally efficient removal of heat produced from the engine. Usually, the fin height varies from 15 to 25 mm.

The air-cooled engines have the following advantages:

i. Its design of air-cooled engine is simple.
ii. It is lighter in weight than water-cooled engines due to the absence of water jackets, radiator, circulating pump and the weight of the cooling water.
iii. It is cheaper to manufacture.
iv. It needs less care and maintenance.

v. This system of cooling is particularly advantageous where there are extreme climatic conditions in the arctic or where there is scarcity of water as in deserts.
vi. No risk of damage from frost, such as cracking of cylinder jackets or radiator water tubes.

Disadvantages of air-cooled engine

i. Relatively large amount of power is used to drive the cooling fan.
ii. Engines give low power output.
iii. Cooling fins under certain conditions may vibrate and amplify the noise level.
iv. Cooling is not uniform.
v. Engines are subjected to high working temperature.

Service of air-cooled engine

Small, single-cylinder engines are cooled by a stream of air developed by fan blades on the flywheel. The air stream is deflected around the cylinder and cylinder head by a metal or plastic cover called a shroud. Additional engine heat is dissipated through cooling fins around the cylinder. The service an air-cooled system can be done as follows:

Step 1: Periodically remove the shroud from around the engine flywheel and inspect the inside for debris.

Step 2: With the shroud removed, visually inspect the flywheel blades for debris and damage.

Step 3: Visually inspect cooling fins on the cylinder and cylinder head. Use a wooden stick or clean paint brush to clear away any debris. When the engine is cool, wipe the surfaces of the cooling fins, cylinder, and cylinder head with a cloth. Even the tip of a cooling fin can have a surface temperature of over 38°C.

Step 4: Replace the shroud over the flywheel and cylinder. Make sure the flywheel blades do not strike the shroud.

B. Liquid (Water) cooling system: In a liquid cooling system, liquid jackets are provided around the engine cylinder or liners. The circulating liquid/coolant in these jackets absorb the heat from the cylinder surface and then the heated water/coolant is cooled by passing through the radiator. Cooling water jackets are provided around the cylinder, cylinder head, valve seats etc. The water when circulated through the jackets, it absorbs heat of combustion. This hot water will then be cooling in the radiator partially by a fan and partially by the flow developed by the forward motion of the vehicle. The cooled water is again re-circulated through the water jackets.

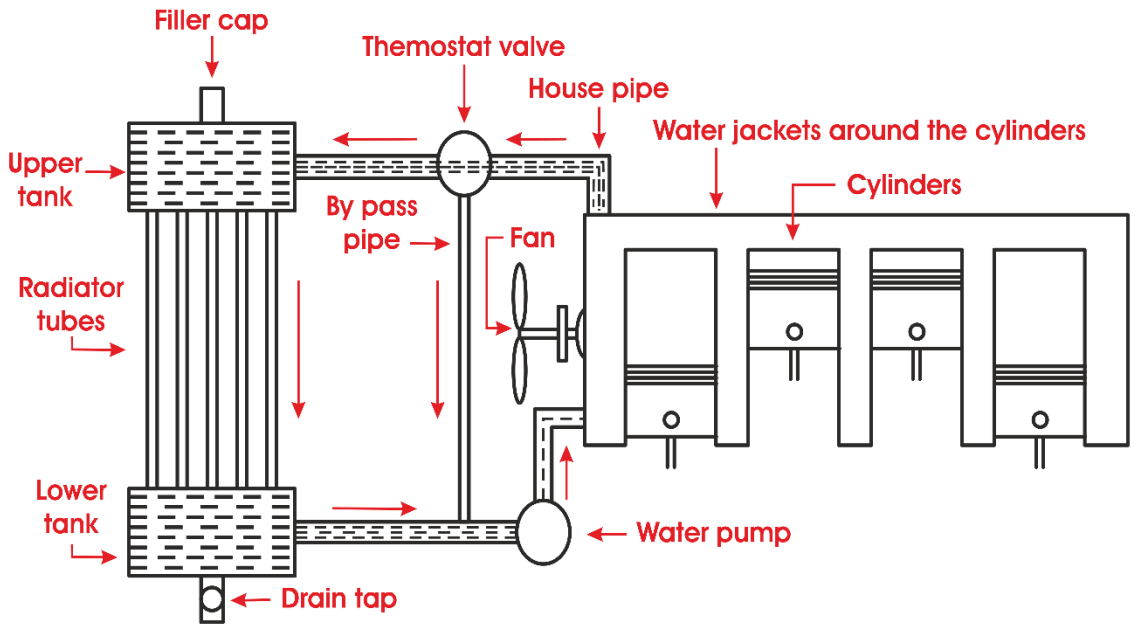


Fig. 1.9: Liquid cooling system

The cooling water is subjected to atmospheric pressure and the water boils at 212°F. A radiator cap is fitted on the radiator neck to provide an air tight seal. The boiling temperature of water increases which improve the engine performance when the water is heated in the radiator under high pressure. Thus, the pressure is regulated and controlled by the radiator cap used in a forced circulation cooling system. The pressure-release valve is set to open at a pressure between 4 and 13 psi when water is 225 °F and 243 °F. Excess

pressure built up in the radiator or in the cooling system is released by the radiator cap's pressure release valve. As engine cools down, a partial vacuum is developed in the cooling stem, which results in the collapse of the flexible hoses and tubes. This is overcome by vacuum pressure release valve which opens the radiator to the atmosphere when engine cools down.

1. Use brands which meet engine manufacturer's specifications.
2. Drain and change the oil at recommended intervals.
3. Select oils which have been performance tested.
4. Never mix oils of various specifications.
5. Bring engine up to normal operating temperature each time it is used.
6. Use clean oil containers and keep covered, sealed, and protected to prevent contamination.
7. Replace or clean filters before they become plugged.
8. Use oil-fuel mixture recommended by manufacturer.
9. Never mix synthetic oils with mineral oils.
10. Select only oil recommended for use in either air cooled or water cooled two cycle engines.

3. FUEL SUPPLY SYSTEM: The purpose of the fuel system of a small engine is to store and supply gasoline to the combustion chamber. To adjust the fuel flow to the combustion chamber, the fuel system contains a fuel tank, strainer, fuel filter, air cleaner, fuel tube lines, carburetor, and governor. All of these components are not present in all tiny engines. Small engines have a little fuel tank to store a small amount of fuel. It has a fuel strainer that can be removed and cleaned at the bottom of the fuel tank. In the fuel delivery line of some engines, there is a removable fuel strainer with a disposable pleated paper filter element. The sediments in the fuel tank are cleaned by the filters.

On a small engine, an air cleaner prevents big particles in the air from clogging the carburetor. Oil bath and dry air cleaners are the two types of air cleaners used on small engines. Some engines feature two filters, one with pleated paper and the other with foam. The air cleaner is enclosed with a facility

for sucking air into the carburetor and pre-mixing it with fuel before it enters the combustion chamber of the cylinder.

Fig.1.10: (A) Wet oil filter (Foam filter and oil container)

Fig.1.10: (B) Dry dual filter (Pleated paper and foam)

In fuel system, fuel is sprayed directly into the engine combustion chamber where it gets mixed with hot compressed air and ignites. It has the following components:

- Fuel tank-stores fuel.
- Fuel feed pump-moves fuel to the injection pump.
- Sediment bowl assembly-collects dust particles.
- Fuel filters-helps clean the fuel.
- Fuel injection pump-times, measures and delivers fuel injection under pressure.
- Fuel injectors-atomize and spray fuel into the cylinders.
- Combustion chambers.

A. Carburetor: The function of carburetor is to mix fuel and air in the correct proportion to the engine combustion chamber. The commonly used in small engines carburetors are of three types, natural draft, updraft, and downdraft based on the direction of air flows from the inlet to the engine manifold. The carburetor supplies correct amount of fuel and air in correct proportion to the

required amount to maintain engine speed.

The carburetors used in small engines are many types and models based on the power, service use and design. Some carburetors have more adjustments than others and depend on the carburetor design. Some carburetors are adjusted with adjusting screws. In some cases, the carburetor is adjusted using screws to allow adjustments of high speed, idle speed, and idle mixture. With the engine running, open the throttle wide. For adjusting the high-speed adjustment, the high-speed adjustment needle is turned forward and backward until the highest speed setting is obtained. For setting to slowest speed, the throttle is moved to the slowest running speed and screw is adjusted. Adjust the idle-speed needle until the recommended idle speed is set. When the idle speed set, adjust the idle mixture until the engine runs smoothly. However, some carburetors allow only high and idle speed adjustments. Here's how to adjust the typical three-adjustment carburetor.

Servicing Fuel Filters: In small engines have a fuel strainer in the bottom of the fuel tank. Others have a removable fuel strainer in the fuel line. Still other small engines use disposable in-line fuel filters made of pleated paper.

To clean sediment from a tank:

Step 1: Drain or siphon all fuel from the tank.

Step 2: With a flashlight, find the lowest point in the tank: the sediment reservoir. Clean all sediment from the reservoir indentation.

Step 3: Wipe sediment from the end of the filter element.

Step 4: Wipe the inside of the tank with a clean rag.

Step 5: Refill the fuel tank.

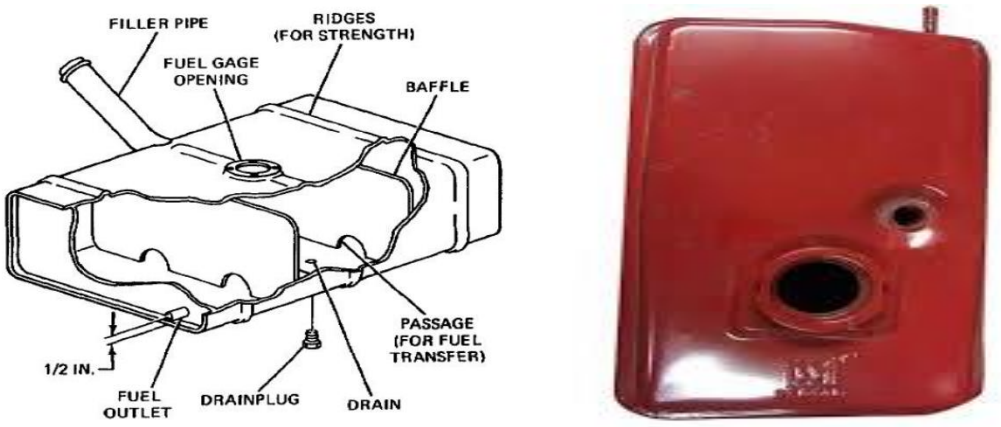


Fig. 1.11: Fuel Tank

How to clean sediment from a fuel strainer?

Step 1: Find and close the shutoff valve on the fuel line.

Step 2: Loosen the lock nut on the bowl retainer and remove the sediment bowl.

Step 3: Empty and clean the sediment bowl. Clean the filter screen. Refill the sediment bowl with fresh fuel.

Step 4: Reinstall the sediment bowl and bowl retainer, tightening the lock nut.

Step 5: Open the shutoff valve.

Fig. 1.12: Fuel filter

Replacing the in-line fuel filter:

Step 1: Find and close the shutoff valve on the fuel line or use a clothespin to pinch the fuel line closed.

Step 2: Disconnect the fuel filter from the fuel line.

Step 3: Replace the in-line fuel filter with an exact replacement part.

Step 4: Open the shutoff valve.

Fig.1.13: In-line filter

Air Cleaners: The air cleaner used in small engine is to prevent large particles present in the air from clogging the carburetor. The two types of air cleaners used on small engines are oil bath and dry. The service an air cleaner is as follows:

Step 1: Remove the cover of the air cleaner, typically by unscrewing a nut on top of the air cleaner.

Step 2: If it is an oil cleaner, remove all oil and contaminants from the center channel of the cleaner, wipe it clean, then replace oil to the indicated level. A dry cleaner cannot be cleaned and therefore must be replaced.

Step 3: Replace the air cleaner cover and make sure all fasteners are securely tightened.

Fig.1.14: Air Cleaner

B. Governor adjustment: A governor is a device that controls the speed of the engine as when the load changes. As the load slows the engine speed down, the governor opens the throttle to return the engine to a set speed. Governors are commonly used on engine-powered electrical generators where constant speed is important. Two types of governors are installed on small engines: mechanical and air-vane. An incorrectly adjusted governor can cause the small engine to operate at excessively high speeds and damage or destroy it.

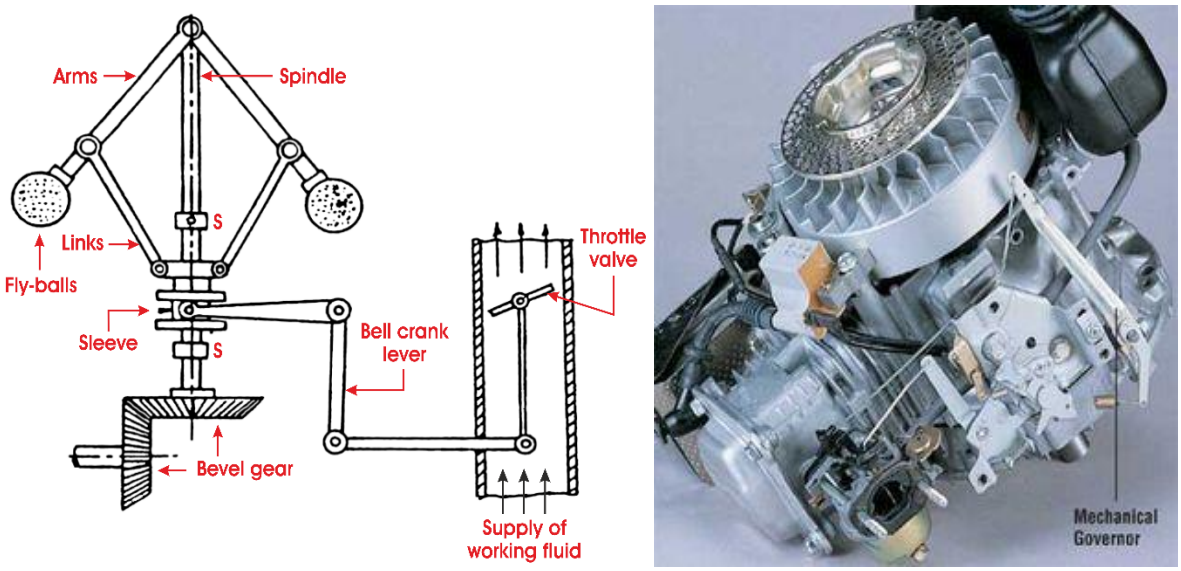


Fig. 1.15: Mechanical Governor

Mechanical governor responds to the centrifugal force created by the engine's revolution**.** Unfortunately, there is no universal adjustment sequence for small engine governors. Much depends on the type of governor, whether the crankshaft is horizontal or vertical, the complexity and pivot points of the linkage, and the intended operating range. Because of these factors, refer to an owner's manual or service manual for your specific engine and application to adjust the governor.

In the next section, learn how the ignition system needs to be routinely serviced so it can deliver a high-voltage spark to help start a small engine.

4. LUBRICATION SYSTEM: The lubrication system prevents friction between moving parts of the engine. It supplies adequate lubricating oil to prevent excessive friction. Special additives are added to the engine oil to increase the engine resistance towards corrosion, engine oil film also has a damping effect. In most engines, oil is sucked out of the oil pan by the oil pump. This is a part of the lubrication system:

- **Oil filter:** It traps the dust, dirt, metal rubbings, and other foreign materials.

Fig. 1.16: Fuel filter

There are two types of filters that are used:

1. **Full-flow filter:** In full flow filters the entire flow of oil is forced through the filter before it reaches the lubrication points.
2. **Bypass filter:** To remove almost all pollutants from motor oil, by-pass oil filtration features a secondary filter.

The lubricants are used to reduce friction and wear of engine moving parts. The oil lubricants assist in dissipating the heat generated in the engine. Due to rise temperature, the lubricants should have high temperature resistance against oxidation and should maintain the required lubricity without losing properties to provide good seal between cylinder walls and piston rings, cleaning, noise reduction and preventing sludge formation.

Functions of engine oil

1. Reduces friction and wear
2. Cools moving parts
3. Helps seal cylinders
4. Keeps parts clean
5. Cushions moving parts

Characteristics of good engine oil

Oils vary in viscosity as temperatures change. It should have required viscosity and viscosity index. The high viscosity index of oil should not vary much with considerable change in temperature. The cloud point, pour point, flash point, specific gravity, carbon residue, acidity number, and oxidation stability are some

of the salient properties which affect lubrication performance of oils. The oils are derived from petroleum cracking, chemicals and vegetable oils. The quality characteristics of the lubricating oils are below:

a. Keeps a protective film on moving parts
b. Resists breakdown at high temperatures
c. Resists corrosion and rusting
d. Prevents carbon build-up
e. Prevents sludge formation
f. Flows easily at low temperatures
g. Resists foaming
h. Resists breakdown after long use

In small engines, the lubricating oil is fed to the moving engine parts either by mixing with the fuel in two stroke engines and is separately fed through oil vents and ports by a pressure fed system in four stroke engines. While larger size engines have pressure feed system which uses a pressure pump to feed oil at a pressure of 2-4 kg/cm^2 from the tank to the moving parts and dissipate heat generated from the parts. The lubricating oil under pressure is fed to the connecting rod, piston rings, camshaft, valves and valve lifters, gears etc. The oil filters are used to remove from dust, metal particles and other harmful particles.

Two stroke engine lubrication

In two-stroke engines, the oil lubricant is pre-mixed with fuel in certain ratio and air fuel-mixture transmitted to the engine. This is termed lubrication is termed as pre-mix lubrication system for the two-stroke engine. The mixture ratio varies from 16:1 to 40:1 parts fuel to one-part oil. In a pre-mix lubrication system, air and fuel are pulled through the carburetor along with the lubricating oil. The air and fuel mix as the fuel is converted to a vapor.

The oil converted is into tiny droplets from the fuel mixture and enters crank case to lubricate the crank, connecting rod and bearings. In a two-stroke engine, some of the oil passes through the intake port and lubricates the cylinder walls

ahead of the piston. These droplets provide lubrication for the areas along of cylinder wall and on the rings. On the compression stroke, the oil helps lubricate the ring or rings and is then burned with the air-and-fuel mixture.

The fuel to oil ratio should be strictly followed. But, too little oil in the mixture won't lubricate the engine properly and will cause engine overheating and seizure. Also, too much of oil in the mixture will cause excessive smoke from the exhaust and buildup excess residue inside the engine. In addition, too much oil can actually "lean out" the 16 parts air to one-part fuel that an engine is designed to receive. This is because the oil displaces the fuel in the mixture. A lean air-and-fuel mixture can cause excessive heat, which can cause engine damage.

For larger horse power small engines use oil injection system to lubricate engine components. The oil is pressurized for injection using a small pump driven by the crankshaft. The oil injection system has many advantages being there is no need to pre-mix oil and petrol. The oil is stored in a separate tank and the pump injects required quantity of oil depending upon the engine speed. The oil injection avoids large quantity of oil being burnt along with fuel unlike pre-mixing of oil.

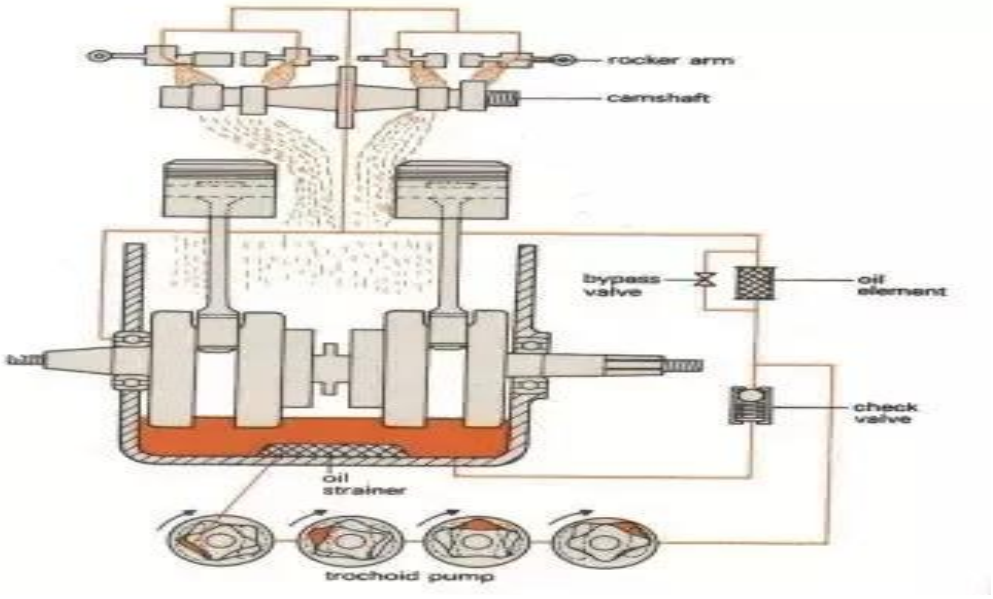


Fig. 1.17: Lubrication process in two stroke engine

Four stroke engine lubrication

Most of the four-stroke engines use the crankcase as a reservoir to store lubricating oil. In most small engines, this oil is either splashed on to the moving components or a pump is used to pressurize the oil and pushed into the components are called as oil-injection systems.

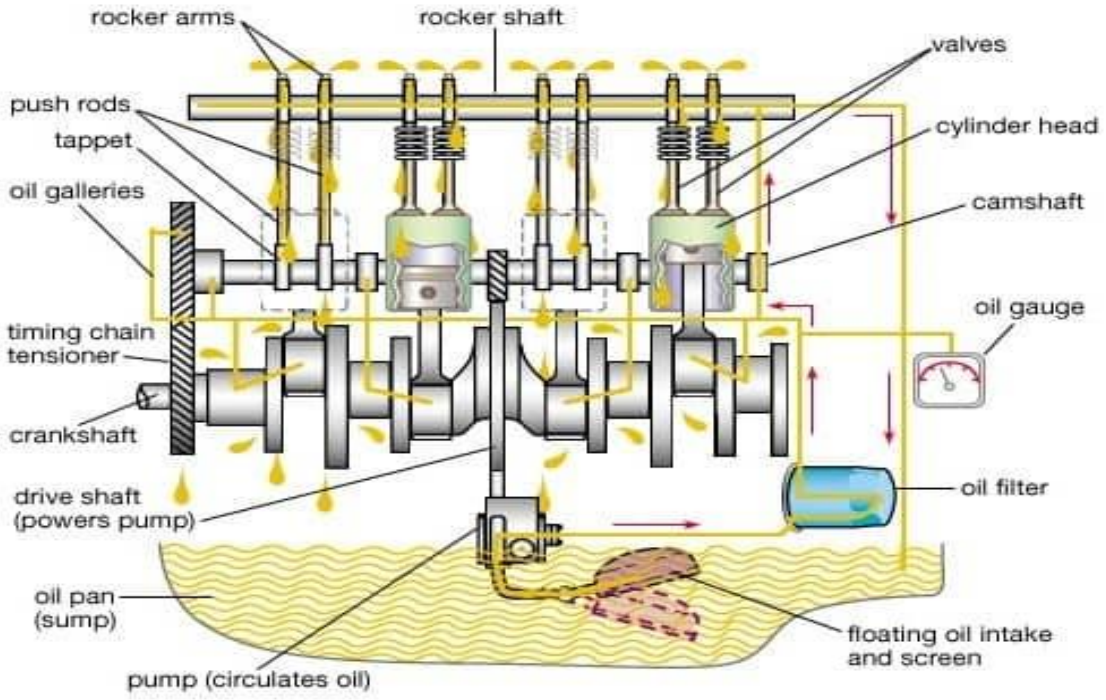


Fig. 1.18: Lubrication proces in four stroke engine

The common pressurized oil lubrication systems oil is either splashed onto the moving components or pressurized by a pump and pushed into the components.

Lubrication Methods: The three main methods of lubrication are as follows:

a. Splash lubrication system: In this case, the oil is splashed onto different working parts of the engine using big end bearing caps, small scoops, crankpin webs, or dippers. These dips into the oil at every revolution and oil gets scattered or splashed.

The splash-type lubrication system is common in small higher horse power four-stroke engines. The crankcase is filled with oil to a specified level. Attached to the bottom of the connecting rod is an oil flinger or dipper. Each time the

connecting rod passes to the bottom of the crankcase, the attached flinger or dipper brings oil up from the crankcase and splashes it around inside the engine.

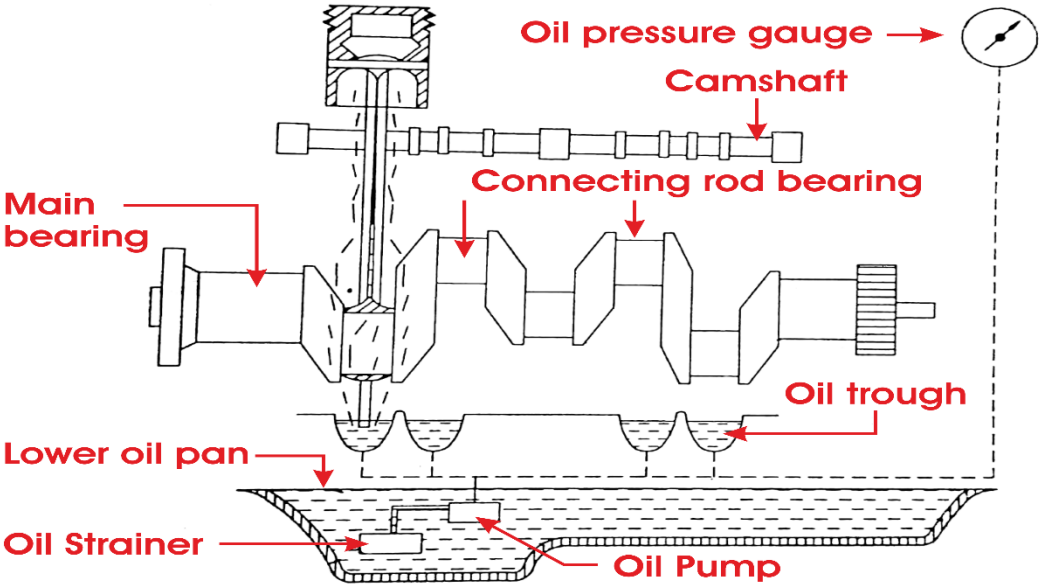


Fig.1.19: Splash Lubricator System

b. Forced feed lubrication system: The oil pump is an important part of the forced feed lubrication system, which consists of:

- Piston pump.
- Tank with vent, to balance the inside and outside pressure, and a filter that traps impurities.
- Oil outlet hole on the guide bar.

The crankshaft drives the oil lubrication pump, which draws oil from the tank and pushes it onto the guide bar via the outlet hole. The movement of the chain then distributes the oil along the entire length of the guide bar.

Oil pumps dispense lubricant in different ways, and the oil flow can be:

- **Fixed flow:** If the lubricant is pumped at a constant rate.
- **Zero flow when idling**: In this case the pump is connected to the clutch coupling and only operates when the chain rotates.

- **Adjustable** by means of an adjuster screw, which enables the oil dosage to be set based on the length of the guide bar, the wood being cut and the season.

Some models have an automatic oil pump that is calibrated to guarantee adequate lubrication in all working conditions, but which is also adjustable according to your needs, and dispenses no oil when idling. To ensure a well-oiled guide bar and chain**,** make sure the tank is full of fresh, good-quality lubricant and regularly clean the chainsaw's oil pumps**.** But before cleaning it, check whether the chainsaw oil pump is working properly first. Simply point the chainsaw guide bar down towards a dry, uniform surface, and throttle to medium speed for a few seconds. If everything is in order, you will see a stream of tiny oil droplets fall to the ground from the moving chain.

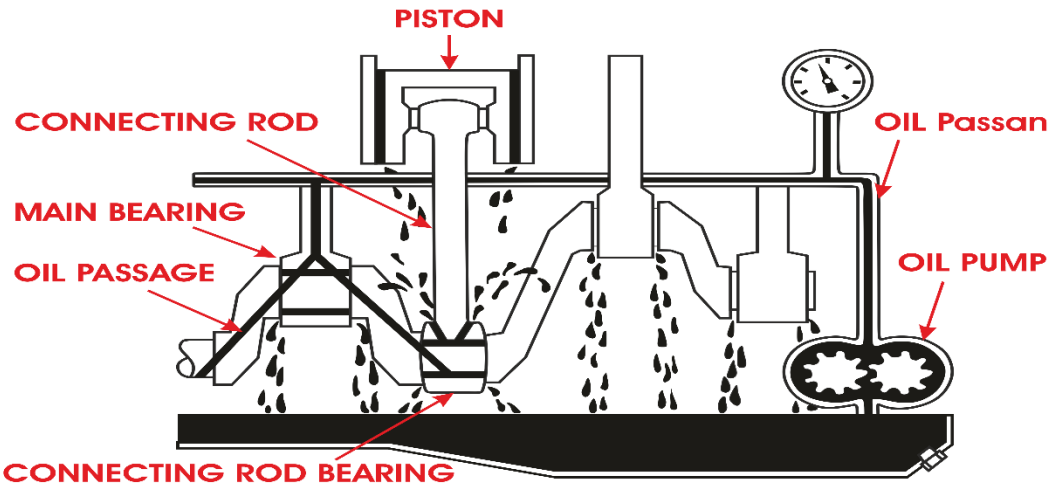


Fig.1.20: Force feed lubrication system

Selection and use of lubrication oils: The selection of lubrication oils for best engine performance should have below qualities:

1. Keeps a protective film on moving parts.
2. Resists breakdown at high temperatures.
3. Resists corrosion and rusting.
4. Prevents carbon build-up.

5. Prevents sludge formation.
6. Flows easily at low temperatures.
7. Resists foaming.
8. Resists breakdown after long use.

The oils are classified either by Society of Automotive Engineers (SAE) or American Petroleum Institute (API) based viscosity and other properties. Chemicals added to oil to provide extra performance as additives. These additives are used to improve the frictional resistance, antifreeze chemicals, anti-foaming, anti-wear, anti-oxidative chemicals are added to improve the lubricating properties of oil. The oils used manufactured from petroleum are called as minerals oils, from chemicals are termed as synthetic oils and bio lubricants.

Oil lubricants should be changed by checking the quality (viscosity) condition of oil and the colour of the lubricant oil. The oil filter should be changed as per the condition and schedule of engine maintenance recommended by the engine manufacturer. Oil breather should be cleaned appropriately. If engine oil level drops from the recommended level, oil should be topped to the required level. The engine should be started and worked for sufficient time so that oil from the all galleries and tubes run out through the drain plug.

c. Combination of splash and force feed: In this method combination of both splash as well as force feed are used some parts lubricated by splash and some by force feed method.

5. Ignition System: The ignition system is used in two and four stroke petrol engines. Here, the air and petrol are mixed and spark is used for igniting fuel-air charge in the combustion chamber. However, in contrast to this when diesel is used as fuel, the diesel is injected to the compressed air at very high pressure to a temperature at which the diesel is burnt completely. Fuel injectors used to inject the diesel but in small and higher power petrol engines use fuel injectors instead of carburetor. The three basic types of ignition systems are used in engines for applications in agriculture and others outdoor power equipment are

i. Magneto ignition system
ii. Battery ignition system

iii. Electronic ignition system

All three types of systems use an ignition coil. Either a battery system makes use of electronic switch or the magneto system make use of the breaker points to perform the triggering switch function. The electronic ignition system uses electronic components to perform the switching function, but its power source will be either a battery or a magneto. However, the larger engines with high power, attached with heavy equipment have starter systems and lights make use of battery ignition systems. Electronic ignition systems contain electronic components that perform the switching action in the ignition circuit and are used in newer engines.

i. Magneto ignition system

Magneto systems are used in equipment where electricity is only needed to power the spark plug, without starter system or lighting.

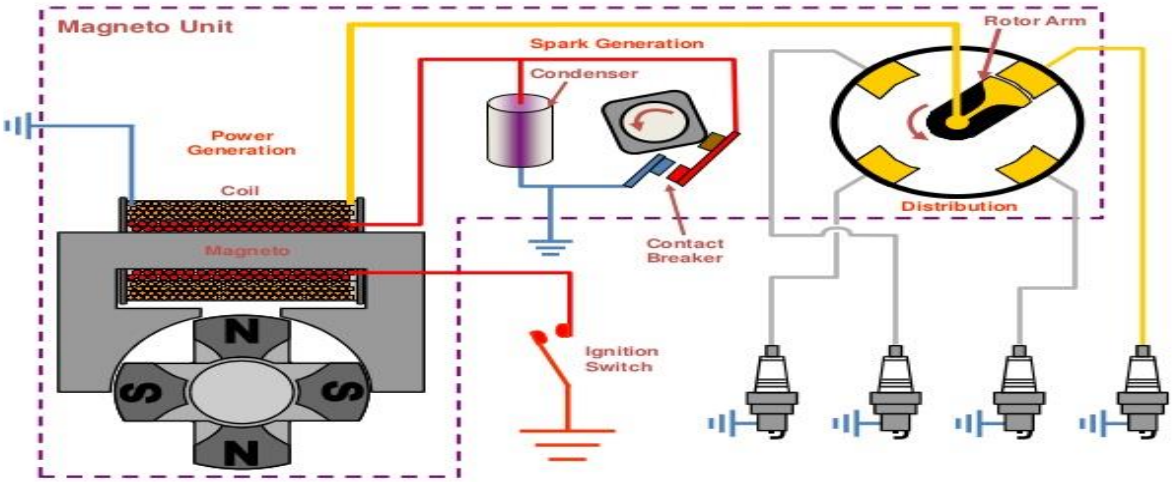


Fig.1.21: Magneto ignition system

The ignition coil is mounted in a stationary position near the flywheel. When the flywheel spins, the magnets will induce a voltage in the primary winding of the ignition coil. These magnets will pass the ignition coil as the flywheel rotates. In order for the magneto system to work, the ignition coil must be mounted in a stationary position close to the flywheel. The small air gap between the flywheel's edge and the ignition coil is important for the magneto system to function properly.

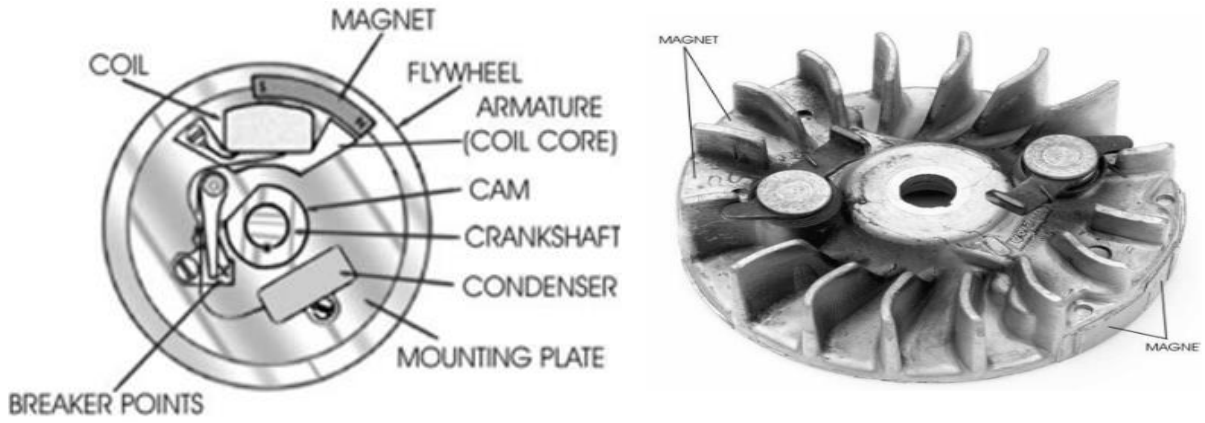
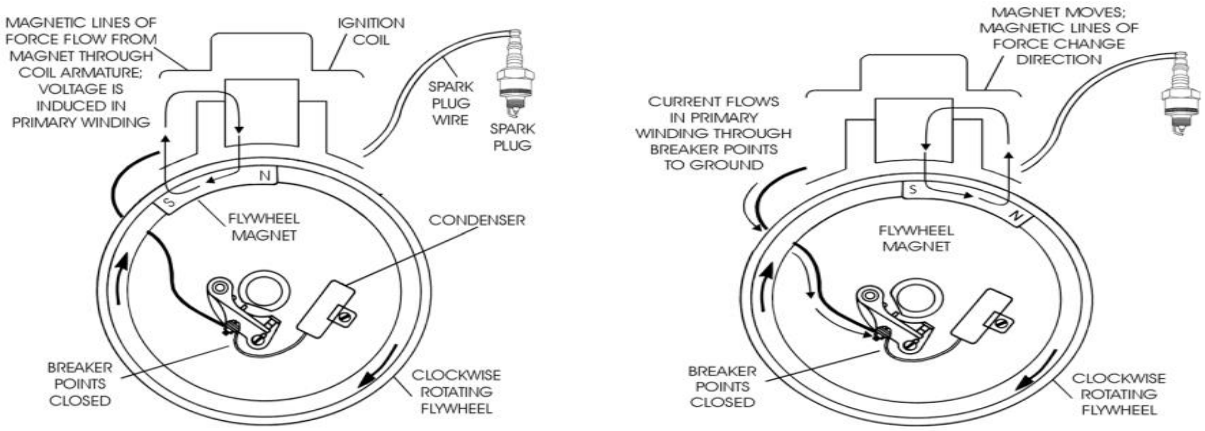


Fig.1.22: Parts of magneto ignition system

As the small magnet passes the ignition coil, it generates a high-voltage spark figure (a), the current flows in the primary winding. Since the magneto is mounted on the crankshaft, it produces a spark every time the piston reaches top-dead-center including the TDC between the exhaust and intake strokes.



(A) **(B)**

Fig. 1.23: Current flow

As the flywheel turns to rotate, the movement of the magnet causes the magnetic lines of force to change direction which result, current to flow in the primary winding. This happens because of the sudden change in the position of the north pole and the south pole of the magnet. The change in the direction of the magnetic lines of force will cause a current to flow in the primary winding of the

transformer. The primary winding is connected to the breaker points. Since the breaker points are closed at this time, the current flows through the points. The voltage in the primary winding will induce a low voltage in the secondary winding due to the action of mutual inductance. However, the voltage in the secondary is still too low to jump across the gap of the spark plug.

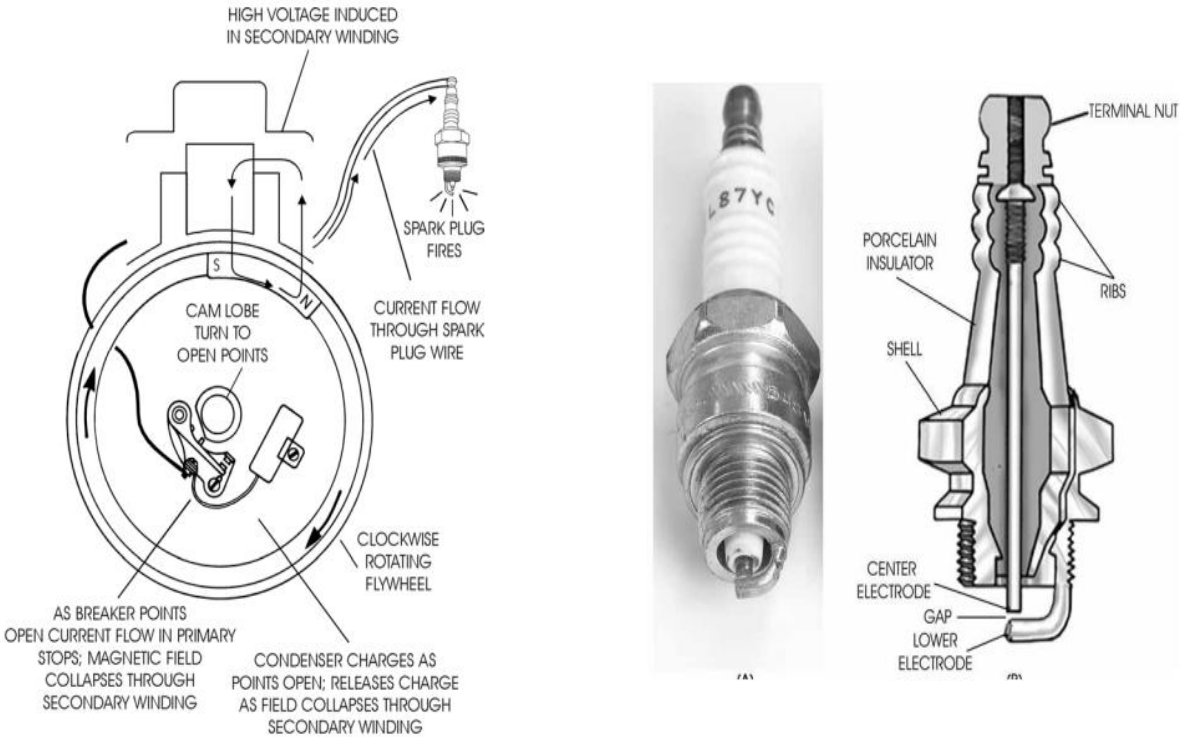


Fig.1.24: Constructional detail of spark plug

At this point, the turning cam lobe in the breaker points assembly turns and begins to open the points. As the breaker points open, the current flow in the primary winding is broken and the points separate, so the current flow in the primary circuit breaks. The magnetic field then collapses through the secondary winding, inducing a very high voltage in the secondary. The magnetic field around the primary winding is lost through the secondary winding of the transformer. As this occurs, any current left in the primary circuit is absorbed into the condenser. The absorbing action of the condenser prevents the remaining voltage in the primary circuit from arcing across the breaker points.

