MAIZE SHELLING AND SHELLER MACHINE MAINTENANCE SERVICE BUSINESS

TRAINING COURSE FOR YOUTH AGRI-ENTREPRENEURS

Ethiopian Agricultural Transformation Institute

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Table of Content

OVERVIEW OF THE MODULE

This module is intended to provide training to unemployed youth who need to engage in maize shelling business using an engine-operated maize sheller. Mechanized maize shelling practice, being less expensive, and resulting in reduced grain loss, will increase the production of maize without consuming more labor. The main objective of this module is to equip individuals with the necessary knowledge, attitude, and skills to successfully operate mechanical maize sheller at its best capacity.

The module has 5 sections.

- **Section 1.** Deals with the postharvest handling stages prior to shelling operations. The section describes methods to identify the maturity stages of maize, discusses various approaches for maize harvesting, and gives backgrounds for facilitating shelling operations to be mechanized.
- **Section2.** Discusses the different methods used for shelling maize, introduces modern maize sheller machines, describes the different types of maize shelling, introduces main components,
- **Section3.** This section discusses the details of maize sheller operation and adjustment requirements of mechanical Sheller machines for best performance.
- **Section 4.** Is about operational safety and off-season machine handling procedures.
- **Section 5.** Deals with methods to improve shelleing performance and procedures required to identify and amend different operation related problems.

The Agriculture-focused Dignified Employment for Youth (ADEY) program is implemented by the Ethiopian Agricultural Transformation Institute in partnership with the Mastercard Foundation to enable 611,343 inclusive and dignified work opportunities for young women and men and support youth entrepreneurship, employability, and sustainable livelihoods in the agribusiness sector.

INTRODUCTION

Maize is one of the most widely grown crops in Ethiopia. It has a high productivity and is grown in most cereal producing areas. Due to its high production volume and wide area coverage, it is an attractive crop to do business for young people to work with.

Maize is a strategic food crop grown in 13 agro-ecological zones covering 90% of Ethiopia. In any one year, smallholder farmers produce over 95% of the total maize. Maize constitutes more than 60% of the caloric intake of a typical household. This indicates the significance of the crop in the livelihood of most Ethiopians. Maize shelling, also known as corn shelling, is the process of separating the grains kernels from the cob (corn). It is an essential step in the production and utilization of maize for various purposes. Shelling allows for the grains to be stored more efficiently, reducing the risk of damage and spoilage. This is particularly important for farmers who need to store their maize for extended periods before selling or consuming it. Shelling also makes it easier to handle and transport maize, as the grains are no longer attached to the cob. Shelling helps to maintain the quality of the maize by removing any damaged or infested grains, which can reduce the overall quality of the maize.

The country has a huge potential to increase the existing national average yield level of 3.2 t/ha to 8.0t/ha under well-managed farm conditions of better maize innovations (including mechanization) and improved extension and marketing system.   This potential can only be realized if production is strongly supported with mechanization. Maize shellers are among the best interventions in modernizing Small-holders farm's agriculture and reduce postharvest losses.

Target participants

Any citizen who has completed grade 8 and satisfies the entry requirements is eligible to enroll in this training section.

SECTION 1: HARVEST AND POSTHARVEST CONSIDERATION FOR MAIZE CROP

Overview of this section: This sections deals with the basic procedures for proper postharvest handling of Maize . It helps to Understand simple procedures to determine crop maturity.

Learning objectives

At the end the training, trainees will:
- Understand postharvest handling activities and identify causes of postharvest losses.
- Make assessment on levels of crop maturity.
- Learn Commonly used maize harvester and their functions.

Duration: 4hrs
Training Methods
- Lecture and Discussion
- Brainstorming
- Practical demonstration
- Practical exercice
- Role playing

Pre-assessment question

- What do you expect after the end of this section?
- What methods are commonly used for harvesting of maize in your local area?

1.1 METHODS OF IDENTIFYING MATURITY OF MAIZE

A. Visual Inspection

Determining the optimal time for harvesting maize involves assessing several key indicators related to the maturity of the crop. Here's a practical guide to help you know when maize is ready for harvest:

- **Kernel Color and Texture:** Monitor the color of kernels. Mature maize kernels typically change from milky white to yellow or golden yellow, depending on the variety. The kernels should also feel firm when pressed between your fingers.
- **Husk and Silk Appearance:** The husks should be dry and brown, and the silks (female flower structures) should be brown and dried out. This indicates that pollination has occurred and the kernels are developing.
- **Ear Development:** Evaluate the size and shape of the ear (cob). Kernels should be uniformly developed from the base to the tip of the ear.

B. Kernel Development

- **Kernel Color:** Mature maize kernels should be fully developed and uniformly colored. For grain maize, kernels should be firm and hard when pressed with a thumbnail.
- **Milk Line:** This is a line that appears on the kernels as they mature. Initially, kernels are soft, and the inside appears milky. As the maize matures, a distinct line develops between the milky and solid portions of the kernel, progressing from the base to the tip. When this line reaches the top of the kernel, the maize is mature.

C. Ear and Plant Characteristics:

- **Ear Size and Shape:** A mature maize ear should be filled out completely with plump kernels that extend to the end of the cob.
- **Plant Leaves:** As maize matures, the leaves of the plant start to dry and turn brown, particularly from the bottom of the plant upwards.

D. Days to Maturity: Knowing the expected number of days to maturity based on the maize variety can help in predicting when it is likely to be mature and ready for harvest. This information is typically provided by seed suppliers.

E. Test Harvest: Conducting a test harvest involves manually opening a few ears and examining the kernels. Kernels should be fully developed and show signs of maturity such as a hardened texture and distinct coloration.

F. Black Layer Formation (for Grain Maize): In grain maize, a definitive sign of maturity is the formation of a black layer at the base of each kernel. This indicates physiological maturity and the optimal time for grain harvest.

G. Timing Based on Purpose: The timing of maize harvest can vary depending on its intended use (e.g., silage, green corn, dry grain). Silage maize is often harvested earlier when kernels are still soft and milky, whereas grain maize is harvested later when kernels have hardened and dried.

1.2 METHODS OF DRYING MAIZE

Drying maize (corn) effectively is crucial to ensure the kernels are properly dried and preserved for shelling and storage. Here are some methods commonly used for drying maize:

- **Field Drying:** Natural Air Drying: In areas with low humidity and good air circulation, maize can be left in the field to dry naturally. This method is often used for grain maize. The maize is left on the stalk until the kernels have dried down to a moisture content suitable for harvesting (around 20-25% moisture). Once the husks start to dry and turn brown, and the kernels dent when pressed, maize is usually ready for harvest.
- **Harvest and Air Dry:** Shelling on the Ear: After harvesting the maize, you can leave the ears intact and hang them or lay them in a well-ventilated area, protected from rain and excessive moisture. This allows the ears to air dry naturally. Ensure good air circulation around the maize to prevent mold growth.
- **Mechanical Drying:** Drying Bins: Mechanical drying involves using specialized drying bins or silos equipped with fans and heaters. Maize is loaded into the drying bin, and heated air is blown through the maize to reduce its moisture content. Temperature and airflow are carefully controlled to ensure uniform drying without damaging the kernels.
- **Sun Drying:** Sun Drying on Racks: In some traditional settings, maize can be spread out on racks or mats in the sun to dry. This method requires good weather conditions with low humidity and ample sunlight. Turn the maize regularly to ensure even drying.
- **Artificial Heat Drying:** High-Temperature Drying: In commercial settings, maize can be dried using high-temperature dryers that blow heated air through the maize. This method allows for faster drying but requires careful monitoring to prevent overheating, which can damage the maize kernels
- **Combination Drying:** Combining Methods: Some farmers use a combination of drying methods to achieve optimal results. For example, starting with natural air drying in the field and then finishing drying in a mechanical dryer to ensure consistency and reduce moisture content to desired levels.
- **Moisture Testing:** Monitoring Moisture Levels: Throughout the drying process, it's essential to monitor the moisture content of the maize kernels regularly using a moisture meter. Maize should be dried to around 13-15% moisture content for safe storage and shelling.

