UNIT 10 RICE MILLING TECHNOLOGY

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10.0 OBJECTIVES

After reading this unit, you should be able to:

- explain the need and objectives of rice milling;
- understand the different methods and levels of milling operation;
- describe the limitations of single stage milling and advantages of multistage milling;
- explain different stages involved in modern rice milling with flow diagram;
- describe the principles of different milling operations and machinery used for milling;
- highlight the importance of packaging and packaging materials used for rice; and
- describe the importance of different components of rice milling operation with respect to the economics of milling.

10.1 INTRODUCTION

Rice milling is the most important post harvest process that produces edible rice from paddy. Paddy seed contains a rough, inedible, woody outer covering called husk. The inner kernel, called brown rice, again contains some soft outer layers, jointly called bran.

The process of removing husk and bran layers (partially or fully) from the paddy grain in order to produce edible rice is called Rice milling. Dehusking is the step of removal of husk. After dehusking paddy, we get brown rice. Debranning is the process of removal of different layers bran (pericarp and the testa, the aleurone layer and germ, partially or completely) from brown rice. This produces the edible milled rice or the white rice.

Unlike other food grains, rice is mostly cooked and consumed in the whole grain form. Loss of kernel integrity results in brokens. Production of brokens means quantitative and qualitative loss of edible rice. This also means reduction in the marketable price and poor economics of milling operation. The milling yield of rice is determined by factors like husk content of the paddy variety, degree of milling and grain breakage. Moisture content, variety and type of paddy (raw/parboiled) and rice milling machinery affect the milling yield. Shortcomings in all the pre and post-harvest operations affect rice milling.

Rice milling operation should ideally maximise the yield of good quality edible rice, minimise losses and processing cost. Milling equipment ranging from the simplest pestle and mortar or a *dhenki* to a large, modern computer controlled complex systems are employed for milling. Hand pounding used to be part and parcel of village life. The range of equipment available in the market for rice milling is also expanding continuously. Understanding the principles of operations and the most commonly used equipment being used for rice milling is of utmost importance.

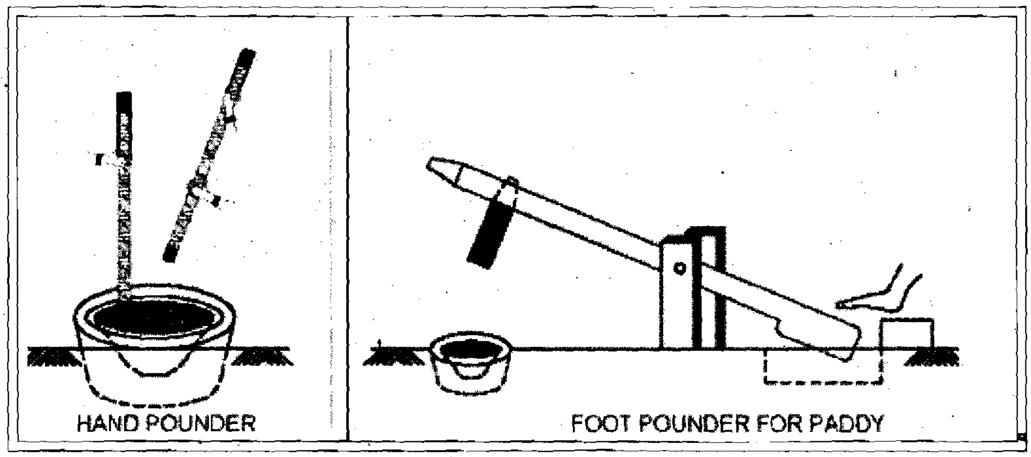


Fig. 10.1: Traditional Milling Methods

10.2 TRADITIONAL MILLING OF RICE IN *DHENKI*

Of the various methods available for obtaining white rice, the first method is pounding of paddy by hand or foot operated pounding units (*dhenki*) (Fig. 10.1). Pounding of paddy is still practiced in some rural areas. In these units, milling takes place due to the impact of the pounder. During repetitive pounding, rice breaks and the polish will also be non-uniform. Approximate capacity of hand pounding is 50 kg paddy per day per person. The outturn is generally about 50% and yield of whole kernels is very low.