When the magnetic field collapses in the secondary winding, a high voltage is induced in the secondary winding. Simultaneously, the electric charge absorbed and stored in the condenser flows back into the primary winding. This discharging action results to increase the voltage in the secondary circuit. The very high potential induced in the secondary winding causes current to flow through the spark plug wire and arc across the spark plug gap. The flywheel continues to turn and the magnet positions itself again against the ignition coil to result a very high voltage in the secondary winding to produce spark and the process is repeated as a cycle.

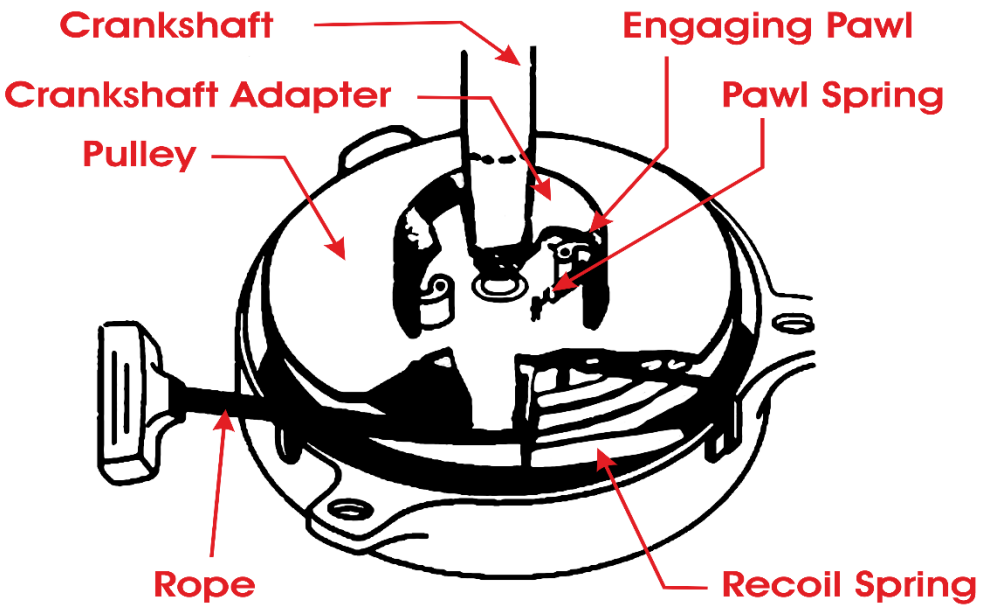


Fig.1.25: Re-winding system

Engine rope wind and re-winding system is mostly employed in all light weight small engines. The flywheel with rope pulley wound with rope and recoil spring and engaging pawl gear is used in the engine starting system. But in battery assisted ignition system of engines make of make dry battery to produce sparks instead of magneto.

ii. Battery ignition system: A battery ignition system consists of a 6-volt or 12-volt battery that is charged by an engine-driven generator, an ignition coils that increases voltage, a device that interrupts current from the coil, a distributor

that directs current to the correct cylinder, and a spark plug that project into each cylinder.

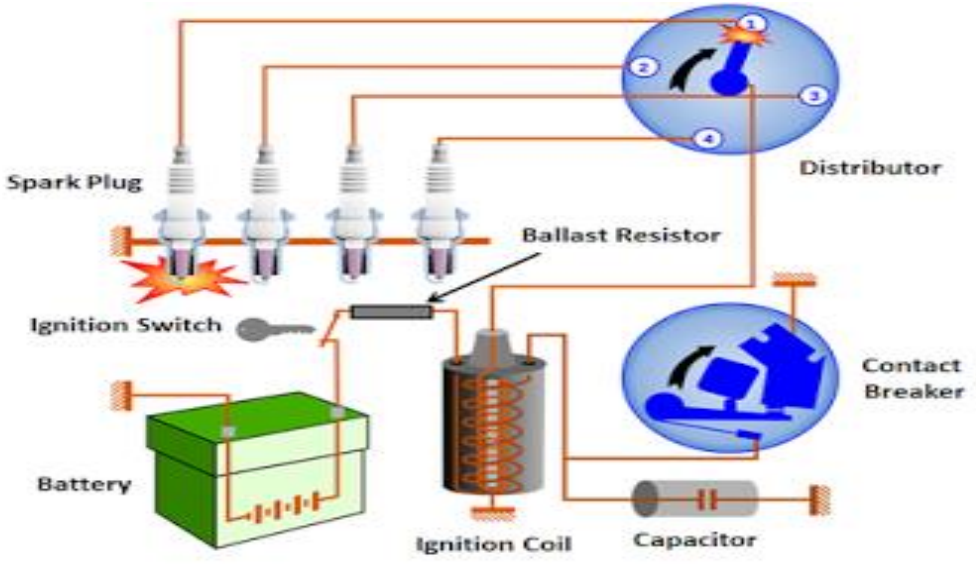


Fig.1.26: Battery ignition system

Servicing of battery ignition system

A battery is a device containing electrical cells that produce and store direct current. Batteries used to start and operate small engines typically store 6-volts or 12-volts. Here's how to service a battery ignition system:

Step 1: Service battery and charging system.

Step 2: Service ignition controller.

Step 3: Service spark plug(s).

Step 4: Service flywheel.

Servicing of battery and charging system are as follows:

Step 1: Use a voltage tester to verify that the battery is storing sufficient voltage. Each cell develops approximately 2-volts (1.9 to 2.1-volts). A 6-volt battery testing lower than 5.7-volts or a 12-volt battery lower than 11.4-volts should be recharged to rated voltage or higher.

Step 2: If the battery is conventional/acid type (has three or six caps on top),

use a hydrometer to check the density of the liquid electrolyte in each cell. The density or specific gravity should be between 1.26 and 1.28 at room temperature. If it is below 1.25, recharge the battery. The difference in specific gravity between any two cells should be no more than 0.05. Note that a sealed maintenance-free battery (dry type) cannot be tested in this way.

Step 3: Clean battery terminals using a small amount of baking soda and a stiff wire brush. Clean battery cables the same way.

Step 4: Inspect the cable insulation for corrosion and breaks; replace as needed.

Servicing of mechanical-breaker ignition

For many years, mechanical-breaker ignition systems were the most popular of all ignition systems. The high voltage electricity from the coil is turned on and off using contact points and a condenser. The spark must be correctly timed to reach the spark plug at the exact moment when the piston is at the top of its travel and the fuel-air mixture is fully compressed.

Here's how to service a mechanical-breaker ignition:

Step 1: Remove the cover from the stator plate to expose the breaker points and condenser.

Step 2: Manually turn the crankshaft until the high point of the cam lobe opens the contact points. Inspect the points for uneven wear or damage. If necessary, replace the breaker points and condenser.

Step 3: Slightly loosen the points set screw and place the appropriate thickness gauge between the two contacts. (Check your owner's or service manual for the correct gap.) Move the points setscrew until the thickness gauge is touching both contacts but can be withdrawn without moving them.

Step 4: Tighten the points set screw.

Step 5: Check the points gap with the thickness gauge again. Tightening the set screw may have changed the gap.

Step 6: Clean the points with lint-free paper to remove any oil left by the thickness gauge.

Note: Some mechanical-breaker ignitions can be set using a dwell meter. If you have a dwell meter, refer to the unit's operating instructions and the ignition specifications to determine what dwell angle setting is correct and how to set it.

Fig.1.27: Mechanical-breaker ignition

To adjust a mechanical-breaker ignition, loosen the points set screw and use a thickness gauge to check the gap between the breaker contacts.

Timing mechanical-breaker ignition: To work efficiently, the spark must be delivered to the combustion chamber at the exact moment that the piston is at or near TDC (top dead center). The procedure, to time the ignition spark is follows:

Step 1: Loosen the adjustment nut(s) on the stator so it can be turned.

Step 2: Disconnect the coil lead wire from the points.

Step 3: Connect a lead of the continuity tester light or ohmmeter to the breaker point terminal and the other to the housing or a ground location.

Step 4: Rotate the stator until the light or ohmmeter indicates that the points have opened the circuit (light off or resistance high).

Step 5: Tighten the adjustment nut(s) on the stator without moving it.

Step 6: Reconnect the coil lead wire to the points.

Servicing capacitor-discharge ignition: Capacitor-discharge ignitions (CDIs) store and deliver voltage to the coil by way of magnets, diodes, and a capacitor.

The mechanical points of a breaker point ignition are replaced with electronics. The only moving parts are the magnets on the flywheel. That's why this system is sometimes called a breaker less ignition. Because there are no breaker points on this system, there is no requirement for timing. However, the trigger module performs the same function as points. There must be a specific gap between the trigger module and the flywheel projection. Refer to your owner's or service manual for specific steps to setting this gap. The typical steps to setting the trigger module gap on a CDI system are the following:

Step 1: Remove the lead from the spark plug to prevent starting. Ground the spark plug lead by attaching it to the shroud.

Step 2: Rotate the flywheel so the projection is aligned with the trigger module.

Step 3: Loosen the trigger module adjustment screw(s) and insert a thickness gauge of the correct thickness (typically 0.005 to 0.015 inch) in the gap.

Step 4: Move the trigger module until it touches the thickness gauge, making sure the projection and module surfaces are parallel.

Step 5: Tighten the trigger module adjustment screw(s) and replace the spark plug lead.

Servicing of spark plug: The spark plug in a small engine should withstand high voltage, high heat, and millions of ignitions during its life cycle. A new spark plug requires about 5,000 volts of electricity to jump the gap. A used spark plug may require twice as much voltage to function. So, servicing the spark plug is important for engine operation. The servicing of spark plug is as follows:

Step 1: Disconnect the lead wire from the top of the spark plug.

Step 2: Using the appropriate spark plug wrench, loosen the plug from the cylinder head. Before removing the plug, clean debris from around the spark plug base.

Step 3: Note the electrode appearance. Excessive buildup of slugs or burnt

carbon around plug points indicates incorrect fuel-air mixture, incorrect carburetor adjustment, weak spark voltage, or poor air cleaner maintenance are some of the causes for this.

Step 4: Clean the carbon deposits on the spark plug points and surface with a soft cloth and the electrode with a wire brush or spark plug cleaning kit. If the electrode is worn or damaged, replace the spark plug with same size and heat range to avoid any damage to the engine.

Step 5: Using a feeler gauge, set the gap on the spark plug electrode to the manufacturer's recommendations.

6. Governing system: Governing system or governor is the main controller of the hydraulic turbine. To manage the turbine's speed or power production, the governor changes the water flow through it. The governor can change the speed of the generators and the frequency of the system.

Governing System in IC Engines: The governor is the mechanism or device that keeps the engine running at a consistent speed regardless of the load on it. Governing is the technique for maintaining a consistent speed.

There are three different methods for adjusting the engine's power in response to the governor's action, and these methods differ in the mechanical mechanisms used to regulate the power. The standard centrifugal governor is employed to control the speed in all circumstances.

Methods of Governing: The following is the usual classification adopted for the various methods of governing:

(a) Hit and Miss Governing: The governor's action causes the fuel inlet valve to remain closed during a cycle, preventing any fuel change from entering. As a result, the engine will go through an idle cycle. In other words, when the engine speed exceeds a specific threshold, the charge is prevented from entering the cylinder, and combustion is delayed for a few cycles. As a result, the engine idles for a few cycles.

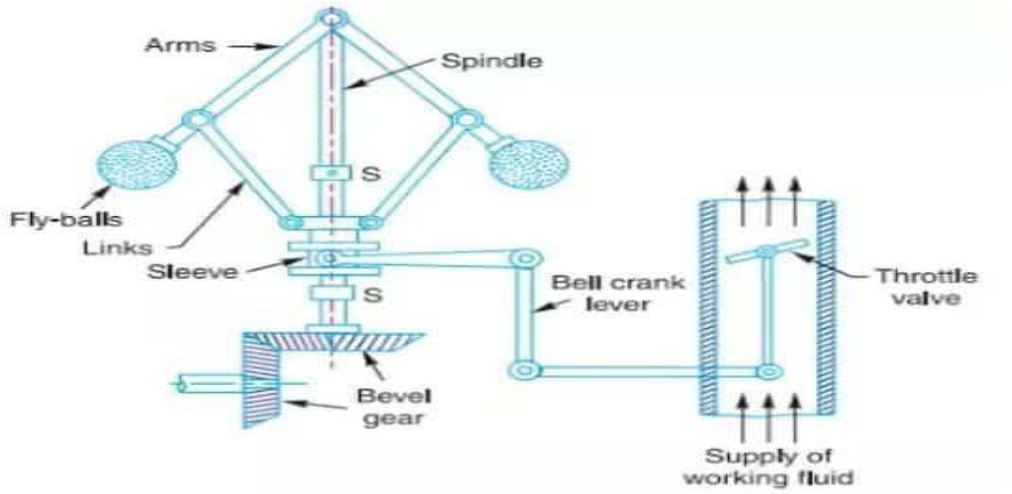


Fig.1.28: Hit and Miss Governing

Disadvantages:

1. Efficiency decreases because of idle cycles along with actual working cycles.
2. Since the combustion is missed during same cycles, it produces very uneven turning movement for the crank shaft.

The hit and miss mechanism operate on the exhaust valve of tiny, light oil engines, preventing it from opening when the engine speed is too high; the burned gases are therefore kept in the cylinder and alternatively compressed and expanded until the engine speed is lowered.

(b) Quantitative Governing: This method controls the amount of mixture (fuel and air) that enters the cylinder, hence varying the engine's output. This is sometimes accomplished by throttling the mixture before it enters the cylinder, with the throttle valve movement being controlled by the centrifugal governor lift. In gas engines, another approach of quantitative governing is to change the lift of the inlet valve, reducing the amount of mixture entering the cylinder.

When the load on the engine increases, the engine's speed reduces, and the fly weights move inwards (indicated by dotted arrows) and the sleeve moves downwards as a result of the reduced speed. The throttle valve is then opened more, allowing more charge to enter the engine cylinder, resulting in increased power and a stable engine speed.

When the load on the engine decreases—speeds rise—fly weights move outwards (as represented by the arrow)—the throttle valve closes—the supply of charge is reduced. As a result, the engine produces less power and maintains a constant speed.

(c) Qualitative Governing: In this way of governing, the centrifugal governor changes the strength of the mixture, hence modifying the quality of the mixture. This is accomplished by controlling the amount of fuel that enters the cylinder while maintaining a steady air supply. This regulating mechanism is employed in all heavy oil engines that use pure air compression.

The governor controls the amount of fuel that goes into the cylinder. It can change the stroke of the oil pump, return a portion of the gasoline to the oil tank, or delay the shutting of the fuel pump's suction valve. All of these strategies will result in a different cut-off point.

Important Types of Centrifugal Governors used with the Engines

Following are the important centrifugal governors:

(i) Watt Governor (Simple Conical Governor): When the load reduces and the speed increases, the fly weights move outwards, as represented by the arrows, lifting the sleeve. When the load is increased, the weight travels inwards (as represented by the dotted arrows) and the sleeve moves downwards (Fig. 1.29)

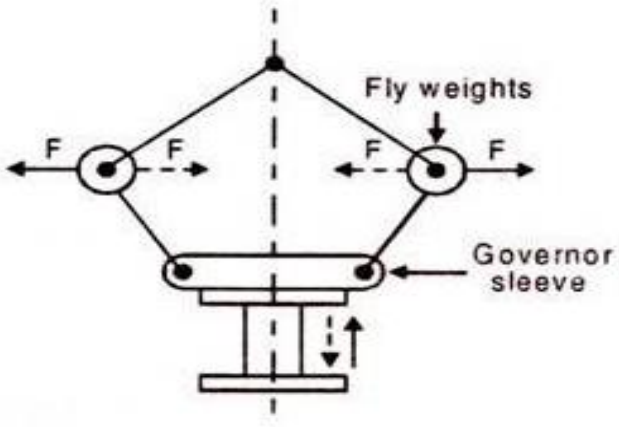


Fig.1. 29: Watt Governor

(ii) Porter Governor: The watt's governor is known as the Porter Governor when the centre load is provided on the sleeve.

(iii) Proell Governor: This governor has fly weights on the lower links' extensions, and it has a centre load.

(iv) Hartnell Governor: As depicted, it primarily comprises of two bell crank levers and a compression spring. Fly weight and end rollers are attached to one end of the bell crank levers. At O, the levers are pivoted. When the speed is increased, the fly weight moves outwards, and the lever at O lifts the rollers and sleeve against the spring compression.

(v) Gravity Governor with Spring Control: Figure 1.30 depicts a gravity governor that is controlled by a spring. It is primarily made up of two bell crank levers. On one end, there are rollers, and on the other, there are fly weights. The rollers will be sitting on the cap that forms the shaft's top end. As indicated, a spring is provided under the cover.

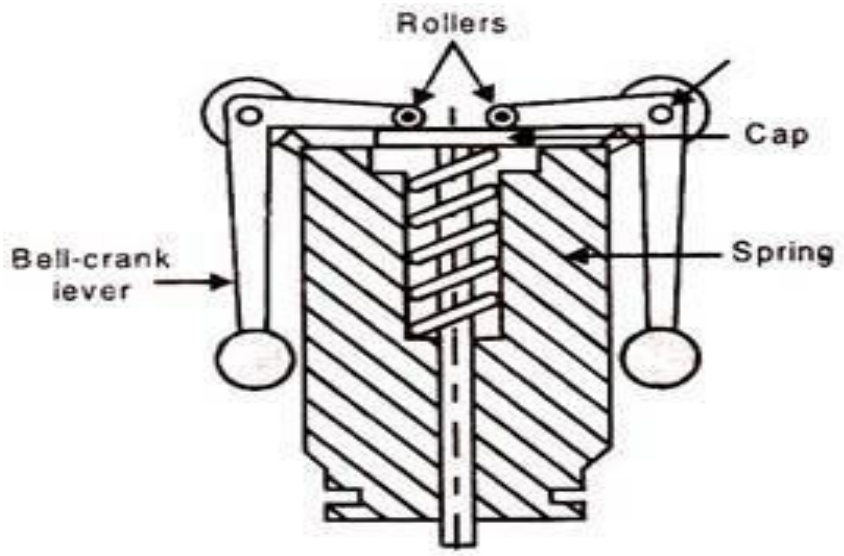


Fig. 1.30: Gravity governor with spring control

Practical Exercise

Activity 01: Make a list of the various system in an engine.

Material required:

1. Pen
2. Notebook
3. Pencil
4. Eraser
5. Sharpener

Procedure:

1. First, take a permission from tractor workshop owner.
2. Then, identify the various system of an engine.
3. Make a list of various system of an engine.
4. Write down their name and specification.
5. Draw a figure of various system of an engine.

Activity 02: Draw the diagram of intake system of tractor.

Material required:

1. Pen
2. Notebook
3. Pencil
4. Eraser
5. Sharpener

Procedure:

1. First, take a permission from tractor workshop owner.
2. Then, identify the intake system of an engine.
3. Draw a figure of intake system.

Activity 03: Draw the diagram of exhaust system of tractor.

Material required:

1. Pen

2. Notebook
3. Pencil
4. Eraser
5. Sharpener

Procedure:

1. First, take a permission from tractor workshop owner.
2. Then, identify the exhaust system of an engine.
3. Draw a figure of exhaust system.

Check Your Progress

A. Answer the following question

1. What is the various system of an engine?
2. Define cooling system of an engine.
3. Explain the lubrication system?
4. What is governing system and explain different method of governing?
5. Describe the ignition system and their types.

B. Fill in the blank

1. A well-functioning air intake system feeds the engine with a ..... supply of clean air.
2. The air-cooled system is used commonly in small engines ..... HP used in agricultural machines.
3. A battery is a device containing ..... cells that produce and store direct current.
4. When the engine speed exceeds a ..... threshold, the charge is prevented from entering the cylinder.
5. The governor can change the ..... of the generators and the ..... of the system.
6. A new spark plug requires about ..... volts of electricity to jump the gap.
7. Efficiency ..... because of idle cycles along with actual working cycles.

C. Match the following

Column A	Column B
1. Fuel tank	**A. Magneto system**
2. This governor has fly weights on the lower links' extensions, and it has a centre load.	**B.** 
3. This system is used in equipment where electricity is only needed to power the spark plug, without starter system or lighting.	**C. Proell Governor**
4. Fuel filter	**D.** 
5. In-line fuel filter	**E.** 

SESSION 3: TOOLS AND MEASURING INSTRUMENTS USED IN AN ENGINE

Quality tools and measuring instruments are always needed for the service of small gas engines since many dimensions and tolerances are critical for proper engine operation. When making engine service and repairs, measurements must be made to determine if parts are within specified limits and tolerances if replacements and adjustments are made.

1.6: TOOLS AND MEASURING INSTRUMENTS USED IN AN ENGINE DURING REPAIR AND SERVICING WORK

1. Micrometer: The micrometer is a precision instrument designed to accurately measure pistons, crankshafts, valve stems, and other small engine components. An outside micrometer is used to measure thicknesses and outside diameters. The inside micrometer, is designed for taking measurements of internal dimensions. A blade micrometer, is used to take measurements in narrow slots. The micrometer's anvil and spindle faces are to be clean. The micrometer should always be checked for proper calibration before use.

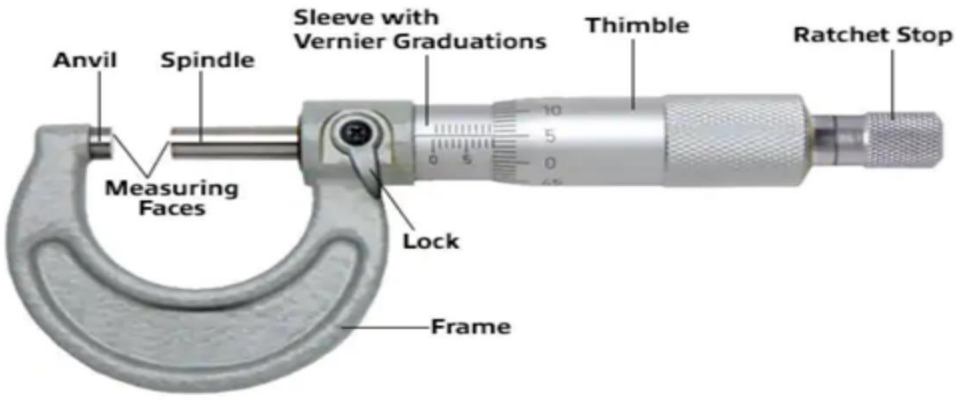


Fig. 1.31: Micrometer

2. Telescoping gauge: Telescoping gauge are "transfer-type" measuring instruments. They do not provide a direct dimensional reading. A telescoping gauge, like the one in below figure can be used to transfer the distance from A to B to a micrometer.

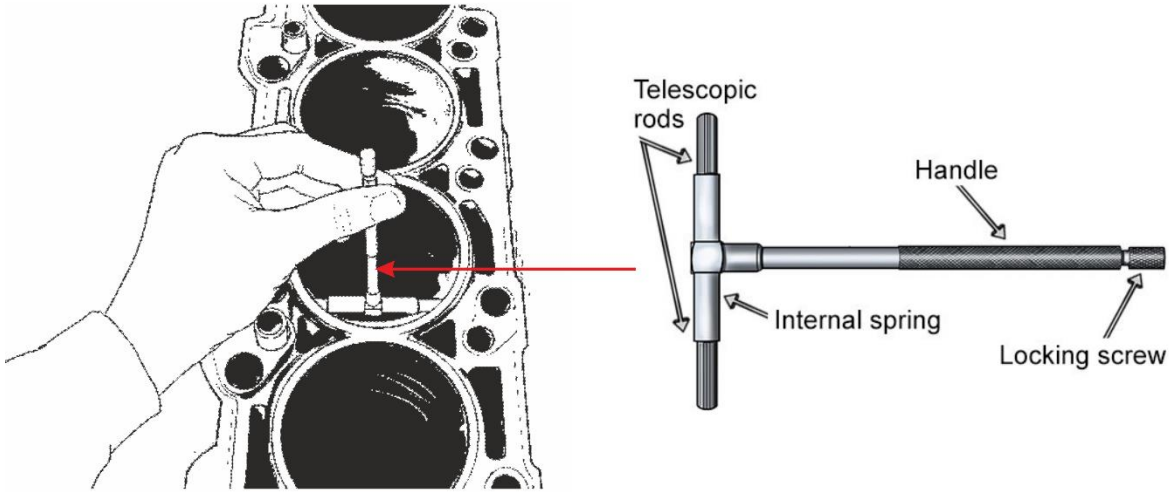


Fig.1.32: Telescoping gauge

Telescoping gauge is used to determine the diameter of a cylinder for that loosen the lock screw on the end of the handle, so that the telescoping parts can be retracted, locked, and placed in the cylinder. Once the gauge is located in the cylinder, release the lock screw to allow the telescoping ends to extend. The handle must be held perfectly in line with the centerline of the cylinder being measured. Also, it is essential that the telescoping ends be aligned exactly across the true diameter of the cylinder as in figure. When the true diameter has been located, use the opposite hand to gently tighten the lock screw, securing the telescoping ends. When removing the gauge from the cylinder, tilt the handle so that it can be removed without changing the setting. After the gauge is removed, measure the distance between the telescoping ends with a micrometer.

3. Thickness gauges: Thickness gauges are sometimes called "feeler gauges" because they rely on the user's sense of feel for accuracy. They are used to measure small spaces and gaps between surfaces. Thickness gauges are used to measure spark plug gap, breaker point gap, and piston ring gap etc. Thickness gauges consist of a set of metal leaves that vary in thickness. Each leaf has its decimal thickness etched onto its surface as observed in the figure.

Fig.1.33: Thickness gauges

Some leaves are as thin as 0.0005 inch or in millimeter and may be damaged if not handled carefully. It is sometimes necessary to select several leaves to equal a desired thickness. When using a thickness gage, the leaves must be perfectly clean. Avoid bends and distortions. These conditions will increase the total thickness which results in measurement errors.

4. Valve spring tension tester: The function of the valve springs is to close the valves quickly and securely. If spring tension is inadequate, valve leakage and poor valve timing can occur. The valve spring tension tester shown in figure is designed to test valve spring tension with the aid of a torque wrench. The information plate on the base of the tester converts pounds-inch and pounds-foot of torque to pounds of applied force or in SI units. Some torque specifications are also provided in metric newton meters (N-m).

Fig.1.34: Valve spring tension tester

5. Combination square: The combination square has many uses. It is often used to measure the length of valve springs and check them for straightness, Fig. 1.35. For accuracy, always place spring and square on a flat, machined surface.

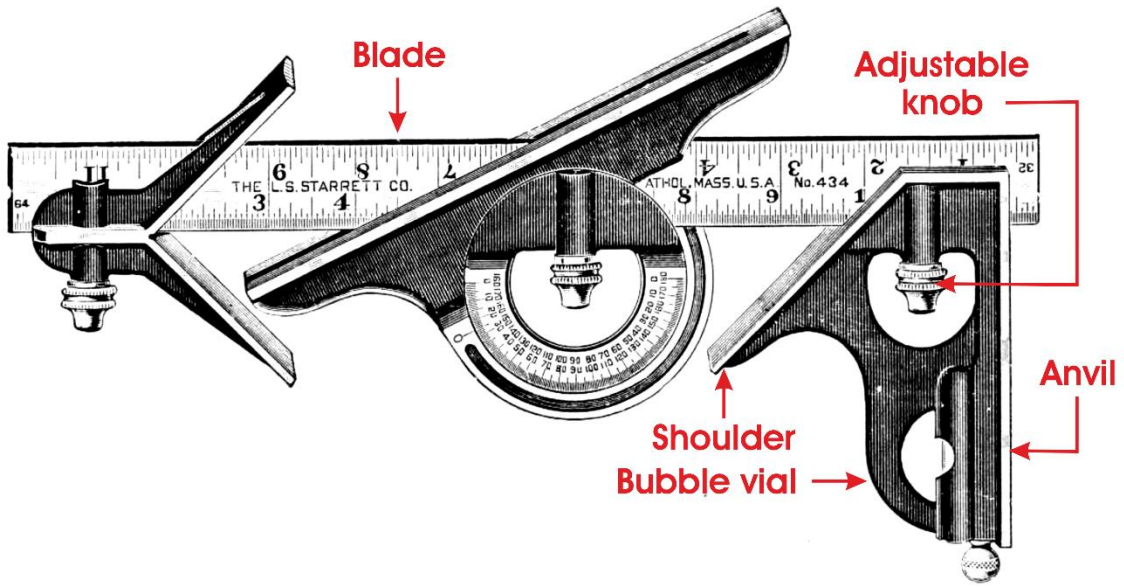


Fig.1.35: Combination square

6. Dial indicator: Dial indicators are precision instruments that are very useful for measuring the movement of various parts, Fig.1.36. They are also used to check for surface irregularities and run-out. The dial indicator is equipped with a spring-loaded spindle, which is placed against the part to be measured. A needle on the instrument's dial is used to indicate the amount of movement made by the part being tested. The needle rotates over the dial indicator's face, which is calibrated in thousandths of an inch, ten-thousandths of an inch, or hundredths of a millimeter. The indicator's bezel can be revolved to locate the zero line on the dial face under the needle. The zero line coincides with the initial position of the needle and serves as a reference point when checking for movement. The dial indicator can be mounted on a variety of devices that are designed to hold it in the desired location.

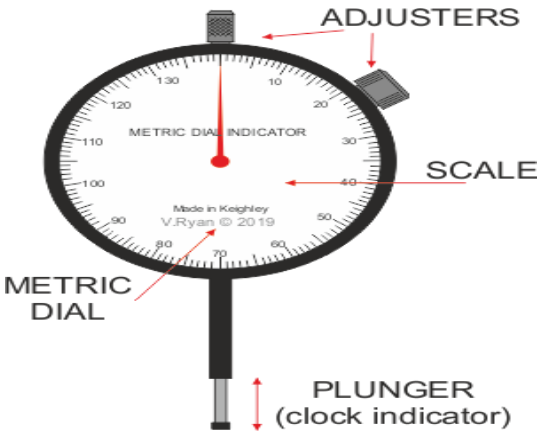


Fig.1.36: Dial indicator

7. Screw pitch gauge: This gauge is used to determine the number of threads per inch on bolts, screws, nuts, and in threaded holes. Each leaf of the gage is marked with the number of threads per inch or millimeter; it will match when the leaf is placed onto the screw, bolt, etc. Use exact leaf until one leaf fits exactly into the threads. Read the number on the leaf to determine the number of threads per inch or millimeter on the item checked. Screw pitch gages are available for both standard and metric threads.

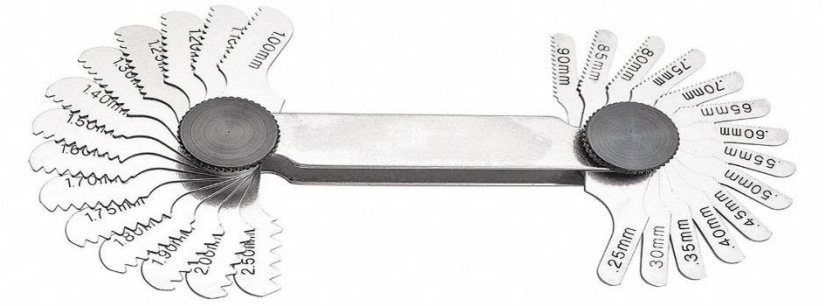


Fig.1.37: Screw pitch gauge

8. Wrenches: Many types of wrenches available to suit all practical situations encountered in servicing of small engines. The wrench includes box-end wrenches, open-end wrenches, adjustable wrenches, Allen wrenches, socket wrenches, and torque wrenches. The type of wrench used may depend on the kind of fastener installed or removed. Box-end, open-end, adjustable, and socket wrenches are used on hexagon head bolts and nuts.

Open-end wrenches, should be used when it is not possible to encompass the

nut or bolt head with a box-end wrench or a socket. Box-end wrenches can be used where partial or full-turn clearance is available. Box-end wrenches may be six or twelve sided and are less likely to slip around the bolt head corners than open-end wrenches or adjustable wrenches.

Combination wrenches have a box on one end and are open on the other. A tubing wrench is used on metal tubing connection fittings. While applying force to a wrench, always pull the tool instead of pushing on it. This will prevent hand and knuckle injury if the wrench should accidentally slip from the bolt head.

Adjustable wrenches should be used when other wrenches are not available. Adjustable wrenches are used similarly to open end wrenches and should also be pulled in the correct direction. Due to the movable jaw in adjustable wrenches, they are likely to loosen and slip around the corners of bolts and nuts.

Fig.1.38: Wrenches

Many types of socket sets are available. For small engine work, sets with standard and deep length sockets, one ratchet wrench. Adjustable wrenches should always be pulled in the correct direction when tightening or loosening bolts and nuts. The movable jaw should always face the turning direction. The jaws should be adjusted to fit the bolt or nut as tightly as possible. Sockets are extremely useful when bolts or nuts are recessed in counter bored holes. Allen wrenches/keys are used to remove or install hex socket-head screws.

Fig.1.39: Adjustable wrench

Allen wrenches/ keys may be the conventional right-angle style or straight with tee handles. The correct size Allen wrench should be used to avoid slipping in the hexa socket recess and damaging the socket.

Fig.1.40: (A) Allen wrenches/keys **(B) Socket set**

Torque wrenches are used to tighten threaded fasteners to a specific torque setting. Torque is the turning force applied to the fastener. Set torque wrench to the required load, the wrench socket is placed on the bolt head and the handle is drawn until a click can be felt and heard.

9. Pliers: Pliers are extremely useful tools for gripping, bending, pulling, and, in some cases, cutting wires. They should not be used to replace wrenches. Pliers are not designed for tightening purpose as they usually damage surfaces when used in this way. Different are shown in figure below. "Vise-Grip" pliers, is designed to apply great clamping pressure and have large gripping teeth. Needle nose pliers, are very useful for bending small wires and gripping items that have fallen into small recesses.

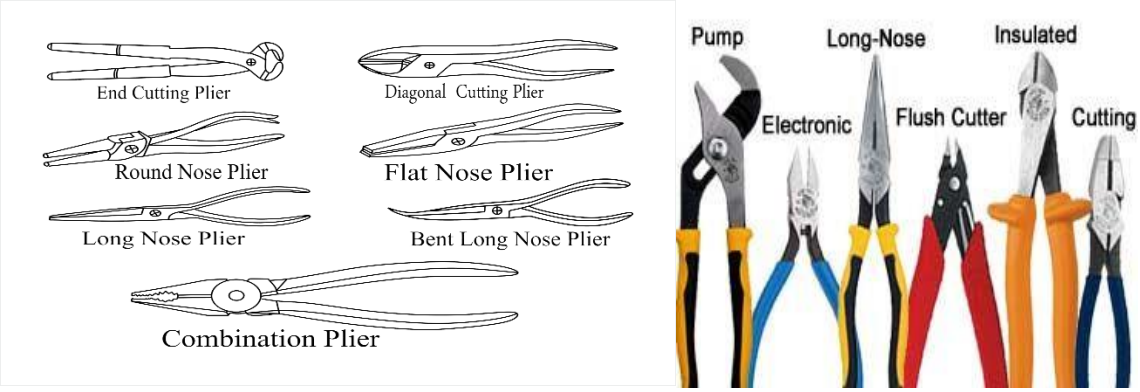


Fig.1.41: Different types of Pliers

10. Retaining ring plier: Inside and outside retaining rings are used to keep a part from moving axially on a shaft (in a direction parallel to the centerline of a shaft). For example, a sliding gear may be limited from moving too far by a retaining ring set in a groove machined into a shaft. Retaining rings are made from spring steel and must be installed and removed with special retaining ring pliers, such as those shown in figure. To install an outside retaining ring, the nibs of the pliers are inserted into the small holes in the ring and the ring is expanded by squeezing the plier handles. The ring is then slid over the shaft to the machined groove, where it is released. For internal retaining rings, the ring is compressed to fit inside a cylindrical hole when the plier handles are squeezed.

Fig.1.42: Retaining ring plier

11. Screwdriver: Different types of screwdrivers are used while servicing and repairs of small engines. Standard screwdrivers are available in a variety of shapes and sizes as shown in figure below. The proper size blade should be used to match the length and thickness of the screw head slot. In addition to installing and removing screws, screwdrivers are also used to apply leverage to move or separate parts. Screwdrivers are available in a variety of sizes to accommodate

various sizes of screws and bolts. In tight situations, the length of a regular screwdriver may prohibit its use. When this occurs, an offset screwdriver can be very useful. Offset screwdrivers are available with standard heads.

Fig.1.43: Screwdriver

12. Hammer: These tools are extremely useful for small engine work. Ball peen hammers are used for tapping things into place. They are often use conjunction with other tools, such as punches and chisels. The ball peen hammer is considered to be a hard-faced hammer because its head is made of steel while using a ball peen hammer for engine work, care must be taken so that parts are not dented or deformed by the hard faces.

Fig.1.44: Ball pen hammer

The ball peen hammer is also used with pin punches to install locking pins in holes or with cold chisels to shear bolts, pins, or sheet metal. Ball peen hammers are available in a variety of sizes and are rated according to weight. A hammer's weight is usually stamped on the side of its head.

13. Punches: Different types of punches are used for workshop and engine service and repair work. Center punches have hardened steel points and are

used to make depression in metal surfaces before drilling. The depression helps to start the drill and keep it in the desired location. The center punch works with a 90-degree point angle. Prick punches are similar to center punches. However, the point angle of a prick punch is 60°.

Fig.1.45: Different types of punches

The prick punch is used to make a very small depression prior to using the center punch to enlarge the depression for drilling. Center punches and prick punches are driven with a ball peen hammer. Pin punches of various diameters and lengths are available for driving straight pins, tapered pins, and roll pins in and out of holes. A ball peen hammer is used to apply the driving force to the punch. Drift punches are tapered and are used to align holes in mating parts, allowing a bolt or pin to be passed through the parts.

14. Cold chisels: Cold chisel is used for cutting tool that can shear bolts, pins, rivets, sheet metal, rods, and other materials. The cold chisel is made of special tool steel, which is hardened and tempered by heat-treatment. The cutting edge is very hard and sharpened to an angle between 60° and 90°. A 60° angle is used for shearing sheet metal.

Fig.1.46: Cold chisel

A 90° angle is for shearing bolts and rivets. The cutting edge can be sharpened when it becomes dull and may need heat treatment after several grindings. It should have a slightly curved edge for shearing and a straight edge for cutting flat surfaces. Although the portion immediately behind the cutting edge is tempered for toughness, the chisel's shank portion is annealed (made soft) to prevent it from shattering. When the shank end of the chisel becomes flared, it should be reground to remove the flared portion.

15. Gear puller: These tools are used for pulling gears and bearings from shafts. Gears and bearings are press fit on to shafts and have to be pulled with considerable force to be removed. The gear puller is designed to provide this pulling force. Gear pullers can be used for many applications and are often used to remove flywheels, gears etc., from small engines.

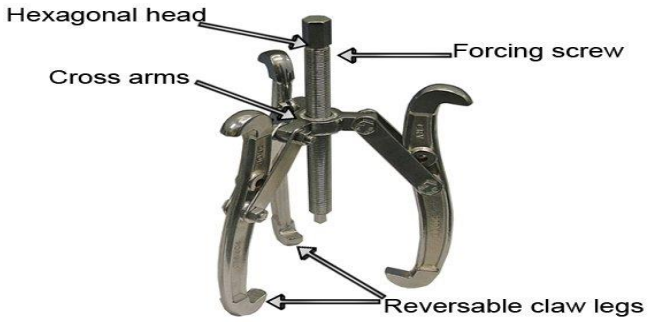


Fig.1.47: Gear puller

16. Bench Vice: The machinist vice is useful for holding the parts while they are worked on. Some vices can be swiveled for convenient positioning of the work piece. The jaws are hardened steel and have a rough gripping surface while some have smooth faces to hold work parts to prevent marking on the pats when held tightly between the faces. Sheet copper, soft aluminum or wood can be used to pad the jaws. The anvil portion of the vise can be used to flatten sheet metal or to straighten bent parts. Always be careful not to distort or damage parts by over- tightening.