1.3 METHODS OF MAIZE HARVESTING

1.3.1 TRADITIONAL HARVESTING METHOD

Traditional methods of maize harvesting vary depending on the region and cultural practices. Some common traditional methods include hand harvesting using machetes or sickles, cutting the maize stalks close to the ground, and then bundling them into sheaves or stacks to dry (Figure 1). After drying, the maize ears are manually removed from the stalks, often by beating or rubbing them, and then collected for storage or further processing. These methods have been used for centuries and are still employed in many rural areas.

Figure 1. Traditional harvesting methods

1.3.2 MECHANICAL HARVESTING METHODS

Mechanized methods of maize harvesting involve the use of specialized machinery to automate the process. The most common machine used for maize harvesting is the combine harvester. The combine harvester moves through the field, cutting down the maize stalks. The stalks are then pulled into the machine, where the grain is separated from the rest of the plant. The maize kernels are collected in a hopper, while the remaining plant material (stalks, leaves, etc.) is expelled out of the back of the machine. The harvested maize is then either unloaded directly into storage bins or transported to a processing facility for further cleaning and drying.

Mechanized harvesting is much faster and more efficient than traditional methods, allowing farmers to harvest larger areas in a short time. It also reduces the amount of labor required for harvesting, making it possible for fewer people to manage larger farms.

Three different types of machines are available for harvesting corn. The simplest machine snaps the ears from stalks and does not remove husk called snapper. Picker-husker is one that snaps the ears from stalks and removes the husk also. The most recent development is a machine that snaps the ears from stalks and shells in the field. This type of machine is called picker-sheller. Tractor-mounted and self-propelled corn harvesters are available in different sizes i.e., 2-row, 4-row, and 6-row (figure 2).

Sometimes these units are interchangeable. The shelled corn may be delivered to a trailing wagon or to a tank on the machine. When a grain combine is to be used for corn, a corn head is installed in place of the grain header. A corn head has the basic gathering and snapping components listed above (similar to a corn snapper) plus a conveying system to deliver the ears to the combined cylinder for shelling.

Figure 2.six row corn head and Combine-harvester in operation.

1.3.3 FUNCTIONAL COMPONENTS OF CORN HARVESTER

The basic components for all types of mechanical maize harvesters include a gathering unit to guide the stalks into the machine (corn Head) , snapping rolls to remove the ears from the stalks, and lugged gathering chains to assist in feeding the stalks into the rolls and moving the stalks and snapped ears rearward through the snapping zone.

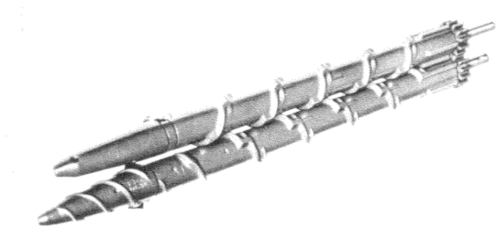

Figure 3. A pair of Snapping roles for corn Picker

Post assessment questions

1. What are the methods for identify the maturity level of maize?
2. What are the advantages of mechanized maize harvesting over traditional methods?
3. What are the main components of maize harvester?
4. Go to maize plantation area and identify the maturity indices of the crop

Takeaway message

Mechanized harvesting is much faster and more efficient than traditional methods.

SECTION 2: MAIZE SHELLERS; TYPES AND OPERATIONAL PRINCIPLES

Overview of this section

This section covers the knowledge, attitude, and skill required to identify the different methods used to perform maize shelling operations, their working principles, and results to be gained by using different methods of maize shelling.

Learning objectives

At the end of this training section the trainee will be able to:

- Identify different methods of maize shelling.
- Identify benefits of using mechanical maize Shelers
- Identify the different power sources and functional components of mechanical maize shellers
- Understand operational principles of modern maize shelling

Duration: 24 Hrs

Training Methods

- Lecture and Discussion
- Brainstorming
- Practical demonstration
- Practical exercice
- Role playing

Pre-assessment question

- What do you expect after the end of this section?
- Which type of machine you used for maize shelling in your locality?
- What do you know about the operational principles of maize Sheller?

2.1 MAIZE SHELLERS

2.1.1 IMPORTANCE OF MAIZE SHELLING

Maize shelling, also known as corn shelling, is the process of removing or separating the grain kernels from the cob (corn). It is an essential step in the production of maize for various purposes. Shelling allows for the grains to be stored more efficiently and reduces the risk of damage and spoilage. This is particularly important for farmers who need to store their maize for extended periods before selling or consuming it. Shelling also makes it easier to handle and transport maize, as the grains are no longer attached to the cob. Shelling helps to maintain the quality of the maize by removing any damaged or infested grains, which can reduce the overall quality of the maize.

2.1.2 METHODS OF MAIZE SHELLING

Traditional method

The easiest traditional system for shelling maize is to press the thumbs on the grains to detach them from the ears. Another simple and common shelling method is to rub two ears of maize against each other. These methods require a lot of labor, a worker can hand shell only a few kilograms per hour. Shelling of maize can be more efficiently accomplished by striking a bag full of ears or heads with a stick. Maize can also be shelled by rubbing the ears or heads on a rough surface. Small tools, often made by local artisans, are sometimes used to hand-shell maize. With these tools, a worker can shell 8 to 15 kg of maize an hour.

Animal trampling, where animals are made to walk on the maize cobs to remove the grains, is another method of shelling. Using a pestle and mortar to detach the maize grains from the cobs is also used to shell maize in some places. A manual method is time-consuming and not suitable for large-scale shelling. These methods are inefficient and can lead to excessive grain damage. The advantages and disadvantages of traditional maize shelling methods includes:

Advantages:

- Low Cost: Traditional methods like hand shelling and beating with sticks are cost-effective compared to mechanized options.
- Accessibility: These methods are accessible to smallholder farmers who may not have access to mechanized equipment.
- Cultural Relevance: Traditional methods may align with cultural practices and local norms, making them more acceptable in certain communities.

Disadvantages:

- Labor-Intensive: Traditional methods are laborious and time-consuming, especially as labor becomes scarcer among smallholder farmers
- Low Productivity: Hand shelling and beating with sticks are inefficient and result in lower productivity compared to mechanized shelling
- Grain Damage: Manual shelling methods can lead to reduced grain quantity and quality, with higher chances of grain damage
- Health Risks: Manual shelling can cause physical discomfort, such as burning sensations in the hands and impaired arm muscles and joints, affecting worker health.

In general, while traditional maize shelling methods may be cost-effective and culturally relevant, they are labour-intensive, less productive, and can result in grain damage and health risks for workers.

Figure 4. Hand-haled maize shelling

Modern /Mechanical/ method

In most instants, mechanical maize shelling method uses a power-driven machine to automate the separation of kernels from cobs. The machine consists of a power source, hopper, feeding system, shelling chamber, and separating mechanism. The shelling chamber separates kernels from cobs using rotating elements. The separating mechanism removes kernels using screens, sieves, or air blowers. Motorized maize shellers are powered by an electric motor, PTO, or engine, offering increased efficiency, higher throughput, and reduced labor compared to manual or traditional methods. This method is commonly used in commercial processing facilities or larger-scale agricultural operations.

Figure 5. Mechanical maize sheller in operation

2.1.3 IMPORTANCE OF MECHANICAL MAIZE SHELLER

Increased Efficiency: Maize shellers significantly improve the efficiency of maize processing. They can shell maize cobs at a much faster rate compared to manual methods, saving time and labor.

Improved Quality: Maize shellers are designed to remove the kernels from the cobs while minimizing damage. This helps preserve the quality of the maize kernels, ensuring that they are intact and suitable for various applications such as food processing, animal feed, or seed production.

Cost Savings: The use of maize shellers can lead to cost savings in labor and time. Manual shelling is a labor-intensive task that requires significant manpower. By using a sheller, the need for manual labor is reduced, and the time required for shelling is minimized, resulting in cost savings for farmers and food processors.

Post-Harvest Loss Reduction: Maize shellers help reduce post-harvest losses by efficiently removing and separating kernels from the cobs. In traditional manual shelling methods, a considerable amount of maize can be lost due to inefficient or incomplete shelling, breakage, and quality-related losses. Maize shellers minimize such losses and contribute to overall food security.

Scalability: Maize shellers are available in various sizes and capacities, ranging from small-scale machines suitable for individual farmers to large industrial-grade equipment. This scalability allows farmers and food processors to choose a sheller that best fits their specific needs and production scale.

Timesaving: Shelling maize manually can be a time-consuming process, especially when dealing with large quantities. Maize shellers enable faster processing and freeing up time for farmers to focus on other essential activities.