10.3 ENGELBERG HULLER

Industrialisation and the seriousness of the food problem in the post-war era necessitated mechanisation of rice milling industry. Engelberg huller was introduced at this juncture.

Engelberg huller (Fig.10.2) is the most widely used single step rice mill for small scale milling. Lakhs of hullers are in operation all over the rice producing countries of Asia. It is called the 'huller' in India and Sri Lanka and 'Kiskisan mill' in the Philippines and Thailand.

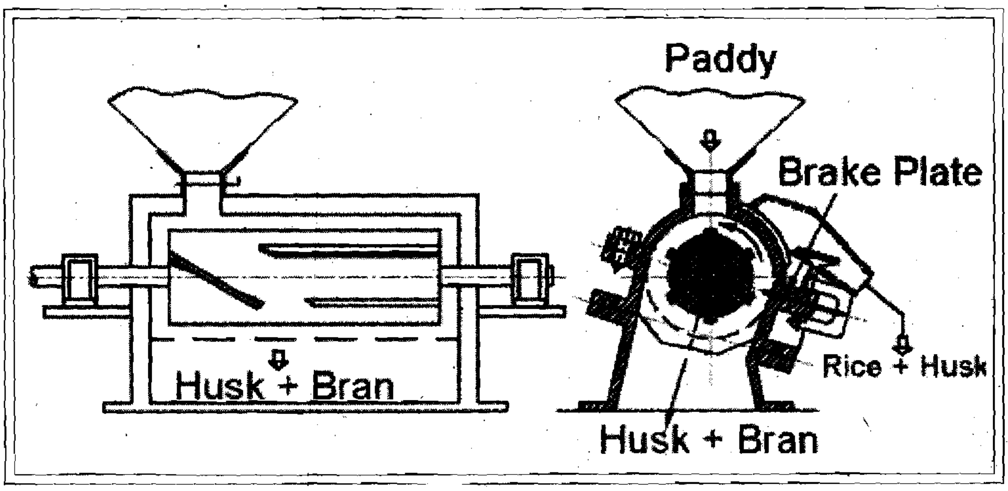


Fig. 10.2 : Engelberg Huller

Huller consists of a ribbed Cast Iron cylinder mounted on a rotating shaft, fitted inside a cylindrical housing. The bottom half of the housing is fitted with a slotted sheet. The axial movement of paddy is accomplished by the truncated screw on the rotor. The grain flow and degree of milling are controlled by adjusting the position of the brake plate. Friction between the grains and steel parts of the huller causes husk and bran to be scraped off. This mixture of ground husk and bran along with fine brokens pass through the slotted screen of the housing. A mixture of polished rice and husk is delivered from the discharge end of the huller. Husk is aspirated off to collect polished rice.

In hullers, paddy is subjected to excessive pressure and friction which result in heating, low output and high breakage. Average rice recovery, especially in the case of raw rice, is low – 63% or even less. Since dehusking and polishing operations are combined, the by-products, husk and bran are mixed together and the economic value of this resultant mix rather low. Also, the specific energy consumption of the huller mill is high.

Hullers are, however, simple in design, easy to operate and maintain. Generally, they can be manufactured locally. These units are mostly located in villages where the mill area is small, transportation facilities are poor, parboiling is prevalent and quality standards are not assumed to be critical. Hullers can mill even small quantities of paddy and therefore, they are also used for custom milling.

The mill/ milling operation may be modified to reduce the excessive milling pressures. But, in such cases, paddy needs to be recycled two or three times. Improvements in huller, viz., modifications in the configuration of the spiral screw, screen, position of the rice outlet, rpm etc., has been attempted to obtain a better milling outturn with lesser breakage.

Multi-stage milling using battery of hullers (e.g. double huller system) provides a slight improvement in quantity of rice and quality of by-products. In this system, in the first stage operation, huller is set for dehusking and the husk is aspirated off from the resultant mixture. Mixture of paddy and brown rice is polished in the second stage and the husk-bran mixture is sieved to get better quality of by-products.