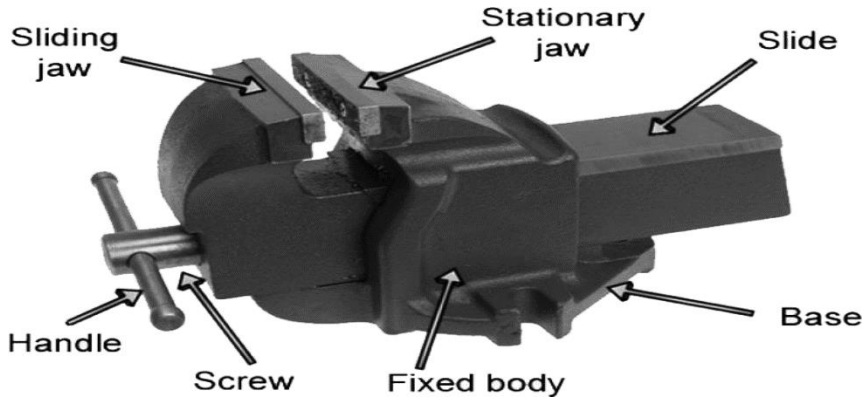


Fig.1.48: Bench Vice

1.7: General Safety Tips

- Always wear personal protection clothing such as safety goggles with shields, earmuffs or earplugs, leather or cotton gloves, long pants, and rubber-soled work boots or shoes.
- Remove any loose debris (trash, tree limbs, rocks, etc.) before you start.
- Make sure the area where you will be working is clear of all other workers or bystanders. Check the operator's manual for proper clearance of flying debris.
- Never operate a machine while under the influence of alcohol, drugs, or medication.
- Never remove any safety guards or shields. They are there for your protection.

Practical Exercise

Activity 01: Make a list of tools used for repair and maintenance.
Material required:

1. Pen
2. Notebook
3. Pencil
4. Eraser
5. Sharpener

Procedure:

1. First, take permission from workshop owner.

2. Then, identify the tools used for repair and maintenance.
3. Make a list of tools used for repair and maintenance.
4. Write down their name and specification.
5. Draw a figure of selected tools used for repair and maintenance.

Activity 02: Make a list of different types of punches.

Material required:

1. Pen
2. Notebook
3. Pencil
4. Eraser
5. Sharpener

Procedure:

1. First, take permission from the agriculture machinery shop owner.
2. Then, visit the shop.
3. Next, Identify the different types of punches that are available in the shop.
4. Make a list of different types of punches that are available.
5. Write down their name and specification.
6. Draw a figure of different selected types of punches.

Activity 03: Draw the sketch of telescoping gauge.

Material required:

1. Pen
2. Notebook
3. Pencil
4. Eraser
5. Sharpener

Procedure:

1. First, visit the automobile shop.
2. Then, Identify the telescoping gauge that is available in the shop.

3. Write down its name and specification.
4. Draw a sketch of a telescoping gauge and label their parts.

Check Your Progress

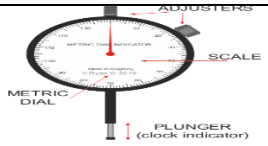
A. Answer the following question

1. Describe the tool used during the repair and maintenance of the engine.
2. What is a micrometer and how it is used in automobiles?
3. Define the ball pin hammer.
4. Write the importance of bench vice and also draw a neat sketch of it.
5. How gear puller is used?
6. What is the role of a cold chisel?
7. Write the different types of screwdrivers which are used in automobiles for repairing an engine.
8. Write the general safety precautions should be taken during the repair and maintenance of an engine?

B. Fill in the blank

1. A ..... micrometer is used to take measurements in narrow slots.
2. Telescoping gauge is used to determine the diameter of a ..... for that loosen the lock screw on the end of the handle.
3. Vise-Grip pliers is designed to apply great ..... pressure and have large gripping teeth.
4. When the ..... end of the chisel becomes flared; it should be reground to remove the flared portion.
5. The proper size of blade should be used to match the ..... and ..... of the screw head slot.

C. Match the following

Column A	**Column B**
1. This gauge is used to determine the number of threads per inch on bolts, screws, nuts.	**A.** 
2. Valve spring tension tester	**B. Gear puller**
3. Dial indicator	**C. Screw pitch gauge**
4. These tools are used for pulling gears and bearings from shafts.	**D. Combination square**
5. It is used to measure the length of valve springs and check them for straightness.	**E.** 

SESSION 4: TROUBLESHOOTING IN TRACTOR ENGINE

You know how strong and adaptable a tractor can be if you own one. However, regardless of which system you have or how you use it, you will ultimately need to troubleshoot certain typical problems.

1.8: Troubleshoot of tractor engine

Table 1.2: Troubleshooting in the Tractor's Engine

First read tractor manual

- You should read the tractor manual to decide how often your tractor should be serviced and stick to that schedule. When it comes to repairing your model, the manual will most likely give you with instructions. A minor problem can most likely be resolved quickly by consulting the owner's manual for advice.

Tractor won't start

Sometimes big problems are caused by simple parts. Start the troubleshooting process by checking the fuses.

- **Check the Spark Plugs:** A faulty spark plug can cause problems with a tractor's engine. There are a few frequent symptoms that a spark plug needs to be replaced: the tractor has difficulty starting, has low fuel consumption, and has poor performance.
- **Check the battery:** Check the battery to see if it's low or dead, then charge or replace it as required. And also check **Battery connection is loose or corroded -** Use a wire brush to clean the connections and retighten.
- **Check the Carburetor:** Another major source of tractor engine troubles is a faulty carburetor. The tractor engine's carburetor may struggle to blend air and gasoline if it becomes clogged. This may affect

the tractor's performance in the short run. If left untreated, it can cause considerable damage and necessitate costly repairs in the long run.

- **Check the fuel system:** See if the fuel line is blocked. If so, clean it and replace the fuel filter.
- **Check fuel shutoff valve is closed (Off):** Open the fuel shutoff valve at the water separator.
- **Check the stale fuel/improper fuel level:** Drain fuel and refill with new fuel to capacity.
    - **How will you know?**

      If the smell is stale or sour, open the gas cap and waft it toward your nose; if it is, flush it. As you empty the tank, pay attention to the appearance of the stale fuel; it isn't as clear as fresh fuel and frequently contains clumps.
- **Check the plugged fuel filter:** Replace fuel filter.
    - **How will you know?**

      The fuel filter may need to be replaced if you've noticed a drop in performance before the engine won't start.
- **Check transmission gearshift:** If the transmission gearshift lever is not in the right position, then place the range shift lever to neutral.
- **Check throttle lever:** If the engine throttle lever is not pushed forward then move the throttle to half throttle.

- **Check viscosity of oil:** If engine oil shows wrong viscosity, then change engine oil and fill with correct viscosity oil for conditions.
    - **How will you know?**

      Pull out the manual and make sure the last time you changed your engine oil that you used the manufacturer’s recommended oil viscosity.
- **Check air intake filter:** Check air intake filter is plugged or not then clean or replace air filter elements.

- **How will you know?**

  If you've been experiencing lower gas mileage/run-time and less consistent power, it's likely your fuel filter. If the filter is covered in oil, torn, or shows cracks, it needs to be replaced.

- **Check fuse:** If fuse is blown then **c**heck and replace faulty fuses.
  - **How will you know?**

    Test the suspected fuse with a multimeter. Test that the multimeter is functioning by touching the testing rods together. You should get a no resistance reading.

Troubleshooting in the Fuel System

- Fuel system problems might be difficult to detect since they have a subtle and gradual effect on the tractor's performance. A jammed fuel control lever is the most prevalent cause, as it makes it difficult for fuel to reach the engine. Add some lubrication to the mix. If it doesn't work, it's time to take your vehicle to a service centre.

Troubleshooting in the Tractor Implements

- Tractors can be combined with a variety of implements. These useful attachments allow the tractor to handle a wider range of activities, but they might wear out and cause problems over time.
- For example - Cutting implements rely on blades that are prone to wear and strain. The blades become increasingly dull as they are used. They eventually lost a lot of their ability at cutting through the undergrowth. After that, you'll need to take the blades out and sharpen them. Always refer to the tractor manual for instructions on how to carefully remove and sharpen blades.

Overheating • Radiator's coolant keeps your tractor engine from overheating, so make sure it's topped up and clean. Check the radiator on a daily basis and top off the coolant as needed. There could be a leak if you're running low on coolant on a regular basis. If you suspect this is the case, keep an eye on the tractor throughout the day and, if it's obvious that something is wrong, have it serviced.
Tire Wear and Tear • For effective operation, a tractor's tyres must be maintained and inflated on a regular basis. Because of the weight of your machine, as well as any towing equipment or payloads it may be hauling, it's critical that the tyres are in good working order. Replacing a large tractor tyre is an expensive proposition, therefore keeping them in good condition can keep you from having to do it frequently. Check the pressure in each tyre to ensure it meets the manufacturer's requirements, which are usually listed on the tyre wall or in the owner's manual. To achieve best performance, you may wish to modify the tyre pressure slightly for different tasks.

Table 1.3: Troubleshooting in the Tractor's Engine

Topic	Problem/Causes	Remedy
Clutch System		
Noise while pressing the clutch pedal	• Lack of lubrication in Clutch release bearing.	• Lubricate.
	• Clutch release bearing damage.	• Replace.
Noise while pressing the clutch pedal	• Lack of lubrication in pilot bearing.	• Lubricate.
	• Pilot bearing damage	• Replace.

	• Clutch disk hub loose on input shaft.	• Replace the worn-out parts.
Clutch slippage	• Clutch pedal free play.	• Adjust & correct (25 to 35 mm).
	• Broken or weak pressure spring.	• Replace springs.
	• Release lever height incorrect.	• Adjust & Correct (SC. 40 to 44mm) (DC 28 to 36 mm).
	• Grease or oil on facings.	• Replace the facing, check source.
	• Glazed clutch facing.	• Replace facing.
	• Glazed flywheel or pressure plate face.	• Correct by machining or replace.
	• Warped clutch facing.	• Replace the clutch facing.
	• Warped flywheel or pressure plate face.	• Correct by machining or replace.
Clutch not disengaging while pressing clutch	• Clutch pedal free play more.	• Adjust & correct.
	• Release lever height setting improper.	• Adjust & correct.
Wear of clutch facing	• Driver clutch pedal riding.	• Keep foot off clutch pedal.
	• Excessive and incorrect use of clutch.	• Reduce use.
	• Cracks in flywheel or pressure plate face.	• Correct by machining or replace.

	• Weak or broken pressure spring.	• Replace spring.
	• Clutch pedal free play less.	• Adjust & correct.
Clutch pedal hard	• Lack of lubrication in pedal linkage.	• Lubricate.
	• Clutch pedal- jam on clutch shaft.	• Grease the shaft.
	• Release lever height setting improper.	• Adjust & correct.
Clutch Pedal Pulsation	• Engine and transmission improper.	• Realign.
	• Flywheel face run out more.	• Correct run out or replace.
	• Release lever not evenly adjusted.	• Adjust & correct.
	• Pressure plate assembly misaligned.	• Realign.
	• Warped pressure plate or clutch facing.	• Replace.
	• Clutch plate nut free on.	• De and check clean.

1.9: TROUBLESHOOTING OF AN ENGINE

Troubleshooting is a systematic analysis of the symptoms that indicate engine malfunction. Because it would be impracticable to detail all of the possible problems in a reciprocating engine, just the most prevalent ones are discussed. Most difficulties can be solved with a thorough understanding of the engine systems combined with logical reasoning.

Table 1.4: Troubleshooting in the Engine (Automobile)

Trouble	Causes or Problem	Solution
Engine fails to start	• Lack of fuel.	• Check fuel system for leaks fill fuel tank. • Clean dirty lines, strainers, or fuel valves.
	• Under-priming.	• Use correct priming procedure.
	• Over-priming.	• Open throttle and unload engine by rotating the propeller.
	• Incorrect throttle setting.	• Open throttle to one-tenth of its range.
	• Defective spark plugs.	• Clean and re-gap or replace spark plugs.
	• Defective ignition wire.	• Test and replace any defective wires.
	• Defective or weak battery.	• Replace with charged battery.
	• Improper operation of magneto or breaker points.	• Check internal timing of magnetos.
	• Water enters in carburetor.	• Drain carburetor and fuel lines.
	• Internal failure.	• Check oil sump strainer for metal particles.
	• Magnetized impulse coupling, if installed.	• Demagnetize impulse coupling.

	• Frozen spark plug electrodes.	• Replace spark plugs or dry out plugs.
	• Mixture control in idle cutoff.	• Open mixture control.
	• Shorted ignition switch or loose ground.	• Check and replace or obtain correct idle.
Engine fails to idle condition properly	• Incorrect carburetor idle speed adjustment.	• Adjust throttle stop to obtain correct idle.
	• Incorrect idle mixture.	• Adjust mixture (Prefer manufacturer's manual for proper procedure).
	• Leak in the induction system.	• Tighten all connections in the induction system. • Replace any defective parts.
	• Low cylinder compression.	• Check cylinder compression.
	• Faulty ignition system.	• Check entire ignition system.
	• Open or leaking primer.	• Lock or repair primer.
	• Improper spark plug setting for altitude.	• Check spark plug gap.
	• Dirty air filter.	• Clean or replace.
Low power and engine	• Mixture too rich; indicated by sluggish engine	• Check primer. • Re-adjust carburetor mixture.

running uneven	operation, red exhaust flame, and black smoke.	
	• Mixture too lean; indicated by overheating or backfiring.	• Check fuel lines for dirt or other restrictions. • Check fuel supply.
	• Leaks in induction system.	• Tighten all connections. • Replace defective parts.
	• Defective spark plugs.	• Fill tank with recommended grade.
	• Improper grade of fuel.	• Clean points. • Check internal timing of magneto.
	• Magneto breaker points not working properly.	• Test and replace any defective wires.
	• Defective ignition wire.	• Replace connectors on spark plug wire.
	• Defective spark plugs terminal connectors.	• Adjust valve clearance.
	• Incorrect valve clearance.	• Check and replace or repair.
	• Restriction in exhaust system.	• Remove restriction.
	• Improper ignition timing.	• Check magnetos for timing and synchronization.

Engine fails to develop full power	• Throttle lever out of adjustment.	• Adjust throttle lever.
	• Leak in induction system.	• Tighten all connections and replace defective parts.
	• Restriction in carburetor air-scoop.	• Examine air-scoop and remove restriction.
	• Improper fuel.	• Fill tank with recommended fuel.
	• Propeller governor out of adjustment.	• Adjust governor.
	• Faulty ignition.	• Tighten all connections. • Check system. • Check ignition timing.
Rough running engine	• Cracked engine mounts.	• Repair or replace engine mounts.
	• Unbalanced propeller.	• Remove propeller and have it checked for balance.
	• Defective mounting bushings.	• Install new mounting bushings.
	• Lead deposit on spark plugs.	• Clean or replace plugs.
	• Primer unlocked.	• Lock primer.
Low oil pressure	• Insufficient oil.	• Check oil supply
	• Dirty oil strainers.	• Remove and clean oil strainers.
	• Defective pressure gauge.	• Replace gauge.

	• Air lock or dirt in relief valve.	• Remove and clean oil pressure relief valve.
	• Leak in suction line or pressure line.	• Check gasket between accessory housing crankcase.
	• High oil temperature.	• See 'high oil temperature' in trouble column.
	• Stoppage in oil pump intake passage.	• Check line for obstruction. • Clean suction strainer.
	• Worn or scored bearings.	• Overhaul engine.
High oil pressure	• Insufficient air cooling.	• Check air inlet and outlet for deformation or obstruction.
	• Insufficient oil supply.	• Fill oil tank to proper level.
	• Clogged oil lines or strainers.	• Remove and clean oil line or strainers.
	• Failing or failed bearings.	• Examine sump for metal particles and, if found, overhaul engine.
	• Defective thermostats.	• Replace thermostats.
	• Defective temperature gauge.	• Usually caused by weak or stuck rings.
	• Exceeded blow-by.	• Overhaul engine.
Excessive oil consumption	• Failing or failed bearing.	• Check sump for metal particles and if found, an

		overhaul of engine is indicated.
	• Worn or broken piston rings.	• Install new rings.
	• Incorrect installation of piston rings.	• Install new rings.
	• External oil leakage.	• Check engine carefully for leaking gaskets or O-rings.
	• Leakage through engine fuel pump vent.	• Replace fuel pump seal.
	• Engine breather or vacuum pump breather.	• Check engine, and overhaul or replace vacuum pump.

1.10: REPAIR AND MAINTENANCE OF TRACTOR

1.10.1: Maintenance of tractor: The tractor plays an important role in agriculture mechanism field. Proper and timely maintenance is required to keep your tractor in good operating order for a long time at the lowest cost. There are following maintenance which helps in maintaining long life of a tractor such as-

- **First read the owner's manual:** Manufacturer has specific instructions for basic care of tractor, and they have the expertise to give the best advice on how to do it. It also tells the right intervals for routine maintenance of a tractor.
- **Obtain tools:** It is important points in tractor maintenance. Tractor maintenance requires numerous wrenches and other tools in large sizes than for automobile.
- **Protect the tractor from the elements.**

- **Check fluids regularly.**
- **Check tyre inflation:** If tyres run with excessively low pressure, tread wear increases. Adjust air pressure for the type of work planned for the day ahead. If road travel is expected, add a few pounds of pressure to each tyre. If tillage is expected, reduce pressure by a few pounds.
- **Keep an eye on belts and hoses.**
- **Keep the brake linkages lubricated, and make sure the brakes are adjusted equally.**
- **Watch the gauges:** Keep an eye on the temperature, oil pressure, and tachometer. The temperature gauge should be marked with a normal operating range, but any time the indicator says the temperature is over 220 ^{0}F(104^{0}C), the engine is running hot. If equipped with a diesel engine, the oil pressure should be between 40 and 60 PSI. The tachometer tells how many revolutions per minute the crankshaft is running.
- **Check the filters regularly:** Most systems in tractors are equipped with filters to protect against dirt, water, or other contaminants that could cause failure of the components. Check the air filter often. Tractors are often operated in very dusty conditions, and in some cases, the filters must be cleaned daily or weekly. Clean the air filter with a shop vacuum or with compressed air. Replace the air filter when it cannot be cleaned satisfactorily, or if the filter is damaged.
- **Check radiator screen:** It often operated in conditions where debris may accumulate on the radiator, so they usually have a front screen or grill to prevent plant matter, insects, or pollen from clogging the radiator.
- **Lubricate the tractor:** As tractors have many moving parts that require greasing. Use a grease cartridge pressure gun, clean the fitting, attach the hose, and pump grease until the associated seal begins to expand, or grease is seen oozing out of the attachment you are lubricating. Look for grease fittings on steering components, brake and clutch linkages, and three-point hitch pivot points.
- **Do not overload the tractor:** Put the desired weight on the tractor.

1.10.1.1: ROUTINE MAINTENANCE OF A TRACTOR

1. Daily / Everyday inspection task for your tractor after 10-12 hours of field work, you should:

- Check the oil-level in the engine that can be done 15 minutes after the engine has cooled down. If you found below, the oil-level should be reloaded with the accurate level mark.
- Check the water level of your tractor radiator and refill it as per requirement.
- Clean the air-cleaner of the tractor and check the oil level. If it is less, fill it with clean and dirt-free oil to the required level.
- Check for leaks and damage or loose pipes or cables. Repair for leaks, big or small, may simply require tightening or replacing tubes or tightening drain plugs.
- Check the glass sediment bowl beneath the fuel filter for water or material. Some latest models of tractor also have to check windows and their blockages for hydraulic reservoir fluid levels.

2. Weekly inspection task for your tractor after 60-70 hours of field work, you should:

- While performing the daily inspection and maintenance measure.
- Fill up the tractor's fuel tank.
- Check the air pressure in the tires of tractor. If the air pressure is low, get the required air.
- Check the elasticity of the fan-belt under the pressure of the thumb. It should stretch to a degree of 12 & 18 milli-meters.
- Clean the air pressure and fill it with an oil of the right grade.
- The water stored in the oil filter should be drained out weekly by the drain plug.

- Check the water-level of the battery. If water is found below the limit, fill it with distilled water.
- Check the level of the oil in the gear box.
- Apply grease to the clutch shaft and bearings, brake control, bearing of the fan, hub of the front wheel, tie rod and the radius cross.

3. Two weeks' inspection task for your tractor after 130-140 hours of field work, you should:

- Repeat the weekly schedule of maintenance.
- Apply oil to the Dynamo and the Starter of your tractor.
- Clean the carbon dirt in the smoke-tube.
- Change the engine oil. For this, keep the tractor in starting position for a while and then switch it off so as to heat up the entire oil, then drain out the oil through the drain plug and fill fresh and clean oil of the right grade.
- Clean the metallic oil filter. In case the oil filter is made of paper, element, cloth, etc. then change them.
- Check the performance of clutch and brake; it should be 15mm long. Adjust it according to the need.

4. Monthly inspection task for your tractor after 250 hours of field work, you should:

- Repeat every step of two-week maintenance.
- If it is advised to clean the primary diesel filter, (in the manual supplied with the tractor) clean it or change it if required.
- Wash the filters of the valve of the oil-tank.
- Check the water in the battery. If its relative density is below the mark, change the battery or refilled it with distilled water.

5. Two months inspection task for your tractor after 500 hours of field work, you should:

- Follow and repeat the monthly schedule of maintenance.
- Change the other element of diesel filter.
- Get the injector and diesel pump checked by an experienced mechanic.
- Contact your authorized dealer or an experienced mechanic for the inspection of valve.
- Get the dynamo and the self-starter inspected.
- Clean the entire oil tank.

6. Quarterly inspection task for your tractor after 1000-1200 hours of field work, you should:

- Follow the bi-monthly maintenance schedule.
- Drain out the oil of the gear box and fill it with a clean oil of the right grade.
- Drain out the oil of the back-axle and fill clean oil.
- Change the oil of the Belt-pulley.
- Clean the filter of the Hydraulic pump.
- Change the steering oil.
- Change the grease of the front wheel.

1.10.2: REPAIRS OF TRACTORS

Table 1.5: Repairing of tractor

Trouble	Problem	Remedy
Engine does not start	• Battery not fully charged.	• Charge the battery fully.
	• Starter pinion jammed.	• Adjust the pinion.
	• Faulty switch.	• Repair or change the switch.
	• Air lock in fuel system.	• Bleed the fuel line.

	• Injectors faulty.	• Check it on injector testing machine.
Engine gives out black smoke	• Air cleaner choked.	• Clean it well.
	• Engine over loaded.	• Reduce the load from the engine.
	• Excess fuel injected.	• Check the injection pump and injector.
Engine does not take sufficient load	• Valve clearance incorrect.	• Adjust the correct gap.
	• Valve spring broken.	• Replace it.
	• Injection timing incorrect.	• Check it and correct it.
	• Exhaust pipe blocked.	• Clean it well.
Engine runs in idle condition but does not run-on load	• Fuel lift pump faulty.	• Repair it.
	• Fuel filter blocked.	• Clean the filter.
	• Fuel tank vent blocked.	• Clean the vent.
	• Faulty injector.	• Check the injectors.
Engine get overheated very soon		
(a) Fault in cooling system	• Leakage in cooling system.	• Check the leakage.

	• Defective water pump.	• Repair the pump.
	• Thermostat valve not opening properly.	• Adjust the valve.
	• Radiator chocked.	• Clean the radiator.
	• Fan belt loose or broken.	• Change the belt.
(b) Inefficient combustion	• Injection timing wrong.	• Check the timing.
	• Engine overloaded.	• Reduce the load on the engine.
	• Exhaust pipe chocked.	• Clean the exhaust pipe.
	• Fault in injector.	• Test the injectors.
(c) Improper lubrication	• Oil filter choked.	• Clean it.
	• Lubricating oil dirty.	• Replace it.
	• Oil viscosity too high.	• Use correct grade of oil.
	• Lubricating pump defective.	• Repair it.
Clutch slips	• Pedal adjustment not corrects.	• Adjust the play.
	• Burnt or worn clutch lining.	• Repair or replace the lining.
Clutch does not disengage	• Clutch lining rusted.	• Repair it.

	• Clutch pad not properly adjusted.	• Adjust the play.
Poor braking	• Excess play of the brake pedal.	• Adjust the play.
	• Oil leakage in break chamber.	• Check the leakage.
	• Acting stroke of the right and left pedal different.	• Stroke should be made same.
Brake pedal does not return smoothly	• Broken return spring.	• Replace it.
	• Grease runs short at each sliding section.	• Remove rust and apply grease.
Hydraulic system does not lift and drop	• Lack of hydraulic oil.	• Fill it up to mark.
	• Pipe sucks air.	• Remove the leakage.
	• Filter clogged.	• Clean the filter.
	• Broken control valve.	• Replace it.
	• Broken cylinder.	• Replace the cylinder.
Source: Jagdishwar Sahay, Elements of Agricultural Engineering. http://m.wikihow.com http://www.hobbyfarms.co		

Practical Exercise

Activity 01: Make list of maintenance of a tractor.

Material required:

1. Pen
2. Notebook
3. Pencil
4. Eraser
5. Sharpener

Procedure:

1. First, take permission from the tractor workshop owner.
2. Then, identify the parts of a tractor.
3. Make a list of the parts of a tractor.
4. Write down their name and specification.
5. Prepare the chart of maintenance of a tractor.

Check Your Progress

A. Answer the following question

1. Describe the maintenance of a tractor.
2. How tractor would be procured from any damage?
3. How you can identify any trouble in your tractor?

B. Fill in the blank

1. Proper and timely maintenance is required to keep your tractor in good ……. order for a long time at the lowest cost.
2. If tyres run with excessively low pressure, tread wear …….
3. Check the battery to see if it's …… or ……., then charge or replace it as required.
4. The tractor engine's ……. may struggle to blend air and gasoline if it becomes clogged.
5. The anvil portion of the vice can be used to ……. sheet metal or to straighten bent parts.

SESSION 05: STANDARD PROCEDURE FOR ATTACHING ENGINE WITH VARIOUS AGRICULTURE MACHINERY AS PER MANUAL

In agriculture, the tractor is used to execute a variety of tasks in the field. As a result, doing this task or process in the field necessitates a large number of matching implements. As a result, for various field operations, the tractor should employ the appropriate matching implements. Before start any filed operation with matching implements, tractor must follow these steps for field operations preparations:

- Tractor preparation instructions
- Check the tractor's horsepower should be appropriate for the matching implements.
- Then, adjust the width of the front and rear wheel tracks.
- For tractor stability, provide enough front-end ballast.
- All plough adjustments must be completed.
- According to the tractor operator's manual, select the load and depth control settings according to matching implements.

1.11: Various agriculture machinery attachment with the tractor engine

Now for some specifics on how to match an implement with the tractor to a standard method:

1. Drawbar: A solid link between a hauling vehicle and its hauled load is known as a drawbar. Rail transport, large and small road trailers, industrial and leisure trailers, and agricultural equipment all employ drawbars.

Fig. 1. 49: View of Drawbar

Implement Hitching

Follow these steps for hitching to a drawbar:

1. Place the tractor in such a way that the hole in the drawbar lines up with the hole in the implement hitch. This is called spotting. You may need to practice this skill.
2. Turn off the engine, park the tractor, or apply the brakes.
3. Use the proper-sized hitch pin and security clip to secure the implementation.
4. Remove the chock blocks from the wheels and raise the implement jack stand.
5. As necessary, connect the PTO shaft, hydraulic hoses, and/or electrical connections. On these topics, refer to the applicable task sheets.

2. PTO (Power Take-off): The term "power take-off" refers to the process of transferring energy from one source to another. It's a mechanism that sends power from a tractor's engine to a machine or implement that doesn't have its own engine. To use a PTO, you must connect it to a PTO-driven implement and activate it.

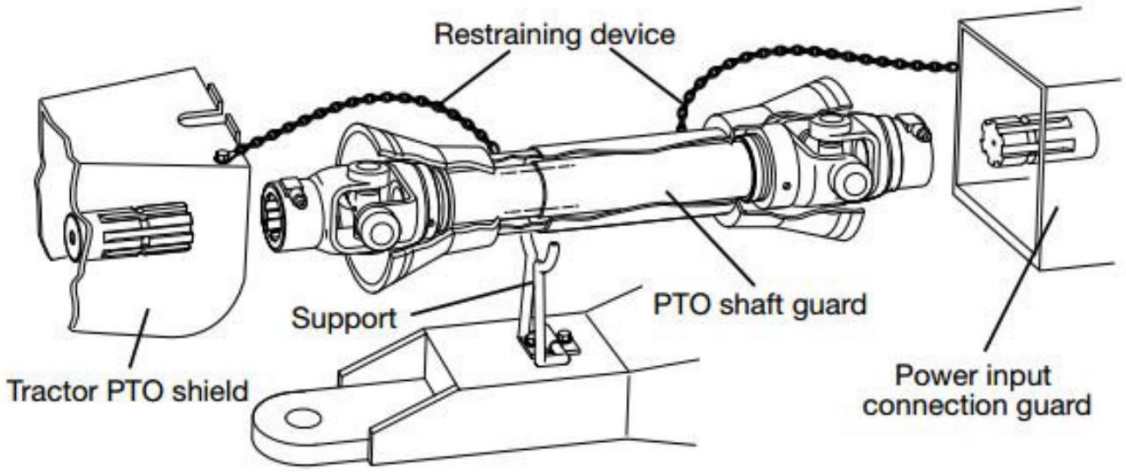


Fig. 1.50: View of PTO (Power Take-off)

Here, will show you how PTO works on a tractor.

1. The input shaft of the PTO taps energy from the tractor's engine and transfers it to a hydraulic pump.
2. The hydraulic pump then uses the energy to create pressure, which forces hydraulic fluid to flow until it reaches hydraulic equipment where it does useful work.
3. Some equipment that a PTO can operate includes cotton pickers, mowers, and harvesters.

On a tractor, how do you engage the PTO?

If your tractor has a transmission PTO or live PTO, make sure the transmission is in neutral and the parking brake is engaged before proceeding with the steps below. If your tractor has an independent PTO, you can continue to the steps below without stopping it, but be sure it isn't running at full speed.

For live and transmission PTO

1. Begin by fully depressing the clutch pedal and holding it there.

2. After that, turn the PTO switch to the "ON" position.
3. Typically, the PTO switch is found on the dashboard.
4. To get the PTO to engage properly, keep the clutch pedal depressed for around 5 seconds.
5. After 5 seconds, softly release the clutch pedal.
6. When the PTO is effectively activated, an indicator light may illuminate beside the PTO switch.

For independent PTO

Because you don't have to deal with the clutch, independent PTO is quite simple to utilise.

1. Start by sliding the PTO selector lever away from the "OFF" position to engage an independent PTO.
2. The PTO switch should then be turned to the "ON" position.
3. On the right side of the operator's seat, the PTO selector lever and PTO switch are normally found.
4. Please keep in mind that certain independent PTOs only have a lever-style PTO switch, and the PTO will activate as soon as the lever is turned to the "ON" position.
5. Tractor models with both a selector lever and a PTO switch are specifically intended to reduce the possibility of unintentional engagement.

3. Three-point hitch: It's a common hitch for attaching ploughs and other implements to a tractor for agricultural or industrial use. The three points resemble a triangle or the letter A, depending on your perspective. In engineering, three-point attachment is the simplest and only structurally defined means of attaching two bodies.

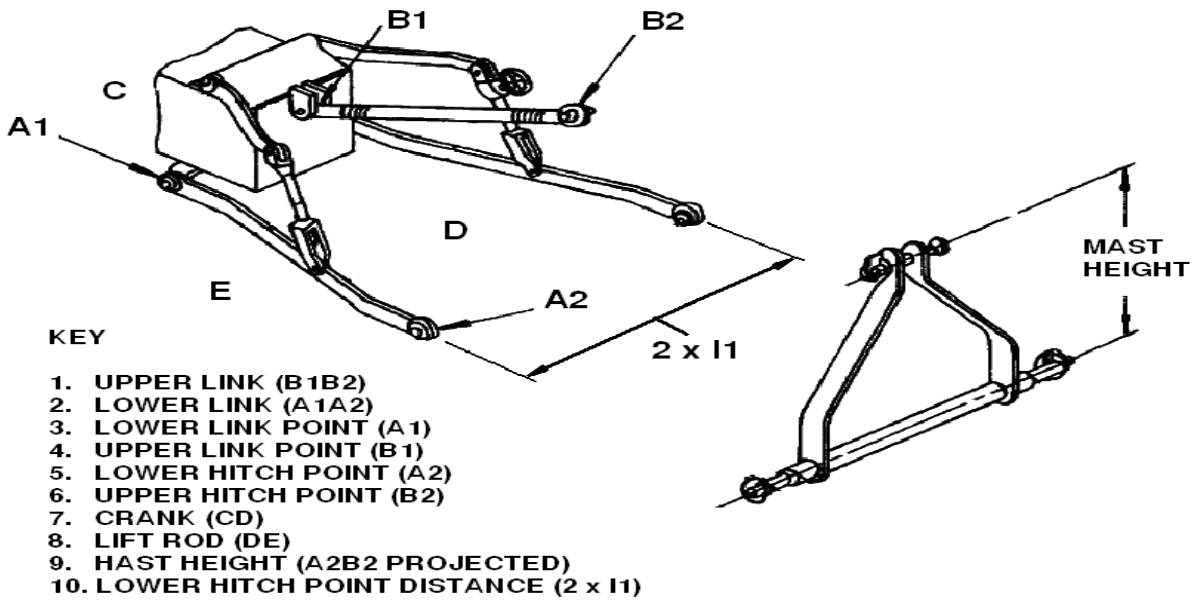


Fig. 1.51: View of Three- point hitch

Implement Hitching

Follow these steps for hitching to three-point hitch attachment:

1. To gain clearance, move the stationary tractor drawbar forward.
2. Adjust the tractor so that the draught arms' pin holes line up with the implement hitch locations.
3. Adjust the draught arms to fit the implement hitch points by raising or lowering them.
4. Turn off the engine, park the tractor safely, and apply the brakes.
5. Use the right size hitch pin and security clip to secure the left draught arm to the implement hitch point. The right arm is the next to be joined.
6. Remount the tractor and start it so that the hydraulic system can elevate the lift arms if necessary.
7. Connect the top link of the 3-point hitch to the upper hitch point of the implement. To adjust, raise the lift arms to extend, or drive ahead with the implement down to shorten. If the top link has been modified too many times, the implement may not be level. The machine may not function properly if it is not level. If you're having trouble levelling the machine, get assistance.
8. Use the right size hitch pin and security clip to secure the upper hitch pin.

4. Mould Plough: The mould board plough is one of the oldest agricultural implements, and it is widely regarded as the most significant tillage tool. Plowing consumes the most traction energy of any agricultural operation. Despite the fact that yield studies have shown that ploughing has no obvious advantage in some crops under specific conditions, the mould board plough is still the most widely used equipment for initial tillage in seedbed preparation.

Fig. 1.52: View of Mould Board Plough

Adjustments of M.B. Plough: The following changes are required to improve M.B. Ploughing results:

a) Ploughing the soil: - The top link on the tractor controls the plough's level. Lengthen the top link if the back end of the plough beam is higher than the front end. Shorten the top link if the back end of the plough beam is lower than the front end. The length of the tractor's right lower link is adjusted to control lateral levelling. Prior to operation, these adjustments must be done using the plough.

Fig.1.53: View of M.B. Plough attached with tractor three-point linkage

b) Horizontal suction or land suction: It is the amount that the point of sharing is bent away from the land side. The suction's goal is to get the plough to take the right amount of furrow width. The longest distance from the straight edge to the plough bottom is determined horizontally by placing a straight edge on the side of the plough running from the heel of the landside to the point of share. Typically, the amount is around 3/16 inch.

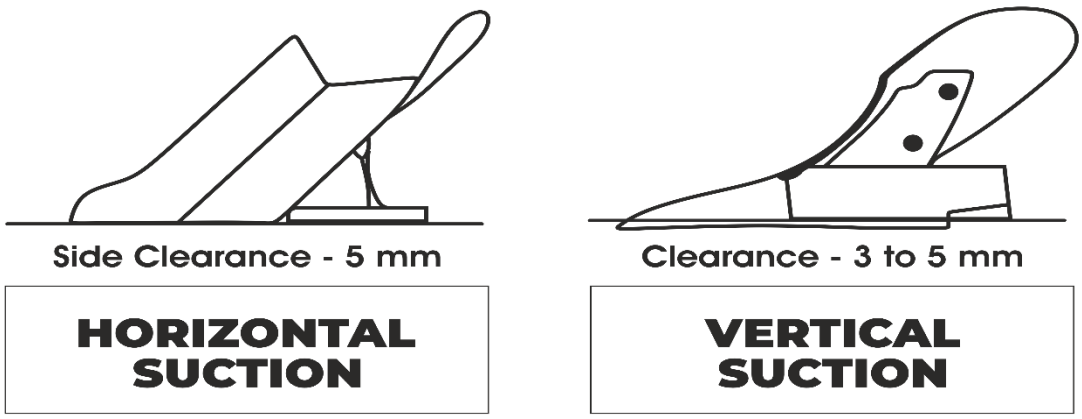


Fig. 1.54: View of adjustment of M.B. Plough

c) Vertical suction or down suction: When the plough is pulled forward, the point of share is bent downward to let the plough to penetrate the soil to the right depth. Depending on the sort of plough and the soil it will work in, the amount of suction will range from 1/8 to 3/16 inch.

d) M B plough draught: The kind of soil is the most important external aspect to consider when determining the draught of any plough. To press the plough into the soil on exceptionally hard ground, it is often essential to add weight to the wheels. For complete ploughing, the depth and width of cut per bottom have an impact on draught. Another aspect that boosts the draught is speed; doubling the pace raises the draught by around 20% to 25%.

e) Deeper ploughing adjustment: The tractor hydraulic system's position and draught control levers can be used to determine the plough's depth. However, the following methods can be used to gain more depth:

- Increasing the plough's weight.
- Suction from above

- Set the plough in virtually vertical position and add weight to the plough if the ground is covered in trash. Ploughing using a notched plough produces greater results in such soils.

f) Driver's caution:

- Before ploughing, inspect all nuts and bolts of the MB Plough.
- Ploughing on stony soil is not recommended.
- The tractor should be in high first gear.
- Ploughing the field at least twice if the soil is hard.

g) Hazard: Before ploughing with M B Plough, make sure no one is standing near it.

Instructions for use (attaching the plough to the tractor)

A. Make sure all nuts and bolts are securely fastened before mounting the M.B. plough.

B. Connecting the tractor to the plough.

- Place the plough on the flat patch of land that has been properly levelled.
- Return the tractor to the ploughing position (Do not drag the plough up the tractor).
- First, connect the tractor's left arm to the plough.
- Attach the plough's centre arm. To assemble, lengthen the screws on both sides to the same length. If the arm is too short or too long, adjust both at the same time with the screw until they are aligned with the hole on the central arm.
- Turn the screw until the mounting pin is at the same level as the hole on the tractor arm to attach the lower right arm.
- Lift the plough after it's been attached and align the control arm with the ground.

5. Tractor trailer: A tractor attached to a semitrailer or trailer, used for transporting loads. A combination of a tractor and a trailer or semitrailer, used in trucking.

Fig. 1.55: View of Trailer

Coupling or hook-up of trailer to tractor

1. Look for broken, loose, or missing pieces on the fifth wheel and kingpin. Make that the fifth wheel is properly lubricated and positioned.
2. Examine the location for available maneuvering space. Make sure the trailer and cargo are both secure.
3. Make sure the tractor is parallel to the trailer. Align the kingpin with the throat of the fifth wheel.
4. Return to your original position SLOWLY. STOP just as you're about to make touch.
5. Set the parking brake and shift into neutral to secure the tractor.
6. Measure the height of the trailer in relation to the fifth wheel. When the fifth wheel is backed in under the trailer, it should be positioned so that it rises slightly.
7. Join the air-lines together.
8. Fill the trailer with air.
9. Engage the trailer brakes and start the engine.
10. Back under the trailer:
    - Shift into the lowest reverse gear to go.
    - Release the parking brake on the tractor.
    - As the trailer apron makes contact with the tractor's fifth wheel, the trailer will be lifted onto the tractor's fifth wheel.

• When you hear the jaws closing around the kingpin, come to a complete stop.

11. Use a tug test to check the connection.
12. Make sure the car is secure.
13. Look over the coupler.
14. Check the air-lines and connect the power cord.
15. Raise the trailer supports to the desired height.
16. Take out the chocks.

6. Cultivator: A cultivator is a farm implement or machine that stirs the soil around a mature crop to promote development and eliminate weeds.

Fig. 1.56: View of Cultivator

Procedure for coupling the cultivator to tractor

1. First, take the tractor at level surface.
2. Then, took the tractor near to the cultivator (attaching implement) with low gear.
3. Pick out the stepper pin first.
4. Now set all three levers.
5. After that on the tractor and move back near the implement with low gear.
6. Apply hand break.
7. First fix left lower link.
8. Then fix right lower link. If you see the link is not adjusting proper therefore use lift rod to set the right lower link.

9. For fixing of top link-
    - First unlock it.
    - Remove hitch pin and link pin.
    - Adjust the top link
    - Now put hitch pin and link pin.
10. After that lock the top link.
11. Start the tractor.
12. Lift the implement through main lever.
13. When lifting, check the implement that it parallels lifting and dropping opposite to the ground surface.

7. Rotavator: A rotavator is a piece of machinery that is used to churn and aerate the soil before seeding or laying turf. This is a crucial phase in the land preparation process. The Rotavator twisted and broke up the soil using a series of blades.

Fig. 1.57: View of Rotavator

Procedure for coupling the cultivator to tractor

1. First, take the tractor at level surface.
2. Then, took the tractor near to the rotavator (attaching implement) with low gear.
3. Pick out the stepper pin first.
4. Now set all three levers.