2.1.4 TYPES OF MAIZE SHELLER

The types of maize shellers include hand-crank maize shellers, engine or electric driven maize shellers, and tractor (PTO) driven maize shellers.

Shelling by hand

The easiest traditional system for shelling maize is to press the thumbs on the grains to detach them from the ears (Figure 4). Another simple and common shelling method is to rub two ears of maize against each other. Shelling of maize can be more efficiently accomplished by striking a bag full of ears or heads with a stick. Maize and sunflowers can also be shelled by rubbing the ears or heads on a rough surface. Small tools, often made by local artisans, are sometimes used to hand-shell maize.

Hand-held maize shellers.

Manually operated simple device to remove maize grains from the dehusked cobs. During operation, the sheller is held in left hand and the dehusked maize cob in right hand (for right hand person). As shown in Figure 5, the cob is inserted in the sheller and is given forward and backward twist or given clockwise and anticlockwise strokes repeatedly. The tapered edges of the fins dig into the space between the rows of the grains in the cob and with the forward or backward stroke the grains are released from the cob. After grains are separated from one end of cob, the other end is inserted in the sheller to complete the shelling. Due to the taper edges of the fins, which are projected inside the sheller body, one end of the sheller has larger opening and the other smaller. Therefore, for shelling the larger end of the cob it is inserted in the larger opening of the sheller and the smaller opening of the sheller is used for smaller end of the cob.

Figure 6. Different models of Hand operated maize sheller

Shelling by animal trampling.

Animal trampling shelling" is a traditional method of shelling maize (corn) that involves using animals to separate the kernels from the cobs. This method is commonly practiced in rural areas where mechanical or automated maize shellers are not available. The maize cobs are harvested from the fields and brought to a designated area for shelling. The area should be large and free from any potential hazards. A circular enclosure or pen is constructed using wooden or metal barriers to contain the maize cobs. This enclosure prevents the animals from wandering off and keeps the shelled kernels contained. Usually, livestock animals such as cattle, horses, or donkeys are used for trampling. These animals are selected based on their size, strength, and ability to trample effectively. The maize cobs are spread evenly within the enclosure, creating a layer of cobs for the animals to walk on. It's important to ensure that the layer is not too thick to avoid excessive damage to the kernels. The animals are then led into the enclosure and allowed to walk freely over the maize cobs. As they walk and move around, their weight and hooves exert pressure on the cobs, causing the kernels to separate from the cob. After the trampling process, the animals are removed from the enclosure, and the shelled kernels are collected. The remaining cobs and debris are typically sifted or winnowed to separate them from the kernels. The collected kernels may require further cleaning to remove any remaining debris, husks, or damaged kernels. This can be done through hand sorting or using simple winnowing techniques.

2.2 POWER-OPERATED SHELLERS

Power-operated maize shellers improve the maize shelling process when compared to traditional or hand-shelling methods. These machines are powered by electric motors, engines, walking tractors, and PTO. Power shellers greatly enhance efficiency by shelling corn at a much faster rate and requiring less manpower. Furthermore, they provide a more consistent shelling percentage while minimizing damage to the kernels, which is crucial for maintaining the quality of the product. The capacity of these shellers varies depending on the model and is capable of processing anything from a few kilograms to several tons per hour, catering to both small and large-scale operations. It is important to note that these machines need a suitable power source, whether electric, diesel, or a tractor's power take-off (PTO). Regular maintenance is essential to ensure the smooth operation of these machines, allowing them to remain an asset for maize processing.

2.2.1 ENGINE-OPERATED/ SELF-PROPELLED/

An engine-operated maize sheller are farm machine that utilizes a gasoline or diesel engine to efficiently remove kernels from maize cobs. This mechanized approach significantly reduces the time and effort required for shelling maize compared to traditional manual methods.

Engine-powered maize shellers come in various sizes to suit the needs of small large-scale farms. They can be powered by either gasoline or diesel engines, depending on personal preference and fuel availability. These machines offer several advantages over manual shelling, including increased efficiency, reduced labor requirements, and minimized grain damage during the shelling process.

Figure 7. Engine-driven maize sheller (engine mounted on the machine)

2.2.2 WALKING TRACTOR ATTACHED MAIZE SHELLER

A maize sheller attached to a walking tractor is a common agricultural setup used for shelling maize efficiently. The walking tractor, also known as a two-wheel tractor or power tiller, provides the motive power. The maize sheller is attached to the walking tractor through pulley and belt/PTO shaft of the tractor. This allows the rotational power from the tractor's engine to be transferred to the sheller, enabling it to function.

Figure 8. Walkman tractor driven maize sheller

2.2.3 POWER TAKE-OFF (PTO) DRIVEN MAIZE SHELLER

A maize sheller attached to a walking tractor is a common agricultural setup used for shelling maize efficiently. The walking tractor, also known as a two-wheel tractor or power tiller, provides the motive power. The maize sheller is attached to the walking tractor through pulley and belt/PTO shaft of the tractor. This allows the rotational power from the tractor's engine to be transferred to the sheller, enabling it to function.

Figure 9. PTO-driven maize sheller

2.3 MAJOR COMPONENTS OF MECHANICAL MAIZE SHELLER

The common type of maize sheller has the following major components:

- Feeding unit
- Shelling unit
- Cleaning unit
- Grain and cob outlet
- Power unit
- Safety features.

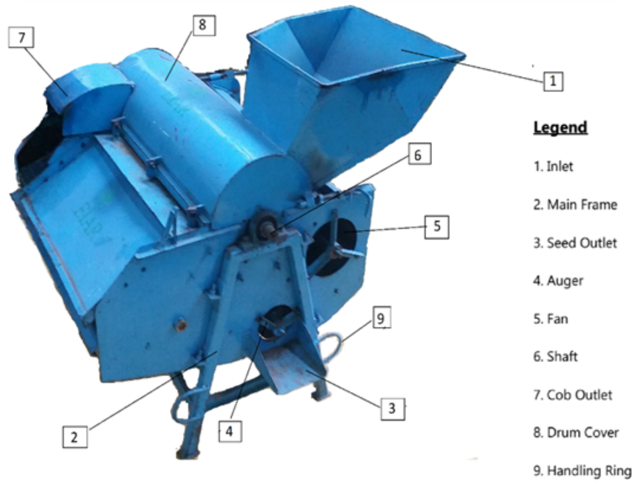

Figure 10. Components description of common maize sheller

1. Feeding unit

The feeding unit is designed to ensure a steady supply of maize cobs into the sheller, optimizing the shelling process for higher efficiency and productivity. It is a crucial component that plays a significant role in the shelling process, admitting maize cobs into the sheller. The feeding process involves one person feeding the maize cobs into the sheller, while two or more people supply maize cobs to the feeder, and another person removes spent cobs. A fifth person collects the clean grain from the delivery chute. The feeding unit is metered by a regulatory chute which enables to regulate of the amount of cob introduced to the shelling unit. Overall, the feeding unit of a maize sheller is essential for the seamless operation of the sheller, ensuring a continuous supply of maize cobs for effective separation of kernels from the cobs.

2. Shelling unit

- **Drum:** A shelling drum is the major component of maize sheller used for actual detachment of maize kernels from the cob. The drum is designed to apply mechanical force to detach the kernels, typically using rotating cylinders or bars with spikes or notches that collide with the kernels, breaking them free from their encasement.

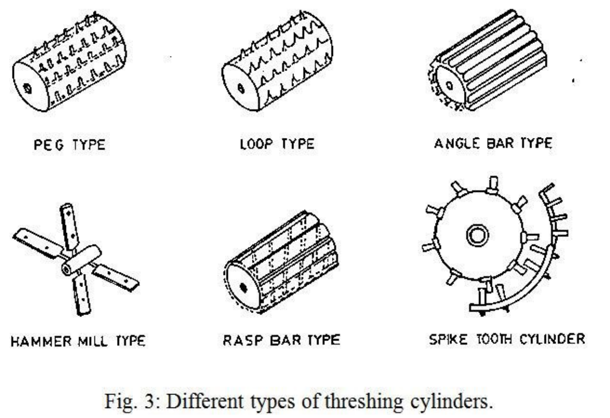

Figure 11. Different types of shelling drums

3. Concave

The concave on a maize sheller is a crucial component that plays a key role in the shelling process. It is a stationary part of the machine that works in conjunction with a rotating shelling drum to achieve the detachment of maize kernels from the cobs. The concave is designed to create the necessary abrasion against the rotating drum, keeping the maize cobs to be shelled near the tip of the drum facilitating the separation of the kernels from the cobs efficiently.