However, huller as such is a poor dehusker. Some polishing also takes place during dehusking itself resulting in loss of bran. To overcome this limitation, units specially meant for dehusking are incorporated in the improved huller mills prior to polishing in hullers.

Sheller-cum-huller mill, centrifugal sheller huller mill, rubber roll sheller huller mill are some of the improved versions of these multi-stage milling units meant for small scale milling of rice. A Mini rice mill incorporates all the components of a modern rice mill in a miniature form.

10.4 MODERN MILLING TECHNOLOGY

A flow chart of important operations, followed in sequence, for milling of rice in a modern rice mill is shown in Fig 10.3. The operations are as follows:

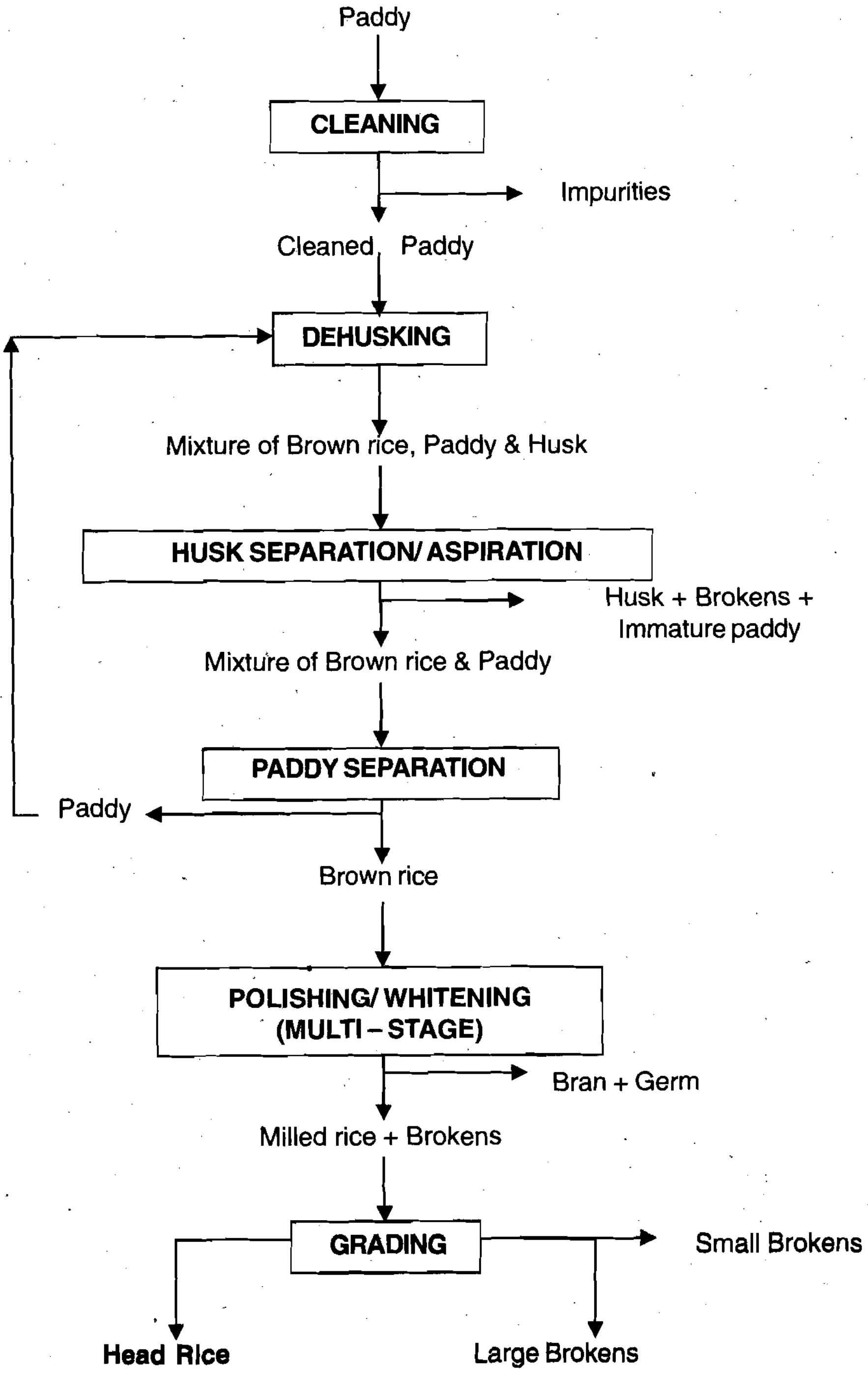


Fig. 10.3: Schematic diagram of rice milling operations

Cleaning	Removes foreign matter such as sand, stones, straw, seeds of other grains and pieces of iron from paddy.
Dehusking	Removes husk from paddy with minimum damage to the grain.
Husk separation	Removes husk from the mixture obtained after dehusking.
Paddy separation	Separates brown rice from unhusked paddy, paddy then returned for dehusking.
Debranning	Removes all or part of the bran layers from brown rice to produce polished rice.
Grading	Separates brokens from head rice. Brokens are separated into different sizes.

Bucket elevators are used to move the grain from one machine to the next for continuous operation. Conveying, bagging, weighing and other associated operations are also done as required. The standard sizes of the plant and machinery are 1, 2 and 4 tonnes paddy per hour TPH, though 6 TPH plants are also being introduced now.

Major difference in different types of rice mills can be seen in the application of cleaners, paddy separators and polishers. Compartment type paddy separators and cone polishers are adapted in one type of mills whereas the other type uses drum type cleaners; tray type paddy separators and horizontal type primary and final polishers. Combination of the two types is also very common. Cone polishers are generally preferred for milling parboiled paddy.

A short description of the different steps and of machines used for each step in milling is as follows:

CLEANING

Cleaning is the process of separation of impurities from the paddy stock. Paddy arriving in the mill usually contains foreign matter (materials other than paddy grain). These contaminants usually get mixed in the field and during handling and transportation. Upon arrival at the mill, foreign matter should be removed from paddy stock. Cleaning, therefore, is the first step in modern rice milling. Cleaning not only enables the production of clean rice but also protects milling machinery and improves milling capacity.