5. After that on the tractor and move back near the rotavator with low gear.
6. Apply hand break.
7. First fix left lower link with help of link pin and lock it.
8. Then, fix right lower link with help of link pin and lock it.
9. After that add PTO shaft to rotavator to tractor
10. For fixing of top link-
    - First unlock it.
    - Remove hitch pin and link pin.
    - Adjust the top link
    - Now put hitch pin and link pin.
10. After that adjust and lock the top link.
11. Start the tractor.
12. Lift the implement through main lever.
13. When lifting, check the implement that it parallels lifting and dropping opposite to the ground surface.

8. Hole Digger: It is a machine or tool that is used to drill holes in the ground surface. It is the quickest technique of digging holes in farm land because it is a PTO driven implement. It can dig holes with a diameter of 6", 9", 12", or 18". It comes with a unique steel cutting tip with semi-double fighting that can withstand harsh conditions. It has a heavy-duty gearbox and PTO shaft with overload prevention via a slip clutch.

Fig.1.58: View of Hole Digger

Procedure for hook up the post hole digger to tractor

1. First, take the tractor at level surface.
2. Apply hand break.
3. Then, took the tractor near to the post hole digger (attaching implement) with low gear.
4. Attach the main shaft of post hole digger to the top link and also lock it with pin.
5. After that attach PTO shaft to post hole digger to tractor.
6. Then, first fix the left lower link with help of link pin and lock it.
7. Then, second fix the right lower link with help of link pin and lock it.
8. Start the tractor.
9. Lift the implement through main lever.
10. When lifting, check the implement that it parallels lifting and dropping opposite to the ground surface.

9. Harrow: A harrow is a tool used in agriculture to break up and level the surface of the soil. Its effect is so distinct from that of the plough, which is employed for deeper tillage. Fields are frequently harrowed to smooth off the rough finish left by ploughing operations.

Fig.1.59: (A)View of Spike tooth harrow (B) Offset Disc Harrow

Procedure for coupling the harrow to tractor

1. First, take the tractor at level surface.
2. Then, took the tractor near to the harrow (attaching implement) with low gear.
3. Pick out the stepper pin first.
4. Now set all three levers.
5. After that on the tractor and move back near the implement with low gear.
6. Apply hand break.
7. First fix left lower link.
8. Then fix right lower link. If you see the link is not adjusting proper therefore use lift rod to set the right lower link.
9. For fixing of top link-
    - First unlock it.
    - Remove hitch pin and link pin.
    - Adjust the top link
    - Now put hitch pin and link pin.
10. After that lock the top link.
11. Start the tractor.
12. Lift the implement through main lever.
13. When lifting, check the implement that it parallels lifting and dropping opposite to the ground surface.

Practical Exercise

Activity 01: Make list of different types attaching or hookup implement of tractor.

Material required:

1. Pen
2. Notebook

Procedure:

1. First, take permission from the agriculture machinery shop owner.
2. Then, visit the shop.
3. Next, identify the different types of attaching or hookup implement of tractor that are available in the shop.
4. Make a list of different types of attaching or hookup implement of tractor that are available.
5. Write down their name and specification.
6. Make a report on the same.

Activity 02: Draw the sketch of mould board plough.

Material required:

1. Pen
2. Notebook
3. Pencil
4. Eraser
5. Sharpener

Procedure:

1. First, take permission from the farm machinery shop owner.
2. Then, visit the shop.
3. Next, Identify the mould board plough that are available in the shop.
4. Write down its name and specification.
5. Draw a sketch of a mould board plough and label its different parts.

Activity 03: Draw the sketch of cultivator.

Material required:

1. Pen
2. Notebook
3. Pencil
4. Eraser
5. Sharpener

Procedure:

1. First, take permission from the farm machinery shop owner.
2. Then, visit the shop.
3. Next, identify the cultivator that are available in the shop.
4. Write down its name and specification.
5. Draw a sketch of a cultivator and label its different parts.

Check Your Progress

A. Answer the following question

1. List the attached implements used in tractors during different field operations.
2. Explain the three-point linkage and how it is used in a tractor.
3. Define the term PTO. And also explain its importance in tractors?
4. Write the importance of the drawbar and also draw a neat sketch of it.
5. What is an MB plough? Write the step of coupling the MB plough to the tractor.
6. What is the role of rotavator? Explain the procedure of hookup the rotavator to the tractor?
7. Describe the post-hole digger. And also sketch the diagram of it.

B. Fill in the blank

1. A ……. link between a hauling vehicle and its hauled load is known as a drawbar.

2. A mechanism that sends ..... from a tractor's engine to a machine or implement that doesn't have its ..... engine.
3. To get the PTO to engage properly, keep the clutch pedal depressed for around .....
4. It is the quickest ..... of digging holes in farm land because it is a ..... driven implement.
5. The rotavator ..... and ..... the soil using a series of blades.

C. Match the following

Column A	**Column B**
1. It is a piece of machinery that is used to churn and aerate the soil before seeding or laying turf.	**A.** 
2. This is a farm implement or machine that stirs the soil around a mature crop to promote development and eliminate weeds.	**B.** 
3. This is a tool used in agriculture to break up and level the surface of the soil.	**C.** 
4. It is one of the oldest agricultural implements, and it is widely regarded as the most significant tillage tool.	**D.** 
5. These machine or tool that is used to drill holes in the ground surface.	**E.** 

UNIT 2: LAND LEVELLING/SHAPING MACHINE

2.1: Introduction

Land development is the most expensive aspect of farming. It entails clearing the jungle, opening the soil with deep tillage equipment, transporting soil from high to low locations, constructing farm roads, field bunding and levelling, and so on. Crawler tractors with heavy duty ploughs and dozers, high horsepower tractors with dozing and hoeing attachments, scrapers, ditchers, chisel ploughs, sub-soilers, terracer, levellers, and other self-propelled and heavy equipment are needed for these tasks.

Tillage activities, which are defined as the mechanical manipulation of soil to produce the ideal seedbed and offer the best environment for seed germination and plant growth, are carried out.

SESSION 01: IMPORTANCE OF LAND LEVELLING/SHAPING

Land levelling is used in agriculture to change the land topography to create a desired terrain surface, with selected field slopes, affecting the water movement on the soil surface, improving irrigation and drainage, and the effectiveness of cultivation operations. This also reduces labour requirement for water application. The levelling of ploughed fields prevents the top fertile soil from being carried away by strong winds or washed away by rain water. The levelling of ploughed fields helps in the uniform distribution of water in the fields during irrigation and also helps in preventing the loss of moisture. It is a process for ensuring that the depths and discharge variations over the field are relatively uniform and, as result, that water distributions in the root zone are also uniform.

There are two land levelling theories:

1. To provide a slope for better water supply.
2. To level the field to its best condition with minimum soil movement.

2.2: Advantage of land levelling/shaping

- Higher yield.
- lesser weed control in the field.
- Larger farming area.
- Precise level and smoother soil surface.
- Faster seeding/Less work.
- Better use and uniform distribution of water.
- Better crop establishment.
- Reduction in irrigation time and water for irrigation.
- Less effort in crop management.
- Uniformity in crop maturity.
- Time efficiency in completion of task.
- More uniform moisture environment for crops.
- Improved field traffic ability (for subsequent operations).
- Good germination and growth of crop.
- Reduced seed rate, fertilizers, chemicals and fuel requirements.

2.3: Different types of land levellers or levelling machines

1. Animal drawn scoop (Karaha): The scoop (scraper or karaha) has one 'U shaped' bowl made of steel sheets and two handles are fixed to it with the help of fasteners. Mild steel round bar is bent to a sortable shape and next to the front of scraper to make provision for hitching the animal yoke. One pair of animals is required to operate the implement. The leveller is used for filling minor depressions and levelling minor irregularities in the field. Initial ploughing and loosening of the soil are necessary before operating this level Animal drawn scoop.

2. Animal drawn (Patela) harrow: The animal drawn patela harrow consists of a heavy batten made of Sal wood having 1.5-to-2-meter length and 10 cm thickness on which a mild steel angle frame is fixed by means of screws. The

frame carries a bar to which curved and pointed hooks are attached. The hooks behind the levelling board collect trash and root stumps.

Fig. 2.1: Animal drawn (patela) harrow

3. Animal drawn buck scraper: This is a simple machine consisting of a vertical board, tail boards handle and hitch. This machine is very much efficient for land grading when animal power is to be utilized for small and medium fields.

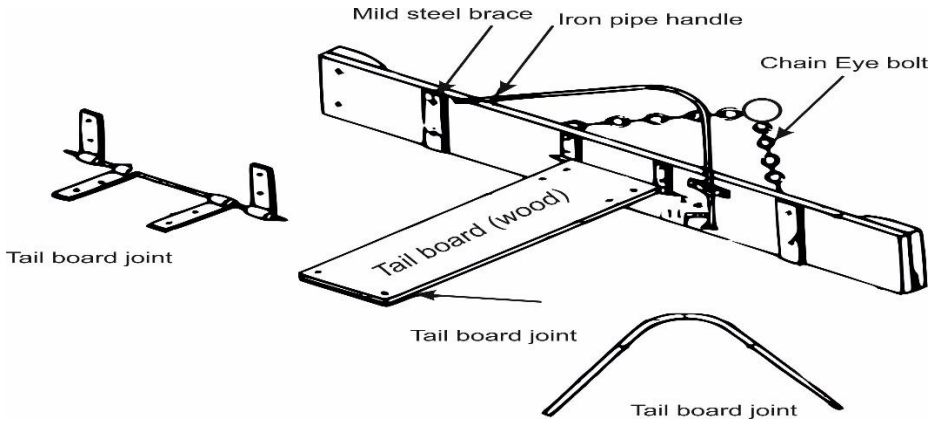


Fig. 2.2: Animal drawn buck scraper

4. Terracer blade: It is used for levelling the land, filling the field depressions, back fillings the pits, and farmyard clearing etc. it is attached to the tractor with the 3-point linkage system and is hydraulically controlled. It consists of replaceable blade attached to curved steel body, side wings and indexing arrangement for tilting and angling of the blade. The cutting blade is made of medium carbon or alloy steel and the cutting edge is hardened and sharpened. The blade with body is also called mould board. The mouldboard can be angled

left or right by lifting the spring-loaded latch pin and by turning the mouldboard. To tilt the blade for ditching or terracing the blade is tilted to the desired angle by moving the index pin.

Fig. 2.3: Terracer blade

The depth of cutting is controlled by hydraulic system of the tractor. The blade can be pitched forward and back or tilted at 15° to 30° left or right. It can be reversed for back filling. For increasing the length of blade, extensions are provided.

Operation performs by terracer blade

1. **Casting:** The blade should be angled horizontally to allow the material to slide along it easily. The vertical angle (tilt) of the blade must be set to suit the conditions. This is controlled by the lift arm levelling lever provided at the right side of the tractor in 3-point hitch system.
2. **Ditching:** The horizontal angle should be at its sharpest. This is obtained by removing the shift pin and turning the mouldboard so that the last hole in the circle plate is in line with the shift pin hole, then replace the shift pin. It is suggested that the blade be set in an offset position and then use the shorter blade side to be the cutting side. This reduces the load movement on the end of the blade. The tilt angle of the blade is adjusted by means of the adjustable levelling lever on the tractor 3- point

hitch. For the sharpest angle, lengthen the centre link on the tractor as far as possible. Also, lower the lift arm levelling lever as far as possible.

3. **Levelling:** The blade should be straight across, i.e., 90˚ to the line of travel of the tractor, in other words 0˚horizontal angle. There should be 0˚ vertical angle, i.e., the lift arms on the tractor 3-point hitch should be parallel to the ground. The cutting pitch of the blade should be the opposite of that used in side ditching and casting, with the cutting edge behind the top edge of the mouldboard. This adjustment is made with tractor centre link.
4. **Terracing:** Use a combination of ditching, casting, and levelling. The first cut is into the hillside in the ditching position. Continue until the terrace is at proper depth, then switch to the casting position until the terrace width is established. It may be necessary to use the levelling position to complete the job.
5. **Backfilling:** Mouldboard can be manually rotated 180 degrees for backfilling operations. This position requires a careful setting of the Top Link allowing a blade angle which does not tend to bury itself, but move across the top of the ground. Backfilling is a very critical operation because the blade tends to dig into the ground. The backfilling operation should be performed with the mainframe straight behind the tractor with the Blade set in the centre position.
6. **Grading:** Grading can be accomplished with the use of the planer wheel (Accessory Equipment). Set the mouldboard pivot to the desired angle, lower the blade to the ground, and then set the depth of cut with the hydraulic cylinder. Do not drop the planer wheel on the ground. This could result in damage to the planer wheel or hydraulic cylinder.

5. Hydraulic Scraper: The hydraulic scraper is towed behind the tractor. The scraper consists of cutting blade, hydraulic system, hitch point, hitch bar, apron, bowl, wheels, apron cylinder, side frame bucket cylinder, spring, and side arm. The scraper working is controlled by the hydraulic arrangement. The blade is made of alloy steel and has self-sharpening

tungsten carbide cutting edge. For operation, the scraper is attached to the tractor, hydraulic system connected and apron is raised. With the forward movement of the tractor, the blade penetrates into the soil and fill bucket bowl gets filled. The apron is closed after the bucket is filled and the scraper is moved to the point of unloading. For unloading, the bucket is tilted hydraulically. The machine cuts to grade, hauls the load for fairly long distances and spreads the soil evenly at the desired location.

Fig. 2.4: Hydraulic Scraper

The capacity of carrier type scrapers ranges from 1 to 2.5 cubic meters. For medium size and small level levelling work the wheeled type scrapers are used. To operate such scrapers, it is necessary to loosen the ground with a plough or harrow. The scrapping operation is done by pushing the soil in a short distance and dumping at a desired place.

The depth of cut is regulated with the control valve. By activating the control valve lever in one direction, it will lower the scraper blade for loading. Activation of the lever in the opposite direction will raise the blade.

6. Laser Leveller: The Laser-controller system requires a laser transmitter on tripod, a laser receiver on bucket/scrapper, survey receiver for prediction about flat land adjustment, an electrical control panel and a twin hydraulic control valve. The laser transmitter transmits a rotating laser beam, which is used as the reference datum by the laser receiver mounted on the levelling bucket. The control panel mounted on the tractor interprets the single from the receiver and

opens or closes the hydraulic control valve, which raises or lowers the bucket. Levelling requires soil to be shifted from the high points of the field to the low points in the most cost-effective way. Fields need to be ploughed and a topographic survey undertaken before levelling commences.

Fig. 2.5: View of Laser Leveller

Following are the components of laser leveller-

1. **Drag Bucket:** The bucket can be either 3-point linkage mounted on or pulled by a tractor drawbar. Bucket dimensions and capacity will vary according to the available power source and field conditions.
2. **Laser Transmitter:** The laser transmitter mounts on a tripod which allows the laser beam to sweep above the tractor un-obstructed.

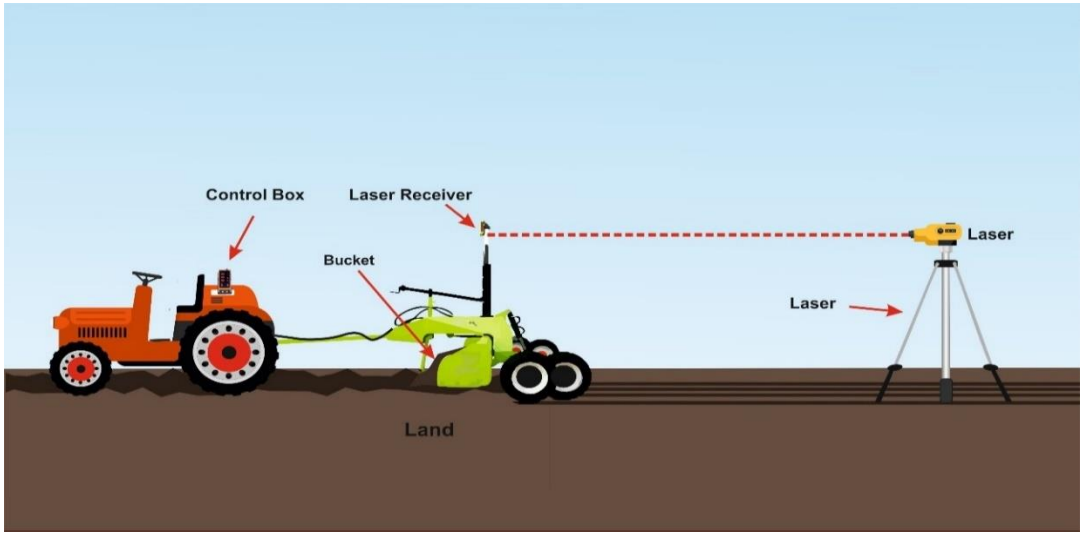


Fig. 2.6: Components of laser leveller

3. **Laser Receiver:** The laser receiver is an Omni-directional receiver that detects the position of the laser reference plane and transmits these signals to the control box. The receiver mounts on a manual or electric mast attached to the drag bucket.
4. **Control Panel:** The control box accepts and processes signals from the bucket mounted receiver. It displays these signals to indicate the drag bucket's position relative to the finished grade. The control box mounts on the tractor within easy reach of the operator.
5. **Hydraulic Control System:** The hydraulic system of the tractor is used to supply oil to raise and lower the levelling bucket.

How to Laser-level works on the field/land

Laser levelling requires soil to be shifted from the high points of the field to the low points in the most cost-effective way. In most situations fields will need to be plough and a topographic survey undertaken before levelling commences.

Following steps to be followed: -

1. Ploughing the field**.**
2. Conducting a topographic survey.
3. Levelling the field.

1. **Ploughing the Field:** With the help of mouldboard or disc plough, prepare the field.
2. **Conducting a Topographic Survey:** Once the field is ploughed, you should conduct a topographic survey to record the high and Low spots in the field. From the surveyed readings you can then establish the mean height of the field by taking the sum of all the readings and dividing by the number of readings taken. Then, using a field diagram and the mean height of the field can be determined strategically to effectively move soil from the high to low areas. Lasers are used to accomplish a topographic survey. The laser surveying system is comprising of a laser transmitter, a tripod, a measuring rod and a small laser receiver. A major advantage of laser surveying is the accuracy, simplicity of use and only one person is needed.

3. **Levelling the field:** Levelling a field involves the following steps:
    a. The laser-controlled bucket should be positioned at a point that represents the mean height of the field.
    b. The cutting blade should be set slightly above ground level (1-2 cm).
    c. The tractor should then be driven in a circular direction from the high areas to the lower areas in the field.
    d. To maximize working efficiency, as soon as the bucket is near filled with soil the operator should turn and drive towards the lower area. Similarly, as soon as the bucket is near empty the tractor should be turned and driven back to the higher areas.
    e. When the whole field has been covered in this circular manner, the tractor and bucket should then do a final levelling pass in long runs from the high end of the field to the lower end.
    f. The field should then be re-surveyed to make sure that the desired level of precision has been attained.

7. Front end dozer and back hoe: Tractor front end dozer is mounted in front of the tractor and back hoe in the rear. The dozer and back hoe can be easily removed and joined to the tractor. The dozer consists of a thick curved plate and hardened strip. The strip has sharp cutting edge and is joined the curved plate of the dozer with fasteners. Therefore, the strip can be replaced on wearing or becoming blunt. The dozer plate is joined to the tractor with sturdy arms and can be raised or lowered with hydraulic system of the tractor. Back hoe consists of a bucket with digging fingers, hydraulic cylinder, arms and base for attaching to the rear of the tractor. The bucket position is manipulated by hydraulic system. The digging fingers are hardened and can be replaced on wearing or becoming blunt.

Fig. 2.7: Front end dozer and back hoe

Back hoe is used for excavating soil, making foundation for building, making trenches for pipe and cable laying, garbage handling, widening of rural roads and removal of bushes and trees etc. Dozer is used for agricultural land levelling, making bunds in the farms and terracing of farm, road making and site clearance, for trench filling at dam project, after laying cable or pipe etc.

2.4: Safety while operating land development equipment's

1. Ensure that the operator is familiar with the operator's manual of the equipment, especially the safe operating procedures and he has received training on the equipment/machinery.
2. Make sure that equipment is properly maintained and that all safety devices (shielding, guards, etc.) are functioning properly.
3. Never attempt to adjust, clean, or unclog any part of a machine while the engine is running.
4. Do not allow passengers on the machine at any time for any reason,
5. Always leave adjustable height components on machinery when operating front end loaders in the lowered position when not in use.

6. Do not wear loose clothing, wear eye, hearing, & foot protection.
7. Tractors and equipment's operated on public highways must be equipped with Slow Moving Vehicle (SMV) emblems and lights that meet the CMVR (Central Motor Vehicles Rules) standards.
8. If working around or under a raised implement, make sure that it is blocked or supported by something other than the cylinder itself.

2.5: Off season storage of land development equipment

1. Clean it with water.
2. Check for worn parts including belts and hoses, loose bolts, leaks, electrical connections, hydraulics, etc.
3. Remove and sharpen or replace blades on cutting equipment.
4. Check tires for wear and damage. Make sure they're inflated to storage specification.
5. All the ground-working components should be thoroughly cleaned and coated with a lubricant or other protective coating to prevent rust.
6. Lubricate all moving parts and check all grease points.
7. Store equipment in a shed.

Practical Exercise

Activity 01: Make a list of land levelling/shaping machine for agriculture.

Material required:

1. Pen
2. Notebook
3. Pencil
4. Eraser
5. Sharpener

Procedure:

1. First, take a permission from agriculture machinery shop owner.
2. Second, identify the land levelling/shaping machine available in the shop.
3. Make a list of land levelling/shaping machine.
4. Write down their name and specification.
5. Draw a figure of land levelling/shaping machine.

Activity 02: Visit the field to identify the parts of terracer blade.

Material required:

1. Pen
2. Notebook
3. Pencil
4. Eraser
5. Sharpener

Procedure:

1. First, take a permission from farm owner.
2. Second, identify the parts of terracer blade.
3. Make a list of parts of terracer blade.
4. Write down their name and specification.
5. Draw a figure of parts of terracer blade.

Check Your Progress

A. Answer the following question

1. What do you mean by land levelling?
2. Explain the role of land levelling/shaping machine?
3. Write the difference between scraper and terrace blade.
4. Describe the different types of land leveller machine used for field levelling/shaping.
5. Explain the working principle of land laser leveller.
6. Describe the working principle of dozer and back hoe.

B. Fill in the blank

1. The ..... is used for filling minor depressions and levelling minor irregularities in the field.
2. The frame carries a bar to which ..... and ..... hooks are attached.
3. The control box accepts and processes signals from the ..... mounted receiver.
4. The ..... consists of a thick curved plate and hardened strip.
5. The laser surveying system is ..... of a laser transmitter, a tripod, a measuring rod and a small laser receiver.

C. Match the following

Column A	**Column B**
1. This is a simple machine consisting of a vertical board, tail boards handle and hitch.	**A. Casting**

2. The bucket can be either 3-point linkage mounted on or pulled by a tractor drawbar.	**B. Hydraulic control**
3. The laser transmitter mounts on a tripod which allows the laser beam to sweep above the tractor un-obstructed.	**C. Animal drawn buck scraper**
4. This is the system of the tractor is used to supply oil to raise and lower the levelling bucket.	**D. Laser Transmitter**
5. The blade should be angled horizontally to allow the material to slide along it easily.	**E. Drag Bucket**

UNIT 3: POWER TILLER

3.1: INTRODUCTION

Out of the total cultivation land in India, about 86% constitute marginal (less than 1 hectare) and small (1-2 hectares) holdings. Power tiller works best on smaller land holdings (up to 2.5 hectares) and where the horse power requirement is lower. Most of the power tillers are diesel operated with a horse power ranging from 8 to 15. Mostly it is used in very intensive cultivation of paddy, intercropping for horticulture and plantations.

Apart from rotary tiller with additional fittings to the power tiller, it is capable of performing operations right from primary tillage to transportation of crops which may include ploughing, harrowing, cultivation, planking, ridging and furrowing, sowing, fertilizer application, pumping water, inter-culture, plant protection, harvesting, threshing and lastly the transport operation. In short the power tiller can render all these services for many types of crop production. Obviously, it has become a choice for those farmers who need a mechanical source of power for smaller farm operations.

SESSION 01: POWER TILLER, IMPORTANCE AND THEIR USE

Power tiller is a single axle, self-powered and self-propelled tractor, which can pull and power various farm implements such as rotary, cultivator, harrow, plough, seed drill, reaper, and trailer.

Fig. 3.1: Power Tiller

3.2: Importance of power tiller

1. Power tillers are available at a marginal price.
2. They are very compact and requires less space.
3. Maintenance cost for power tillers are low compared to tractors.
4. Power tillers are most beneficial for marginal farmers.
5. Power tillers can be operated in various terrains such as water flooded fields, hilly terrains, flat lands and dry fields.
6. They are more useful in regions where there is shortage of labor.

3.3: Uses of power tiller

1. Power tiller with rotary and fitted with cage wheel for rice field preparation.
2. Power tiller with tyres and fitted with rotary for tillage and weeding in unsaturated soils.

Fig. 3.2: Different use of power tiller in field

3. Power tillers with rubber tyres and used for haulage.
4. Power tillers with rubber type or lugged wheel and used for drawbar work like ploughing, cultivating, furrow making, ridge making, sowing, weeding, spraying, digging, irrigation pump operating, harvesting, threshing alternator operating.

Practical Exercise

Activity 01: Draw a figure of power tiller.

Material required:

1. Pen
2. Notebook
3. Pencil
4. Eraser
5. Sharpener

Procedure:

1. First, take a permission from farm owner.
2. Second, visit the farm.
3. Then, identify the power tiller.
4. Make a list of parts of power tiller.
5. Write their specification.
6. Draw a sketch of power tiller.

Check Your Progress

A. Answer the following question

1. What is power tiller?
2. Explain the importance and use of power tiller?
3. Make a list of power tiller used in different purpose.

B. Fill in the blank

1. Power tillers with rubber tyres and used for …….
2. Maintenance cost for power tillers are ……. compared to tractors.
3. Most of the power tillers are diesel operated with a horse power ranging from …. to ….
4. Power tiller is a ……. axle, self-powered and self-propelled tractor,
5. Power tillers are available at a …… price.

C. Multiple choice question

1. Power tiller with rotary and fitted with cage wheel for ..... field preparation.

   A. Cotton B. Rice C. Sugarcane D. Mango

2. In India marginal land holding farmer is-

   A. less than 1 hectare B. 1-2 hectare

   C. 2-10 hectare D. Above 10 hectare

3. It can be operated in various terrains such as water flooded fields, hilly terrains, flat lands and dry fields.

   A. Harrow B. Dozer

   C. Power tiller D. Tractor

4. Power tillers are most beneficial for ..... farmers.

   A. Large B. Medium

   C. Small D. Marginal

SESSION 02: CONSTRUCTION DETAILS AND WORKING PRINCIPLE OF POWER TILLER

It is very important of construction or specification should be read before you buy the any machinery. How it works and their specification details. Construction detail should clear their features about what is the use of that parts and how they will work.

3.4: Power tiller parts

A power tiller consists the following main parts:

- Engine
- Transmission gear
- Clutch
- Brakes
- Rotary unit

All the power tillers are fitted with an I.C. engine. At present, most of the power tillers are fitted with diesel engine.

3.4.1: Operation

- The main clutch is a lever on the handle.
- The lever can be shifted to 'on' or 'off' position while operating in the field.
- When the lever is shifted to 'on' position, the power from the engine is transmitted through the main clutch to the various parts of power tiller.
- When the lever is shifted to 'off' position, the power from the engine is cut-off from the rest of the transmission.

3.4.2: Power transmission in power tiller

- For operation of power tiller, the power is obtained from the I.C. engine, fitted on the power tiller.
- The engine power goes to the main clutch with the help of belt or chain.

- From main clutch, the power is divided in two routes, one goes to transmission gears, steering clutch and then to the wheel.
- The other component goes to the tilling clutch and then to the tilling attachment.

A. V-belt: It is usually used to transmit power from the engine to the main clutch, because V – belt has very high efficiency and it works as a shock absorber also.

B. Engine: Single cylinder, diesel, air/water cooled, 8-15 HP.

C. Main clutch: Power goes from the engine to the main clutch.

D. Clutch: The main function of clutch in a power tiller are:

- To transmit engine power to transmission gears.
- To make power transmission gradually and smooth.

The clutch is divided into two types: -

1. Friction clutch: Friction clutch is generally used for bigger power tiller. Usually it is a dry type multiple disc clutch.

2. V – belt tension clutch: V – Belt tension clutch is used for small power tillers.

E. Transmission gear box: Transmission box consists of gears, shafts and bearings. The speed change device may be either Gear type or belt type.

F. Brakes: All power tillers have some braking arrangement for stopping the movement. Most of the power tillers use inner side expansion type brake.

G. Wheels: Usually 2 pneumatic tyres are used in power tillers. The pressure of the type ranges from 1.1 to 1.4 kg/cm^2.

H. Rotary tiller unit: Power tiller has a rotary unit for field operation which may be centre drive type or side drive type. The centre drive type has got transmission at the centre and the side drive type the transmission at one side.

The centre drive type has the following characteristics:

- Tilling width can be widened.
- Rotary unit is light in weight.
- Fixing of attachment is easy.
- The tine shaft can be detached easily.
- Mounting and dismounting of rotary unit is very easy.
- It may leave some portion of the field untilled.
- It has one-point support on the ground.

The side drive type has the following characteristics:

- Deeper tilling is possible.
- The arrangement is useful for hard soil.
- It has two-point support on the ground.

I. Rotary tines: Rotary tines are used in rotary unit for soil cutting and pulverization purpose. Rotary tines are of three types namely, straight tines, curved tines and sliding tines.

J. Steering clutch lever: Steering clutch is provided on the grip of the right and left handles. When the left side is gripped, power is cut-off on left side of the wheel and the power tiller turns to the left. Similarly when the right side is gripped, the power tiller turns to the right.

Practical Exercise

Activity 01: Make a list of power tiller parts.

Material required:

1. Pen
2. Notebook

Procedure:

1. First, take a permission from farm owner.
2. Second, visit the farm.

3. Then, identify the power tiller.
4. Make a list of parts of power tiller.
5. Draw a figure of power tiller parts.
6. Label it and write their use.

Check Your Progress

A. Answer the following question

1. What are the main parts of power tiller?
2. Write the working operation of power tiller.
3. Why V-belt is used in power tiller?
4. Explain the rotary tiller unit.
5. Which type of clutch is used in power tiller.

B. Fill in the blank

1. The engine power goes to the ……. clutch with the help of belt or chain.
2. Friction clutch is generally used for ……. power tiller.
3. Power tiller has a ……. for field operation which may be centre drive type or side drive type.
4. When the lever is shifted to 'off' position, the power from the engine is ……. from the rest of the transmission.

C. Multiple choice question

1. It is a box consists of gears, shafts and bearings in it.
   A. Gear B. Brakes C. Transmission D. Tank
2. It is usually used to transmit power from the engine to the main clutch, because it has very high efficiency and it works as a shock absorber also.
   A. Clutch B. Gear C. Brakes D. V – belt
3. This type of clutch is used for small power tillers.
   A. Friction clutch B. V-belt tension clutch
   C. Cone clutch D. Single plate clutch

SESSION 03: AVAILABILITY OF POWER TILLER IN INDIA, SELECTION CRITERIA AND PREVENTIVES MAINTENANCE

Power tillers are the most useful and significant agricultural invention, with a variety of utility-based qualities that make them remarkable in usage. In the year 1963, power tillers were created. These power tillers are a versatile hand tractor that is typically used for rotary tilling as well as other minor or commercial tasks. Power tillers are the most effective for advancing and tillage operations. Power tillers are used well in India for seedbed operations, intercultural, and wide-spaced cropping's.

3.5 Make models and sizes of Power tiller available in India

In India, a power tiller tractor implement is one of the most important tools for farmers. VST, Greaves Cotton, Kmw by Kirloskar, and more other companies make power tiller tractor implements. Tillage is the category for this tool. Furthermore, with the best power tiller implement in India, farmers can practice effective agriculture. In Indian agriculture, the price of a power tiller implement is also important. Here the detail of some model and size of power tiller available in India:

Table 3.1: Make and model of power tiller

S.No.	Name of the manufacturers	Models	Sizes in horse power (Ps)
1.	M/s. Greaves Cotton Ltd., Ranipet, Tamil Nadu - 632403	GREAVES GS 15 DIL S, GREAVES GS 14 DLX, GREAVES MAHABALI GC 14 DI.	12.8 to 14.5
2.	M/s. Kavi Agro Agency, Trichy - 620001(T.N.)	KAVI-GN15L, KAVI-DF15L.	14.8

3.	M/s. Chirag Corporation, Kolkata - 700 001	Divya Shakti, Divya Shakti Gold.	12.6 to 13.3
4.	M/Sunrise International, Kolkata - 700 001	Sunrise DI, Sunrise Super.	13.2 to 14.3
5.	M/s. Bengal Tools Limited, Kolkata - 700028	SHRACHI SF- 15DI, Shrachi All Rounder, Shrachi Champion, Shrachi Virat 13HP.	11.8 to 14.7
6.	M/s. Kerala Agro Machinery Corpn. Ltd, Athani-683585	KAMCOKMB-200, KAMCO Super DI, KAMCOKMB 200 DI.	9.1 to12.0
7.	M/s. Assam Saii Motors Pvt. Ltd., Kolkata – 700 006.	RHINO 15 DI.	13.5
8.	M/s. Kirloskar Oil Engines Ltd, PUNE - 411003	Kirloskar KMWMEGA-T15, Kirloskar KMWMEGA-T12 LW , Kirloskar KMW-MEGA-T 15 N, Kirloskar KMW-MEGA-T 12 LW-S.	12.4 to 15.2
9.	Samyak Motors Pvt., Ltd, Coimbatore, Tamilnadu-641110	Samyak ST 960.	12.4
10.	M/s. George Maijo Industries Pvt. Ltd Chennai – 600 034	DFAMGC DF-15 DLG.	13.6
11.	M/s. Indra Marshal Power pvt Ltd Indore – 452015	Indra Marshal.	14.0
12.	M/s. V.S.T. Tillers Tractors Ltd Malur, Kolar	VST SHAKTI 130 DI,VST SHAKTI 130 DI*	8.8 to15.5

	District -563130	S, VST SHAKTI 135 DI ULTRA, VST SHAKTI 135 DI ULTRA * S, VST SHAKTI VWH 120, VST SHAKTI 165 Dl S Power Plus.	
13.	Kubota Agricultural Machinery India Pvt. Ltd., Chennai - 600119	KUBOTA PEM 140 DI.	13.5
14.	M/s. Renaissance Powel Products Pvt. Ltd, Coimbatore - 641 658	BHEEM BMT 1200DI.	9.9
15.	M/s. BCS India Pvt. Ltd. Ludhiana - 141112	BCS 740.	9.1
16.	M/s. D. K. Diesels Pvt. Ltd. Rajkot - 36 0024	DK 125 DI.	10.1

3.6 Selection of power tiller: There are more than 15 manufacturers of power tillers, manufacturing more than 30 models in different horse power range are available in the market. Hence it is difficult for the farmers to choose right power tiller for his use. Various factors are affecting the right selection of a power tiller, these includes, different cropping pattern, land holding, soil conditions, and topography of soil and many others.

A. Cropping pattern: Though the power tillers are used in every part of the country. It is mostly in paddy cultivation especially on small and medium farms and for the farm operations in hilly areas, orchards and forestry. In hilly region fields are very small and sloppy having terraces, light weight power tillers are more suitable so that they can be carry while shifting in terraces.

B. Type of Soil: Power tiller are mostly used in medium and light soil in wet

land and dry land condition however they preferred in paddy fields particularly when the farmers having less than 2 hectares of land.

C. **Repair facilities:** Before purchasing a power tiller, it is better to check that the dealer is proving repair facilities at your workplace and he is having sufficient stock of essential genuine spares with him.
D. **Initial cost, running cost and resale value:** Power tiller may have less initial price, fuel efficient and having less maintenance, cost of spare parts are comparable and spares are easily available in nearby area.
E. **Brand Image:** Population of the power tiller and other products in the area, satisfied customer and opinion maker, Publicity of the products and organisation, should be considered. An Indian product is always preferable to ascertain the supply of spares in future.
F. **Availability of matching implements:** Whether the implements like plough, seed drill, cultivators and other important implements are matching with the horsepower of the power tiller available in the market.
G. **Versatility:** Check its suitability for dryland, wet land and haulage work.
H. **After sales-service:** The dealer must have good record of prompt and quality service, having genuine spare parts, excellent behavior and manufacturer is giving sufficient warranty and free services.
I. **Safety and comfort:** From the CFMT&TI Budni and SRFMT&TI Anantpur test reports of the power tiller, we may check details of performance of noise, vibration, turning ability and safety guards etc.

3.7 Adjustments and preventive maintenance of power tiller

Preventive maintenance of power tiller involves taking the necessary precautions and actions to prevent accidents or power tiller failures from occurring before they happen.

3.7.1 Objectives of preventive maintenance

a) To reduce failures: for obtaining maximum availability when needed.
b) To save on operating cost: for minimizing repairing cost.

c) To prevent accident: for ensuring the safety of worker.
d) To improve working condition: for quality of product/output.

3.7.2 Activities of preventive maintenance

a) It includes equipment inspection & checks.
b) Cleaning and servicing.
c) Periodical care and adjustments (lab & field).
d) Partial or complete overhauls at specific period.
e) Coolant/water, oil changes and lubrication wherever required.
f) Record of equipment deterioration, so they know replace or repair worn parts before they cause system failure and analysis.

There are some major preventives maintenance of power tiller: -

1. Checking of engine oil: Check oil level with the cold engine. Never operate the power tiller if the oil level is above maximum level mark or below level mark on oil level dipstick. Operating the engine under these conditions causes a loss of power, excessive fuel consumption, overheating and damage to the engine.

1. Park power tiller on level terrain.
2. Shut engine 0ff.
3. Wait for some time.
4. Remove oil level dipstick**.**
5. Clean oil level dipstick.
6. Insert oil level dipstick into the engine and remove it again.
7. While checking the oil level the dipstick should be hold horizontally and the oil level should be in region, between the minimum and maximum marks.
8. If the oil level is below the minimum mark, add the specified engine oil via fill port.

2. Tension of V-belt: An excessive slackness or tightness of V- belt will shorten the life of belt itself and the machine. A severely slack V-belt will cause belt-slip, resulting in lower power output. Check the tension in the V-belts by pushing

down in the middle with four fingers. The drop should be as per manufacturers recommendation.

Fig. 3.3: V- belt

Method of adjustment:

1. Loosen the securing nuts under the engine for smooth motion of engine.
2. Loosen the locking nut.
3. Turn the adjusting nut clockwise to make the engine move forwards, until the V-belts are properly tensioned.
4. Tighten the nuts.

3. Adjustment of clutch clearance

1. Shift the clutch brake handle to "engage" position.
2. Adjust the length of the pull rod until the hole of the disengaging cam approximately aligns with that of the guide sleeve of the disengaging cam.
3. The correct length of the pull rod is obtained, tighten the nut.
4. Shift the clutch-brake handle to “dis-engage" position.
5. Adjust the clearance between the clutch throw-out levers and throw- out bearing in a range of 0.4-0.7 mm with the help of a filler gauge.

4. Adjustment of brakes: When the clutch lever is pulled over the "dis-engaging" position by 25-30 mm (or as per Manufacturers recommendations) the tiller begins to brake.

Method of adjusting:

1. Move the clutch lever to the "dis-engaging" position.
2. Loosen the double nuts and adjust their positions.
3. Adjust the clearance between the lug and nut to approximate 12 mm.
4. Tighten the nuts.

5. Adjustments of steering control

1. Disengage" the steering clutch completely.
2. Loosen the nut.
3. Adjust the length of the pull rod so that the clearance between the steering lever and the handle grip ranges from 2-4 mm.
4. Tighten the nut.

6. Adjustment of throttle control system: The throttle control system should be so adjusted that the lever can operate either to accelerate the engine to maximum speed or to stop the engine timely.

Method of adjustment:

1. Loosen the setscrew.
2. Turn the throttle lever counter- clockwise to the extreme position.
3. Turn the governor control knob to the throttled wide open position.
4. Tighten the set screw.

7. Adjustment of chain tension in transmission box.

The chain in the transmission box gets worn and slack after certain time. Proper tension is necessary. Method of adjustment:

1. Open the chain case.
2. Tighten the adjusting bolt with hand till the chain gets into proper tension.
3. Tighten the bolt.

Practical Exercise

Activity 01: Make a list of make, models and sizes of power tiller available in India.

Material required:

1. Pen
2. Notebook

Procedure:

1. First, search the different company website of a power tiller.
2. Second, collect the information from the company sites.
3. Make a list of power tiller make, model and size available in India.
4. Write down the specification of power tiller.

Activity 02: List out the major preventive maintenance for power tiller.

Material required:

1. Pen
2. Notebook

Procedure:

1. First, take permission from power tiller shop.
2. Second, visit the power tiller shop.
3. Read the manual of power tiller.
4. Write the major preventive maintenance for power tiller.

Check Your Progress

A. Answer the following question

1. List the name of manufacture company of power tiller in India.
2. Write the selection criteria of power tiller.
3. Describe the preventive maintenance and adjustment of power tiller.