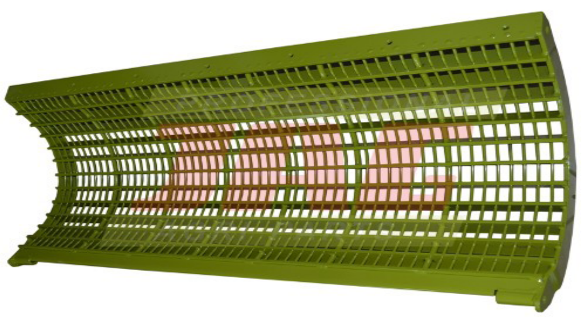

Figure 12. perforated Metal Concave

4. Cleaning unit

The cleaning unit on a maize sheller is a crucial component responsible for ensuring the separation of grains from other plant material. The cleaning unit typically consists of a fan that is powered by the main motor and the sieves. The cleaning process is essential for enhancing the quality of the harvested maize by eliminating any unwanted materials before the kernels are further processed or stored.

I. Sieves:

The sieve on a maize sheller plays a critical role in the separation process of maize kernels from the cobs. It is a component designed with small holes or perforations that allow the kernels to pass through while retaining the cobs. The shelled kernels fall directly onto the sieve and are separated from the cobs, ensuring a clean and efficient separation process. The sieve is an essential part of the maize sheller as it facilitates sorting and contributing to the overall effectiveness and quality of the shelling operation. Recently there are different designs of shelling machines which excludes the need for incorporating sieves as cleaning unit. Instead, they use the concave substituting sieves for cleaning purposes.

II. Blower/aspirator:

Maize shellers often incorporate a blower or aspirator that plays a vital role after the kernels are separated from the cobs. This component creates a strong stream of air within the sheller. This air current then acts like a sorter, carrying away lightweight materials like dust, chaff, and pieces of broken cobs. By removing these impurities, the blower significantly improves the final product's cleanliness. It is especially important for commercial applications where debris-free kernels are crucial for storage and further processing. In some sheller designs, the blower might even play an additional role by helping to direct the flow of kernels towards the collection area.

5. Grain and Cob Outlets

Grain outlet: The grain outlet on a maize sheller is the component used for the discharge of the shelled maize kernels after the shelling process. As the maize cobs are fed into the sheller, the shelling mechanism separates the kernels from the cobs. The shelled kernels then fall through a sieve or screen with small perforations that allow the kernels to pass through while retaining the larger cob material. The grain outlet provides an opening or chute through which the shelled maize kernels are collected, typically into a container or bag, for further processing or storage.

Cob outlet: The cob outlet on a maize sheller is the component used for the discharge of the empty maize cobs after the kernels have been separated during the shelling process. As the maize cobs are fed into the sheller, the shelling mechanism separates the kernels from the cobs. The empty cobs are then directed towards the cob outlet to be expelled from the machine. The cob outlet is designed to allow the larger cob material to be discharged separately from the shelled maize kernels, which are collected through a different outlet. The cob outlet enables the efficient disposal or collection of the maize cobs, which can then be used for other purposes, such as animal feed, fuel, or further processing.

6. Power transmitting unit

Belt and Pulley: The pulleys, linked by the belt, are responsible for transmitting power from the source to various shafts in the maize sheller. This power transmission mechanism enables the operation of different components of the sheller, such as the shelling drum. The pulley ratios defined by the size of pulleys on the maize sheller determine the required speeds for different processes within the shelling mechanism. By adjusting the pulley sizes and ratios, the speed of critical components like the shelling drum can be optimized for efficient shelling operations.

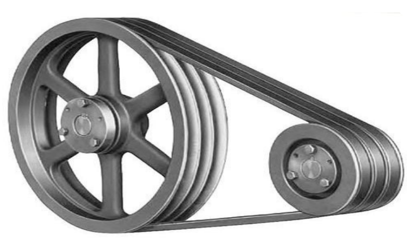

Figure 13.Belt and pulley type power transmission unit

Power take-off and universal joint: The PTO provides the necessary power to operate the maize sheller. It allows the sheller to be powered by a tractor or other farm vehicle, enabling mechanized shelling operations.

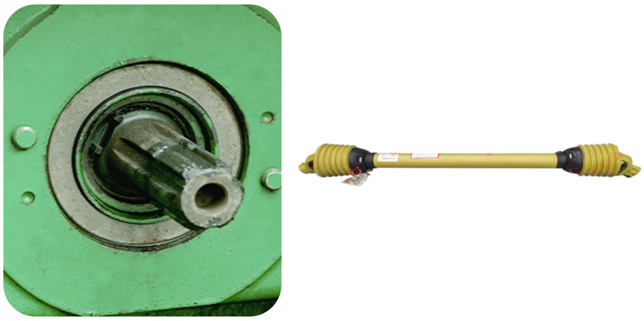

Figure 14.PTO shaft and universal joint type coupling

2.4 OPERATION PRINCIPLES OF MECHANICAL MAIZE SHELLER

The operation principles of a mechanical maize sheller typically involve the following steps:

- **Feeding:** In the first stage, the bundle of maize cob to be shelled is fed through the feeding inlet. Control the rate of feed passing into the machine to prevent overloading.
- **Shelling:** In the second stage, the bundle is conveyed to a rapidly rotating shelling drum and stationary concave. The drum which is driven by power from engine and rotates at the desired rpm, will shell the crop by the impact and rubbing action between the drum and concave. The shelled grain passes through the concave and will be guided to the grain outlet. Likewise, the chaff being lighter than the grain, is blown by the blower and thrown out.
- **Cleaning:** In the last stage, after shelling, the cob in the shelling is thrown out through the cob outlet onto the ground. The stream of air separates and cleans the grain. Light cob fragments, along with other impurities, are winnowed away by the blower. The clear grain is collected through a grain outlet.

Post assessment questions

- What is the difference between traditional and mechanical maize sheller
- Discuss the operational principles of mechanical maize sheller
- What are the major components of mechanical maize sheller?
- What is the function of tractor PTO for Maize shelling operation?

Takeaway message

- Understanding functional components and operational principles of modern maize shellers is prerequisite for operating and handling of this very important mechanical devise.

SECTION 3: MECHANICAL MAIZE SHELLERS: OPERATION AND ADJUSTMENT.

Overview of the section

This section covers the knowledge, attitude, and skill required to perform mechanical maize shelling operations, make proper machine adjustments, and maintain machines for safe and efficient operation.

Learning objectives

At the end of this training section the trainee will be able to:

- Operate engine or PTO-driven maize Sheller using proper procedures
- Be able to distinguish the difference between Diesel and Gasoline engines
- Identify factors affecting the shelling performance of maize Sheller.
- Fixe or troubleshoot operation defects.
- Evaluate the performance of the maize shelling operation.

Duration: 24 Hrs

Training Methods

- Lecture and Discussion
- Brainstorming
- Practical demonstration
- Practical exercice
- Role playing

Pre-assessment question

- What do you expect after the end of this section?
- Which type of machine you used for maize shelling in your locality?
- What do you know about the operational procedures for running of engine-driven maize Sheller?
- What is troubleshooting?

3.1 PROCEDURES FOR MAIZE SHELLING

The following basic steps should be followed for shelling operation:

1. Position the sheller on a level area close to the crop stack
2. Spread cloth, canvas, or mat underneath the sheller to collect spilled grain from the grain discharge chute or due to shattering during shelling.
3. Install all machine components including, cylinder, concave, cover, and feed hopper if dismantled during field transport.
4. Position the sheller so that the cobs and debris are thrown in the direction of the prevailing wind.
5. Check each belt's alignment and tension. Adjust the idler pulley on the blower/cylinder belt to correct tension.
6. Check pulley surfaces. Rough grooves must be smoothened with a fine file if nicked.
7. Open the cover and check all pegs on the shelling cylinder for tightness. Loose pegs will damage the machine and can be dangerous to the operators.
8. Examine the peg teeth for wear. Maximum wear occurs at the feed end of the cylinder and is more prominent at the leading side in the direction of rotation.
9. Rotate the shelling cylinder manually at least five revolutions to ensure that there are no obstructions or interferences.
10. Make sure there are no loose or missing bolts and set screws.
11. Lubricate all places that need greasing and insure for stalking.
12. Check engine oil and fuel levels.
13. Start the engine and allow it to warm up.
14. Feed the sheller with the crop to be shelled for performance checking.
15. Increase cylinder speed and/or concave clearance if excessive amounts of unshelled and unseparated grain are observed with the straw.
16. The recommended Drum speed or Optimum shelling and cleaning are obtained with cylinder speeds of 400 to 600 rpm.