Differences in the physical characteristics of paddy and impurities are used in the cleaning process to bring about separation of impurities from the mill stock. Based on the size, impurities are classified into large impurities, small impurities, and impurities as the same size of paddy. Large impurities normally consist of rice straw, panicles, bag string, soil, stones and some times, iron parts. Small impurities consist of dust, sand, mud balls, weed seeds, insects and small stones. Impurities of the same size as paddy can be immature, empty grains, stones and iron particles. Impurities which are larger or smaller in size than paddy are removed by sieves. Vibrating or rotating sieves or a combination of both can be used for this purpose.

Lighter impurities are removed by aspiration. This also creates a hygienic work environment. Ferrous impurities are removed by the use of magnetic separators. Impurities of the same size of paddy, but heavier than paddy are removed by destoners/ specific gravity separators. Cleaners may have built-in destoners. Often, intake paddy is subjected to a preliminary partial cleaning (scalping) prior to storage and mill cleaning.

In some old/ traditional mills, open type, two-sieve reciprocating sifters are employed. Only size separation is possible in these units. Being an open system, dust formation is considerable. Sieves also get clogged and the cleaning efficiency will be low.

Modern rice mills will have improved cleaners. A few types of more popular cleaners are described herein.

A. Closed type double action cleaner

The closed type double action cleaner is shown in Fig. 10.4. Paddy is fed into this machine through the inlet opening at the top. The suction fan draws air through the moving bed of grains and separates dust and light impurities which drop to the cone-shaped bottom of the aspiration housing for automatic discharge. Paddy falls on to a vibrating sieve with large perforations which removes large impurities such as straw, big stones etc. Paddy and remaining small impurities fall

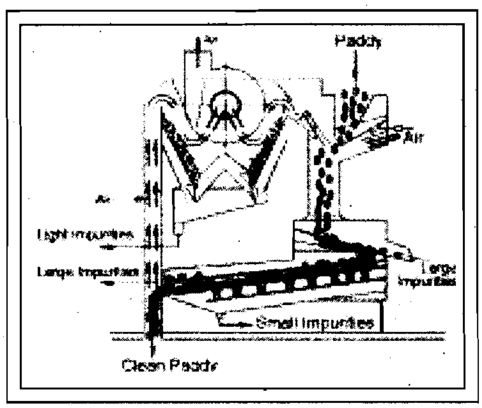


Fig. 10.4 : Closed type double action cleaner

to the bottom vibrating sieve with small perforations which removes small impurities. Overflow from this sieve is again subjected to strong aspiration to remove the last traces of light impurities and dust.