B. Fill in the blank

1. Power tiller are mostly used in ……. and ……. soil in wet land and dry land condition.
2. An Indian product is always preferable to ascertain the supply of ……. in future.
3. An excessive …… of V- belt will shorten the life of belt itself and the machine.

C. Multiple choice question

1. Power tiller available in India with maximum size in horse power.
   A. 9.1 B. 12.3 C. 14.8 D. 15.5
2. Adjust the clearance between the clutch throw-out levers and throw-out bearing in a range.
   A. 0.2 – 0.4 mm B. 0.3-0.5 mm C. 0.4-0.7 mm D. 0.4-10 mm

SESSION 04: OPREATING TECHNIQUES, PERIODICAL MAINTENANCE AND TROUBLE SHOOTING OF POWER TILLER

A power tiller is a multi-purpose, multi-function compact vehicle that is meant for rotational tilling and other minor farm tasks. These machines come with a plough, sprayer unit, seed cum fertiliser drill, cage wheel, and other attachments. They are also less expensive to buy and maintain than a traditional tractor. Marginal farmers with tiny landholdings love them because of their compact size, multi-utility, great labour potential, minimal maintenance cost, and affordable pricing.

These powerful devices can live longer and function to their full extent if properly maintained. The following are some useful maintenance advice for power tiller owners.

3.8 Operating techniques of power tiller in case puddling, seeding and planting, Inter-culture, plant protections, harvesting, material handling and transportation: -

Power tiller is used for different purpose such as follow:

1. Puddling operation: Puddling operation is done before transplanting the paddy seedlings. For this field operation, power tiller is fitted with lugged wheels or drum type cage wheels depending upon the soil conditions after removing the rubber tyres for better traction. Rotary is fitted with bent tines. Tail wheel is also to be replaced with float for adjusting the depth. Minimum two puddling operations are required and at least 8-10 cms of water should be available in the field for best puddle and proper levelling off the field.

Fig. 3.4: Puddling operation in the field by power tiller

2. Seeding and planting: Seed cum fertilizer are attached with the power after removing rotary assembly. It is used for sowing seeds and fertilizer in a row. The attachment consists of seed box with cup feed metering mechanism, lifting arrangement, seed cut off clutch, tool bar, hoe type furrow openers and seating attachment, all mounted on an easily detachable articulated double wheeled frame. The cup feed seed mechanism is driven by chain and sprockets from the ground wheel. The lifting of tool bar disengages the clutch transmitting power to the seed-metering shaft. The spacing between furrow openers and the depth of sowing are easily adjustable. Normally it is used for sowing seed of Wheat, Soya Bean, and Bengal Gram etc**.**

Fig. 3.5: Seeding operation in the field by power tiller

3. Inter-culture: Inter-cultivation, is the cultivation of soil between crop rows. In other words, the soil between two rows of crop is cultivated using dedicated cultivator for weeding, improving soil aeration and loosening the soil compaction. Machine is mostly used in soybean, sorghum, Bengal gram, pigeon pea etc. where the row spacing is wide enough for the power tiller to pass without damage to the plants. It is suitable for medium and light soils.

Fig. 3.6: Power tiller for inter-culture

4. Plant protection: The sprayer is used for spraying pesticides and insecticides to avoid the pests. Either a HTP sprayer or a boom sprayer can be mounted with the power tiller. HTP sprayer is used to spray in (1) Coconut (2) Chikku (3) Pomegranate (4) Grapes (5) Guava (6) Banana (7) Papaya (8) Mango plants, while boom sprayer is used for row crop spraying.

Fig. 3.7: Plant protection machine - HTP sprayer and Boom sprayer

5. Harvesting: Power tiller front mounted vertical conveyer reaper windrower, can cut the crop and lay it in the form of windrow for easy picking. It consists of a conventional cutter bar assembly, crop row dividers with star wheels, covers, pressure springs and vertical conveyor belts. Cutter bar is given reciprocating motion by crank wheel. Crop row dividers with star wheels enter the standing crop, help in lifting, gathering and guiding the crop towards the cutter bar. After the crop is cut, held in a vertical position during its passage by means of pressure springs and star wheels. Vertically held crop is then delivered towards right side of the machine in a windrow perpendicular to the direction of movement of machine with the help of lugged conveyor belt. The power is transmitted through an intermediate shaft to the gearbox on windrower either by belt or by shaft drive. A front mounted vertical conveyor reaper is the most common reaper, to harvest wheat and paddy crops having width of cut is about 1.6m.

Fig. 3.8: Harvesting operation in the field by power tiller

6. Material Handling and transportation: Trailer of 1.5 tons capacity can be fitted for transport of goods with the power tiller.

Fig. 3.9: Material transportation by power tiller

3.9 Periodical maintenance of power tiller: To keep power tiller working for a long time at a minimum cost, it requires an adequate and timely maintenance. Read the operation and maintenance manual given by the power tiller manufacturer and follow the procedures mentioned: -

I. Daily / Everyday (After 10 hours of work)

1. Check oil level in different assemblies on a horizontal surface. Top up, if necessary, when the engine is cold.
2. Top up the fuel tank, if necessary, preferably in the evening, after day's work to avoid condensation.
3. Clean the radiator (in case of water cooled engine). Remove dust and dirt accumulated in the core and top up the cooling system, using clean water.
4. Make sure that the tension of the V-belts driving the alternator and the fan is in accordance with the manufacturer's recommendations.
5. Check the tightness of the fuel, oil and water pipes and hoses, cleaners, fillers and drain plugs to avoid leakage.
6. Make sure that the inflation of the front and rear tyres is in accordance with the manufacturer's recommendations.
7. Check all the fastening bolts and screws, and make sure that they are tight.

II. After 50 hours of work

1. Check the elasticity of the fan-belt under the pressure of the thumb. It should stretch to a degree of 10 to 15 milli-meters.
2. The water stored in the fuel filter should be drained out by the drain plug.

Fig. 3.10: Fuel filter in power tiller

3. Remove sediments from the air-pre-cleaner bowl. If dirt in the oil bath gets settled up to 5 mm, it should be cleaned & filled with fresh engine oil. In case of dry type air cleaners, if recommended by the manufacturer clean the outer filter.

Fig. 3.11: Air-pre-cleaner

III. After 200 hours of work

1. Change the engine oil. To do so, keep the power tiller in starting position for a while and then switch it off so as to heat up the entire oil, then drain out the oil through the drain plug and fill fresh and clean oil of the right grade.
2. In case the oil filter is made of paper, element, cloth, etc. change them.

Clean the metallic oil filter.

3. If it is advised to clean the primary diesel filter, (in the manual supplied with the tractor) clean it or change it.

IV. After 400-500 hours of work

1. Wash the gear box and change the recommended lubricating oil.
2. When the flywheel is T.D.C. on the compression stroke, mark in line with timing indicator, and then adjust valve clearance.

3.10 Trouble shooting in power tiller

It is very important part of any machinery, to check their working condition are proper or not. If it is not in right condition, then assess the fault and solved it. Here some detail of troubleshoot of power tiller.

Table 3.2: Troubleshoot of power tiller

SYMPTOMS	PROBABLE CAUSE	REMEDY
1. Engine fails to start or stops soon after starting	• No diesel in the tank.	• Fill up the tank with sufficient quantity of diesel.
	• No Fuel supply (Fuel cock in the closed position).	• Open the fuel cock.
	• Throttle Lever not pressed down properly.	• Press down the throttle lever fully.
	• Air in the fuel system.	• Remove air from the fuel system and fuel line.

	• Poor Quality of fuel; Water in the fuel.	• Drain the fuel completely, clean the fuel system and refill with good quality fuel.
	• Fuel pump nozzle out of order.	• Approach authorized service station.
	• Insufficient and improper fuel supply.	• Clean the hole in the fuel tank cap, change the fuel filter element.
	• Air cleaner clogged.	• Wash and clean the air cleaner element and fill the oil container with oil up to the designated level.
2. Engine fails to take load	• Exhaust restricted.	• Clean the silencer and flange.
	• V-belts are loose.	• Tighten the belts or replace if required.
	• Engine over-loaded.	• Reduce the load.

3. Exhaust smoke excessive (Black smoke)	• Unsuitable fuel used.	• Thoroughly flush the fuel system and use the correct fuel as recommended.
	• Nozzle out of order (Poor atomization).	• Approach authorized service station.
4. Excessive exhaust smoke (Blue white smoke)	• Excessive oil in the crank case.	• Drain to the normal level.
	• Excessive clearance between cylinder and piston (in this case, smoke may come out through the crank case breather hole also).	• Piston rings, Piston, cylinder liner etc., are to be changed. Approach authorized service station.
5. Engine overheats	• Water low in cooling system.	• Stop the engine and let it cool. Check up for leakage and rectify, Replenish the water.
	• Radiator core or grill covered with dirt accumulation.	• Check and clean radiator.

	• Fan belt loose or broken.	• Adjust the tension or replace the belt.
	• Engine continuously overloaded.	• Reduce the load.
	• Lubricating oil level low.	• Replenish oil up to the required level.
6. Abnormal sound from the main clutch	• Clutch liner or bearing damaged.	• Approach authorized service station.
7. Steering clutch does not return to its original position even after the lever is released	• Steering clutch spring may be weak or steering clutch arm shaft maybe tight in the guide.	• Approach authorized service station.

Practical Exercise

Activity 01: List-out the trouble shooting in power tiller.

Material required:

1. Pen
2. Notebook

Procedure:

1. First, collect the manual of power tiller.
2. Second, read the manual of power tiller.
3. Make a report of trouble shooting in power tiller.

Activity 02: Make a list of safety guidelines and tips during power tiller operation.

Material required:

1. Pen
2. Notebook

Procedure:

1. First, collect the manual of power tiller.
2. Second, read the manual of power tiller.
3. Make a report of safety guidelines and tips of power tiller.

Activity 03: Make a list of off-seasonal storage of power tiller.

Material required:

1. Pen
2. Notebook

Procedure:

1. First, collect the manual of power tiller.
2. Second, read the manual of power tiller.
3. Make a list of off-seasonal storage of power tiller.

Check Your Progress

A. Answer the following question

1. Describe the operating techniques of power tiller.
2. Write the procedure of periodical maintenance.
3. Why trouble shooting is important for power tiller?

B. Fill in the blank

1. Puddling operation is done before …… the paddy seedlings.
2. Seed cum fertilizer are attached with the power after removing ……. assembly.
3. If dirt in the oil bath gets settled up to ……., it should be cleaned & filled with fresh engine oil.

4. The water stored in the …… should be drained out by the drain plug.
5. The cup feed seed mechanism is driven by …… and …… from the ground wheel.

C. Multiple choice question

1. The water should be available in the field for best puddle and proper levelling off the field.
   A. 4-8 cm B. 6-8 cm C. 8-10 cm D. None above
2. A front mounted vertical conveyor reaper is the most common reaper, to harvest wheat and paddy crops having width of cut is about …….
   A. 1.6 m 2. 2.2 m 3. 2.10 m 4. 3.1 m
3. Engine fails to take load due to……
   A. Exhaust restricted B. V-belts are loose
   C. Both A and B D. None

UNIT 4: NEW TECHNOLOGY AND FUTURE OF AGRICULTURE MACHINERY

4.1: Introduction

Nowadays, the demand of food increasing with the time. Due to over population of people in the world, but in the agriculture sector faces the problem of lack of labour and power source (machinery) to fulfill the demand of food. Therefore, high demand of agriculture machinery is increased.

Food demand is increasing all the time nowadays. Because of the world's overpopulation, the agriculture sector suffers a labour shortage as well as a lack of power (equipment) to meet the demand for food. As a result, there is a higher need for agricultural machinery.

SESSION 1: IMPORTANCE OF PNEUMATIC PLANTER

The basic objective of sowing operation is to put the seed and fertilizer in rows at desired depth and seed to seed spacing, cover the seeds with soil and provide proper compaction over the seed. The recommended row to row spacing, seed rate, seed to seed placing and depth of seed placement vary from crop to crop and for different agro-climatic conditions to achieve optimum yields.

Traditional methods include manual broadcasting, opening furrows by a country plough and dropping seeds by hand and dropping seeds in the furrow through a bamboo/metal funnel attached to a country plough. For sowing in small areas dibbling i.e., making holes or slits by a stick or tool and dropping seeds by hand, is practiced. Multi-row traditional seeding devices with manual metering of seeds are quite popular with experienced farmers. Traditional sowing methods have the limitations; such as non-uniform distribution of seeds, poor control over depth of seed placement and high seed rate, requires thinning to maintain plant population, poor plant stand, weeding is a problem, lower yields etc. and results in increased production cost.

Therefore, use of seed drills and planters could be good option which facilitates line sowing and easy mechanized intercultural operations as well as harvesting

operations. The main function of the seed drill and planters are to meter seeds of different sizes and shapes and place the seed in the acceptable pattern of distribution in the field. Place the seed accurately and uniformly at the desired depth in the soil and cover the seed and compact the soil around it to enhance germination and Using planters, seed germination efficiency increases many folds at reduced seed rate compare to conventional planters.

4.2: Pneumatic planter

Pneumatic Planter (Precision) is a tractor operated machine which uses pneumatic metering mechanism for placing of seeds & fertilizer at a certain depth with uniform spacing. Establishing a good crop stand helps attaining maximum and uniform germination of seeds, resulting in vigorous seedlings in the field.

Fig. 4.1: Pneumatic Planter

How does a pneumatic planter work for PTO?

Pneumatic planter is trailed type equipment, operated by PTO to generate vacuum air to distributary precise seed sowing through disc. The distance between the rows is adjustable and the seeding distance can be varied from 2 inch to 20 inch. The covering of the seed is made by two rollers with adjustable pressure spring.

4.2.1: Advantages of Pneumatic Planter

- Drops one seed at a time no missing, no doubling.

- Saving of costly seed.
- No damage to seed during sowing operation.
- Precision in sowing can increase the yield from 10% to 15%.
- Uniform depth of sowing - better stand, better growth of roots, no waviness - better yield.

4.2.2: Constructional Features

The pneumatic planter consists pf main frame, aspirator blower, disc with cell type metering plate, individual hopper, furrow openers, PTO driven shaft, ground drive wheel etc. Pictorial view of the pneumatic planter is shown in Fig. 4.2 Specifications of the pneumatic planter are given in table 4.1.

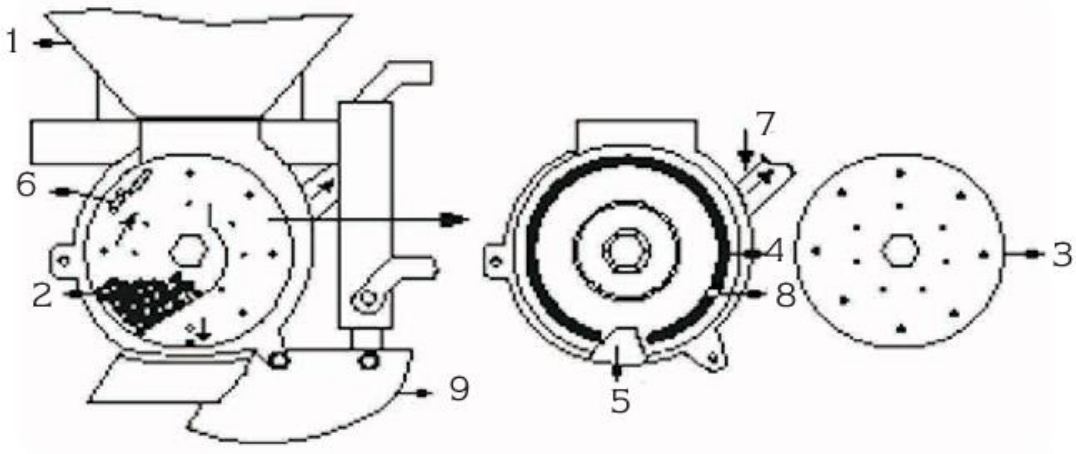


Fig. 4.2: Line Diagram of Pneumatic Planter

Note: 1. Seed hopper 2. Seed 3. Seed plate 4. Air suction canal 5. Air cut 6. Separator 7. Vacuum tube to fan 8 Infrared receiver of electronic counter 9. Furrow opener

4.2.3: Working principle of pneumatic planter

The metering device is powered by a pair of ground wheels through chain and sprocket. Power to the aspirator blower is given by PTO shaft of the tractor. The disc is mounted to a vacuum retaining plate made of Bakelite material having outer diameter 295 mm and thickness 40 mm. Suction pressures inside the metering unit is created by connecting it to a vacuum pump. The vacuum

retaining plate is equipped with a baffle to release the vacuum pressure of the seed disc. The rotating seed disc carries the seeds attached to the seed holes under negative pressure and drops only when the holes passed through the baffle that releases the suction pressure. The dropped seed fall in the furrow opened by furrow opener and cover with the soil. To view the movement of the seeds inside the metering disc, the seed disc is provided with a protective cover made of mild steel and transparent acrylic plastic. There is no mechanical damage to seeds in pneumatic seed metering. Irregular and light weight seeds are also metered efficiently.

Fig. 4.3: View of Pneumatic planter in field operation

4.3: Operation procedure, care and troubleshooting for pneumatic planter

4.3.1: Operation procedure

In order to have a good quality work the seed should be placed at uniform depth and uniform quantity in all the furrow openers without causing any damage to the seeds. No furrow opener should be left opened and the soil cover should be compacted firmly to promote easy germination. This can be obtained by carrying out the following operation procedure:

1. Employ the standard hitching procedure as for mounted implements. Reverse the tractor to seed cum fertilizer drill. Attach the left link, then the right link by adjusting the length of the right left arm, the top link and stabilizer chain after centring the equipment.

2. After the equipment is hitched to the tractor make the preliminary adjustment.
3. Now fill the seed boxes 3/4th of its capacity, also assure that seeds are free from the clods *etc*.
4. Lift the equipment and rotate the drive wheel to ensure that seed is falling freely from the metering device, seed tube into the furrow opener.
5. Take the equipment to the field, select the point from where the operation is to be started. As the tractor enters the field lower the equipment using the position control levers.
6. Check that the drive wheel is touching the ground fully or not, if not, lengthen the top link. Then continue driving the tractor for about 10-meter distance and stop again. Check to see the drop of seed. Also check the penetration of furrow openers. If the desired depth is not obtained adjust the Position control lever, till the desired depth of planting is obtained.
7. Once the check and adjustments have been made, finish the operation in the first land, then move to the second land and so on.

4.3.2: Care and Maintenance

The following care should be taken for smooth and efficient functioning of pneumatic planter.

1. Check the suitability of metering systems in respect of the seed to he used.
2. Ensure the calibration of metering system to obtain the desired seed rate of the crop to be taken under cultivation.
3. Ensure the placement of seeds at proper depth.
4. Ensure the coverage of seeds and compaction of soil cover.
5. Check the performance of the attachment.

4.3.3: Maintenance Schedule Daily

1. Clean the furrow openers, covering device and seed tube.

2. Apply grease to all existing grease points.
3. Check that all the nuts and bolts are properly tightened.
4. Ensure the replacement of the parts, if any broken.

4.3.4: Periodically

1. At the end of the season check the entire machine and make a list of broken and worn out parts to and ensure its repairs or replacement.
2. Thoroughly clean the seed hoppers and then apply a coating of heavy oil on moving parts.
3. Clean the furrow openers, tubes and the metering system.
4. Detachable link chain should he coated with oil.
5. If the planter has pneumatic wheel then the drill planter unit should he jack up for its storage in a clean dry place, provided with proper sheds.

4.3.5: Precautions

1. Operator must ensure the levelling of the planter with respect to the ground.
2. The planter should always be operated at optimum speed in order to ensure uniform of seeds and fertilizer.
3. After entering in to the field the operator must select suitable method of operation keeping view the topography of the field.
4. Before the operator starts the operation metering mechanism lever should be locked properly calibrated scale.
5. Before starting the operation, the operator should check the slippage/skidding or the wheel. He should ensure that it should not be more than that desired level) which has already taken into the consideration at the time of calibration.
6. Depth of sowing should be kept uniform throughout the operation by locking the positon control lever.
7. Operator should ensure the proper and smooth working of agitator.

8. Check that all working parts have been protected properly by providing the guards or cover.
9. When the tractor is in operation, the operator should not allow any person to sit on the tractor or to stand on the planter.
10. No adjustment either on tractor or on planter should be made during operation.
11. Operation should be done by the skilled operator only.

4.4: Trouble shooting of pneumatic planter during sowing operation

Table 4.1: Different problems, causes and their remedies in planters

S.No.	Problem	Cause	Remedy
1.	**Furrow opener not penetrating.**	• Hard ground. • Worn out opener. • Planter not in level.	• Use springs to increase the pressure on runners. • Replace or weld additional plate to replace worn out opener. • Re-adjust the opener. • Adjust hitch clevis.
2.	**Soil not properly covered.**	• Soil condition.	• Use covering blades adjust them properly. • Set planter deeper.
3.	**Soil loose around the seed.**	• Cloddy soil condition. • Insufficient press wheel pressure.	• Use rubber type or press wheel pressure. • Increase the pressure on press wheel by dead weight.
4.	**Marker line not visible.**	• Marker shoe or disc improperly set.	• Adjust angle and set more weight.

5.	**Inaccurate seed drop.**	• Poorly graded seed. • Planter speed too fast • Wrong seed plates. • Planter out of time. • Bottom plate turned to wrong side up. • Chain on wrong sprocket.	• Use uniformly graded seed. • Use recommended planter speed. • Use recommended seed plate. • Check timing of planter. • Check bottom plate. • Check the chain on wrong sprocket.
6.	**Scattering of hills in the row.**	• Planter out of time clogging. • Planter speed too fast. • Shaft spring out of adjustment. • Check shaft bending. • Worn out opener. • Poorly prepared seedbed.	• Re-time the planter. • Do not back with furrow opener on ground. • Use recommended planter speed. • Adjust the shaft spring tension. • Check misalignment of shaft. • Replace or weld additional plate to replace worn out opener. • Prepare seed bed thoroughly.
7.	**Planter misses the set of hills.**	• Clutch not engaged properly.	• Repair it. • Replace or repair.

		• Clutch lever worn out or loose. • Clutch spring weak.	• Replace spring.
8.	**Irregular Planting speed in row.**	• Action of cut-off knocker. • Wrong seed plate.	• Check in knocker housing. • Check uniformity of seed plates.
9.	**Irregular spacing.**	• Drive wheel slipping.	• Reduce down pressure on units.
10.	**Seeds cracking.**	• Wrong seed plate. • Bottom plate turned to wrong side up.	• Repeat plate selection procedure. • Check bottom plate.

4.5: Off-Season maintenance after planting the seeds

- Visually inspect meter for broken, worn, or missing parts
- Disassemble meter and check bearing
- Bead blast interior and exterior of meter, brush holder, lock assembly, chamber, seals, and other parts
- Inspect and re-install and/or replace seals
- Re-Install plastic meter parts
- Install new brush
- Index hub and seed disks
- Adjust disk to housing clearance
- Lubricate lock with corn head grease and re-install
- Paint and/or re-paint row number on disk and housing

- General Recommendations: Never store seed disks in row unit. Seed disks should be cleaned in warm water and soap after planting. Spray flat side of seed disks with graphite spray after cleaning.
- Store seed disks on a rack or dowel to prevent warping. Meters should be stored in a heated area. Seals should be wiped clean at the end of planting season.

Practical Exercise

Activity 01: Draw a sketch of pneumatic planter.

Material required:

1. Pen
2. Pencil
3. Notebook
4. Eraser
5. Sharpener

Procedure:

1. First, take a permission of any farm machinery shop.
2. Then, visit the shop.
3. After that, identify the pneumatic planter available in the shop.
4. Write down their specification which are available in the shop.
5. Draw a neat sketch of the pneumatic planter and also label their parts.

Activity 02: Make a list of various operations carried out by a pneumatic planter.

Material required:

1. Pen
2. Pencil

3. Notebook

Procedure:

1. First visit the field.
2. Then, identify the various operations performed by pneumatic planter.
3. List out the various operations performed by pneumatic planter in the field.
4. Make a report of various operations performed by pneumatic planter.

Activity 03: Make a list of safety guidelines for operation of a Pneumatic Planter.

Material required:

1. Pen
2. Pencil
3. Notebook

Procedure:

1. First visit the field.
2. Then, identify the various operations performed by pneumatic planter.
3. List out the safety guidelines for operation of a pneumatic planter.

Check Your Progress

A. Answer the following question

1. What is pneumatic planter?
2. Briefly explain the major parts of a pneumatic planter.
3. What precaution should take while operating a pneumatic planter?
4. How a Pneumatic planter is stored in off-season? What are the major precautions one should take in storing the pneumatic planter in off-season?

B. Fill in the blank

1. Multi-row traditional ……. devices with manual metering of seeds are quite popular with experienced farmers.
2. Lift the equipment and rotate the ……. to ensure that seed is falling freely from the metering device.
3. Operator must ensure the ……. of the planter with respect to the ground.
4. The metering device is powered by a pair of ground wheels through ……. and …….
5. ……. to the aspirator blower is given by PTO shaft of the tractor.
6. The ……. retaining plate is equipped with a baffle to release the vacuum pressure of the seed disc.

SESSION 2: USE OF POWER WEEDER AND MULCHER

In this session we will talk about power weeder and mulcher role and their importance in agriculture field. Before we start our topic power weeder. We need to focus on-

4.6: WHAT IS WEED?

Weeds are defined as the unwanted plants in crop fields which grow along with the main crop. They are strong and dominating competitors for crops. Their seed production, quick population establishment, and adaptation characteristics make them tough competitors and help in their survival. Weeds compete for essential components required by crops. They compete for light, water, nutrients, and space. They reduce the yield and sometimes they are sources of diseases as well.

In all cereal and other crops produced and consumed all around the world, weeds are the main constraint in the production and a direct determinant for crop yield reduction. Weeds reduce the yield from 40% to 65%and its eradication is the most important challenge faced by the farmers.

It can be eradicated by hand weeding, chemical means, by using herbicides or by mechanical weeders. Hand weeding is the most efficient method in weeding but is not well suited due to more time consumption coupled with labour intensive operation and expenditure. Chemical method, show promising results in weed eradication but restricted due to its ill-effect on human beings and environment.

Mechanical weeding promotes the plant growth as a result of increased soil aeration, root length and better tiller production. This may be done by traditional hand aided weeding tool, manual operated mechanical weeder and power weeders.

4.7: Power weeder

A power weeder is a piece of farm machinery used for secondary tillage. Another

word for teeth is shanks, which penetrate the soil by being dragged straight through it. Another machine that achieves a similar result through the rotating motion of discs. It is also known as power tiller.

The power weeder is used for removing weeds, stirring and pulverizing the soil and for loosening the soil after the crop begins to grow in crop fields, vegetable gardens, basins of orchard trees and plantations. In general, diesel engines are employed in them. Also there are variety of attachments available for the weeder making it a multi-purposeful machine. These machines are widely used for weeding in cotton, tomato, tapioca, paddy, sugarcane, pulses and various other plant fields

4.7.1: Special Features

- Simple design hence low maintenance cost.
- More output hence cost saving.
- No labourers required hence self-sufficiency.
- Easy to operate.
- Most important - Reasonable cost.

Power weeder should be used in land that has already been ploughed using tractor and has sufficient moisture. It is used for inter-cultivating, turning the soil, weeding, aerating and making rows for plantation.

Fig. 4.4: Power weeder

4.7.2: ATTACHMENT OF POWER WEEDER

Power weeder is also known as an inter-cultivator. Depending on the type of work, size and functionality, people also consider a Mini Weeder or Mini Tiller.

- Power weeder is used for inter-cultivating, turning the soil, weed removing, aerating, and making rows for plantation.
- It is easy to handle, maneuver, transport.
- Some areas of application are vegetables, cotton, tobacco, mango, Banana, Arecanut and guava plantations.
- It is also used for gardening and in small farms.
- It is also Used in Secondary tillage.

Power weeder helps in-

- Ploughing the soil evenly
- Removing weeds from the ground
- Swift Tilling & Digging of the soil by breaking the soil and making it more fertile.
- Efficient and Uniform Soil Leveling

4.7.3: WORKING PRINCIPLE OF POWER WEEDER

Power weeder are devices used for removing the weeds, stirring and pulverizing the soil and for loosening the soil after the crop has begun to grow. It is manufactured by using high quality raw materials with the help of latest machines. These machines are widely used for weeding cotton, tomato, tapioca, paddy, sugarcane, pulses and various other plant fields.

This rotary power weeder consists of high speed motors, tiling width of these power weeder ranges from 40-60 cm and the tiling depth ranges from 10-15cm. The motors in this machine are diesel operated and can work efficiently for a longer time. The blades present in this paddy power weeder rotate efficiently for cutting and mulching of soil. This power weeder is self-propelled with a fully

functional gear box having one forward and reverse gear transmission with clutch.

These Rotary Power weeder are easy to operate, the weeding between the rows can be easily achieved since this machine is well suited for inter crop weeding. The farmers can avail this mini power weeder in market leading prices.

4.7.4: Features of power weeders:

- Four stroke engine type.
- High performance.
- Advanced fuel injection system.
- Low fuel consumption.
- Large torque for heavy working.
- Sweep blades and ridges can be fitted

4.8: Periodic Maintenance of power weeder or power tiller

Marginal farmers with tiny landholdings love them because of their compact size, multi-utility, great labour potential, minimal maintenance cost, and affordable pricing. These powerful devices can live longer and function to their full extent if properly maintained. The following are some useful maintenance advice for power weeder or tiller owners-

1. **Management of lubrication:** Engine oil, coolants, gear oil, transmission oil, and chain case oil all play an important role in the tiller's operation. The tiller consumes/uses more oil as a result of heavy use and a hard working environment. As a result, oil levels must be checked frequently.

i). **Engine oil:** Check the engine oil level on a daily basis. Using the dipstick, check to see if the oil level is higher than the minimum. Choose the best engine oil for your tiller at all times. This will allow you to keep your engine operating for longer.

ii). **Coolant:** Make sure the coolant is never below the minimal level by checking it every day. If the coolant level falls below the minimum, mix 3

parts water with 1-part OEM (original equipment manufacturer) suggested coolant concentration to make coolant water. Replace the coolant every 6 months or when the harvest season is through.

iii). **Gear oil and rotary chain case oil:** The gear oil maintains the transmission running smoothly, while the rotary chain case oil keeps the joints rotating smoothly. These oils, like other lubricants, require daily inspection and replacement.

iv). **Grease:** In addition to the oil, moving parts and joints, such as the rotary cup, require grease. Clean and grease them on a regular basis, as directed by the manufacturer.

2. **Filters should be cleaned**

i). **Oil filters:** When it comes to car maintenance, the oil filter is frequently overlooked. When the oil filter is not replaced, it becomes worn out. As a result, the contaminants that have accumulated in it are able to escape and return to the engine. Make care to clean or replace these filters on a regular basis.

ii). **Fuel filters:** Maintaining and replacing fuel filters will keep dust and big contaminate particles from entering the fuel tank.

iii). **Air cleaner bowl:** By absorbing impurities in the air, the air cleaner provides cleansed air to the engine. The dusty climate of the fields, especially during dryland operations, causes these filters to quickly deteriorate. As a result, regular cleaning and changing is required.

3. **Check the tension of the fan belt:** The fan belt's tension decreases over time due to continuous use. The machine's efficiency suffers as a result of the reduced stress. Every day, press the middle of the fan belt to check the tension. If the tension falls below the optimal level, such as 10-12 mm, tighten the nut that holds the fan belt.

4. **Examine the tyres:** Make that the field operation's tyre pressure is set to the recommended PSI. Check the tyre pressure on a daily basis and replenish it if necessary. Also, look for any signs of wear and tear or damage.

5. **Bolts should be tightened:** Bolt loosening is commonly caused by frequent use and engine vibration. After each use, inspect it and tighten it if necessary.
6. **Main clutch wire free play:** Proper adjustment of free play for lever 15 to 20 mm recommended.
7. **Steering clutch wire lubricant:** Change after in every 50-hour operation. Apply an appropriate amount of engine oil.

4.9: Mulch

A mulch is a layer of material applied to the surface of soil. Reasons for applying mulch include conservation of soil moisture, improving fertility and health of the soil, reducing weed growth and enhancing the visual appeal of the area.

4.9.1: Mulches for weed control

Crop production systems are gravely vulnerable to weeds. Non-chemical weed control such as mulches is required due to herbicide-resistant weeds and environmental pollution caused by herbicides. Several types of plastic mulches have been investigated for controlling weeds in different kinds of cropping systems. Among these, black plastic mulch has been found the most effective and popular. However, due to environmental demerits of plastic mulch, degradable or biodegradable mulches have been suggested as alternative to black plastic mulch. More research and funding should be provided for the development and field application of e-gradable/bio-degradable mulches. Several kinds of straw mulches have also been investigated and provide encouraging results for weed control in field crops. Nevertheless, some of the studies indicated that straw mulch may not provide viable weed control under certain field situations. In some studies, the paper mulches have also provided some promising results for weed control in different crops. Many types of organic wastes have the potential to suppress weeds if appropriately converted to a mulch.

4.10: ROTARY MULCHER

Rotary Mulcher (SHAKTIMAN) is robust and reliable implement for mulching of vineyards, orchard pruned materials, grass, bushes, crop residues like sugarcane trash, wheat & paddy straw, maize stalk etc. Mulcher shreds the crop residues/grass into small pieces and spread on the field. Which serves as bio mulch and decomposes gradually, improving overall organic structure of soil. Built with fine quality component like all other SHAKTIMAN products, this mulcher yield higher productivity and in turn ensures greater satisfaction.

Fig. 4.5: Rotary Mulcher

4.10.1: Advantages of rotary mulcher

- It is highly compatible to shred vineyards & orchard pruned materials, grass, bushes, crop residues like sugarcane trash, wheat & paddy straw, maize stalk as thick as 5 cm in diameter.
- Bio-mulch serves dual proposes – Benefits of mulching and improve soil fertility after decomposition effectively shaves sugarcane stubble, results in harmonious growth & higher yield.

4.10.2: Features of rotary mulcher

- Rear Roller with height adjustment - ensures uniform and compact mulching layer.
- Free moving Gear Box - Ensure safety of Tractor at the time of sudden

switch off.

- Electronically Balance rotor - Ensure vibration free working of mulcher to minimize maintenance.
- 3-point linkage - suitable for cat I & II Standard input RPM 540 Side.
- Drive Belts - Side Drive Transmission: 4nos. BX 54 belt.

Practical Exercise

Activity 01: Draw a sketch of power weeder.

Material required:

1. Pen
2. Pencil
3. Notebook
4. Eraser
5. Sharpener

Procedure:

1. First, take a permission to farm machinery shop owner.
2. Then, visit the farm machinery shop.
3. After that identify the power weeder available in the shop.
4. Write their name and specifications.
5. Draw a neat sketch of power weeder and label their parts.

Activity 02: Draw a sketch of rotary mulcher.

Material required:

1. Pen
2. Pencil
3. Notebook
4. Eraser
5. Sharpener

Procedure:

1. First, take a permission to farm machinery shop owner.

2. Then, visit the farm machinery shop.
3. After that identify the rotary mulcher available in the shop.
4. Write their and specifications.
5. Draw a neat sketch of rotary mulcher and label their parts.

Check Your Progress

A. Answer the following Question

1. What is weed?
2. Explain role of power weeder in farming.
3. Describe the working principle of power weeder.
4. What are the periodic maintenance of power weeder?
5. What do you mean by mulch?
6. Explain the features of rotary mulcher.
7. Describe the function of rotary mulcher.

B. Fill in the blank

1. A power weeder is a piece of farm machinery used for ..... tillage.
2. Power weeder is ..... with a fully functional gear box having one forward and reverse gear transmission with clutch.
3. ..... production systems are gravely vulnerable to weeds.
4. The ..... maintains the transmission running smoothly, while the rotary chain case oil keeps the joints rotating smoothly.
5. ..... weeding promotes the plant growth as a result of increased soil aeration, root length and better tiller production.

SESSION 03: FEATURE OF REAPER AND BINDER, COMBINE HARVESTER AND BALER

At the time of harvesting different types of machinery used for different operations such as cutting, binding and threshing etc., to produce the crop with quality.

4.11: Reaper: Harvesting of cereal crops especially wheat and rice is a serious problem. There is a tremendous crop loss when untimely rain is experienced. Delayed harvesting causes grain shattering due to over maturity. The standing crop in the field can be harvested with the use of reapers. A reaper may be classified as animal-drawn reaper, animal-drawn engine operated reaper, tractor rear mounted PTO operated reaper, power tiller operated or tractor front mounted vertical conveyer type reapers and tractor mounted reaper binder.

4.11.1: Animal-drawn reaper

It consists of a cutter bar of 1.05 m length. The power to drive the knife bar is given from the ground wheel by means of gear box, crank and connecting rod mechanism. As the machine is pull forward by a pair of bullocks, a reciprocating motion is imparted to the knife bar with a peak cutting velocity of about 100 m/min. The crop is cut due to shearing action. The effective field capacity of machine varies between 0.2-0.3 ha/h.

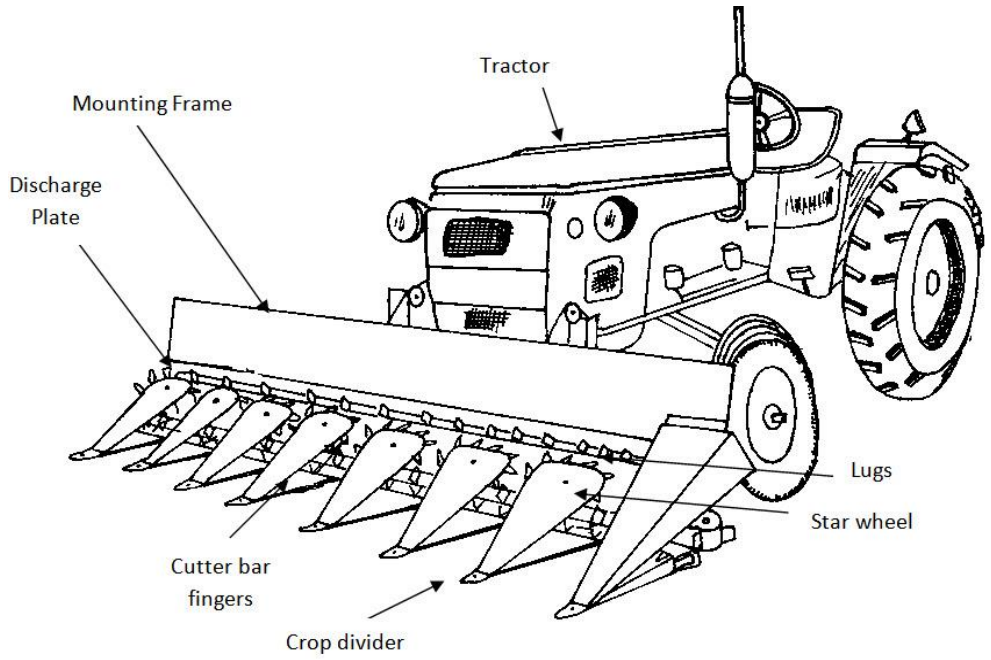
Fig.4.6: Animal-drawn reaper

Animal-drawn engine operated reaper: It has a cutter bar of 1.35 m length. A 2 hp 4-stroke petrol engine operates the cutter bar. The drive to the cutter bar from engine is given through V belt and gearbox. It can cover 0.2-0.4 ha/h with field efficiency of about 80%.

Power tiller/Tractor front mounted vertical conveyer reaper windrower: A machine called vertical conveyor reaper–cum-windrower can cut the crop and lay it in the form of windrow for easy picking.

It consists of a conventional cutter bar assembly, crop row dividers with star wheels, covers, pressure springs and vertical conveyor belts. Cutter bar is given reciprocating motion by crank wheel. Crop row dividers with star wheels enter the standing crop, help in lifting, gathering and guiding the crop towards the cutter bar. After the crop is cut, held in a vertical position during its passage by means of pressure springs and star wheels. Vertically held crop is then delivered towards right side of the machine in a windrow perpendicular to the direction of movement of machine with the help of lugged conveyor belt.

A front mounted vertical conveyor reaper is the most common reaper, to harvest wheat and paddy crops. It can also be used for harvesting of soybean and other similar crops. Engine operated reaper can be operated with a 5-6 hp engine, whereas, tractor operated reapers can be operated with 25-35 hp tractor.



(A)

(B)

(C)

Fig.4.7: Self-propelled vertical conveyor reaper-cum-windrower

4.11.2: Self-propelled reaper binder

It is suitable for harvesting and making bundle of wheat, paddy and other oilseeds and pulse crops. It is operated by 9 kW diesel engines. The riding type self–propelled vertical conveyor reaper windrower is powered by a 9 kW, single cylinder, water cooled diesel engine having rated engine speed of 3000 rpm. It is provided with four pneumatic wheels; two driving wheels in the front having agricultural tread pattern tyres and two steering wheels at the rear having automotive tyres. Other systems include clutch, brakes, steering, hydraulics, and power transmission and an operator's seat is available to make the machine riding type.