3.2 ENGINE/TRACTOR OPERATING INSTRUCTIONS

Engines and tractors share some common principles when it comes to operation and maintenance.

Operation refers to the process of making the equipment (engine/tractor) work, primary jobs is following manufacturers recommendations (user manual).

Pre-operation of your engine

Pre-operation of the engine involves a few steps. Here's a general guide:

- Check the Oil Level: Before starting the engine, make sure to check the oil level. Refer to the manufacturer's instructions for the specific Robin engine model you're using.

- Do not screw oil gauge in to the oil filler neck to check oil level
- For the engine with oil bath air cleaner, fill the engine oil up to the specified level of oil bath (oil pan)
- Wipe of any spilled fuel before starting the engine
- Filling the tank while the engine during off running
- Fill the fuel tank with the appropriate fuel (usually gasoline) according to the manufacturer's recommendations

During operating your engine

During starting/running the engine involves a few steps. Here's a general guide:

i. Starting

- Open the fuel chock
- Turn the stop switch to the ON position
- Close the chock lever, If the engine is cold, turn the choke on and If the engine is hot, leave the choke off.
- Pull the starter handle slowly until resistance is felt. This is in the compression point. Return the handle to the original position and pull swift. Do not pull out away the rope after starting the engine, allow the starter handle to return to the original position while still holding the handle.

ii. Running

- After starting the engine, gradually open by turning choke lever and keep it finally opened.
- After the engine started, set the speed control lever at the low-speed position and warm up it up without load for a few minutes
- Gradually move the speed control towards high-speed position and set the required engine speed.
- Whenever the high speed is not required, slow the engine down and move the speed control lever to save fuel and extend engine life.
- Pull the starter cord quickly

iii. Stopping

- Set the speed controller lever at low-speed position and allow the engine to run at low speed for 1 and 2 minutes before stopping
- Turn the stop switch counterclockwise and
- Close the fuel chock
- Pull the starter handle slowly and return to its original position when resistance is felt the operation is necessary to outside moist air from intruding into a combustion chamber.

3.3 IDENTIFYING DIESEL AND GASOLINE ENGINES

The following table summarizes the key differences between diesel and gasoline engines, highlighting aspects such as ignition, fuel type, combustion process, efficiency, torque vs. horsepower, durability, fuel efficiency, application, and maintenance requirements.

FEATURE	DIESEL ENGINE	GASOLINE ENGINE
Ignition	Compression-ignition engine: Ignites fuel by compressing air in the combustion chamber.	Spark-ignition engine: Ignites fuel-air mixture using a spark plug.
Fuel Type	Uses diesel fuel, which is thicker and less volatile than gasoline.	Uses gasoline, a lighter and more volatile fuel.
Combustion Process	Compression-ignited injection: Fuel is vaporized and ignited by high-temperature compressed air.	Spark-fired combustion: Fuel-air mixture is ignited by a spark plug.
Efficiency	Higher thermal efficiency, about 20% more efficient than gasoline engines.	Lower thermal efficiency compared to diesel engines.
Durability	Known for durability and longevity, with a life expectancy of around 250,000-300,000 miles.	Generally less durable than diesel engines, requiring maintenance sooner.
Fuel Efficiency	More fuel-efficient due to higher energy density and lower RPM performance.	Less fuel-efficient compared to diesel engines.
Application	Commonly used in heavy-duty vehicles like trucks, buses, and construction equipment.	Typically found in lighter vehicles such as cars, motorcycles, and scooters.
Maintenance	Requires less maintenance and has a longer life cycle compared to gasoline engines.	Often needs more frequent maintenance and may have a shorter life expectancy.

Table 1. The difference between diesel and gasoline Engine

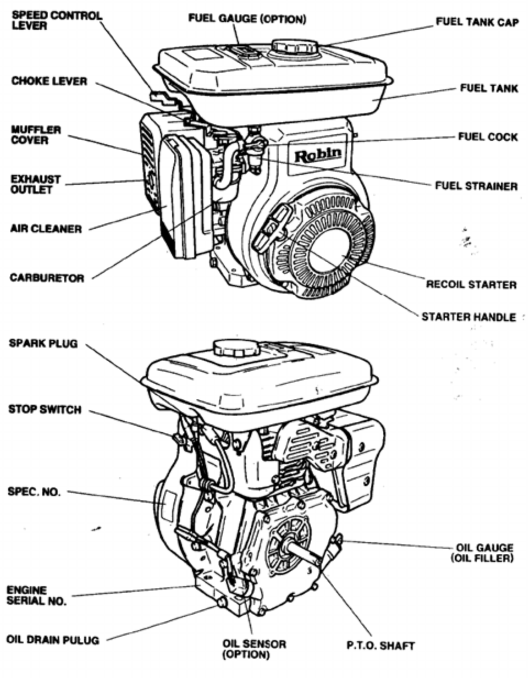

Figure 15. Engine Components

3.4 FACTORS AFFECTING SHELLING PERFORMANCE.

Crop factors

Cob size: The size and shape of the unshelled maize cobs can affect the shelling performance. Larger cobs can be more difficult to shell, leading to increased shelling time and potential damage to the kernels.

Crop variety: Different varieties of maize can have distinct characteristics that impact the shelling performance. For example, some varieties may have stronger kernels or larger cobs, which can affect the shelling efficiency and grain damage. The shellability of maize is another factor that can affect the shelling performance. Maize with higher shellability is easier to shell, resulting in better shelling efficiency and lower grain damage.

The moisture content of the crop: The moisture content of the maize crop can significantly affect the shelling performance. Excessively dry or moist crops can lead to increased kernel damage and cob breakup, which can negatively impact the overall shelling efficiency.

Machine factors

Types of shelling drum: The shelling drum type on a maize sheller plays a significant role in determining the shelling performance of the machine. The type of shelling drum used can influence various factors that impact the efficiency and quality of the shelling process.

Shelling drum diameter: A larger diameter drum can increase the shelling capacity and efficiency of the machine. The size of the shelling drum influences the contact area and the force applied to the cobs during the shelling process. A larger drum diameter can provide more surface area for effective shelling, especially for larger or irregularly shaped cobs

Beater shape, size, and number: The combination of beater shape, size, and number directly influences the shelling efficiency by affecting the force applied, the contact area with the maize cobs, and the efficiency of grain separation. Proper selection and design of beaters are essential to achieve high shelling efficiency and minimize kernel damage.

Concave Clearance: The gap between the rotating cylinder and the stationary concave in a maize sheller, plays a significant role in shelling performance. A narrower clearance increases the force of interaction between the cylinder and the cobs. This can lead to higher shelling efficiency, meaning a greater percentage of kernels are removed from the cobs. On the other hand, it results result in cracks or damage to the kernels during the shelling process. Thus, proper adjustment of the concave clearance based on the size and moisture content of the maize cobs is essential to ensure thorough shelling while minimizing grain breakage.

Operational factors

Cylinder speed: An increase in drum speed can lead to improved maize shelling efficiency, likewise it can increase crop damage. Optimal drum speeds can lead to enhanced shelling performance and increased output capacity, contributing to overall efficiency.

Feed rate: The amount of unshelled maize cobs fed into the sheller per unit of time directly influences the shelling capacity of the machine. Higher feed rates can increase overall shelling capacity, and reduce cleaning and shelling efficiency. The feed rate can affect the level of grain damage during the shelling process. To maintain optimal shelling performance, the feed rate should be adjusted considering other operational parameters, such as cylinder speed and concave clearance. Proper synchronization of these factors can help to achieve the desired shelling efficiency, capacity, and grain quality.