B. Drum type cleaner

The main features for drum type cleaner is given in Fig. 10.5. In this type of cleaner, paddy flow is made uniform by thorough distribution of stock, while feeding into the rotating scalper. Straw and other comparatively large impurities are flipped out of the scalper and discharged separately. Small pieces of straw, light impurities, dust and very light immature grains are exhausted by means of an in-built blower. The cleaner may also have an in-built destoner.

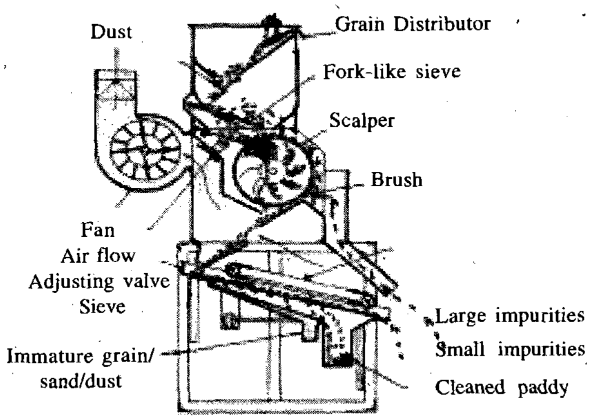


Fig. 10.5 Drum type cleaner

C. Sieve separator

The sieve separator is shown in Fig. 10.6. In these cleaners, a set of sieves gyrate. The machine makes three separations by size: foreign matter larger than paddy, paddy and material smaller than paddy. In addition, material lighter than paddy is subjected to thorough aspiration.

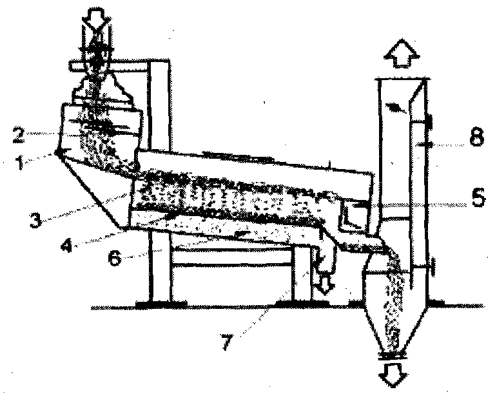


Fig. 10.6 : Sieve Separator

The stock is fed by a gravity spout into the centre of the inlet box (1) oscillating with the machine. A distribution baffle (2) with adjustable slide gate distributes the stock across the entire width of the screen. Then the stock flows over the upper screen (3). The throughs from this first screen drop onto the lower screen (4), while the overs are discharged laterally through the outlet section (5) The throughs of the second screen drop onto the bottom screen (6) which is removed at the outlet (7) The overs from the second screen are subjected to aspiration. The air flow rate is adjusted by changing the cross section of the aspirator limb portion by setting the plate (8).

DESTONING

Impurities such as stones, dirt (mud balls), or metal pieces about the same size as paddy flow out with the stream of grains from the "sieve-aspirate" type of cleaners. Based on differences in density of grains and stones, destoning is achieved. These machines can be of two types, viz., blowing type (pressure type) or suction (vacuum) type.