The harvesting system include crop row dividers, star wheels, standard cutter bar having 76.2 mm pitch of knife section, vertical conveyor belts and wire springs. The effective cutter bar width is 1.2 m. The crop row dividers enter the standing crop and the star wheels guide the crop towards the cutter bar and help in slightly lifting the crop after it is cut, and in turning it at right angle, prior to its conveying by the lugged conveyor belt. The two lugged flat belts convey the cut crop towards the centre of the machine and moves back on a platform where it makes a bundle of about 5 kg each. At the end, the crop is discharged on the ground in the rear. Working capacity of reaper binder is 0.3-0.4 ha/h. Weight of the machine is about 450 kg.

Fig.4.8: Self-propelled reaper binder

4.11.3: Uses of a reaper cum binder

- Harvesting and Binding of Grain Crops in a single operation.
- Used for grain crops of height up to 85 to 110 cm.
- Harvesting and binding of 0.40 ha field in 1 hour, with consumption of 1-liter diesel only.
- Different cutter bar can also be attached to the same machine for harvesting *berseem, mentha, lucern*, paddy stubbles and other fodder crops.

4.11.4: Problems and adjustments of reaper

For proper field efficiency and minimum grain loss, correct field layout and preparation of the field are the most important factors. A swath of about 1.5 m width is required to be first cut all around the field to make passage for the tractor to travel. Alternately, the farmer may want to sow some other crop which could be harvested earlier than the main crop to save the trouble of the hand-harvesting of the initial swath. There are two different modes of turning at the corners as shown in the "Guidelines for proper working of the Reapers." In round turning, the corners are cut in an area to permit the turning of the reaper without pressing or trampling of the stalks by the outer shoe and swath divider. This, however, is not necessary in the poop method of turning. Machine adjustments like the height of the cut and the adjustment of the rakes are made next before starting the operation. As the cutter bar is provided on the right hand side the

reaper should be worked in a clockwise direction in the field. The reaper should be run for some distance and the size of the crop-bunches be examined. To make bigger or smaller bunches, the frequency of the sweeping rake needs to be adjusted accordingly. Care should be taken to keep the delivery end of the platform about 15 cm above the ground to facilitate easy dropping of the bunches. The forward speed of the tractor should be carefully selected in accordance with the crop and field conditions. Under Indian field and crop conditions the forward speed is limited to 3 km/h or so. Since the bunches are laid on one side, the passage for the subsequent run of the tractor is cleared automatically. The harvested crop is later tied into bundles of required size manually. The following table gives the common problems in the operation of the reaper-binder which can be remedied through necessary adjustments:

Table 4.2: Problems and adjustments of reaper

S. No.	Part	Problem	Adjustment
1.	**Reel**	i). Does not rotate. ii). Improper gat hering of crop.	i). Check tension of reel belt. Reel by hand to ensure that the drive pulley key and belt are secured. ii). Adjust height according to height of crop.
2.	**Cutter bar**	i). Unsatisfactory cutting.	i). Reduce forward speed. ii). Correct the registration. iii). Sharpen the knife sections or replace if worn out.

			iv). Check drive belt tension. If loose, tighten.
3.	**Binding and tying mechanism**	i). Broken or torn twine. ii). Loose or untied knot. iii). Frequent untied bundles. iv). Improper cutting of twine.	i). Remove twine and clean needle eyelet and pliers. ii). Reduce tension on twine under the tension plate through fly-nut. iii). Tighten the twine disc with the help of spring loaded screw-bolt provided for the purpose. iv). Adjust spring tension and smooth face of pliers by emery paper.
4.	**Conveyor**	i). Bundles keep collecting on conveyor. ii). Conveyor slackened and bundles not conveyed at regular internal.	i). Check the tension or the v-belt over the conveyor roller pulley. ii). Tighten the canvas conveyor with help of the sum buckles provided.
5.	**Bundle size**		i). Increase or decrease

			the size of bundles by increasing or decreasing the tension of trigger. For this the trigger spring is hooked on to different holes provided.

4.12: Combine Harvester

Before the advent of modern-day agricultural machines, farmers had to harvest crops by carrying out a series of laborious tasks. First came the process of 'reaping' where they had to cut down the plants with a long-handled cutting tools. Next came 'threshing' which involved the separation of the grain from the chaff by beating the cut stalks. Finally, they had to separate the actual grains from any remaining debris to make them suitable for use in a mill in a process called winnowing. All this took a lot of time and a lot of people. This scenario has changed since the introduction of the combine harvester.

The combine harvester, or simply combine, is a versatile farm machine designed to efficiently harvest a variety of grain crops. The name derives from its combining four separate harvesting operations—reaping, threshing, gathering, and winnowing into a single process. Combine harvesters are one of the most economically important labour saving inventions, significantly reducing the fraction of the population engaged in agriculture.

The present day combine harvesters are being mostly used for harvesting two major crops namely wheat and paddy. Other crops can also be harvested with combines like, maize, soybean, pulses oats, rye, barley, sorghum, flaxseed, sunflowers etc. with slight changes in the design of combine. A combine harvester consists of header platform, reel, cutter bar, crop divider, platform auger, feeder conveyer, cylinder, concave and grate, fan, chaff sieves, straw

walkers, grain sieves, grain auger, tailing auger, grain elevator, grain container and grain unloading auger.

According to source of power used, combines may be classified as self-propelled combines and tractor operated or trailer type combine. Self- propelled combines use a propelling power source to do various operations. In tractor operated combine, the power is being optioned through detachable tractor. Only at the time of harvesting tractors are attached and rest of the times it can be used for other farm operations.

4.12.1: Constructional features of combine harvester

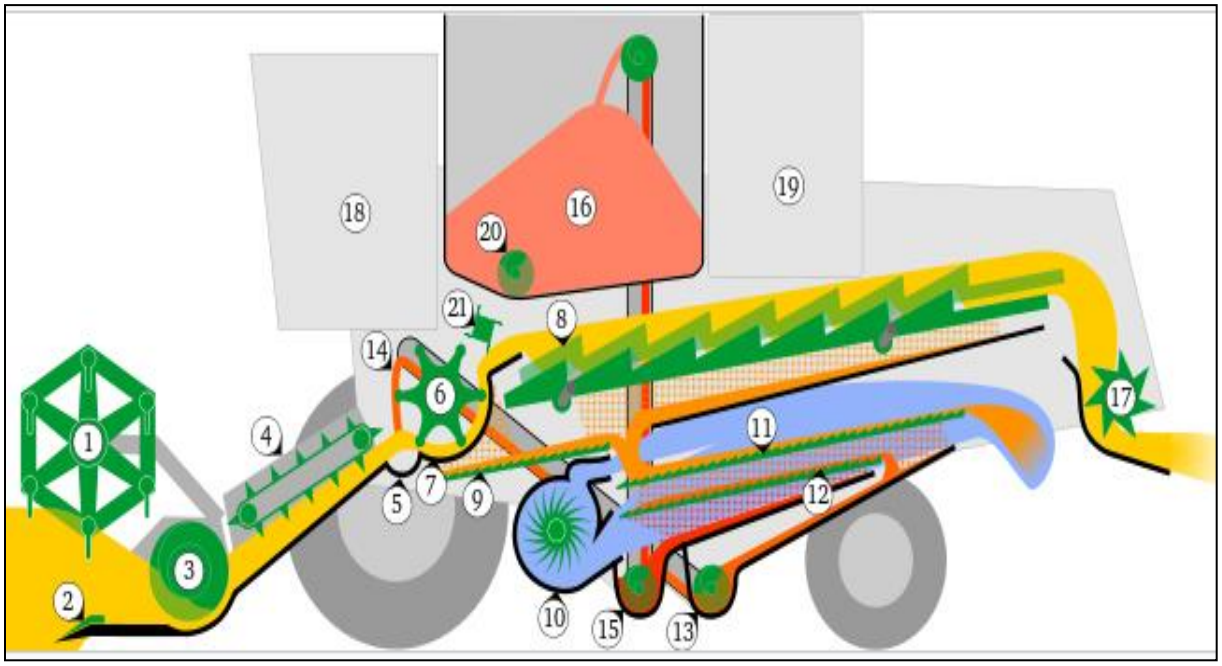


Fig. 4.9: Combine Harvester

1. Reel	**2. Cutter bar**	**3. Header auger**
4. Grain conveyor	**5. Stone trap**	**6. Threshing drum**
7. Concave	**8. Straw walker**	**9. Grain pan**
10. Fan	**11. Top adjustable sieve**	**12. Bottom sieve**
13. Tailing conveyor	**14. Re-threshing of tailing**	**15. Grain auger**
16. Grain tank	**17. Straw chopper**	**18. Driver's cab**
19. Engine	**20. Unloading auger**	**21. Impeller**

4.12.2: Detail of constructional features

A. Headers: The crop is gathered in by the header at the front, which has a pair of sharp pincers called crop dividers at either end.

B. Reel: A slowly rotating wheel called the reel (or pickup reel) pushes the crops down toward the cutter. The reel consists of a number of wide slats or arms with battens arranged parallel to the cutter bar to hold the crop being cut by the knife and to push and guide it to feeder conveyor auger. The reel may be of spring type or slat type. The reel gets power through suitable gears and shafts. The reel revolves in front of cutter bar while working in the field. The cut crop is then fed to cylinder and threshing takes place between cylinder and concave units of machine.

C. Cutter Bar: The cutter bar runs the entire length of the header underneath the reel. Its teeth (sometimes called mowing fingers) open and close repeatedly to cut off the crops at their base. Behind the cutter bar, the cut crops are fed toward the center by spinning augers (screws) and travel up a conveyor to the processing mechanism inside the main part of the combine.

D. Threshing unit: The basic components of threshing unit of combine are similar to that of power thresher. The threshed material then moves to oscillating straw walker, which separate the grain from straw. A threshing drum beats the cut crops to break and shake the grains away from their stalks.

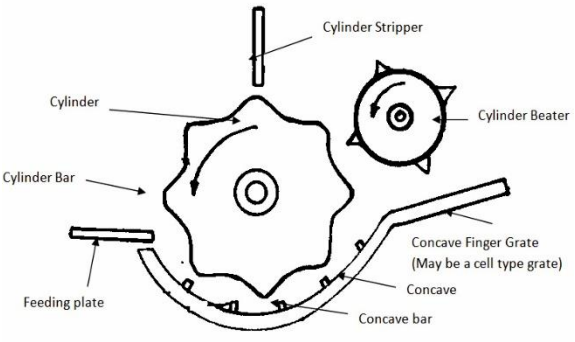


Fig.4.10: Threshing unit

E. Cleaning unit: It consists of a number of sieves and fan which cleans the grain. The grains fall through sieves into a collecting tank below. The un-

threshed grains pass through tailing auger and go to cylinder for re-threshing. The unwanted material (chaff and stalks) passes along conveyors called straw walkers toward the back of the machine. The grain passes through an elevator and collected in a hopper or directly unloaded to the trailer. The fan is adjusted such that the chaffs are blown off to the rear of the machine. The size of the combine is indicated by the width of cut it covers in the field.

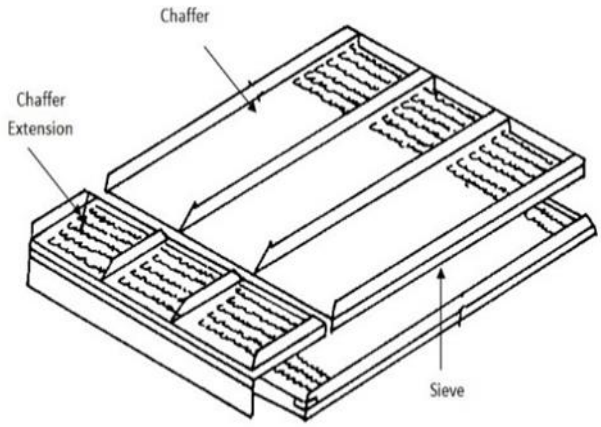


Fig.4.11: Cleaning unit

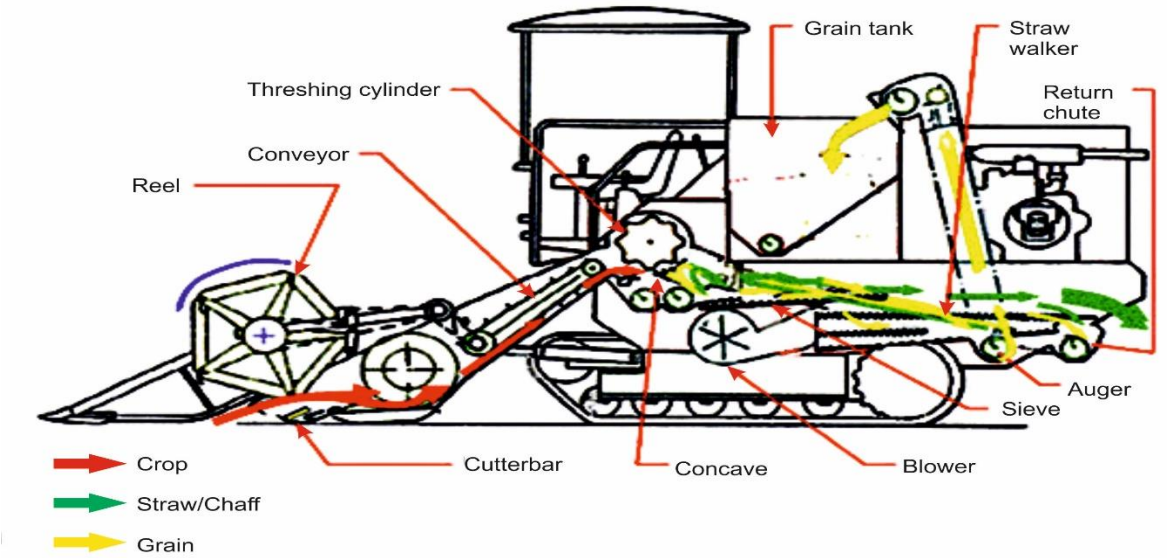


Fig. 4.12: Operating condition of combine harvester

4.12.3: Guidelines for safety in operation

The combine operator is responsible not only for his safety but also for the safety of others who may be working on or just be near the machine. The operator must be aware of hazards and remain alert to situations that are potentially dangerous. This includes pre-operational checks, starting, transporting, towing, operating, field repair and maintenance and stopping the combine.

Key points and supporting information

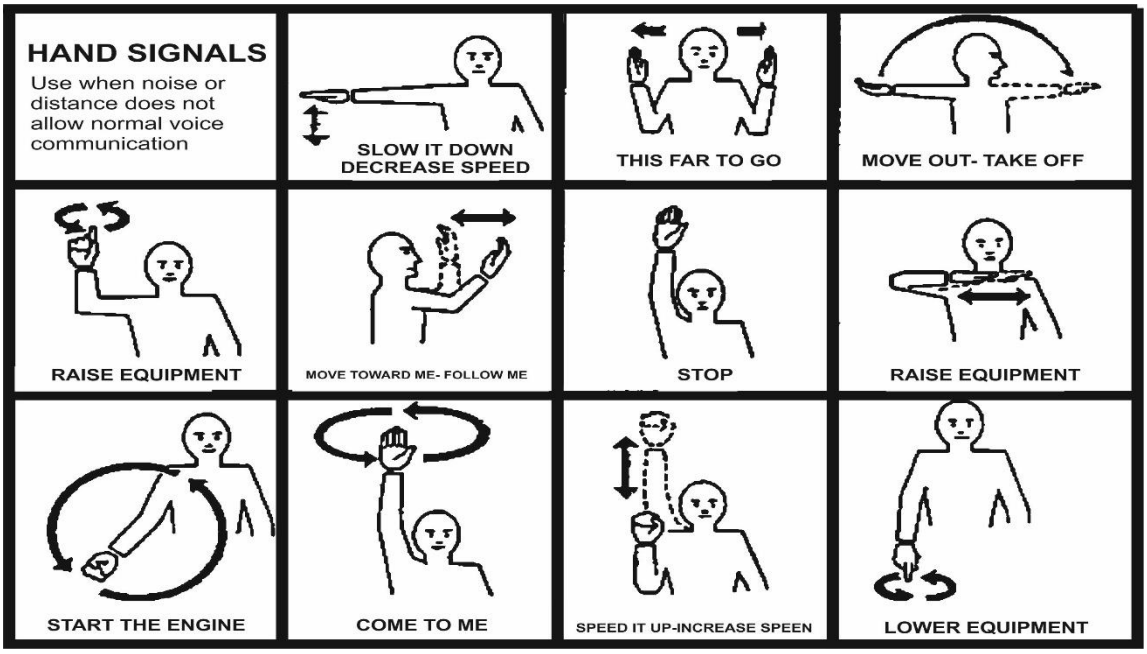


Fig.4.13: Hand Signals

A set of hand signals have been endorsed by several safety institutions. Since spoken instructions are very difficult to hear over the sounds of a combine, a knowledge of hand signals can be extremely helpful to the operator when maneuvering a combine, especially in tight places.

4.12.4: Safety before Starting

a. Before attempting to operate a combine, study the operator's manual. It has information on general safety rules, plus specific safety recommendations for the particular machine. The more you know about the combine, the better prepared you will be to safely operate it.
b. The exhaust fumes from diesel engine are very poisonous. If the combine is run inside a building, be sure to open the doors to provide good ventilation.
c. Always clean the combine before starting. Trash around the exhaust system can cause fires. Oil, grease or mud on ladders or the platform can cause serious falls. If the combine is equipped with a cab, clean the glass to provide maximum visibility.

d. Check the brakes once a week. With hydraulic brakes, make sure that the master cylinder is full of fluid and that no air is present in the lines. Adjust the pedal free travel, if necessary, so that the brakes are engaged with the pedals an equal distance from the floor of the platform. Check the operator's manual for specific instructions.
e. Check the threshing cylinder rocking bar to see it is clear of the cylinder.
f. Make sure that all shields and covers are in place and fastened securely.
g. Remove all service equipment.
h. Always use the handrails and ladders provided on the combine for safe mounting and dismounting.

4.12.5: Starting the Combine

a. Before mounting the combine, make sure that everyone is clear of the machine. Do not allow anyone it ride with you, unless combine is equipped with a passenger seat.
b. Before starting the combine:
   - Disengage header drive.
   - Disengage separator drive
   - Place gearshift in neutral
   - Depress clutch pedal
c. Be careful when using diesel starting fluid. It is extremely flammable.
d. If it is necessary to use jumper cables to start the combine, be careful to avoid sparks around the battery. Hydrogen gas escaping from the battery can explode. Follow the operator's manual instructions for using jumper cables.

4.12.6: Operational techniques

a. Never operate the combine if you are ill or sleepy. Operating safety depends on alert, efficient handling of the combine.
b. Wear safety glasses at all times.
c. Wear clothing that fits snugly to avoid catching clothing in moving parts.

d. Never let anyone ride on the combine unless it is equipped with a passenger seat. A rider's clothing may become entangled in moving parts, or he may be thrown off the machine.
e. Before starting to harvest a field, check it carefully for ditches, fences or other obstacles. Be aware of weather conditions which present safety hazards.
f. Be especially careful when operating on hillsides. Avoid sharp turns that could tip the combine over. Beware of ditches or obstacles--they are doubly dangerous on slopes.
g. If grain tank extensions are used, remember that the added weight may make the combine top heavy and more subject to upsets.
h. Never travel over 10 mph (16 km/h) with a full grain tank. The added weight makes the combine more difficult to maneuver and easier to upset.
i. Always sit down when traveling over rough terrain. A sharp jolt can throw you from the platform or away from he controls.
j. Hillside combines are equipped with automatic or manual leveling devices. Hydraulic cylinders act to level these combines on steep slopes. These machines are equipped with a warning signal that indicates when the leveling system has reached its limit. Be especially careful after the device activates.
k. When using the steering brakes, always turn the steering wheel before applying the steering brakes. Failure to do so can cause the combine to swerve and turn dangerously.

4.12.7: Stopping the combine safely

To make sure drive units do not cause injury when the machine is started again, do the following when stopping the combine.

a. Disengage header drive
b. Disengage separator drive
c. Place gearshift lever in neutral
d. Lower header

e. Apply parking brake
f. Remove ignition key to prevent tampering or accidental starting.

4.12.8: Off season storage care of a Combine:

4.12.8.1: Checklist for Post-Harvest Combine Maintenance

1. Consult operators' manual for post-harvest maintenance and check point.
2. Conduct a quick look over of the machine and develop a to-do list.
3. Blow off dirt and debris both on the outside and inside. Do not forget, harvest debris can attract rodents that can chew on wires and other electrical components.

- Make sure to blow out radiator and other heat exchangers.
- Give the inside of the cab a good cleaning, looking over door weather stripping, seats and other in-cab parts. Consider placing something to deter rodents in the cab.

4. Only wash the outside, trying to keep water off bearings and other moving parts.
5. May be take time to touch up scratches and worn areas with paint.
6. Open inspection plates and look over components.
7. Open concaves and sieves and look over for any issues.
8. Check bearings for any corrosion, spun on a shaft, or if they are loose. Replace all questionable bearings.
9. Change oil and filters while lubricating all grease fittings.
10. Check all lights and make sure they are functioning properly.
11. Check cooling system protection level for your climate, replacing coolant if needed. Also, to protect against corrosion, check supplemental coolant additive (SCA) level and add if necessary for your model.
12. Check all augers and conveyors for wear and damage. Suggest quickly replacing needed components as soon as possible.

- Check walkers and their bearings for damage, cracks or wear.
- The same goes for the rotors while also evaluating alignment and bearings.
- Check over the straw chopper and ensure it is balanced properly without excessive vibration.

13. Check and tighten all belts while inspecting for any cracks and dry rot symptoms.
14. Check feeder house chains and elevator chains for proper tightness and wear.
15. Look over the feeder house paneling especially the floor for excessive wear.
16. Check fountain and unloading augers for damage and any wear.
17. Grease all fittings and lubricate chains and other maintenance points outlined in the operator's manual.
18. Fill with fuel and consider adding a fuel stabilizer for winter storage.

4.13: Straw combines and Straw reapers

A. Straw combine: Straw combine is a machine that cuts and collects the stubble left behind in the field after grain harvesting and converts both of them into small pieces of straw. The machine is pulled and powered by a 45-50-hp tractor. Self-propelled straw combines are also available.

Use of grain combines has helped in timely harvesting of cereal crops and saves from huge grain losses due to bad weather during harvesting period. But, it also results in loss of straw 'bhusa' which is used as cattle feed in most part of the country. After harvesting of crop by grain combine, straw and stubble left in the field are burnt by most of the farmers, which leads to loss of 'bhusa' and environmental pollution. Straw combine is a machine that cuts and collects the stubble left behind in the field after grain harvesting and converts both of them into small pieces of straw. The machine is pulled and powered by a 45-50-hp tractor. Self-propelled straw combines are also available. The 'bhusa' is collected in an enclosed trailer attached behind the machine.

The machine consists of stubble cutting unit, straw collecting unit, feeding unit, straw bruising unit and straw blowing unit. Three different types of straw bruising mechanisms are used in straw combine viz. spike-tooth type, chaff cutter type and serrated saws type bruising mechanism. The major components of machine are reel, cutter bar, auger, feeder, straw bruising cylinder, concave, aspirator blower, sieves and gearbox. It has cutter bar reel, feeding auger and bruising cylinder like a traditional thresher. Straw thrown and stubble left by the grain combine is collected by straw combine and delivered to the cylinder-concave section, where it is cut into pieces and passed through the concave. A reciprocating cutter bar is used for reaping the standing stubbles and the portion of the straw left uncut by the combine harvester. Straw, which passes through the concave, is aspirated by a blower and fed into a trolley on rear side covered by a wire net. For recovering the left grains from the straw, a sieve system is provided below the concave. Working capacity of straw combine is usually 0.4 to 0.5 ha/h and it can make 'bhusa' between 1.5 to 2.5 t/ha. It can recover 55-65% of straw successfully as compare to the traditional method of threshing. The fuel consumption varied from 3.5-4 l/h. There is also a recovery of 75-100 kg of grain per hectare.

B. Straw Reaper Tractor operated straw reaper with storage box mounted above straw reaper for easy turning has also been developed. It has hydraulically unloading device to unload 'bhusa' in the field or at storage place.

It runs the function of cutting, threshing as well as cleaning the straw in one operation. Here, the wheat stalks which are left after combine harvest are cut using oscillating blades while the revolving reel helps in pushing them back toward auger. He processes involves stalks being conveyed back into machine through auger and guide drum where it reaches threshing cylinder that cuts the stalks into small pieces against concave.

4.13.1: Features

- System designed to provide superior separating performance
- Double blower operating behind rushes straw to trolley and at dame time also separates the dust particles
- Fully belt operated machine
- Coming with adjustable cutting height

4.13.2: Benefits of Straw Reaper

- Low fuel consumption.
- High performance in terms of field capacity and efficiency.
- Straw Reaper is a chopper machine which cuts, threshes & clean the straw in one operation. The wheat stalks left after combine harvest are cut by an oscillating blades while revolving reel pushes them back toward and auger. The stalks are conveyed into the machine by the auger and guide drum, which reaches the threshing cylinder which cut the stalks into small pieces against concave.
- It gives superior separating performance. The short fragment (straw) fall through the bars of the concave. Double blower operating just behind rushes the straw to trolley attached and separate the dust particles.

Working principle: A tractor operated trailed type straw reaper with rectangular container. Straw Combine is the machine operates by 35hp or above tractor. It harvests the wheat plant stalk above 8 cm. from the ground level, left in the wheat field after combining, gathers the other harvested, shattered ear heads, un cut plants, pushes them in the threshing/ bruising drum and concave, makes fine quality straw, separates grains getting collected in the tray, blows straw in the trolley through two blower pipes opening in the trolley as part of trolley. After filling off the trolley with straw, operation of the machine is stopped. Then after the straw is transported to the place of storage for unloading or unloaded in the

field. Thus the work of harvesting and threshing, loading and unloading is done simultaneously in the straw combine. While in the other system additional tractor and trailer is required to collect the straw. It also creates the problems of maneuverability in addition to increased initial cost of the system. The straw combine machine has following advantages over the existing straw reaper, (a) tractor and trailer system in terms of improved maneuverability of the machine - reduced turning radius by 4m, (b) easy operation in smaller fields, (c) simple in operation, maintenance, adjustments of the system, haulage in narrow lanes, (d) less fatigue to the machine operator, (e) easy in loading and uploading of the straw, consumption of fuel 5.6 1/h with the developed system against 5.8 1/h in conventional system (saving of 0.200 to 0.300 l/h) as compared to existing system, output capacity of the machine 730 kg/h with the developed system against 600 kg/h in conventional system (saving of 130 kg/h), lesser weight of the machine system by 1000 kg, reduced initial cost requirement.

Fig.4.14: Straw Reaper

4.14: Baler: A baler is a machine used to compress straw into bales for easy transport and storage. Balers are divided into stationary balers, movable and field balers. They are further classified into square balers, rectangular balers and round balers according to the bale shape produced.

Fig. 4.15: Baler

4.14.1: Baler for collection of straw

After combine harvesting, the straw is left on the earth in swaths. The straw should be removed as quickly as possible so that the seedbed preparation can begin thereby establishing next year's crop.

According to density of bale, they could be high (200-350 kg/m^3), medium (100-200 kg/m^3) or low density (<100 kg/m^3) balers. Based on the power used for operation, balers are classified as pull type balers and self-propelled balers. Pull type models are available with either a PTO drive or a mounted engine.

4.14.2: Rectangular balers for collection of straw: Field balers for making rectangular bales have been popular for many years. Smaller balers are powered by a tractor PTO and the larger balers are often equipped with auxiliary engines to drive the machine but may be pulled by a tractor.

4.14.3: Rectangular baler components: The basic functional components or units which make up a baler for rectangular bales are the pickup and elevating unit, feed conveyor, feeder, compression chamber and the tying mechanism. Each of these will be discussed individually-

- **Pickup and elevating unit:** This unit takes the straw from the windrow and elevates it to the point where, a feed conveyor can carry it to the bale compression chamber. It consists of a series of spring loaded tines which

gently lift the windrow and guide it along the stripper bars. At the top of the pickup, the tines retract downward to be ready to lift a new portion of the windrow. On many machines the pickup serves as the elevator but on older machines a separate elevator was used. Balers intended to pick up straw windrowed by mower/racker conditioners may have pickup tines spaced much closer together.

- **Feed conveyor:** This device moves the straw to the side of the bale chamber. Large diameter augers are common feed conveyors. However, on some machines several times extended from the feeder act to convey the material to the bale chamber side. On some older machines, rubber belts were used for this purpose.
- **Feeder:** It takes the straw from the end of the feed conveyor and actually places it into the bale chamber. In most cases the feeder enters the bale chamber when the plunger is forward, for this reason it must be timed accurately with respect to the plunger.
- **Compression chamber:** Straw is compressed in the bale chamber by the plunger which is driven by a large crankshaft and connecting rod. Each new charge of straw is compressed against the previous charges. The partially formed bale moves slowly through the chamber by the plunger forcing new charges against it.
- **Tying mechanism:** The tying mechanism consists of knotters, needles and metering wheel. These parts are responsible for tying each bale when it has reached its correct length. The fingers of the metering wheel extend part way into the bale chamber so the metering wheel turns slowly as the bales pass through the chamber. Rotation of the metering wheel, trip the knotter clutch to engage power to the needles and knotters to tie the bale. The relationship between the metering wheel and the knotter clutch can be adjusted to change the bale length. On most machines this can be done by sliding a collar on the trip arm at the metering wheel.

- **Rectangular pickup baler:** It makes bales from the straw windrow left by the combine. The machine consists principally of a pickup reel, a conveying and feeding system, a compressing chamber, a bale density adjuster, a bale length controller, a needle and tying mechanism. A crank linkage mechanism and a power transmission and hauling system. It is powered from the power take-off of the hauling tractor. The straw windrow is lifted from the ground by a pickup reel having spring teeth and transferred continuously to a conveying and feeding mechanism as the baler forward along the windrow.

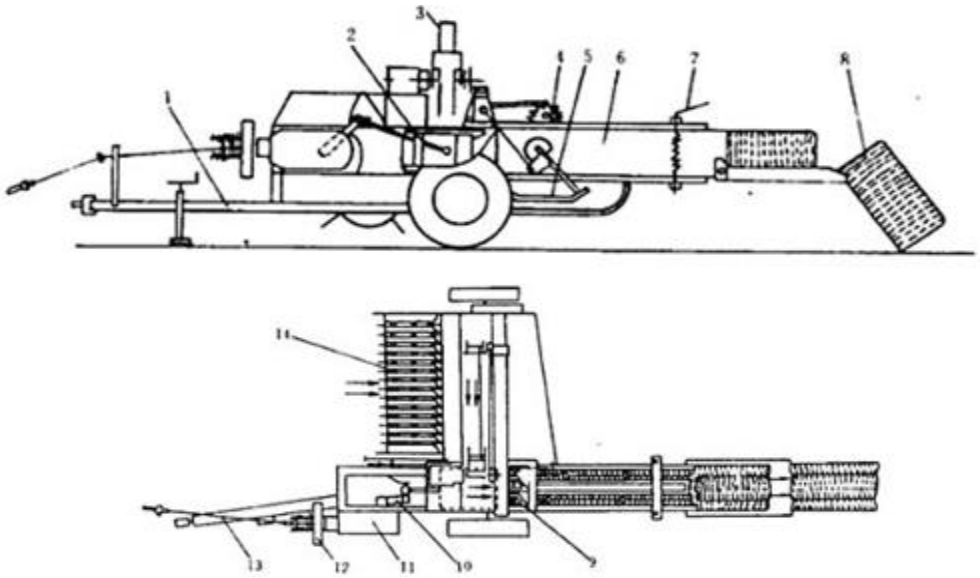


Fig.4.16: Rectangular Pickup Baler

4.14.4: Working Principle: The conveying and feeding mechanism pushes individual charges of straw into the bale chamber from the side at intervals when the piston is withdrawn. The piston reciprocates under the function of the crank linkage mechanism to press the material into the bale. When the bale reaches the required length, the needle and tying mechanism is engaged automatically

to bind the bale which is then pushed out from the chamber by successive bales and is discharged to the ground. Rectangular bales can be lifted and loaded either by hand or by a loading machine mounted on the side of a truck and driven by a ground wheel.

Round balers for collection of straw: Round balers are PTO operated and are pulled directly behind the tractor. It is desirable to use a tractor with front axle to permit straddling the windrow. Large wide windrows are preferred to make round bales which are uniform in diameter. When small windrows are harvested, operators prefer to weave side to side as the bale is formed to avoid tapered bales. Based on the form of working unit, round balers can be classified into long-belt type, short-belt type, chain type and roller type. They are also classified into inside winding type and outside winding type by their working principle. Long-belt and chain types are inside winding; short-belt and roller types are outside winding. According to the chamber size adjustment, balers are classified as expandable chamber round pick up baler, ground roll baler and fixed volume round pick up.

4.14.5: Baler capacities: Baler capacities are affected by:

1. Size of the bales.
2. No. of the plunge stokes per minute.
3. The amount of power available.
4. The durability and reliability of the machine.

4.14.6: Expected break down in balers

1. Overloading due to picking up of foreign objects or slogs of hay and careless operation.
2. Chocking due to the excessive clogging of the straw.
3. Failure of the machine parts like plunger, fly wheel and bolts.

4.14.7: Baler maintenance basics

1. Properly train operators.
2. Refer to the manufacturers checklist.
3. Have an oil maintenance program.

4. Inspect shear blade clearance.
5. Check all the wear parts.

4.14.8: Operation and safe working of balers

A baler is machinery used to compress the cut and raked hay or straw or silage into bales. The advantages of bales are due to its compactness; easy to handle, transport and store. There are three types of balers are used in common. They are square balers, large square balers and round balers. Square balers are used to compress straw or hay into square compressed bales. The square shape is easy to handle and safe compare to round balers. These are used in small scale operations.

Large square balers basic operation is same as that of square operations other than handling of large quantity. Hence, it has higher compression capacity and safe wrapping and tying option. Normally the capacity is 20 to 40 times than the small scale square balers. Round bales are effective for large scale operations with minimal cost. The balers involve typical hazards and risks during operation. Hence suitable precautions have to be made while operating large balers in fields.

4.14.9: The following points are to be considered for safe operation of the balers:

1. The basic modes of operation of balers are: loading, compression and ejection.
2. Operate the balers after thorough understanding of the operation and safety measures.
3. Only trained persons should operate the system.
4. Always follow the safety instructions.
5. Keep away from the path of ejection of bales from the balers.
6. Ensure safe bale ejection by following proper instructions of the supplier.
7. Beware of moving components of the balers while working.
8. Always keep the safety guards in place.
9. Required fire preventive measures are to be carried out.
10. Use proper hydraulic pressures as suggested by the manufacturer.
11. Use the baler for specified material only as directed by the manufacturer.

12. Don't over load the baler than the specified capacity.
13. Using safety glasses and hand gloves are to be followed during the operation of balers.
14. Check the baling wires for damage and do not use damaged wires.
15. Mismatching of baler capacity and quantity of hay/straw or windrow may lead to blockage or improper operation of balers. Hence, care should be taken to select a suitable baler in the selected field.
16. Baling material should be of specified moisture content. Higher the moisture in the materials will cause series problems during baling such as poor core formation, blockage etc.
17. Baling lighter materials during windy condition may be avoided to prevent poor core formation and blockage.
18. Informative manual with relevant information on cleaning blockages, rethreading, dealing with poor core forming etc. to facilitate the operation at difficult conditions.
19. During ejection of bales specifically round bales the landing area may be selected as flat and without any slope.
20. Do not stop a rolling bale as it weighs about 500 kg and rolling gives momentum to the bales. This may lead to accidents to the machinery or person.
21. Inspect all belts or chains for of wear or breakage to avoid blockages and heat buildup.
22. While checking or repairing the balers stop the baler by putting down the power or disengage with the PTO of tractor. Make sure that there is no moving part is in operation before performing the baler repair.
23. Operate the baler at a safer speed.
24. Do not attempt to feed the material into the baler manually either by hand or feet.
25. Remove excessive grease or accumulated crop parts on moving parts.

Fig. 4.17: Straw Baler (straw bales being transported)

4.14.10: Expected break down in baler:

1. Overloading due to picking up of foreign objects or slogs of hay and careless operation.
2. Choking due to the excessive clogging of the straw.
3. Failure of the machine parts like plunger, fly wheel and bolts.

Practical Exercise

Activity 01: Make a neat sketch of combine harvester

Material required:

1. Pencil
2. Eraser
3. Sharpener
4. Notebook or drawing sheet

Procedure:

1. First, visit the farm machinery shop or field.
2. Then, identify the combine harvester.
3. Write their specification.

4. Draw the neat sketch of combine harvester.
5. Write their parts name and label it.

Activity 02: Make a neat sketch of animal drawn reaper

Material required:

1. Pencil
2. Eraser
3. Sharpener
4. Notebook or drawing sheet

Procedure:

1. First visit the farm machinery shop or field.
2. Then, identify the animal drawn reaper.
3. Write their specification.
4. Draw the neat sketch of animal drawn reaper.
5. Write their parts name and label it.

Check Your Progress

A. Answer the following question

1. What is reaper?
2. What is meant by self-propelled reaper binder?
3. Explain the working principle of combine harvester.
4. Describe the constructional features of combine harvester?
5. What safety should take during operating the combine harvester?
6. What are the pre-start checkups of a combine?
7. Make a list of various operations carried out by a combine.
8. How a combine is stored in off-season? What are the major precautions should have taken in storing the combine in off-season?
9. What are the major parts of a baler?
10. What are the major precautions should have taken during operating a baler?
11. How tying is done in making a bale in the field?

12. List out the safety precautions in operation of baler.

B. Fill in the blank

1. The ..... to drive the knife bar is given from the ground wheel by means of gear box, crank and connecting rod mechanism.
2. A front ..... conveyor reaper is the most common reaper, to harvest wheat and paddy crops.
3. The riding type self–propelled vertical conveyor reaper windrower is powered by a ..... kW, single cylinder.
4. Harvesting and binding of ..... ha field in 1 hour, with consumption of 1-liter diesel only.
5. The combine harvester is a ..... farm machine designed to efficiently harvest a variety of grain crops.
6. The piston reciprocates under the function of the ..... linkage mechanism to press the material into the bale.
7. A baler is machinery used to ..... the cut and raked hay or straw or silage into bales.
8. The ..... bales are effective for large scale operations with minimal cost.
9. Engine operated reaper can be operated with a ..... hp engine, whereas, tractor operated reapers can be operated with ..... hp tractor.

C. Match the following

Column A	**Column B**
1. It is a machine that cuts and collects the stubble left behind in the field after grain harvesting and converts.	**A. Cleaning unit**
2. It consists of a number of sieves and fan which cleans the grain.	**B. Baler**

3. It consists of a number of wide slats or arms with battens arranged parallel to the cutter bar to hold the crop being cut by the knife and to push and guide	**C. Elevating unit**
4. This unit takes the straw from the windrow and elevates it to the point where, a feed conveyor can carry it to the bale chamber. It	**D. Straw combine**
5. This is a machine used to compress straw into bales for easy transport and storage.	**E. Reel**

SESSION 04: SOLAR PUMPS AND DRONE

4.15: Solar photovoltaic (SPV) pumps: Nowadays, clean and consistent water supply is mandatory however the number of people at present not have this basic provision. The solar pump using a solar energy system is an attractive technology with environmentally as well as socially for supplying the water in remote locations. So this is always an economically chosen technology. Generally, remote places mainly depend on diesel engines, manpower for supplying the water. These pumps replace the present pumps to provide many benefits like weather-related, and socio-economic. These pumps are mainly applicable in irrigation and water stock.

During this season, the PV panels can generate the most power so that more water can be pumped into the water tank. Because of the ease of PV power-driven water pumps, solar technology is consistent, as well as needs small protection.

Fig.4.18: Solar Pump

4.15.1: Solar Pump: The solar pump block diagram mainly includes a solar panel, water pump, electric motor, and controller. This pump is basically an electrical pump, and this pump uses the electricity which is received from the solar panels to work. These panels store the energy from the solar. The electric motor manages the alternating current or direct current. The controller used in this system adjusts the output power as well as speed.

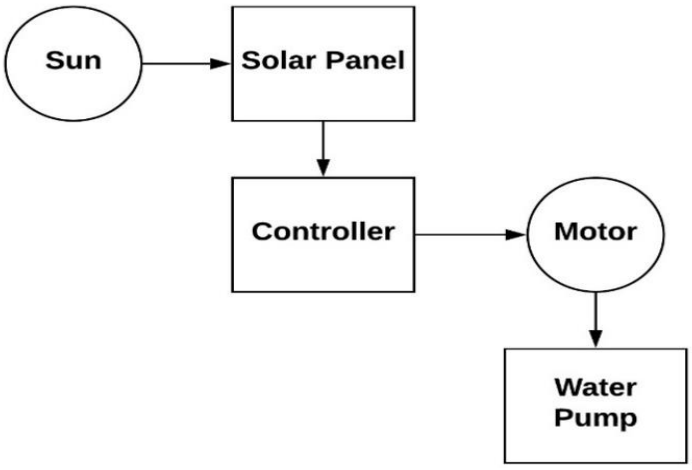


Fig. 4.18: Flow diagram of Solar Pump

How Does Solar Pump Work?