3.5 MACHINE ADJUSTMENTS AND TRABLESHOOTING

3.5.1 MACHINE ADJUSTMENT

The performance of a maize sheller is heavily influenced by various machine adjustments, which can optimize efficiency, capacity, and grain quality.

Cylinder/Drum Speed Adjustment

The rotational speed of the shelling cylinder or drum can be varied by adjusting engine speed using throttle device of the engine. Additionally, it can be adjusted by using different diameters of pulleys. Increasing the cylinder speed can enhance shelling efficiency and capacity, but excessive speeds may lead to higher grain damage. Proper adjustment of the cylinder speed based on factors like crop variety, moisture content and feeding rate is essential for achieving optimal shelling performance.

Concave clearance adjustment

Some machines may have a mechanism to adjust the concave clearance. As the clearance decreases the shelling performance the machine increases. However other quality parameters such as grain breakage will increase. Likewise, as concave clearance increases, the output capacity increases. While the shelling efficiency declines.

Synchronization of Adjustments

Optimal shelling performance is achieved by synchronizing the adjustments of various machine components, such as cylinder speed, concave clearance, feeding rates, and cleaning system.

3.5.2 TROUBLESHOOTING

ISSUE	POSSIBLE CAUSE	SOLUTION
Maize Sheller does not start	Power supply issue • Faulty switch or wiring • Motor malfunction • Loosen belts	• Check the power supply and ensure it is connected properly. • Inspect the switch and wiring for any signs of damage or loose connections. Replace if necessary. • Test the motor by connecting it directly to a power source. If it does not run, consider replacing it.
Maize sheller operates slowly	• Insufficient power supply • Worn-out or damaged parts • Improper adjustment	• Check if the power supply meets the sheller's requirements. • Inspect the sheller's components, such as blades and rollers, for wear or damage. Replace if necessary. • Ensure the sheller is properly adjusted according to the manufacturer's instructions.
Grain quality issues	Weak capacity of tractors or engines to provide required RPM for shellers with high moisture.	Ensure proper adjustment of drum speed/RPM and blower fans for efficient shelling.
Malfunctioning during shelling	Shellers spewing out grains, de-husking, or breaking grains due to improper adjustments.	Check and adjust settings like drum speed/RPM, blower fans, and feeding rate for smooth operation.

Wastage during threshing	Excessively green-wet grain and cob fed into the machine, leading to losses.	Control the feeding rate, ensuring the right balance of grain and straw for optimal performance.
Decreased germination in seed production	Threshing at high speed negatively affecting seed germination.	Consider alternative threshing methods or adjust settings to minimize impact on seed quality.
High Cylinder loss	Low cylinder Speed Crop too wet Too much clearance between cylinder and concave	Increase cylinder speed. Wait until crop sufficiently dries Decrease Cylinder-concave clearance.
Poor cleaning of grain	Over threshing Overloading Sieve opening too much Insufficient air from blower	Increase Cylinder-Concave clearance Reduce feed rate Use proper sieve with proper opening Increase wind blast
Grain cracked	Cylinder-concave clearance too-little High cylinder speed Grain too dry	Increase clearance Reduce cylinder speed Keep grain moisture within ranges recommended
Cylinder Wrapping	Grain tough, dump, or heavily infested with weed Striping bar too far from cylinder	Increase cylinder speed slightly Increase beater speed slightly Reduce feed rate Adjust stripping bar

Table 2. Troubles, causes and remedies for good quality and high-performance maize shelling
Source; Harvesting with Combines Agricultural Extension service Ohio State University

PROBLEMS	CAUSES	SOLUTIONS
Engine not started	• A dead battery • Clogged fuel filter or fuel lines • Overheating engine • Contaminated diesel fuel • Jammed fuel injection pump • Empty fuel tank • Radiator hose damage • Cold weather	• Check/test or replace the battery • Clean air filter or fuel filter • Cool down the engine • Change the fuel and use specific fuel • Check dirt in injection pump • Fill fuel • Check the radiator hose and replace • Check the fuel cup creating a vacuum
Engine stopping automatically	• There is air in the fuel system • Overloading /increase load suddenly • Air filter obstructed	• Drain out the air • Decrease the load • Maintain or brush off
Exhaust with black smoke	• Overload • Air is not enough or leaky	• Decrease the load, if working engine is not properly matched, change it • Clean the air filter, check the cause of leakage and remedy
Exhaust with black smoke	• There is water in diesel fuel	• Clean the fuel tank and diesel • filter, change diesel fuel
Methods and positions of stopping to check when the engine's malfunctioning	• Speed sometimes high and low • Abnormal sound appear suddenly • There is metal knocking sound rhythmically in the cylinder	• Make a constant speed • Check up the engine with local expert/ technicians

Table 3. Engine troubleshooting's

Performance Assessment of maize sheller

The performance evaluation of a maize sheller involves assessing various aspects of its operation and output to determine its efficiency, effectiveness, and overall quality of shelling. When evaluating the performance of a maize sheller, it is essential to consider the specific requirements and objectives of the application. Additionally, comparing the performance of different sheller models and seeking feedback from other users or experts in the field can provide valuable insights. Key parameters to consider when evaluating the performance of a maize sheller include:

1. Shelling Capacity

The shelling capacity refers to the amount of maize that the sheller can process within a given time. It is usually measured in terms of weight (e.g., kilograms or Quintal) per unit time (usually in hr). It can be calculated as:

$$C_O = M_C/T \quad \ldots\ldots\ldots\ldots (1)$$

Where: C0 – Shelling (output) capacity (kghr-1)
Mc- Mass of the maize shelled in the machine (kg)
t - Time taken (hr)

2. Shelling Efficiency

The shelling efficiency measures the effectiveness of the sheller in separating the maize. A higher shelling efficiency indicates a more efficient sheller. Shelling efficiency is the ratio of the mass of the shelled maize to the total mass of the maize expressed in percentage as follows:

$$S_E\,(\%) = M_S/M_T \times 100 \quad \ldots\ldots\ldots\ldots (2)$$

Where: - Se =the shelling efficiency (%)
Ms= mass of the shelled maize (kg)
Mt= total mass of the maize (kg) collected from all outlets

3. Unshelled grain percentage

Unshelled grain is the ratio of the quantity of unshelled maize to the total mass of the sample expressed in percentage and given as follows;

$$U_G = M_U/M_T \times 100 \quad \ldots\ldots\ldots\ldots (3)$$

Where: Ug- unshelled grain (%)
Mu- mass of the unshelled grain (kg)
Mt- total mass maize sample (kg)

4. Grain Damage

Grain damage during maize shelling is a major concern, affecting the quality and value of kernels. Factors such as increased drum speed, low clearance between cylinder and concave, low moisture content, and improper feeding practices results grain damage during shelling operation. To reduce grain damage, proper adjustment of cylinder concave clearance, optimum drum speed, harvesting maize during appropriate moisture level, setting controlled mechanical feeders for consistent cob flow, and maintaining a steady pace for manual feeding is crucial. The percentage damage is the ratio of quantity damaged to the total quantity of the sample (Eq. 4).

$$P_D = Q_D/M_T \times 100 \quad \ldots\ldots\ldots\ldots (4)$$

Where: Pd - Percentage damage (%)
Qd- Quantity of damage seeds (kg)
Mt-total mass of the sample (kg)

5. Percentage loss

Percentage loss is the quantity of maize kernel loss from the total quantity of maize expressed in percentage and computed as follows

$$P_L = M_L/M_T \times 100 \quad \ldots\ldots\ldots\ldots (5)$$

Where: Pl- percentage losses (%)
Ml-mass of the lost seeds (kg)
Mt- total mass of the maize crop (kg).

6. Estimating Fuel Consumption

- Take a known sample of unshelled maize in kg (Quintal)
- Fill the fuel tank with fuel.
- Shell the sampled maize with the maize sheller and collect the shelled maize carefully.
- After completing the shelling operation of the sample, refill the known amount of fuel until the fuel tank is filled.
- Record the fuel used for refill using graduated cylinders.
- Convert the fuel consumed during shelling operations to litter and Convert the Amount of maize grain collected kg (Quintal)
- Divide the fuel consumed in litter to the shelled maize shelled in kg (Quintal)

Given:

- Mass of the maize shelled in the machine = 384kg
- Time taken =1hr
- Mass of unshelled maize = 4kg
- Grained damage = 0.2kg/20kg sample
- Mass of grain collected from blower = 12kg
- The total mass of cob = 20kg

Determine

a. Shelling efficiency
b. Output capacity,
c. Percentage of Crop damage,
d. Percentage grain loss
e. Percentage of recovery loss

Post assessment questions

- What is the difference between traditional and mechanical maize sheller
- What are the factors that affects performance of the Sheller?
- What are the main difference between Diesel and Gasoline engines?
- What are the different indices indicating performance of Maize shelling operation

Takeaway message

- Crop factor, machine factor and operator factor can affect the performance of the sheller.