Pressure type destoner

The pressure type destoner is shown in Fig. 10.7. The destoner consists of a reciprocating perforated deck mounted at an angle. Requisite quantity of air is blown from below through the sieve. When paddy containing stone/ heavier impurity is fed at the top of the sieve, air coming through the sieve stratifies the materials according to their density. The heavier impurities (stones) remain on the deck and are carried backward to the top end by the reciprocating motion of

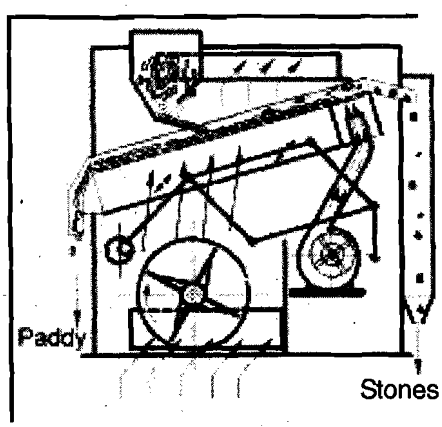


Fig. 10.7 : Pressure type destoner

the deck and discharged. Paddy remains floating and slides down the incline. Separation can be adjusted by regulating the rate of feed, volume of air and sieve inclination.

Vacuum type destoner

Working principle of these units is similar to the pressure type destoner, except that air is sucked through the grain bed from the top of the deck.

In these units, grains are spread uniformly across the entire width of decks by a feeder. On the pre-separation screen, material is stratified according to specific gravity by the oscillating motion of the screen and the air flow i.e., Light materials collect at the top while the heavier ones-including the stone, get to the bottom. The lower layer, which also has the stones, flows upwards and is fed to the final separation zone. Here, stones are separated by a countercurrent of air.

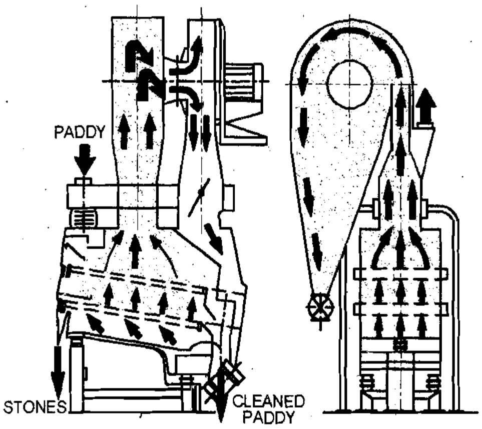


Fig. 10.8 : Vacuum type destoner

Stone-free materials on the two screens, supported by air cushion are discharged at the outlet through rubber valves. Inclination of the screens and the volume of air can be adjusted to achieve optimum separation. These stoners are also available with air-recycling system, as shown in fig 10.8.

Magnetic separator

Magnetic (ferrous) impurities are separated from the paddy stock using magnetic separators shown in Fig. 10.9. Type A is a permanent magnet located in such a way that when unclean paddy moves across it, the iron particles are collected by it. The particles are later cleared manually. Type B is cleaned automatically. The rotating cylinder is turned by the free-flowing paddy. Under the cylinder, there is a half round magnet. As the paddy passes over the cylinder, iron particles are held by the cylinder's magnetic attraction. As the cylinder continues to rotate, when the cylinder is not moving over the magnet, the iron is automatically released and discharged separately.

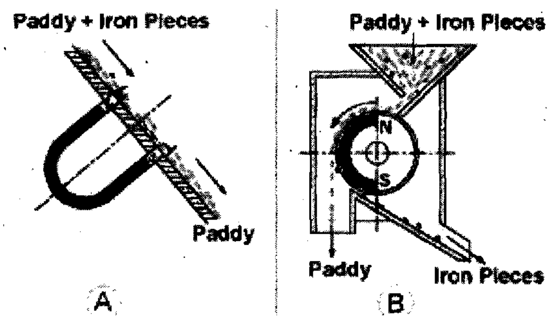


Fig. 10.9 : Magnetic separator

Cleaned paddy is then taken for the next stage of milling i.e. Dehusking.