When the solar energy drops sun rays on the PV panels then the solar panel converts the rays into electrical energy with the help of Silicon wafers fixed within the PV panels. Then the solar energy supplies to the electrical motor to operate the pumping system using cables. By the revolution of the shaft which is fixed to the pump, then the pump begins to pick up the water and supplies to the fields.

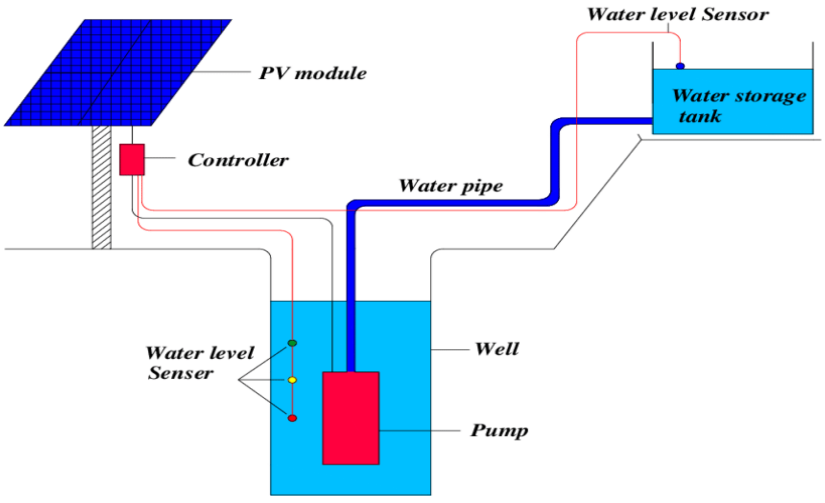


Fig. 4.19: Solar Pump Working

4.15.2: Types of solar pump

The solar-pumps are classified into four types namely submersible solar pumps, surface solar-pumps, DC pumps, and AC pumps.

1. **Submersible Solar Pumps:** These pumps can lift the water up to 650 feet and fit within a big well. Generally, water is pumped throughout the day as the sun is shining & the water is stored in a tank for utilize whenever required. It is suggested to store the water only in a good weather condition because if the weather is not good then the water will not pump. These types of pumps mainly used in places wherever water is accessible at a larger depth & wherever open wells do not exist. The highest suggested depth for pumping is 50 meters.

   Whenever the water deepness in the well is above 20 feet from the surface then these pumps can work by turning off batteries, solar panels, otherwise power source in some cases.

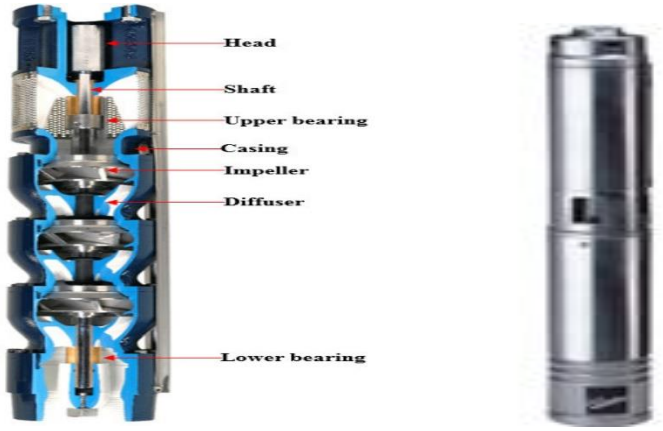


Fig. 4.20: Submersible Pump

2. **Surface Solar Pumps:** These pumps are used in ponds, shallow wells, storage tanks otherwise stream, if the deepness of the water supply in the well is 20 feet or less than 20 feet from the surface. Generally, these pumps can't pick up the water very high from the deep well, they can push the water 200 feet or above distance. These pumps are apt for pumping as well as lifting water from the highest deepness of 20-meters.

3. **DC Solar Pumps:** The motor used in this kind of pump works with direct current, thus there is no need for inverter or battery.
4. **AC Solar Pumps:** The motor used in this kind of pump works with AC, which means the DC generated by the panels gets changed to AC with the help of an inverter**.** This conversion leads to power failure from production & utilization.

How to select solar panels?

The solar panels which are used to power the water pumps are sold singly. Every solar panel_maker provides a table that gives the information about how many amps, watts and volts of power they require to generate the preferred water flow otherwise pick up. Whenever you have chosen the suitable type of solar-pump, then utilize that graph to estimate the accurate watts of panels.

The required amount of panels, as well as pumps, mainly depends on the requirement of pumping the water you wish to pump.

4.15.3: Advantages of solar pump: The solar pump advantages include the following. The installations of solar pumps are flexible & applicable to different applications.

- It allows farmers and other people to handle their water supply for farming, farm animals watering, horticulture farms, irrigation, gardens and other housing applications. drinking etc. Furthermore, these pumps are also used in gas and oil extraction

- Generally, the usage of water in summer is utmost. During this season, the PV panels can generate the most power so that more water can be pumped into the water tank.

- Because of the ease of PV power-driven water pumps, solar technology is consistent, as well as needs small protection.

4.15.4: Disadvantages of solar pump: The solar pump disadvantages include the following-

- It is expensive.
- The output of the panel will depend on the weather.
- It requires a water storage tank as well as a battery.

4.15.5: Applications of solar pump: The applications of solar pumps mainly used where pumping water is required.

- Water supply for animals.
- Water supply for harvest irrigation.
- Water supply for Cooking and Drinking water supply.

4.16: Drone : An agricultural drone is an "unmanned aerial vehicle" (UAV) used to help optimize agriculture operations, increase crop production, and monitor crop growth and crop health. Sensors and digital imaging capabilities can give farmers a richer picture of their fields. Using an agriculture drone and gathering information from it may prove useful in improving crop yields and farm efficiency.

Fig.4.21: Drone

Agricultural drones let farmers see the bird eye view which can reveal many issues such as irrigation problems, soil variation, and pest and fungal infestations. Multispectral images show a near-infrared view as well as a visual spectrum view. The combination shows the farmer the differences between healthy and unhealthy plants, a difference not

always clearly visible to the naked eye. Thus, these views can assist in assessing crop growth, crop health and production.

Additionally, the drone can survey the crops for the farmer periodically to their liking. weekly, daily, or even hourly, pictures can show the changes in the crops over time, thus showing possible “trouble spots”. Having identified these trouble spots, the farmer can attempt to improve crop management and production.

4.16.1: Working principle: Drones are the remotely piloted aircraft systems (RPAS), having a propulsion system, a programmable controller with or without the satellite navigation system, automated flight planning features and capable of carrying payload such as cameras, spraying systems, etc. for accomplishing a given task.

The drone used for agricultural activities is known as agriculture drone. Drones are designed to carry the sensors that can provide real-time information about the crop status or livestock movement, so that decision on operations and management is made efficiently and precisely.

The drone can be either remotely controlled over wireless communication or can be programmed to travel the predefined path using complex navigation algorithms running on on-board controllers fitted with different sensors with digital imaging capabilities such as multi spectral, high-resolution camera systems and actuators, for field survey, crop scouting, spraying and spreading applications and surveillance in livestock and fisheries. Using the data captured through cameras mounted on drone and data analytics, farmers can precisely calculate their land sizes, classify crop types and varieties, develop soil maps along with pest management and properly plan the harvesting of their crops.

These drones can be fully automated to help further improve the scale of operation and productivity. Drones have found several applications in agriculture, however is limited by the country policies on its use context.

Use of drones can be advantageous in the case of pesticide spraying, replacing labour intensive and hazardous conventional methods particularly in difficult

areas such as hills.

4.16.2: Potentials and problems of using drones in agriculture

A. Potentials

1. **Soil analysis for field planning:** Drones can be used for soil and field analysis for irrigation, planting planning, and nitrogen level in soil. Along with this, drone is helpful to produce accurate 3-D maps that can be used to conduct soil analysis on soil properties, moisture content, and soil erosion.
2. **Seed pod planting:** Although invented just yet, some companies have come up with additional attachment below the drone systems able to shoot pod containing seed and plant nutrients into the already prepared soil. This is helping to reduce planting costs.
3. **Crop monitoring:** Crop monitoring is the biggest headache not only for farmers, but also various other others associated in agriculture operations. Drones can be used to set its monitoring routes by gathering datasets at pre-defined scales that relate to crop development and health.
4. **Crop spraying:** Drones can carry suitably sized reservoirs, which can be filled with fertilizers, herbicides, or pesticides for crop spraying on large areas in less time. Crop spraying is much safer and cost-effective by its autonomous and pre-programmed run on specific schedules and routes. Smart farms use drones for agriculture spraying, which reduces the contact of humans with fertilizers, pesticides and other harmful chemicals. Drones enhances spraying capacity up to five times faster than with traditional machinery.
5. **Irrigation:** Drones can help in planning timely irrigation to the identified areas with precision.
6. **Crop health assessment:** Drones fitted with sensors capable of scanning crops using visible and near infrared light can be used to track crop health over period of time and also to monitor response to remedied measures.
7. **Crop surveillance:** It is nearly impossible to estimate the overall state of

crops in large fields. Drones based agriculture mapping can help farmers remain area-wise updated on the plants status and point out which field areas require attention.

8. **Controlling weed, insect, pest and diseases:** Apart from soil conditions, drones can also detect and inform farmers about field areas inflicted by weeds, disease and insect pests. Based on this information, farmers can optimize the use of chemicals needed to fight infestations, hence reducing the expenses and also contribute to better field health.
9. **Tree/crop biomass estimation:** Crop/tree canopy density and distance from ground surface can be measured using ultra compact: Sensors mounted on drones. This enables estimation of the tree/crop biomass change derived from differential height measurements that forms basis for estimating timber production in forest and production estimates in crops like sugarcane.
10. **Scaring birds:** Birds are the major problem after sowing seeds of many crops. This needs labour to protect the field. A couple of drone flights can scare the birds away from field.

B. Problems and bottlenecks

- **Flight Time and Range:** Along with benefits, drones for agricultural use have some limitations. Due to relatively higher payloads, the flight duration of drones used in agriculture is short, ranging from 20-60 minutes. This results in limited coverage of land with every charge. The cost of drones increases significantly with longer flight time.
- **Initial Cost:** Mostly, agricultural drones used for surveying have fixed wings and may cost be costly based on features and sensors necessary for executing its intended use. Some drones are costlier as it includes cost of imaging sensors, software, hardware and tools. The initial cost is also proportional to the payload and flight duration capacities, apart from sensors and features included.

- **Connectivity:** Online coverage is mostly unavailable in the remote farms. Under such a situation, any farmer intending to use drones has to invest in connectivity or buy a drone with local data storing capability in a format that can be transferred and processed later.
- **Weather Dependent:** Under windy or rainy conditions, flying drones is not easy, and are weather dependent.
- **Knowledge and Skill:** An average farmer cannot analyze the drone images as it requires specialized skills and knowledge to translate it to any useful information. Under these circumstances, the farmer has to acquire the skills and knowledge of software of image processing or hire skilled personnel conversant with the analysis software.
- **Misuse:** There is a chance of misuse to infringe the privacy of people and illegal transfer of information.
- Trained skilled manpower is required to operate the drone.

4.16.3: Benefits, costs and saving in using drone

- **Security:** The agriculture sprayer drones are controlled from a distance by trained pilots. This process eradicates the involvement of farmers or farm labourers in direct contact with poisonous chemicals and adverse operational conditions.
- **High field capacity and efficiency:** Drones have very less turnaround time and other field operational delays. The drone can spray 50-100 acres per day depending upon the capacity of drone which is 30 times more than the traditional knapsack sprayer.
- **Wastage reduction:** Due to a high degree of atomization while spraying, 30% of pesticide is saved. Pesticides in the form of chemical fog can be sprayed at all levels of the crop.
- **Water saving:** Drone utilizes ultra-low volume spraying technology, thus saving 90% of water in comparison to traditional spraying methods.
- **Lower cost:** In comparison to conventional spraying methods, the cost of

drone spaying is reduced by 97%.

- **Easy to use and maintain:** The agricultural drone is made rugged. It has low maintenance cost, a long productive lifespan, and its parts replacement is simple, as and when required for the company offering drone services.

4.16.4: Deploying drone technology in agriculture

The modern farming industry is at a turning point. With the development of more advanced farm management techniques, such as precision agriculture, industry professionals now have more tools than ever to improve the accuracy and efficiency of processes.

The use of different types of agricultural drones for solving specific tasks of plant growing is being studied for developing electronic maps of fields, operational monitoring of crop conditions, evaluation of germination, predicting crop yields, checking the quality of ploughing, maintaining environmental monitoring of agricultural land, etc. During the last couple of years, drone market for agriculture has expanded considerably

4.16.5: Future use: There is a large capacity for growth in the area of agricultural drones. With technology constantly improving, imaging of the crops will need to improve as well. With the data that drones record from the crops the farmers are able to analyze their crops and make educated decisions on how to proceed given the accurate crop information.

Farmers will fly a drone over their crops, accurately identify an issue in a specific area, and take the necessary actions to correct the problem. This gives the farmer time to focus on the big picture of production instead of spending time surveying their crops. Additional uses include keeping track of livestock, surveying fences, and monitoring for plant pathogens.

4.16.6: Potentials and benefits of UAV drones for precision agriculture, farming, and crop management

1. A technology that has revolutionized agriculture from planting to harvesting (seeding, sensing, spraying, fertilizing, etc).
2. These drones are Low-cost, widespread available on demand, provide cost-effective monitoring platform, are easy to use, do not require expert operator.
3. It has solved time and cost problems with Satellite imaging and piloted aircrafts.
4. Information can be collected at resolutions measured in just centimetres per pixel.
5. It provides live data from a range of sensors (i.e., multispectral, NIR, Lidar, etc.).
6. These drones perform in-depth analysis of crop health, inventory management, etc.
7. These drones are flexible, both fixed-wing and multi-rotor models can be customized for functionality in different farming application

4.16.7: Affordable prices, low cost per flight

- Apply the optimal amount of any input (water, fertilizer, pesticide, fuel, labour) when and where it's needed to efficiently produce high crop yields.
- Create further sustainability in crops.
- High image detail: Fly over fields taking extremely detailed photos of crops.
- Analysing the crops to determine how healthy they are.
- Can provide thermal infra-red radiation, or TIR images to detect the water stress, disease, insect pests, and weeds.
- Can target a specific area for spraying application.
- Capable of creating three-dimensional maps of fields.
- Identify the nutrient deficiencies.
- Identify fertility levels of different parts of individual fields.

4.16.8: How drones are revolutionizing agriculture

- Unmanned aerial vehicles (UAVs), better known as drones, have been used commercially since the early 1980s.
- Today, practical applications for drones are expanding faster than ever in a variety of industries.
- Responding to the rapidly evolving technology, companies are creating new business and operating models for UAVs.

Among the most promising areas is agriculture, where drones offer the potential for addressing several major challenges.

1. Soil and field analysis

- Drones can be instrumental at the start of the crop cycle.
- They produce precise 3-D maps for early soil analysis, useful in planning seed planting patterns.
- After planting, drone-driven soil analysis provides data for irrigation and nitrogen-level management.

2. Planting

- Drone-planting systems that achieve an uptake rate of 75 percent
- Decrease planting costs by 85 percent.
- These systems shoot pods with seeds and plant nutrients into the soil, providing the plant all the nutrients necessary to sustain life.

3. Crop spraying from sky

- In commercial farming, it's often necessary to take to the skies to spray pesticides, drop seeds, or spot dying crops. Drones can drop a much more targeted load of pesticide than a traditional airplane could.
- Distance-measuring equipment, ultrasonic echoing and lasers such as those used in the light-detection and ranging, or LiDAR, method enables a drone to adjust altitude as the topography and geography vary, and thus avoid collisions.

- Drones can scan the ground and spray the correct amount of liquid, modulating distance from the ground and spraying in real time for even coverage.
- As for the result: increased efficiency with a reduction of in the amount of chemicals penetrating into groundwater.
- Experts estimate that aerial spraying can be completed up to five times faster with drones than with traditional machinery.

4. Crop and field monitoring

- Vast fields and low efficiency in crop monitoring together create farming's largest obstacle.
- Monitoring challenges are exacerbated by increasingly unpredictable weather conditions, which drive risk and field maintenance costs.
- Previously, satellite imagery offered the most advanced form of monitoring. But there were drawbacks. Images had to be ordered in advance, could be taken only once a day, and were imprecise.
- Further, services were extremely costly and the images' quality typically suffered on certain days.
- Today, time-series animations can show the precise development of a crop and reveal production inefficiencies, enabling better crop management.
- Fast Scouting: With drones' agility and speed, spot-checking the farm for damaged fences or diseased crops can take just minutes.

5. Irrigation

- Drones with hyperspectral, multispectral, or thermal sensors can identify which parts of a field are dry or need improvements.
- Once the crop is growing, drones allow the calculation of the vegetation index, which describes the relative density and health of the crop, and show the heat signature, the amount of energy or heat the crop emits.

6. Health assessment

- It's essential to assess crop health and spot bacterial or fungal infections on trees.

- By scanning a crop using both visible and near-infrared light, drone-carried devices can identify which plants reflect different amounts of green light and NIR light.
- This information can produce multispectral images that track changes in plants and indicate their health. A speedy response that can save an entire orchard.
- As soon as a sickness is discovered, farmers can apply and monitor remedies more precisely.
- Increase a plant's ability to overcome disease: in the case of crop failure, the farmer will be able to document losses more efficiently for insurance claims.

Practical Exercise

Activity 01: Make a neat sketch of solar pump.

Material required:

1. Pen
2. Notebook
3. Pencil
4. Eraser
5. Sharpener

Procedure:

1. First, take a permission from agriculture field owner.
2. Second, visit the field.
3. Then, identify the solar pump available in the field.
4. Identify the different parts of solar pump.
5. Make a list of solar pump name, model and sizes.
6. Write down their specification of solar pump.
7. Draw a figure of solar pump.

Activity 02: Make the sketches of drone.

Material required:

1. Pen
2. Notebook
3. Pencil
4. Eraser
5. Sharpener

Procedure:

1. First, take a permission from agriculture institute.
2. Second, visit the agriculture institute.
3. Then, identify the drone available in the institute.
4. Identify the different parts of drone.
5. Write down their specification of drone.
6. Draw a figure of drone.

Check Your Progress

A. Answer the following question

1. What is solar pump and make its block diagram?
2. How solar pump works, make a sketch of its working
3. What are the types of solar pumps available in market?
4. What are the advantages and disadvantages of a solar pump?
5. What are the major applications of a solar pump?
6. What is the drone?
7. Discuss the use of drone in agriculture sector?
8. How drones are revolutionizing in agriculture.
9. What are the role of deploying drone technology in agriculture?

B. Fill in the blank

1. The solar pump using a ..... energy system is an attractive technology with environmentally as well as socially for supplying the water in remote locations.

2. Submersible solar pumps can lift the water up to …….. feet and fit within a big well.
3. The required …….. of panels, as well as pumps, mainly depends on the requirement of pumping the water you wish to pump.
4. Drones can be ……. at the start of the crop cycle.
5. Drones can help in …….. timely irrigation to the identified areas with precision.

C. Multiple choice question

Column A	**Column B**
1. A technology that has revolutionized agriculture from planting to harvesting (seeding, sensing, spraying, fertilizing, etc).	**A. DC solar pump**
2. It is nearly impossible to estimate the overall state of crops in large fields.	**B. AC solar pump**
3. The motor used in this kind of pump works with direct current, thus there is no need for inverter or battery.	**C. UAV drone**
4. The motor used in this kind of pump works with AC, which means the DC generated by the panels gets changed to AC with the help of an inverter	**D. Crop surveillance**

UNIT 5: CUSTOM HIRING OF AGRICULTURAL MACHINERY

Agriculture is a way of life, a tradition that has affected the people of India's mentality, outlook, culture, and economic life for generations. As a result, agriculture is and will remain important to all initiatives for the country's intended socioeconomic development. Agriculture must expand rapidly not merely to attain national self-sufficiency, but also to provide family food security.

SESSION 01: CUSTOM HIRING

5.1 What is Custom Hiring?

Custom hiring is the evolving concept in India and holds an immense potential to change the farm mechanization scenario in India. Average operational land holding size in India is estimated at 1.16 ha. About 85% of the land holdings are operated by marginal and small farmers owning less than 1 ha and 1 to 2 ha holdings, respectively. These farmers are usually unable to invest in costly farm machinery and depend on hiring of implements to carry out agricultural operations in their farms. With continued decrease in average farm size, more farms will fall into the adverse category thereby making individual ownership of agricultural machinery increasingly uneconomical.

In rain fed areas (Annual rainfall <500 mm), the scope for conducting land preparation, sowing and inter-culture operations in time is narrow. Failing to exploit this limited opportunity often leads to decline in productivity, production and input use efficiency in crop production. In high rainfall areas or areas dominated by heavy soils, drainage is more crucial to prevent damage to crop from excess soil moisture in the root zone especially in pulses, oilseeds and cotton. Labour shortage at peak times of demand is a serious problem faced by farmers. Therefore, the mechanization of agriculture has become important for increasing agricultural production and productivity by efficiently and effectively utilizing scarce resources and costly farm inputs improving timeliness, and

reducing labour cost and human drudgery.

Several options are now available to increase the efficiency and timeliness of agricultural operations even on small farms through the use of farm machinery on custom hiring basis. Custom hiring services bridges this gap by connecting these farmers with tractor and equipment owners. The Custom Hiring Centres (CHCs) offer farm equipment and machineries on rental basis to farmers who cannot afford to purchase agricultural machineries and equipment. The CHCs play a pivotal role in introducing high technology agricultural machinery to even small farmers with the objective to boost crop production, improve quality, timeliness and efficiency of agriculture operations.

Custom hiring enables farmers to rent the appropriate equipment, often along with someone to operate it, for a defined period of time only, thus only paying for the services of the machine without having to own it. Often, an operator of the machinery will also be included in rental. The tariff may be charged by the hour, or, in some cases, by area harvested. Usually, the owner of the machinery is responsible for maintenance and major repairs; farmers are only responsible for minor repairs in the field.

Custom hiring can be defined as providing hiring services for various crop specific machines applied for different operations to small and marginal farmers, as per their demand, by setting up own centre and marketing of machine availability.

The Custom hiring model holds the potential to be the best way to introduce high capacity, high quality and sophisticated farm machines to the small farmers in India. The Custom Hiring model enables new machines to be used at their maximum capacity and enables farmers to gain access to latest technology they would otherwise not be able to afford. Custom Hiring can significantly facilitate diversification in agriculture specifically from wheat and paddy to other crops. However, Custom Hiring through private entrepreneurs or co-operatives will help to increase annual use of these equipment thereby making them viable. As the small/marginal holdings constitute 80% of total land holdings in India, the potential for CHCs which will cater to the farm

machinery requirement of such a vast area, is quite huge.

5.1.1: Different models of custom hiring services of agricultural machinery

1. Individual farmer lending
2. Farmers group purchased machineries
3. Co-operatives managed
4. Traders implemented
5. Individual entrepreneur operated
6. NGO supported
7. Govt. supported centres (PPP)

"Custom hiring is the only practical way to introduce high cost, high quality mechanization to the small farming structures prevalent in India".

5.2: Benefits of custom hiring

Custom hiring has been helpful to bring about a significant improvement in agricultural productivity, because of mechanization of agricultural operations. The timeliness of operations has resulted in obtaining optimal yields from different crops, which has been possible by way of mechanization through custom hiring.

For instance, the sowing of wheat is done up to the first fortnight of November. A delay beyond this period by every one week leads to about 1.50 quintals per acre decrease in the yield. This is also correct in the case of other crops and for other farm operations like weeding, irrigation, harvesting, threshing and marketing which need to be performed at appropriate time otherwise the yield and farm income is affected adversely.

Secondly, the quality and precision of the operations are equally significant for realizing higher yields. The various operations such as land leveling, irrigation, sowing and planting, use of fertilizers, plant protection, harvesting and threshing need a high degree of precision to increase the efficiency of the

inputs and reduce the losses. For example, sowing of the required quantity of seed at proper depth and uniform application of given dose of fertilizer can only be possible with the use of proper mechanical devices. When such operations are performed through indigenous methods, their efficiency is reduced.

Thirdly, the time taken to perform sequence of operations is a factor determining the cropping intensity. Tractor operated and self-propelled equipment which have higher output capacity and cut down the number of operations to be performed. This has helped in increasing area under cultivation and increase in cropping intensity.

Higher productivity of land and labour is another factor, which clearly justifies use of improved equipment. Not only the output per hour is more, the total labour requirement is also reduced. Farmers who used the combined harvesters took 45 minutes to harvest, thresh and pack wheat in an acre, which otherwise takes a week and 15 labour days.

The performance and economics of latest agricultural machinery used by the small and marginal farmers has made it possible. The custom hiring is a major factor in farm mechanization in various states across the country.

5.2.1: Advantages of custom hiring centres can be summarized as following:

a) Provides access to small and marginal farmers to costly farm machinery.
b) Farmers who cannot afford to purchase costly machineries and equipment, can use the same on rental basis by paying nominal charges.
c) Facilitates timeliness in farm operations.
d) Availability of tractors, power tillers, irrigation pumps, harvesters and threshers helps in carrying out all agricultural operations at right time.
e) Improves efficient use of inputs: Excess use of Inputs like seeds, fertilizer, chemicals and water is avoided.
f) Reduces drudgery: Tedious and tiresome agricultural operations can be done comfortably without much labour.
g) Promotes increase in cropping intensity wherever feasible: More number

of crops can be grown and managed in a year.

h) Reduction in cost of cultivation: Reduced requirement of inputs and labour reduces the expenditure.

i) Employment and livelihood generation: Increased cropping intensity and production will correspondingly increase man-power requirements for production and post-harvest operations, open up various livelihood opportunities and provide work opportunities to skilled labour and small artisans.

j) Full utilization of farm products and by-products: Availability of machines allow the processing of farm products and by-products.

k) Reduction in losses: Development of harvesting, threshing and processing machines reduce harvest and post-harvest losses (Rice: 10-37 per cent, Maize: 30 per cent reduction).

l) Increases productivity and production: Improved timeliness and increase in cropping intensity facilitate higher productivity and production.

m) Increases value addition of farm products: Secondary and tertiary processing opens up market potential and leads to higher retail prices.

n) Higher income for farmers: Reduced cost of production, higher productivity and production and increased value addition fetches more income for farmers.

Table 5.1: The table below gives a snapshot of change in various farming practices before and after the introduction of custom hiring services:

Farming/Agricultural Operation	**Old Practice**	**New Practice**
Ploughing and seedbed preparation	• MB ploughs and cultivators were used. It ploughs the land to shallow depth	• Reversible MB ploughs and rotavators are used for ploughing and seedbed

	only. The land retained less water & land was not flattened after sowing.	preparation, which ploughs the land deep, mixes the soil better, allowing it to retain more water and give smooth and flattened seedbed facilitating higher germination.
Seed treatment	• Treatment of seeds and mixing with fertilizers were done by hands.	• Seed treatment drums are used for chemical treatment and proper mixing of seeds with fertilizer.
Sowing	• Manual broadcasting of seed and fertilizer or seed drills (with fertilizer mixed) were used.	• Sowing is done using seed cum fertilizer drill, allowing separate placement of seed and fertilizer. Modern techniques like raised bed planting & ridge-furrow sowing are also used.
Weeding and intercultural	• Manual weeding with hand held	• Chemical weeding is done using

	khurpi or chemical weeding with shoulder mounted sprayer, which is highly time consuming because of very low field capacity.	tractor mounted sprayer pumps which gives very high field capacity. • Small tractors (15-20 hp) having narrow tyres are used for mechanical weeding.
Harvesting	• Manual harvesting, Highly labour intensive, time and cost consuming.	• Self-propelled reapers and reaper-binders cuts and bundles crops. It saves time and there is less wastage.
Threshing	• Manual threshing devices and small power threshers. Much dependency on availability of electricity and weather uncertainty too. Also labour intensive, time and cost consuming.	• Tractor drawn mechanized multi crop threshers are used. It reduces time and cost and also reduces dependency on availability of electricity and weather uncertainty is also minimized with timeliness in

		threshing operation. • Accidents have also reduced due to use of safe and automatic feeding type threshers.
Straw management	• Crop/Straw stubbles were burnt to prepare the field for subsequent crops and operations.	• Straw is fully recovered from the field using straw reapers which fetches extra income to the farmers. • Instead of burning, crop stubbles, it is buried well into the soil using rotavator, which improves the soil health.

5.3 Selection of machines for custom hiring

Choosing the right agricultural machinery is essential for a custom hiring service centre to successfully operate the business. Providing required machinery to the farmers to fulfil his demand and at the same time earning profit, are the key factors for the custom hiring business to survive and to create a win-win situation for the farmers' and the business both.

Selection of farm equipment and machines should be in a compatible way with all the farming needs of the area where the custom hiring centre shall be

operating. For example, a harvester should be chosen as per the type of crop grown in the area, and a plough should be chosen as per the soil type. Choosing the right farm machinery offers multiple benefits like saving on operational expenses, generating more profit, and growing more crops with lesser efforts.

5.3.1: Major points to choose the right agricultural machinery

- Land size of the farmers.
- Soil type of the area where the machinery is to be operated.
- Availability of repairing facility or service center
- Considering the resale value
- Brand and model name
- Check the machine design
- Test reports of the machines, and human comfort.

1. **Land size**: A larger machinery would be needed for on-time completion of various agricultural tasks in a bigger size of land. So a CHC should give due consideration to the land area to be served through their enterprise. If the land area is more and the machine is small, the CHC may not be able to serve the area available. On the other hand, if the machine is big and the area is small, the machine will remain underutilized and that will be a loss.
2. **Soil type**: Before buying any farm machinery one should be well aware of the type of the soil in the area. The soil resistance varies in different soil conditions. It is high in heavier soil and low in lighter soil. An implement which can give a desired depth of operation in lighter soil at certain given speed will not be able to do the same quantum of work in the same period in heavier soil. In other words, a machine capable of performing in time for a specified size of field in lighter soil will not be able to do so in heavy soil for the same size of field. Further, the tilth for heavier soil is achieved

later than the lighter soil, which means in any season total number of working hours available for heavier soil will be less than the lighter soil. It indicates that a bigger and strong machine will be more suitable for heavier soil as compared to a same size field of lighter soil.

3. **Type of crops:** Before buying any farm machinery one should also be well aware of the type of the crops grown in the area. Especially, different sowing and harvesting equipment are needed for different crops. For instance, seed drill or planter requirement for sowing wheat, gram, soybean etc. would be different than planter for sugarcane or paddy. Similarly, the harvester requirement for wheat, paddy, soybean would be different than harvester for maize and sugarcane. So considering this, the machinery should be purchased according to the cropping practices prevailing in the area.
4. **Availability of repairing facility or service centre**: It is also essential to make sure that the machinery service centre of the manufacturer or farm machinery brand is available nearby. Factors like; whether the machine is repairable or not, how far is the service station or existence of repair shop, whether components of machine are easily available, how easily the repair can be done, should be given importance to avoid problems at the crucial time of farming operations.
5. **Quality of machine:** Do not make a quick decision about a machine looking at its external appearance only. To avoid any hassle related to parts or servicing availability, consider buying a farm machine from a reputed brand in the agriculture market. Find the latest technology models with the best features, compare with other brands and chose any equipment as per your needs.
6. **Resale value of machinery**: Before making a purchase decision, also consider the resale value of the machinery, as this will affect the profitability of the CHC.
7. **Ease of operation for long working hours:** The selected machine should not need excessive labour and energy to operate. The adaptability to

multiple tasks and long working hours is an important point to consider when buying a farm machine. Select the machine or tool which can work under a wide range of conditions. It must be easy to adopt the equipment to different soil, crop and environmental conditions. Methods and provisions for adjustments of various parts, and adjustment should be easy to make and less time consuming.

8. **Whether or not the machine is an approved design:** Always select a machine which is tested by an authorized testing centre of Govt. of India and a test report is available as per BIS (Bureau of Indian Standards) or ISO (International standard organization) mark.
9. **Human comfort:** Human comfort is an important factor in the selection and operation of equipment. All the controls must be comfortable, stable and adjustable to suit different sized individuals. There should be proper operator safety provisions.

Practical Exercise

Activity 01: Make a list of custom hiring centre in India.

Material required:

1. Pen
2. Notebook

Procedure:

1. First, visit the website of agriculture department.
2. Second, identify the location of custom hiring centre located in your area.
3. Make a list of custom hiring centre.

Activity 02: Visit the farmer field.

Material required:

1. Pen

2. Notebook
3. Pencil
4. Eraser
5. Sharpener

Procedure:

1. First, take a permission from farm owner.
2. Second, ask the farmer for agricultural operation.
3. Then, identify which farming practices are followed by the farmer in their field/farm.
4. Make a list of farming agricultural operation which done by the farmer.
5. Write down their name and application.

Activity 03: Make a list of selection criteria of right agricultural machinery.

Material required:

1. Pen
2. Notebook

Procedure:

1. First, take a permission of owner of agricultural machinery shop.
2. Second, identify the work in which you want to use the machine.
3. Make a list of selection criteria of right agriculture machinery.
4. Write down their name and specification.

Check Your Progress

A. Answer the following question

1. What do you mean by custom hiring in agriculture?
2. What benefit should be provided by the custom hiring centre to the farmer?
3. Write the difference between old practice and new practice of agricultural operations.
4. How you can select the correct agricultural machinery for your field.

B. Fill in the blank

1. Average operational land holding size in India is estimated at ..... ha.
2. Labour shortage at ..... times of demand is a serious problem faced by farmers.
3. Human comfort is an important factor in the ..... and ..... of equipment.
4. Higher ..... of land and labour is another factor, which clearly justifies use of improved equipment.
5. Custom Hiring can significantly facilitate ..... in agriculture specifically from wheat and paddy to other crops.

C. Match the following

Column A	Column B
1. It is a part of the engine which confines the expanding gases and forms the combustion space.	**A. Custom hiring**
2. It enables farmers to rent the appropriate equipment, often along with someone to operate it.	**B. Chemical**
3. This weeding is done using tractor mounted sprayer pumps which gives very high field capacity.	**C. Human comfort**
4. It is an important factor in the selection and operation of equipment.	**D. Cylinder**

SESSION 02: CUSTOM HIRING AND SELECTION PROCEDURE

Agriculture mechanisation improves agricultural output and productivity through improving timeliness, better input management, improving work quality, and lowering post-harvest losses. Farm machinery is growing increasingly expensive, and maintaining it is becoming increasingly complex. As a result, the trend of individual farmers acquiring farm machinery is shifting to groups of individuals or those with the financial means to do so. The decision to develop a farm machinery custom hiring centre is not only tough, but also a wise one, based not just on cost and economic considerations, but also on other factors.

5.4: Suitable farm machinery and equipment for custom hiring

A custom hiring centre should be equipped with a complete set of general-purpose farm machines along with the prime mover and the operator, which can be made available to the small and marginal farmers on rental basis. This is helpful to serve the need of the farmers for conducting various field operations from tillage to threshing, in different crops as per the requirement.

Table 5.2: Following equipment are commonly available for conducting various agricultural operations:

Agricultural Operation	Equipment Available
• **Tillage and Land Preparation**	• MB Plough, Reversible MB plough, Rotavator, Cultivator, Disk harrow and Dozer.

• **Sowing**	• Seed drill, Seed-cum-fertilizer drill, Zero-Till drill and Happy seeder.
• **Planting**	• Raised-bed planter, Potato planter, Garlic planter and Sugarcane cutter planter.
• **Transplanting**	• Rice transplanter.
• **Plant Protection**	• Tractor operated sprayers (high capacity).
• **Harvesting**	• Reaper, Self-propelled Reaper-cum-binder and Combine harvester.
• **Threshing**	• Thresher (High Capacity-Hadamba), Paddy thresher and Maize thresher.
• **Straw management**	• Straw reaper, baler and raker
• **Post-production**	• Cleaner-cum-grader (Power operated), Manual spiral grader, Mini dal mill, Mini rice mill and Mechanical oil expeller.

5.4.1: Different farm machinery and equipment suitable for custom hiring

1. **Mold Board Plough:** All the custom hiring should have a tractor drawn mouldboard plough for deep tillage operation during summer season. The most popular type of plough is two-bottom reversible type for better field capacity and efficiency. This equipment is preferably used with tractor mounted front-dozer for simultaneously levelling the field.

Fig. 5.1: Tractor drawn 3-bottom reversible plough

Particular	Description
• Sizes available	• 1-3 Bottom
• Average price MB plough (2-3 bottom) Reversible plough (2-3 bottom)	• 27,500 (17000 - 45000) • 78,033 (49,500 -1,25,000)
• Annual use in hour(hr)	• 100-200

2. **Rotavator:** A wide range of tractor operated rotavator of varying width ranging from 4 feet to 8 feet is available. However, the rotavator with 6 feet width is the most popular one. Many entrepreneurs procured more than one rotavator in their centre.

Fig. 5.2: Tractor operated rotavator

Particular	Description

• Sizes available	• 4-8 feet
• Average price MB plough (2-3 bottom) Reversible plough (2-3 bottom)	• 1,10,000 (75,000-1,44,000)
• Annual use in hour(hr)	• 100-500

3. **Cultivator:** Cultivator is another popular secondary tillage equipment available with the custom hiring entrepreneurs. They are either shovel type (7-11 tyne) or duckfoot type (5-9 tyne) depending upon the prevailing soil type.

Fig. 5.3: Tractor drawn 9-tyne cultivator

Particular	Description
• Sizes available	• 7-13 Tynes
• Average price in rupees	• Cultivator = 35128 • DF Cultivator = 38978
• Annual use in hour (hr)	• 100-300

4. **Land Leveller:** Tractor operated six to eight feet wide land levellers, both front and back mounted types are also in use in some of the selected custom hiring enterprises. Tractor operated front mounted hydraulically controlled levellers are more popular being used simultaneously during ploughing by mouldboard plough.

Fig. 5.4: Land leveller

Particular	Description
• Sizes available	• Front dozer = 6 - 8 feet • Back dozer = 6 - 7 feet
• Average price in rupees	• Front dozer = 75136 • Back dozer = 22500
• Annual use in hour (hr)	• 100-250

5. **Disc Harrow:** Disc harrow is suitable for secondary tillage operation in lighter soils.

Fig. 5.5: Tractor drawn disk harrow

Particular	Description
• Sizes available	• Disk harrow = 12-18 disks
• Average price in rupees	• Disk harrow = 72,500
• Annual use in hour (hr)	• 100-300

6. **Sowing Equipment:** The most commonly available seeding equipment is tractor operated seed-cum-fertilizer drill (9-11 rows) and seed drill (9-13 rows). However, use of tractor operated zero till drill (11-13 rows) and

happy seeder is also gaining popularity among farmers.

(A) (B) (C) (D)

Fig. 5.6: A. Seed Drill, B. Seed-cum-fertilizer Drill, C. Zero Till Drill, D. Happy Seeder

Particular	Description
• Sizes available	• Seed drill = Mostly 11 row (9-13) • Seed-cum-fertilizer drill = Mostly 9 or 11 row • Zero till drill = 11-13 row • Happy seeder = 7-11 row
• Average price in rupees	• Seed drill = 35000-45000 • Seed-cum-fertilizer drill = 45000-60000 • Zero till drill = 45000-55000 • Happy seeder = 1.5-2.5 lakh
• Annual use in hour (hr)	• Seed drill = 100-250 • Seed-cum-fertilizer drill = 100-250 • Zero till drill = 100-150 • Happy seeder = 100-150

7. **Planting Equipment:** Crops like maize, gram, soybean, pigeon pea and vegetable crops are planted on raised beds. Planting on raised beds improves yield, increases fertilizer use efficiency, better weed management and irrigation water. Bed planting technique is gaining acceptance by farmers because of higher profit.

A. **Sugarcane planter:** A sugarcane planter cuts the sugarcane and feeds into furrow as well as feeding of fertilizer and spraying pesticide is done automatically.

B. **Potato planter:** Potato planting in large parts of the country is done manually which results in varying and non-uniform plant stand, requires large labour force in field preparation and planting. Good business can be made if custom hiring centre (CHC) own a mechanical potato planter.

(A) **(B)** **(C)**

Fig. 5.7: A. Potato planter, B. Sugarcane cutter planter, C. Raised-bed planter

Particular	Description
• Sizes available	• Raised-bed planter: 2-3 row • Sugarcane cutter planter: 2-3 row • Potato planter: 2-4 row
• Average price in rupees	• Raised-bed planter: 0.8-1.0 lakh • Sugarcane cutter planter: 0.8-1.5 lakh • Potato planter: 0.8-1.5 lakh
• Annual use in hour (hr)	• Raised-bed planter: 100-200 • Sugarcane cutter planter: 100-200 • Potato planter: 100-200

8. **Transplanter:** A transplanter is a specialized transplanter used to

transplant seedlings onto paddy field. Rice transplanter can be a good equipment to be owned by custom hiring centre (CHC), as machine transplanting using rice transplanters requires considerably less time and labour than manual transplanting. It increases the approximate area that a person can plant from 700 to 10,000 square metres per day.