SECTION 4: SAFETY PRECAUTIONS DURING MAIZE SHELLING OPERATIONS

Overview of the section

This section covers the knowledge, attitude, and skill required to identify hazards, minimize risk of accident and injuries, and use safety Aids associated with maize Sheller operation.

Learning objectives

At the end of this training section the trainee will be able to:

- Apply safety precautions.
- Identify the cause of machinery operation related hazards.
- Understand and follow general safety procedures
- Manage and Store machinery in appropriate manner

Duration: 4 Hrs

Training Methods

- Lecture and Discussion
- Brainstorming
- Practical demonstration
- Practical exercice
- Role playing

Pre-assessment question

- What do you know about safety precautions?
- What will happen if you don't care about your safety?

4.1 OPERATOR SAFETY ON MAIZE SHELLER MACHINE

4.1.1 OCCUPATIONAL HEALTH AND SAFETY (OHS) HAZARDS

This code of practice is intended to raise awareness of the hazards and risks associated with post-harvest technologies in agriculture and promote their effective management and control.

- To help prevent occupational accidents and diseases and improve the working environment
- To encourage governments, employers and workers to cooperate to prevent accidents and diseases;
- To promote more positive attitudes and behaviour towards occupational safety and health (OSH) in agriculture throughout the sector;

- To ensure that good workplace health ansafety practices are applied to all workers in the workplace regardless of age or gender.

4.1.2 CAUSES OF MACHINERY HAZARDS

The following factors, among many others, are the major causes of machinery hazards.

- Farmer's attitude to machinery use: Farmer's attitude about safety is a very important factor in preventing accident occurrence.
- The operator factor: Machinery operator factor seen as a major determinant in accident causes.
- Operator's emotional condition: The machine operator singularly contributes significantly to farm accidents. The physical and mental condition of the operator may lead to poor decision-making, unsafe actions, or impaired capabilities.
- The machinery condition: Accidents are not always occurring as a result of human error alone, often the machinery condition may be a major contributory factor.
- Engine/power train components: The engine and power train components, if not properly maintained, could be a potential source of injury during operation.
- Electrical components: Frayed or broken wires must be replaced, repair broken gauges, lights and switches. On idle machines, the battery ground cable should be disconnected from the battery to avoid corrosive build-up and possible battery discharge.
- Operator's age constraint: young operators may have knowledge but limited in experience, and their lack of awareness of hazards increases the possibility of an accident. Older workers may be experienced but often have slower reaction times and lacks the agility to react physically to some situations, particularly when the work area is slippery.
- Operator's attitude: Knowledge of hazards alone is not enough to prevent accidents. A positive attitude about safety is needed to make use of the knowledge. Does the operator perceive the power take-off (PTO) operation as hazardous?

4.2 GENERAL SAFETY PROCEDURES

1. Training and Authorization: Ensure that all operators are properly trained and authorized to operate the mobile maize sheller.

2. Personal Protective Equipment (PPE): Operators and those in the vicinity should wear appropriate PPE, including gloves, safety glasses, earplugs or earmuffs, and a dust mask (Figure 12).

3. Site Preparation: Choose a well-ventilated area for shelling operations, away from potential hazards such as power lines or water sources. Ensure the ground is level and stable to prevent the sheller from tipping over.

4. Setup and Inspection: Before starting, inspect the sheller for any damage or loose parts. Set up the sheller according to the manufacturer's instructions and ensure all guards and safety devices are in place and working properly.

5. Power Source: Connect the sheller to a reliable power source and ensure all electrical connections are secure. Avoid using extension cords or overloading circuits.

6. Feeding the Sheller: Feed the maize cobs into the sheller at a steady rate, avoiding overloading or jamming. Keep hands and other body parts away from the intake and discharge points.

7. Blockage Prevention: Monitor the shelling process and listen for any unusual sounds or vibrations. If a blockage occurs, immediately stop the sheller and clear the blockage while ensuring hands are clear of moving parts. Maintain the sheller according to the manufacturer's instructions, including lubrication, cleaning, and replacement of worn parts. Clean the sheller thoroughly after each use to prevent build-up and ensure proper operation.

8. Emergency Stop: Familiarize yourself with the emergency stop button and ensure it is easily accessible in case of an emergency.

9. First Aid: Keep a basic first aid kit nearby in case of minor injuries.

By following these safety procedures, you can help minimize risks and ensure a safe operating environment for mobile maize sheller service. Personal protective equipment is protective clothing, helmets, goggles, or other garments or equipment designed to protect the wearer's body from injury or infection. The hazards addressed by protective equipment include physical, electrical, heat, chemicals, biohazards, and airborne particulate matter.

Figure 16. Personal protective devices

SAFETY ASPECT	DESCRIPTION
Personal Protective Equipment	Recommended personal protective equipment (PPE) that should be worn during maize sheller operation, such as safety glasses, gloves, and hearing protection.
Training and Familiarization	Adequate training and familiarization with the maize sheller's operation, controls, and safety procedures before use to ensure proper handling and awareness of potential risks.
Clear Operating Area	Maintaining a clear and unobstructed operating area around the maize sheller to prevent tripping hazards and allow safe movement during operation.
Proper Clothing	Wearing appropriate clothing that is well-fitted, free of loose ends, and avoids any potential entanglement with moving parts or hazards.
Safe Loading and Unloading	Ensuring safe loading and unloading of maize into the sheller, following recommended procedures and using appropriate tools or equipment to minimize the risk of injury.
Avoiding Reach-in Hazards	Strictly avoiding reaching into the maize sheller or attempting to remove blockages while the machine is running, as this can lead to serious injuries.
Regular Maintenance	Performing regular maintenance and inspections on the maize sheller to ensure its proper functioning, including checking for loose parts, damage, or signs of wear that could pose safety risks.
Safe Power Source	Ensuring that the maize sheller is connected to a safe and properly grounded power source, following electrical safety guidelines to reduce the risk of electrical accidents.
Safe Handling of Fuel	If applicable, using proper procedures for handling and storing fuel (such as gasoline) used by the maize sheller, including safe storage, refueling, and avoiding ignition sources near fuel storage areas.
Emergency Preparedness	Being prepared for emergencies by having access to emergency contact numbers, first aid supplies, and knowledge of appropriate response actions in case of accidents or injuries.

Table 4. General safety precaution during shelling operation

SAFETY ASPECT	DESCRIPTION
Emergency Stop Button	A prominent button that immediately stops the operation of the maize sheller when pressed, ensuring quick and easy shutdown in case of emergencies.
Overload Protection	Mechanisms or sensors that detect excessive load or strain on the machine and automatically stop or reduce power to prevent damage or accidents.
Safety Guards	Physical barriers or shields that enclose moving parts and potential pinch points, preventing access to hazardous areas during operation.

Interlock Systems	Safety mechanisms that ensure certain conditions are met before the maize sheller can be operated, such as ensuring guards are in place or doors are closed.
Safety Labels and Warnings	Clearly visible labels and warnings that provide instructions, precautions, and safety guidelines to users, indicating potential hazards and risks.
User Training and Instructions	Proper training programs and detailed operating instructions that educate users about safe operation, maintenance, and potential risks of the maize sheller.
Electrical Safety	Compliance with electrical safety standards, including proper grounding, insulation, and protection against electrical hazards and shock risks.
Maintenance Safety	Guidelines and precautions for safe maintenance activities, including lockout/ tag-out procedures, ensuring power isolation before servicing or repairs.
Noise and Vibration Control	Design features or measures to minimize excessive noise and vibration levels, reducing the risk of hearing damage and musculoskeletal disorders.
Fire Prevention	Measures to prevent the risk of fire, such as proper insulation, protection against sparks, and adherence to fire safety standards in electrical components.
Safety Certifications	Compliance with relevant safety standards and certifications, ensuring that the maize sheller meets established safety requirements and regulations.