DEHUSKING

The objective of dehusking is to remove the husk from paddy without breaking the brown rice grain. During this process, it is also important not to induce damage to the bran layers. Dehusking was being performed by different types of machines: disc sheller, centrifugal sheller, rubber-belt sheller etc, All modern rice mills now use rubber roll type dehuskers. Details of some of these shellers are presented below:

Disc sheller

This type of dehusker basically consists of two cast iron discs coated with an abrasive material such as emery (Fig. 10.10). The upper disc fixed to the frame remains stationary while the bottom disc rotates. Therefore, it is also called 'under runner disc sheller'. The rotating

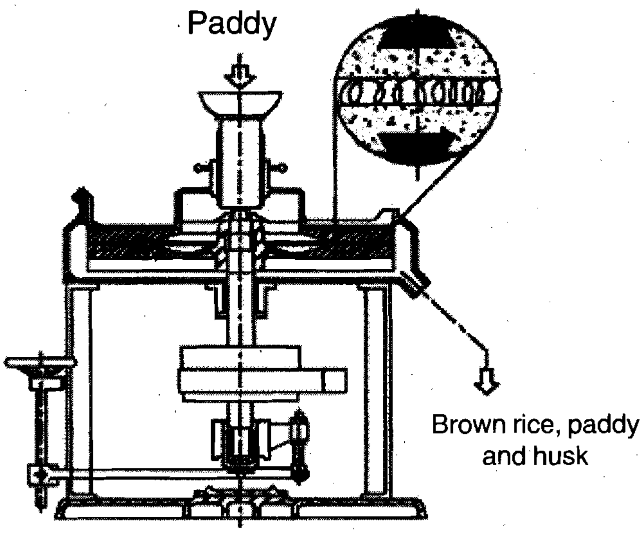


Fig. 10.10 : Disc sheller

disc can be moved vertically up or down and the clearance between the two discs can be adjusted to suit the size of paddy. Paddy is fed through the central feed hopper and the centrifugal action causes radial movement of paddy outward between the discs. During its travel outward, whenever paddy is up-ended, it is caught between the two discs and is dehusked.

Clearance between the two discs is critical to avoid excessive breakage. As the grain has to travel across the entire breadth of the emery disc, some rice breakage does occur in this machine. Some polishing also takes place for the same reason, causing loss of bran. Dehuskers of this type of have now become obsolete.

Centrifugal sheller

It consists of a high – speed rotating impeller disc surrounded by a stationary ring made of rubber (Fig.10.11). Paddy is fed in to the disc rotating at a very high speed. Due to the centrifugal action, grains are forced against the rubber rim. The husk gets cracked by impact, and shelling is effected. Some breakage does occur, especially in the case of dehusking of raw paddy. Shellers of this type are available in small capacity range and are generally preferred for dehusking parboiled paddy only.

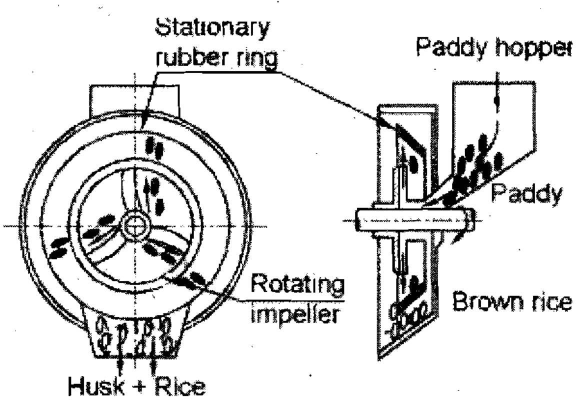


Fig. 10.11 : Centrifugal sheller

Rubber-roll Dehusker

These are the most commonly used type of dehuskers in the modern rice mills. In fact, modern rice mills are characterized by the presence of these types of shellers.

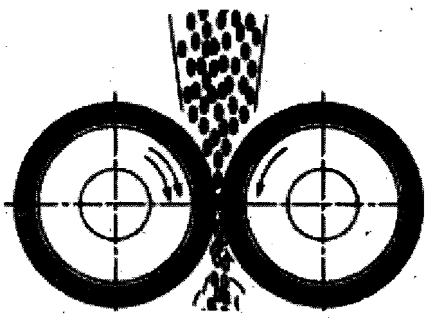


Fig. 10.12 : Shelling action in a rubber roll Dehusker

Rubber-roll sheller consists of two rubber rollers rotating in opposite directions at different peripheral speeds (Fig. 10.12). One roller is fixed in position and the other is adjustable laterally in order to adjust the clearance between the two rolls. These rollers are generally spring loaded (however, the newer machines have a pneumatic system). The difference in peripheral speed along with the spring load subjects the paddy grains falling in to the roll nip to compression and shear which strips off the husk. Rolls are cooled by blowing air on the roll surface. Comparatively higher shelling percent can be maintained in these shellers as compared to others.