(A) **(B)**

Fig. 5.8: A. Walking type transplanter, B. Riding type transplanter

Particular	Description
• Sizes available	• Walking type transplanter: 4-6 rows • Riding type transplanter: 6-8 rows
• Average price in rupees	• Walking type transplanter: 3.5-4.5 lakh • Riding type transplanter: 6-8 lakh
• Annual use in hour (hr)	• Walking type transplanter: 100-150 • Riding type transplanter: 100-250

9. **Thresher:** The custom hiring entrepreneurs procure different types of power operated thresher depending on prevailing cropping pattern in their areas. The most popular ones are tractor PTO driven 25-35 hp multicrop (*Hadamba*) thresher. Apart from this, specialized thresher for paddy and maize are also available in major production areas of these crops. Electrically motor operated threshers are not much popular due to

uncertainty of power supply.

(A) **(B)**

Fig.5.9: A. Tractor operated multicrop thresher,
B. Tractor operated paddy thresher

Particular	Description
• Sizes available	• Hadamba (Multicrop), Paddy, Maize - 25 hp and 35 hp
• Average price in rupees	• 1.8-2.5 lakh
• Annual use in hour (hr)	• 100-300

10. **Tractor Trolley:** Each custom hiring centre should have one or more trolley for transport of produce and byproducts to the clients' premises and markets as well. The trolleys are mostly two wheeled with hydraulic lifting mechanism for easy loading and unloading of goods. Special metallic top covers are also common for collection and transport of *bhusa* while using in pair with straw reaper.

Fig. 5.10: Tractor trolley

Particular	Description
• Sizes available	• Two wheel and four wheel • 6-8 feet
• Average price in rupees	• 1.5-2.5 lakh
• Annual use in hour (hr)	• 250-500

11. **Straw Reaper:** The use of straw reaper for recovering of leftover straw after combine harvesting of *Rabi* cereals (mainly wheat) is gaining popularity at a faster pace. This is not only helpful for obtaining wheat *bhusa* (chaffed straw) as cattle feed but also helpful for solving the menace of straw burning after combine harvester operation, which has become extremely hazardous for environment. This is also one of the most revenue generating activity. The commonly available straw reapers are fitted with 56 to 61 inches' cutter-bar and supported by another tractor-trolley pair for collection and transport of chaffed straw to designated place for storage.

Fig. 5.11: Straw reaper

Particular	Description
• Sizes available	• 56 – 61 inch cutter bar
• Average price in rupees	• 2.7-3.5 lakh
• Annual use in hour (hr)	• 250-500

12. **Other Equipment:** Depending upon the prevailing soil conditions and cropping systems followed, few more selected equipment can be adopted for planting of horticultural crops, conducting operations in orchards, harvesting and residue handling. Power tillers can be used for orchard operations for about 225-300 hours per annum. For harvesting operations, self-propelled walk behind reapers, reaper binders and tractor operated reapers are very suitable.

(A) **(B)** **(C)**

Fig. 5.12: A. Power tiller, B. Tractor operated reaper, C. Self-propelled reaper binder

Particular	Description
• Sizes available	• Power tiller = 12-18 hp • Tractor operated reaper = 2 m cutter bar length • Reaper binder = 10 hp
• Average price in rupees	• Power tiller = 1.25-2.0 lakh • Tractor operated reaper = 0.6-0.8 lakh • Reaper binder = 3.0-3.5 lakh
• Annual use	• Power tiller = 225-300

in hour (hr)	• Tractor operated reaper = 100-250 • Reaper binder = 100-250

5.5: Selection of tractor for custom hiring

The selection of proper tractor and its matching implements has now become more difficult than ever before. More than 75 models of tractors ranging from 20 to 75 hp have put up a number of questions in front of the buyers. Tractor dealers, bankers, relatives, etc. may also influence their decision and choice.

The selection of tractor should result in increased efficiency of operations, less operating costs, and optimum use of capital on fixed costs. Tractor selection should be made on the basis of following criteria:

A. PRIMARY CRITERIA

a. **Size of land holding;** Among the primary criteria of the tractor selection, the size of land holding is very important. Sometimes it happens that a very high horsepower tractor is purchased which remains underutilized causing financial loss in terms of depreciation and interest. Whereas on the other hand, a low horsepower tractor may not be able to complete the work in time and the very purpose of procuring a tractor is defeated. But land holding alone is not a deciding factor, it has its impact along with the types of operations needed.

b. **Type of operation:** The tractor is used for various field operations starting from land preparation to sowing, harvesting, threshing and transportation work. Of these operations, some are difficult and the output in terms of hectares per hour is less than others. Therefore, it is always recommended that while determining the power of the tractor we should consider the field operation which is toughest and time consuming. Normally it is primary tillage operation i.e. ploughing. The highest power requirement in any one operation will be the limiting factor for computation of power requirement of a tractor.

c. Type of soil: The soil resistance varies in different soil conditions. It is high in heavier soil and low in lighter soil. An implement which can give a desired depth of operation in lighter soil at certain given speed will not be able to do the same quantum of work in the same period in heavier soil. In such a case either the speed is to be reduced to allow the tractor to be capable of pulling the load at the desired depth or the depth is to be reduced. In other words, a tractor capable of performing all operations in time for a specified size of field in lighter soil will not be able to do so in heavy soil for the same size of field. The speed and the draft requirement for different field operations in different soil conditions are given in Table 5.3.

Further, the tilth for heavier soil is achieved later than the lighter soil, which means in any season total number of working hours available for heavier soil will be less than the lighter soil. It indicates that a higher power tractor will be more suitable for heavier soil as compared to a tractor needed for same size field of lighter soil.

The implement must be pulled at the proper speed to get optimum performance. High speed operation may cause poor seed placement or soil damage. Low speed operation may cause transmission damage or poor weed kill / soil disturbance.

d. Working time available: The time available for completing a particular field operation is an important factor in deciding the power range of a tractor. If more than one crops are taken in a year, the time available after harvesting of one crop and the seedbed preparation for the second crop will be calculated based on past records. While calculating availability of time, one should refer at least last 4-5 years' record and consider the year in which worst weather situation was prevailing and thus obtain number of calendar days available for various field operations.

Even the calculated period will not be really available for continuous field operation due to unforeseen reasons viz., break-down, non-availability of

man-power, sudden weather interruptions, fatigue, etc. Available working hours depend on timeliness, labour, transportation, maintenance and refueling. There should be provision to allow time to cart and fill seed and fertiliser and re-fuel etc. However, experience reveals that at the most 80% of the available time is spent in field.

In addition to above, field efficiency of the tractor implement combination is only 70 to 80%, which means only 70-80% of operational time is actually utilized in field use and the rest for making headland turns, etc. The field efficiency allows for losses in both time and area covered due to overlapping, filling operations, turning and cutting out corners, making adjustments, changing operators and so on.

Table 5.3: Draft, recommended speed and field efficiency for various implements/equipment

Implements/equipment	**Draft per metre of width, kg**	**Typical speed, km/h**	**Field efficiency, %**
M B plough (200 mm depth)			
Heavy clay soil	1600	4.5	80
Heavy soil	1400	5.0	80
Medium soil	1050	5.0	80
Light soil	700	6.0	80
One way disc plough			
Heavy soil	600	6.0	80
Medium soil	450	6.0	80
Light soil	300	6.0	80
Offset or heavy tandem disc harrow			
Heavy soil	600	6.0	80
Medium soil	500	6.0	80
Light soil	380	6.0	80

Implements/equipment	Draft per metre of width, kg	Typical speed, km/h	Field efficiency, %
Duck foot cultivator			
Heavy soil	450	6.0	80
Medium soil	300	6.0	80
Light soil	150	6.0	80
Seed drill			
Heavy soil	150	5.0	70
Medium soil	90	5.0	70
Light soil	50	5.0	70
Planter			
Heavy soil	175	5.0	70
Medium soil	150	5.0	70
Light soil	180	5.0	70

B. SECONDARY CRITERIA

Once the power range of the tractor is decided, to select a better tractor from the tractors available in the market within the range, it is necessary to give due weightage to the tractor having following plus points.

a. **Number of gears and gear ratio**: A tractor may be selected having more number of gears and gear ratio spaced in such a way that any part of the drawbar pull within its maximum range can be obtained at a comparatively higher speed.

b. **Running cost**: The running cost is another major factor to be considered. Now, when diesel is becoming scarce and costlier, it is necessary that a tractor with less specific fuel consumption should be preferred over others. The BIS has decided to specify the maximum SFC limit of tractors for pto. It varies from 190 g/bhp-h for 50 hp tractor to 210 g/bhp-h for 25 hp tractor. It may also be possible that a tractor may be consuming less diesel

but at the same time its maintenance and repair cost may be very high. Thus, the advantage of low fuel consumption will be nullified as a result of high maintenance cost. The opposite is also possible and under such condition other factors should also be given due weightage. A tractor normally requires major repair after 2000 to 3000 hours of operation and therefore, cost of diesel and lubricants consumption during this period should be compared with that of repair cost to finalize the purchase.

c. **After-sale service and repair facilities**: Before finalizing the purchase of a tractor, it is good to look into the availability after-sales-service facility. It is an open fact that agricultural operations are time bound and in case the spares and the repair facility required in season are not available at hand or near the region, even a tractor having comparatively low running cost may be sacrificed in comparison to the other backed up by an efficient after sale service facility.

d. **Other miscellaneous considerations**: In case the tractor is required to be used for puddling operations, its suitability to be used under wetland operation can be considered as one of the important criteria for its selection.

i. The tractor having provision of automatic draft control system should be preferred over the one having only depth control system.

ii. Lower turning radius helps to minimize loss of time on headland turns, thus increasing field efficiency.

iii. The ergonomically aspects, viz. tractor workplace layout, noise and vibration etc. should also be considered in the selection of tractors which ultimately help in increasing output.

iv. Tractor fitted with telemetry and GPRS will be more suitable for custom hiring operation, because then Signal of its operation and some engine parameters will be sent through SMS during the operation of tractor in remote areas. This data may be useful for better management of tractor fleet.

5.6: Components of cost analysis for custom hiring

Learning to determine the cost of operation of agricultural machinery and equipment is most important and crucial task for the custom hiring service provider. Tractors and machinery are major cost items in farm businesses. Larger machines, new technology and higher energy prices have all caused machinery and power costs to rise in recent years. However, a skilled custom hiring service provider can control machinery and power costs by acting as per the requirement. Making smart decisions about how to acquire machinery, when to trade, and how much capacity to invest in, can reduce machinery costs by as much as 10-20%. Making smart decisions require accurate estimates and calculation of cost of operation.

1. Cost Estimation: Farm machinery/tractor costs can be divided into two categories:

- **Annual ownership costs** (also called fixed costs), which occur regardless of machine use, and this includes depreciation, interest, taxes, insurance, and housing and maintenance facilities.

- **Operating costs** (also called variable costs), which vary directly with the amount of machine use and this includes repairs and maintenance, fuel, lubrication and operator/labor cost.

The true value of these costs is not known until the machine is sold or worn out. But the costs can be estimated by making a few assumptions about machine life,

annual use, fuel and labor prices.

A. Fixed Costs: Fixed cost can be defined as the cost which is incurred whether the machine is used or not used. The components of fixed cost include depreciation, interest on investment, taxes, insurance, housing and maintenance facilities.

i. Depreciation: Depreciation means a reduction in the value of an asset over time, due to wear and tear in particular. Therefore, depreciation is a cost resulting from wear, obsolescence, and age of a machine. The degree of mechanical wear may cause the value of a particular machine to be somewhat above or below the average value for similar machines when it is traded or sold. The introduction of new technology or a major design change may make an older machine suddenly obsolete, causing a sharp decline in its remaining value. But age and accumulated hours of use are usually the most important factors in determining the remaining value of a machine.

Before an estimate of annual depreciation is calculated, an economic life for the machine and a salvage value at the end of the economic life need to be specified. A good rule of thumb is to use an economic life of 10 to 12 years for most farm machines and a 15-year life for tractors, unless it's known that machine will be traded sooner.

Salvage value is an estimate of the sale value of the machine at the end of its economic life. It is the amount expected to receive as a trade-in allowance, an estimate of the used market value if expected to sell the machine outright, or zero if plan is to keep the machine until it is worn out. Salvage value (SV) is 10 % purchase price (PP) of the machine. The annual depreciation value can be calculated by:

$$D = \frac{PP - SV}{L}$$

Where,

D = average annual depreciation, Rs. /year

PP = purchase price, Rs.

SV = salvage value, taken as 10% the purchase price

L = life of machine, years

ii. Interest on Investment: Interest on investment (IOI) is the charge for the use of the money invested on the machine regardless of whether the money was borrowed or not. After depreciation, a large cost component of agricultural machinery is the interest. It is a direct expense item on borrowed capital. Even if cash is paid for purchased machinery, money is tied up that might be available for use elsewhere in the business. Interest rates vary considerably but usually are between 8 to 12 percent. Annual interest is calculated on an average investment by using the prevailing interest rate by the following formula:

$$I = \frac{PP + SV}{2} \times \frac{i}{100}$$

Where,

I = annual interest charge, Rs. /year

PP = purchase price, Rs.

SV = salvage value, Rs.

i = interest rate, per cent

iii. Taxes, insurance, and housing (TIH): Taxes are sometimes collected in some places when the machine has to be registered with the local government. Insurance is the cost of protecting the machine and shelter against accidents and theft. Housing or Shelter is provided to protect the machinery from theft and adverse weather conditions, to make repair work easier and to improve the appearance of the farm.

These three costs are usually much smaller than depreciation and

interest, but they need to be considered. There are no taxes on ownership of farm machinery but recently taxes are put on tractor. Insurance should be carried on farm machinery to allow for replacement in case of a disaster such as a fire or accident. If insurance is not carried, the risk is assumed by the rest of the farm business. There is a tremendous variation in housing provided for farm machinery. Providing shelter, tools, and maintenance equipment for machinery will result in fewer repairs in the field and less deterioration of mechanical parts and appearance from weathering. That should produce greater reliability in the field and a higher trade-in value.

An estimated charge of 1.0-2.0 % of the purchase price is suggested for taxes, insurance and housing costs.

2. Total ownership cost: The estimated costs of depreciation, interest, taxes, insurance and housing are added together to get the total annual/yearly ownership cost. If the tractor/Machinery is used 400 hours during the year, the total ownership cost per hour would be: Annual Ownership cost/hours used per year.

1. **Operating Cost (Variable Cost):** Operating cost also known as variable cost can be defined as the cost which is incurred when the machine is put to use. If the machine is not used, the variable cost will be nil. Therefore, it varies directly with the amount of machine use and this includes repairs and maintenance, fuel, lubrication and operator/labor cost.

i. **Fuel:** Fuel costs can be estimated in two ways. One method is that how many drums of diesel are consumed in a year. The total numbers of litres can be divided by 400 hours and per hour diesel consumption of tractor can be calculated. If fuel meter is attached with the tractor fuel line then exactly for each operation, fuel consumed per hour can be measured.

Average fuel consumption (in litres per hour) for farm tractors on a year-round basis without reference to any specific implement can also be estimated with these equations:

0.15 x maximum PTO horsepower for diesel engines

For our 50-horsepower diesel tractor example: Average diesel fuel consumption = 0.15 x50 horsepower = 7 litres/hour

Average fuel cost per hour = 7 l/hour x Rs. 50/litre =Rs. 350/hour

ii. **Lubrication:** Surveys indicate that total lubrication costs on most farms average about 15 % of fuel costs. Therefore, once the fuel cost per hour has been estimated, you can multiply it by 0.15 to estimate total lubrication costs.

For our tractor example, average fuel cost was Rs. 350 per hour, so average lubrication cost would be:

Lubrication cost = 0.15 x 350 = Rs.52.5/hour

iii. **Repairs and maintenance:** Repair costs occur because of routine maintenance, wear and tear, and accidents. Repair costs for a particular type of machine vary widely from one geographic region to another because of soil type, rocks, terrain, climate and other conditions. Within a local area, repair costs vary from farm to farm because of different management policies and operator skill.

The best data for estimating repair costs are records of your own past repair expenses. Good records indicate whether a machine has had above or below average repair costs and when major overhauls may be needed. They will also provide information about your maintenance program and your mechanical ability. Without such data, though, repair costs must be estimated from average experience.

Repair and maintenance costs are fixed allowances provided for the repair of machine and shelter. Usually estimated at 5-10 per cent of initial cost.

2. **Labor:** Because different size machines require different quantities of labor to accomplish such tasks as planting or harvesting, it is important to consider labor costs in machinery analysis. Labor cost is also an important consideration in comparing ownership to custom hiring.

   Actual hours of labor usually exceed field machine time by 10 to 20 percent, because of travel to and from field and the time required to lubricate and service machines. Consequently, labor costs can be estimated by multiplying the labor wage rate times 1.1 or 1.2. Using a labor value of Rs. 25 per hour for our tractor example:

   Labor cost = 25 x 1.1= Rs.27.5/hr

   Different wage rates can be used for operations requiring different levels of operator skill.

i. **Total operating cost:** Repair, fuel, lubrication and labor costs are added to calculate total operating cost. For the tractor example, total operating cost is:

   Total operating cost = 350 +52.5 +25+27.5 = 455 per hour

ii. **Total cost:** After all costs have been estimated, the total ownership cost per year can be added to the operating cost per hour to calculate total cost per hour to own and operate the machine. Total cost per hour for our example tractor was:

   Total cost = 166 + 455=Rs.621 / per hour

iii. **Implement costs:** Costs for implements or attachments that depend on tractor power are estimated in the same way as the example tractor, except that there is no fuel, lubrication or labor costs involved.

3. Used Machinery: Costs for used machinery can be estimated by using the same procedure shown for new machinery. However, the fixed costs will usually be lower because the original cost of the machine will be lower. And repair costs will usually be higher because of the greater hours of accumulated use.

Therefore, the secret to successful used machinery economics is to balance higher hourly repair costs against lower hourly fixed costs. If you misjudge the condition of the machine such that your repair costs are higher than you anticipated, or if you pay too high a price for the machine so that your fixed costs are not as low as you anticipated, the total hourly costs of a used machine may be as high or higher than those of a new machine.

i. **Total Costs per Operation:** Tractor costs must be added to the implement costs to determine the combined total cost per hour of operating the machine. Total costs in the example are:

Total cost = Rs. 621 per hour

Finally, total cost per hour can be divided by the hourly work rate in acres per hour or tons per hour to calculate the total cost per acre or per ton.

The hourly work rate or field capacity of an implement or self-propelled machine can be estimated from the effective width of the machine (in meter), its speed across the field (in kms per hour), and its field efficiency. The field efficiency is a factor that adjusts for time lost due to turning at the end of the field, overlapping, making adjustments to the machine, and filling or emptying tanks and hoppers.

5.6.1: Calculation of rates for custom hiring

Custom hiring centres are providing general purpose machines suitable to prevailing crops and cultural practices and making them available at nominal rent to farmers in the rural areas. Each unit have at least one tractor, plough, rotavator, cultivator, seed-cum-fertilizer drill, trolley and one thresher, besides

few additional specialized equipment for harvesting and straw management.

For a most common set of machinery available with the custom hiring entrepreneurs, let us make the assumptions as following:

Table 5.4: Machinery and their cost assumptions

S. No.	Name of Machine/Equipment With the Centre	Purchase Price (Rs)	Life in Years	Salvage Value	Annual Use (hours)
1.	Tractor 50-60 hp	725000	10	10% of PP	1250
2.	Rotavator	100000	8	10% of PP	200
3.	Reversible MB plough	75000	10	10% of PP	100
4.	Duck-foot cultivator	40000	10	10% of PP	150
5.	Raised-bed planter	95000	8	10% of PP	100
6.	Walking type rice transplanter	350000	8	10% of PP	200
7.	Seed-fertilizer drill	55000	8	10% of PP	150
8.	Self-propelled reaper-binder	330000	8	10% of PP	200
9.	Multi crop thresher	230000	8	10% of PP	200
10.	Straw reaper	350000	8	10% of PP	150
11.	Tractor trolley	150000	12	10% of PP	200

	Total Investment	**2450000**	--	--	
Other Assumptions					
• Repair & Maintenance- 5 % of PP.					
• Tax, Insurance, Shelter etc.- 3% of PP for Tractor & Self-propelled Machines.					
• Tax, Insurance, Shelter etc.- 1% of PP for other machines.					
• Interest on borrowed capital - 10% p.a.					
• Operator wages- 400/-day of 8 hours i.e. 50/hr.					
• Diesel – Rs. 100 per litre, Lubricant Oil- Rs. 500 per litre.					
• Diesel consumption: Tractor (5 lit/hr), Reaper-Binder (3 lit/hr), Rice Transplanter (3 lit/hr).					
• Lubricant oil consumption: 2.5 to 3 per cent of the fuel consumption on volume basis.					

Calculation of various costs for tractor, one tractor operated implemented and one Self-propelled equipment is shown in the subsequent paragraphs. Costs for other equipment can be calculated on the same pattern. Formulas explained in the earlier paragraphs have been used for calculating the cost and the same have been also shown in the tables of calculation of cost of operation, below.

A. Calculation of cost of operation: The following cost analysis for different machinery are-

i. COST OF OPERATION - TRACTOR

S. No.	**Particulars**	**Value**	**Amount**
1.	Purchase price of Tractor (Rs.)		7,25,000
2.	Life (years)	10	
3.	Salvage value, Rs. (@ % of purchase price)	10	72500

Fixed cost			
4.	Depreciation-Rs./Year [(PP-SV)/L]		65,250
5.	Interest on investment-Rs./Year [(PP+SV)/2 X i/100]	10	39,875
6.	Tax, insurance and shelter (% of PP)	3	21,750
7.	Repair and maintenance (% of PP)	5	36,250
8.	**Fixed cost (Annual)**		1,63,125
9.	Fixed cost (Hourly)- Rs./hr (Annual fixed cost/Annual use)	1250	131
Variable costs			
	Cost of fuel (Rs./l)	100	
	Consumption (l/h)	5	
10.	Cost of fuel (Rs./h)		500
11.	Cost of lubricating oil @3% of Diesel Consumption @500/lit		75
12.	Operator charges (Rs./h)	50	50
13.	Variable cost (Rs/h) – Sl no 10+11+12		625
14.	**Cost of operation of Tractor (Rs./h)- Fixed cost + Variable cost (131 + 625)**		**756**
15.	**Profit @20% over the cost of operation (756 X 0.2)**		**151**
16.	**Custom hiring rate for tractor, Rs./hr (756 + 151 = 907)**	**Or Say**	**910/-**

ii. COST OF OPERATION - ROTAVATOR

S. No.	Particulars	Value	Amount
1.	Purchase price of Rotavator, Rs.	--	100000
2.	Salvage value (% of purchase price)	10	10000
3.	Life of rotavator, years	8	

4.	Annual use, h	200	
5.	Depreciation –Rs./Year [(PP-SV)/L]		11250
6.	Interest on investment –Rs./Year [(PP+SV)/2 X i/100]	10	5500
7.	Repair maintenance @%	5	5000
8.	Shelter @ %.	1	1000
9.	Fixed Cost of operation (Annual), Rs./Year	--	22750
10.	Fixed cost (Hourly) – 22750/200		114
11.	**Variable Cost***	00	00
12.	**Cost of operation of rotavator (Hourly), Rs./hr) - Fixed cost + Variable cost (114 + 00)**	--	**114**
13.	**Total Cost of operation of rotavator with Tractor, Rs. /hr (Cost of operation of tractor + Cost of operation of Rotavator = 756 + 114)**	--	**870**
14.	**Profit @20% over the cost of operation (870 X 0.2)**		**174**
	Custom hiring rate for tractor along with Rotavator, Rs/hr (870 + 174 = 1044)	**Or Say**	**1050/-**
***Note:** As the rotavator is operated by tractor, the variable cost component of tractor will be counted and the variable cost of rotavator itself will be nil.			

iii. COST OF OPERATION - SELF PROPELLED REAPER BINDER

S. No.	Particulars	Value	Amount
1.	Purchase price of Reaper Binder, Rs.		330000
2.	Life , years	8	
3.	Salvage value, Rs.	10	33000
4.	Annual use, h	200	
5.	Depreciation –Rs./Year [(PP-SV)/L]		37125

6.	Interest on investment -Rs/Year [(PP+SV)/2 X i/100]	10	18150
7.	Shelter @1%, Rs.	1	3300
8.	Repair and maintenance @5%, Rs.	5	16500
9.	Fixed cost of operation		75075
10.	Hourly fixed cost, Rs/h (75075/200)		375
11.	Labour charges, Rs/h (Additional Unskilled labour @200/day, i.e. Rs 25/hr of day of 8 hours.	25	25
12.	Cost of fuel (Rs/h) - Fuel consumption 3 lt/hr , Rate - Rs 100/lit		300
13.	Cost of Lubricant (Rs/h)- Oil Consumption 3% of fuel consumption (3X 0.03 = 0.09 lit/h), Rate - Rs 500/lit		45
14.	Variable cost* (Rs/h) – Sl no 11+12+13		370
15.	**Cost of operation, Rs/h - Fixed cost + Variable cost (375 + 370)**		**745**
16.	**Profit @20% over the cost of operation (745 X 0.2)**		**149**
17.	**Custom hiring rate for Self-Propelled Reaper Binder Rs/h (745 + 149 = 894)**	**Or Say**	**900**
***Note:** As the Self-Propelled Reaper Binder is not operated by tractor, but operated by its own engine and consumes fuel and lubricant, the variable cost component is there in calculation.			

On the similar pattern, custom hiring rates for all other equipment can be calculated.

5.6.2: Calculation of payback period

The payback period is the time it takes for an investor to recover the initial

investment cost of a project. It's closely related to an investment's break-even point.

Payback period is a quick and straight forward technique to evaluate investment opportunities and risk, although it is stated in years rather than units like a break-even analysis. The investment would be more appealing if the payback period was shorter, because it would take less time to break even.

Businesses and financial institutions alike utilise the payback period to determine the rate of return on any new asset or technology upgrade. A small business owner, for example, could assess the payback period of solar panels to see if they're a cost-effective alternative.

How to calculate payback period?

To figure out how to calculate payback period in practice, divide the project's original cash spend by the amount of net cash inflow it generates each year. You can assume that the net cash inflow is the same each year when calculating the payback period formula. Years or fractions of years are used to express the result.

- **Payback Period = Initial Investment / Cash Flow Per Year**
- **Payback Period = Initial Investment (cost) / Annual Payback (cash flow)**
- For example, imagine a company invests Rs. 200,0000 in new manufacturing equipment which results in a positive cash flow of Rs. 50,000 per year.

  Payback Period = Rs. 200,0000 / Rs. 50,000

- In this case, the payback period would be 4 years because 200,0000 divided by 50,000 is 4. Long-term investments may be rejected by your finance team or management since they do not want to be bound to the financial responsibility for so long. Comparing all of the investments you're

contemplating and choosing the shortest one will give you an idea of the optimum payback period. A long payback period is usually dictated by your own degree of comfort — if you're paying off one investment, you'll be less able to invest in newer, more promising opportunities.

- **Practical exercise in payback analysis:**

The following exercise is aimed to help students use their payback analysis skills in a practical setting.

Exercise: You work as the production manager for Cosy Llama Socks, a company that makes wacky socks out of llama wool. The company's current sewing machine has reached the end of its useful life; you must therefore choose a new machine. There are various solutions available on the market, each of which saves money since it uses less electricity and/or requires less maintenance than the present model.

For each of the machines, your management accounting analyst prepared the following analysis:

Machine	**A**	**B**	**C**
Cost and Installation (rupees)	50,000	40,000	80,000
Useful life (years)	12	10	15
Annual depreciation (rupees)	5000	4000	8000
Annual cash savings (rupees)	5000	8000	10000

Solution: 1. The formula for calculating the payback period can be given as

- **Payback Period = Initial Investment (cost) / Annual Payback (cash flow)**

Machine	**A**	**B**	**C**

Cost and Installation (rupees)	50,000	40,000	80,000
Annual cash savings (rupees)	5000	8000	10000
Payback period (years)	10	5	8

2. The result is **Machine B** because it's payback period is the lowest.

5.6.3: Calculation of Break-even point

Break-even point analysis: It emphasises that the link between the variables that determine the profit. A break-even analysis determines the point at which cost and revenue are equal. It's a straight forward and understandable way to show management the impact of volume changes on revenues.

Break-even point: The break-even point is the point or level of sales at which losses stop and profits start, or vice versa. It can also be defined as the amount of sales at which there are no gains and no losses. The break-even point is a benchmark that indicates how many units of goods must be sold in order for a business to break even.

When profit is zero at the break-even point, contribution (sales—variable cost) equals fixed cost. There will be a profit if the actual volume of sales exceeds the break-even volume. When all of the fixed costs have been satisfied, the break-even point is reached; after that, all of the marginal contribution reflects income.

Formula: Break Even Point (BEP) in Units = Fixed Costs/Contribution Margin

Contribution margin: The contribution margin per unit can be calculated by deducting variable costs associated with the production of each product from the product's selling price per unit yields. It is expressed mathematically as,

Contribution margin = Selling price per unit – Variable cost per unit

Therefore, the formula for break-even point in units can be expanded as below,
Break Even Point (Units) = Fixed Costs/ (Selling price per unit – Variable cost per unit)
For example: Assume that a company manufactures and sells a single product as follows: Selling price per unit is Rs 30, Variable cost per unit is Rs 10 and Total fixed cost is Rs 2, 00,000.
Soultion: Selling price per unit = Rs 30 and Variable cost per unit = Rs 10

Contribution margin = selling price – variable price

= 30 – 10 = Rs 20

Therefore, put the value of contribution margin in formula, get BEH values in units

Break Even Point (BEP) in Units = Fixed Costs/Contribution Margin
Break-even volume = Rs 2, 00,000 fixed cost/Rs 20 contribution margin

= **10,000 units.**

So, break-even sales to cover fixed costs will be **10,000 units.**

5.7: Government/bank schemes for promotion of custom hiring
These apps connect tractor owners and Custom Hiring Centres (CHCs) operated by tractors and equipment owners directly to farmers seeking farm mechanization solutions, thereby facilitating a fair and transparent rental process while focusing on quality, dependability and timely delivery. Farm Services offers the farmers and renters a wide range of prospects for hiring and renting of farm equipment and connects them directly to negotiate and fulfil their respective requirement.

Services is further fostering digital empowerment of Indian farmers while creating a breed of new rural entrepreneurs, significant job opportunities and employment.

5.8: Guidelines for starting custom hiring

Management of custom hiring centre

- Innovative institutional mechanism was put in place at the village level for management.
- Village Climate Risk Management Committee (VCRMC) was constituted comprising of 12-20 villagers with nominated members as President, Secretary and Treasurer.
- A bank account is opened in the name of VCRMC and is operated by any two signatories.
- The committee fixes the charges for hiring for different implements and hiring rates are to be displayed prominently.
- Farmers' contributory share towards inputs like seeds, fertilizer, animals etc., is also deposited in the bank account. The revenue and expenditure details must be shared with the general body periodically.

Practical Exercise

Activity 01: Make a list of benefits of custom hiring centre.

Material required:

1. Pen
2. Notebook

Procedure:

1. First, visit the website of agriculture department.
2. Second, search the benefits of custom hiring centre.
3. Make a list of benefits of custom hiring centre.

Activity 02: Make a list the agencies involved in facilating custom hiring centre.

Material required:

1. Pen
2. Notebook
3. Pencil

Procedure:

1. First, visit the website of agriculture department.
2. Second, search the different agencies available for custom hiring centre.
3. Make a list of different agencies available for custom hiring centre.

Activity 03: Make a list of guidelines for starting custom hiring.

Material required:

1. Pen
2. Notebook

Procedure:

1. First, visit the website of agriculture department.
2. Second, search the guideline for starting custom hiring.
3. Write the step of guideline for starting custom hiring.
4. Make a report on the same.

Check Your Progress

A. Answer the following question

1. How do you select the suitable machinery and equipment for custom hiring?
2. Write the various agricultural operations by different equipment?
3. Make a list of different suitable machinery and equipment for custom hiring.
4. What is sowing equipment? Describe the following seed drill, seed-cum-fertilizer drill, zero-drill and happy seeder.

5. Write the difference between sugarcane and planter and their specification.
6. What do you mean by transplanter?
7. How straw reaper work?
8. Describe the selection criteria of tractor for custom hiring.
9. Make a list of recommended draft, speed and field efficiency for various machinery/equipment.
10. Describe the cost analysis for custom hiring.
11. How do you calculate payback period and give example?
12. What is break-even point and formulate it?

B. Fill in the blank

1. Surveys indicate that total lubrication costs on most farms average about ..... of fuel costs.
2. Depreciation means a ..... in the value of an asset over time, due to wear and tear in particular.
3. A break-even analysis determines the ..... at which cost and revenue are equal.
4. Payback period is a ..... and ..... forward technique to evaluate investment opportunities and risk.
5. The most popular type of plough is ..... reversible type for better field capacity and efficiency.
6. Planting on ..... improves yield, increases fertilizer use efficiency, better weed management and irrigation water.
7. Fuel costs can be estimated in ..... ways.
8. Bed planting technique is gaining acceptance by farmers because of ..... profit.

C. Match the following

Column A	Column B
1. It cuts the plant and feeds into furrow as well as feeding of fertilizer and spraying pesticide is done automatically.	**A. Interest on investment (IOI)**
2. It means a reduction in the value of an asset over time, due to wear and tear in particular.	**B. Salvage**
3. This is the point of the point or level of sales at which losses stop and profits start, or vice versa.	**C. Sugarcane planter**
4. It is the charge for the use of the money invested on the machine regardless of whether the money was borrowed or not.	**D. Break-even**
5. These value is an estimate of the sale value of the machine at the end of its economic life.	**E. Depreciation**

Answer Key

S.No.	Fill in the blank	Match the following/ Multiple choice question
Unit 01- Session 01	1. Air 2. less than 3. crankshaft 4. spark plug 5. fuel	1. C 2. D 3. A 4. B
Unit 01- Session 02	1. Steady 2. 1-15 3. Electrical 4. Specific 5. Speed and frequency 6. 5000 7. Decrease	1. E 2. C 3. A 4. B 5. D
Unit 01- Session 03	1. Blade 2. Cylinder 3. Clamping 4. Shank 5. Length and thickness	1. C 2. A 3. E 4. B 5. D
Unit 01- Session 04	1. Operating 2. Increases 3. low or dead 4. Carburetor 5. flatten	

Unit 01- Session 05	1. solid 2. Power, own 3. 5 seconds 4. Technique, PTO 5. twisted and broke up	1. E 2. D 3. A 4. C 5. B
Unit 02- Session 01	1. Leveller 2. curved and pointed 3. Bucket 4. Dozer 5. comprising	1. C 2. E 3. D 4. B 5. A
Unit 03- Session 01	1. Haulage 2. Low 3. 8 to 15 4. Single 5. Marginal	1. B. Rice 2. A. less than 1 hectare 3. C. Power tiller 4. D. Marginal
Unit 03- Session 02	1. main 2. bigger 3. rotary unit 4. cut-off	1. C. Transmission 2. D. V – belt 3. B. V-belt tension clutch
Unit 03- Session 03	1. medium and light 2. spares 3. slackness or tightness	1. D. 15.5 2. C. 0.4-0.7 mm
Unit 03- Session 04	1. Transplanting 2. Rotary 3. 5 mm 4. fuel filter 5. chain and sprockets	1. C. 8-10 cm 2. A. 1.6 m 3. C. Both A and B
Unit 04- Session 01	1. Seeding 2. drive wheel 3. Levelling 4. chain and sprocket 5. Power 6. vacuum	
Unit 04- Session 02	1. Secondary 2. self-propelled 3. Crop 4. gear oil	

	5. Mechanical	
Unit 04- Session 03	1. Power 2. mounted vertical 3. 9 4. 0.40 5. Versatile 6. Crank 7. Compress 8. Round 9. 5-6 , 25-35	1. D 2. A 3. E 4. C 5. B
Unit 04- Session 04	1. Solar 2. 650 3. Amount 4. Instrumental 5. planning	1. C 2. D 3. A 4. B
Unit 05- Session 01	1. 1.16 2. peak 3. selection and operation 4. productivity 5. diversification	1. D 2. A 3. B 4. C
Unit 05- Session 02	1. 15 % 2. reduction 3. point 4. quick and straight 5. two-bottom 6. raised beds 7. two 8. higher	1. C 2. E 3. D 4. A 5. B

Glossary

Additive: A material that is added in modest amounts to something for a specific reason.

Agriculture: The art and science of cultivating the soil, growing crops, and raising livestock is known as agriculture.

Anvil: An anvil is a metalworking tool made consists of a huge block of metal (typically forged or cast steel) with a flattened top surface, which is used to strike another object.

Atmospheric pressure: An atmosphere is a unit of measurement equal to the average air pressure at sea level at a temperature of 15 degrees Celsius (59 degrees Fahrenheit) and it is denoted by 'atm'. One atmosphere is 1,013 millibar, or 760 millimeters (29.92 inches) of mercury. It is also known as barometric pressure.

Baffle: A baffle is a thin flat device that is suspended in a liquid or gas flow to partially restrict it.

Breathing: The process of moving air into and out of the lungs to permit gas exchange with the internal environment, primarily to flush out carbon dioxide and bring in oxygen, is known as breathing (or ventilation).

Camshaft: A camshaft is a rod that rotates and slides against machinery to convert rotational motion into linear motion.

Centrifugal force: It is an inertial force that appears to act on all objects when viewed in a rotating frame of reference.

Clearance volume: At the end of the piston stroke, this is the entire volume left in the cylinder. This includes the volume between the piston's end and the cylinder head, as well as the volume in the valve ports, suction valve guards, and discharge valve seats.

Combustion chamber: The area within the cylinder where the fuel/air mixture is ignited is known as the Combustion Chamber.

Compression ratio: In an internal combustion engine, the compression ratio is the ratio between the volume of the cylinder and the volume of the combustion chamber at their highest and smallest values.

Compression ring: The top or closest ring to combustion gases, the compression ring, is subjected to the most chemical degradation and operates at the highest temperature.

Configuration: The placement or arrangement of a thing's parts or elements in relation to one another.

Crankcase: The crankcase serves as the "body" of the engine, holding all of the other components together.

Crankshaft: It is a shaft driven by a crank mechanism consisting of a series of cranks and crankpins through which the connecting rods of an engine is attached.

Carburetor: A carburetor is a device that mixes air and fuel in an optimal air–fuel ratio for combustion in internal combustion engines.

Crawler tractor: This type of tractor for moving through hard or muddy ground, a tractor with a continuous roller belt over cogged wheels on each side is used.

Distilled water: Water that has been heated into vapour and then condensed back into liquid in a separate container is known as distilled water.

Distortion: It is the act of twisting or altering something out of its true, natural, or original state.

Downdraft: The meaning of downdraft is a downward current of gas (such as air during a thunderstorm).

Foreign material: It means natural vegetative matter that is not from the property where the fire is occurring. No material can be brought from off-site to be included in a permitted burn.

Friction: It is the force that prevents one solid item from slipping or rolling over another.

Gasoline: Gasoline, often known as petrol, is a clear, flammable liquid generated from petroleum that is primarily used as a fuel in most spark-ignited internal combustion engines.

Germination: The process of an organism growing from a seed or spore is known as germination.

Governor: It is device that automatically maintains the rotary speed of an engine or other prime mover within reasonably close limits regardless of the load.

Groove: A groove weld in which one side of both parts' joint edges is prepared in the shape of a J, resulting in a final U shape to the completed weld.

Machinery: A group of devices with moving parts that are used to perform specific jobs.

Manifold: A pipe or enclosed area with many holes for bringing gases into and out of an automobile engine.

Mechanical energy: The sum of kinetic and potential energy in an object employed to perform a specific task is known as mechanical energy.

Muffler: A muffler, it also known as a silencer, is a device that reduces the noise produced by an internal combustion engine's exhaust, particularly a noise-deadening device that is part of an automobile's exhaust system.

Movements: The act or process of moving, especially when it involves a change of location or position.

Momentum: It is defining as the product of the mass and velocity of an object.

Magneto system: It's an ignition system in which a magneto [produces high voltage] is utilised to generate energy, which is then used for a variety of purposes, including powering vehicles.

Oxidation: The loss of electrons by a molecule, atom, or ion during a reaction is known as oxidation.

Pollutant: A pollutant, also known as a novel entity, is a material or energy that is introduced into the environment that has unintended consequences or reduces the utility of a resource. These can occur naturally or as a result of human activity.

Precision: It is termed as the quality or state of being precise.

Protrusion: A item that sticks out from a place or surface.

Reciprocate: To go in a straight line or way backwards and forwards.

Refill: It is the process to fill something again.

Radiator: Radiators are heat exchangers that are used to transmit thermal energy from one medium to another for cooling and heating purposes.**:**

Rubbing: It is the process of rub any substance one other surfaces.

Resonator: A resonator is a device or system that exhibits resonance or resonant behavior. That is, it naturally oscillates with greater amplitude at some frequencies.

Scavenging: It is the process of replacing an internal combustion engine's exhaust gas in a cylinder with a fresh air/fuel combination for the following cycle.

Sediment: It is a naturally occurring substance that is weathered and eroded, then moved by wind, water, or ice, or by the force of gravity acting on the particles.

Slotted: To place something in a space that is specifically created for it.

Thermal conductivity: It is a measure of its ability to conduct heat.

Throttle: The portion of a vehicle that regulates the amount of fuel that goes into the engine to control the speed.

Torque: It is the measure of the force that can cause an object to rotate about an axis.