Table 5 General safety precaution while working with sheller Engine.

Post assessment questions

- What are the general safety procedures?
- What are the steps you follow for storing machinery after completion of work?

Takeaway message

- Applying safety first principle can save the worker and the machine.

SECTION 5: SHELLING MACHINE AND ENGINE MAINTENANCE

Overview of the section

Mechanical Threshers are very expensive and complex machines; hence they need to be well operated and maintained to preserve their service life and maximise their profitability. This section covers the knowledge, attitude, and skill required to perform routine maintenance and pre-operational checks of mechanical maize shellers.

Learning objectives

At the end of this training section the trainee will be able to:

- Perform routine maintenance of maize Sheller
- Conduct preventive and corrective maintenance of maize Sheller and prime movers.

Duration: 16 Hrs

Training Methods

- Lecture and Discussion
- Brainstorming
- Practical demonstration
- Practical exercice
- Role playing

Pre-assessment question

- What is routine maintenance and why is it applied for Maize sheller?
- What are the procedures to conduct routine maintenance of engines of Maize sheller machine?
- How frequent will an engine be overhauled?

5.1 WHY TO CONDUCT PREVENTIVE MAINTENANCE

Why should you implement a Preventive Maintenance Program? Preventive Maintenance Benefits

- **Decrease Downtime**- problems are found before they cause breakdowns.
- **Save Money** - Problems are discovered in their early stages, while they are still minor repairs.
- **Extend Machine Life**- Regular maintenance increases the life of the machine.
- **Increase Equipment Value**-Detailed maintenance and repair records kept on the machine increases the value.
- **Keep Equipment Safe**- Good Maintenance= Safer Machine

5.2 GENERAL PREVENTION REQUIREMENTS

- Read the Owner's Manual and follow recommendations.
- Perform Daily Maintenance before operating the machine.
- Check the thresher for damage and potential failures before operation.
- Allow the engine to warm up to operating temperature before use.
- Follow service recommendations and keep the machine and its engine properly serviced
- Never overload the thresher operate only as it was designed to be used.

5.3 PRE-OPERATION (DAILY) CHECKS

Check the following before starting Engines

- Engine Oil Level
- Hydraulic Fluid Level
- Coolant Level
- Air in Tires
- Belt Tension
- Fuel Level
- Wheel Lugs
- Battery
- Safety Equipment

Service Intervals when to conduct services

5.4 ROUTINE MAINTENANCE

5.4.1 PROCEDURES FOR CONDUCTING ROUTINE MAINTENANCE OF MAIZE SHELLER

Routine maintenance of a mechanical maize sheller is essential to ensure its optimal performance, longevity, and safe operation. Here are some key maintenance tasks that should be performed regularly:

Cleaning: Regularly clean the maize sheller to remove any debris, dust, or residue that may accumulate during the shelling process. Use a brush, compressed air, or a vacuum cleaner to clean the shelling components, including the drum, sieves, and any other relevant parts. Pay particular attention to areas where maize kernels or other materials may get lodged.

Lubrication: Proper lubrication is crucial for the smooth operation of mechanical components. Refer to the manufacturer's guidelines to identify the specific lubrication points on the maize sheller. Apply lubricant, such as oil or grease, to these points as recommended. Ensure that the lubricant used is appropriate for the specific components and operating conditions of the sheller.

Inspection: Regularly inspect the maize sheller for any signs of wear, damage, or misalignment. Check for loose bolts or fasteners and tighten them if necessary. Inspect belts, chains, and gears for signs of wear or damage and replace them as needed. Examine the drum, sieves, and other critical components to ensure they are in good condition and functioning properly.

Belt Tension: Belt tension is crucial for engine-driven maize shellers, as it transmits power from the engine to the shelling mechanism. Loose belts can reduce power delivery and hinder shelling efficiency. Proper belt tension ensures the shelling mechanism functions effectively. Excessively tight belts can cause premature wear and tear. To achieve optimal performance, follow manufacturer recommendations and regularly check and adjust tension. Replace worn belts that lose elasticity over time. Neglecting belt tension can lead to inefficiencies, potential damage, and safety hazards.

5.4.2 PROCEDURES FOR CONDUCTING ROUTINE MAINTENANCE OF MAIZE SHELLER ENGINE

Engine maintenance is crucial for ensuring your engine runs smoothly, efficiently, and lasts for a long time. Consult the engine manufacturer's guidelines for the recommended service intervals and maintenance tasks. These guidelines may vary depending on factors such as engine type, usage, and environmental conditions. Here are some key routine maintenance procedures for engines:

Oil changes and filter replacement: This is probably the most critical routine maintenance task. Engine oil lubricates moving parts, reduces friction, and helps keep the engine clean. Regular oil changes and filter replacements are essential to remove contaminants and maintain optimal engine performance.

Air filter cleaning/replacement: The air filter cleans the air entering the engine, preventing dirt and debris from harming internal components. A clogged air filter can reduce engine power and fuel efficiency. Check and clean or replace the air filter as recommended in your owner's manual.

Cooling system check: The cooling system keeps the engine from overheating. This involves checking coolant levels and condition, inspecting for leaks, and ensuring the radiator and hoses are functioning properly. Refer to your owner's manual for specific instructions.

Spark plugs and ignition system (for gasoline engines): Spark plugs ignite the air-fuel mixture in the engine cylinders. Over time, spark plugs can wear out and need replacement. A worn spark plug can cause rough idling, reduced fuel efficiency, and difficulty starting. Consult your owner's manual for recommended replacement intervals.

Belt and hose inspection: Belts and hoses drive various engine components, such as the alternator. Inspect these components for signs of wear, cracking, or fraying. Replace worn or damaged belts and hoses to prevent engine damage or failure.

Battery maintenance: Check the battery terminals for corrosion, ensure cleanness and connection. Test the battery's charge periodically & replace it if it no longer holds a charge or exhibits signs of deterioration.

Regular inspections: Conduct visual inspections of the engine compartment for any signs of fluid leaks, loose connections, or unusual noises. Address any identified issues promptly to prevent further damage.

5.5 MACHINE STORAGE AFTER SHELLING

Storing thresher machines properly is essential to ensure their longevity and efficient performance. Whether you’re using traditional methods or modern machinery, here are some guidelines for storing thresher machines:

- Clean the Machine Thoroughly: Before storing the thresher, make sure to clean it thoroughly. Remove any debris, chaff, or leftover grain. This helps prevent rust and ensures that the machine is ready for the next use
- Remove Belts and store in a dry place: Take off any belts or moving parts that can be detached easily. Store them separately in a dry location. This prevents moisture damage and extends the life of the belts
- Clean and apply oil to exposed metal surfaces to prevent rusting.
- Choose a clean, dry location: Find a clean, dry area for storing the thresher. Ideally, this should be indoors or under a protective cover. Exposure to rain, dust, and extreme temperatures can lead to deterioration over time
- Cover the machine: Use a cover or tarp to protect the thresher from dust accumulation. Dust can clog moving parts and affect performance. Keeping the machine covered also prevents direct exposure to sunlight, which can cause fading and damage1.
- Inspect and Repaint Parts: Check for any parts that need repainting. If you notice rust or peeling paint, touch up those areas. Properly painted surfaces are less likely to corrode. Additionally, apply oil to exposed metal surfaces to prevent rusting.

? **Post assessment questions**

- List the procedures for conducting routine maintenance of maize sheller
- What are the procedures you follow for conducting routine maintenance of maize sheller engine?

Take away message

Proper and timely maintenance of Shelling machine and its engine can elongate the machine economic life and increase machine performance.

Business risks and possible mitigation measures

NO	Possible risks	Risk response
1	Technical nature of machinery business may pose difficulty to understand for trainees	Preparation of module in local language simplifying terms and procedures
2	Adverse effects of climate changes and consequential variations in rainfall pattern may shorten timing for machinery operations.	Using modern approaches and digital technologies to locate service areas with better environmental conditions
3	Low productivity and small land holding of small-scale farming affect profitability of Sheller hire business.	Give priority for organized farmers' groups such as production clusters, large-scale farmers, organized farmer groups, seed multipliers and others
4	Timing of shelling doesn't match with farmers financial status (low cash availability during threshing season)	Use different approaches to render services with credit scheme

Reading materials

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