For efficient dehusking, compression and shear forces should be at the optimal level. Also, during operation, there should not be roll-to-roll contact, as this leads to generation of excess heat, wear and tear and discoloration of grains. Effectiveness of rubber roll sheller depends on: Circumferential speed of the rolls, Speed differential between the rolls, Pressure between rolls, Roll hardness, Gap between the rolls and Feeding rate and uniformity.

As regards the absolute value of speeds, higher the circumferential speed, higher is the capacity. But, speed is restricted by grain breakage, development of excessive heat and stress on the rubber, shearing and failure. In normal circumstances, circumferential speed is limited to 13 m/s. Greater the speed differential, stronger is the shearing effect. However, if this is too strong, grains tend to break due to excessive strain. Speed ratio of the slow to fast rollers may lie between 0.75 to 0.8, corresponding to a difference of about 2 ms^{-1} in their absolute speeds. Low compressive pressure between the rolls results in lower dehusking. But if this is increased beyond a limit, it results in higher breakage of rice. Low rubber hardness results in higher wear and poor life of rubber rolls while with higher hardness, grains break. Hardness of rubber should be about 85-90 shore number. Generally, gap between the rubber rolls will be kept at half the thickness of paddy. Larger gap would result in lower dehusking percent and smaller gap results in stripping of bran layers/ grain breakage/ excessive roll heat/ vibration and noise. If the feeding all along the roll length is not uniform, rolls wear locally, resulting in poor life of rolls.

During dehusking, rubber rolls wear out due to roughness and abrasive nature of paddy husk. Due friction during dehusking, temperature of the rolls increases. Heating results in softening of rubber and increases wear rate. Due to the difference in speed of the two rollers, the wear rate of rolls is also not uniform. This causes changes both in the absolute and differential speeds of the rollers resulting in poor hulling efficiency. To obtain more operational life per pair of rubber rolls, they should be frequently interchanged to ensure uniform wear. It is better to interchange rolls for every 2-3 mm of wear.

Life of rubber rolls

Durability or life of the rubber rolls varies with cleanliness of paddy, moisture content, pressure applied to the rolls, working temperature of rolls, paddy variety (abrasiveness of the husk, short or long grain) as well as the quality/hardness of rolls. A pair of good quality rubber rolls is generally expected to give a life of about 100T for raw paddy and 200 T for parboiled paddy. Life of rolls is generally high for parboiled paddy because during the course of parboiling, husk would have opened out making dehusking easier. Experiments conducted indicate that the rolls used between the third and sixth month after manufacture give optimum life.

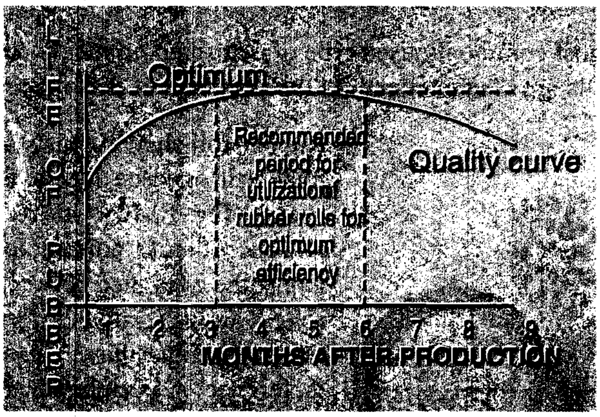


Fig. 10.13 : Milling capacity rubber rolls Vs Age

HUSK SEPARATION

Shellers produce a mixture of brown rice (whole and broken), unhusked paddy grains and husk, sometimes even bran and germ. Separation of these fractions involves size separation and/or aspiration. Sieving prior to aspiration helps in separation and recovery of brokens, which would otherwise be carried away along with husk. Immature paddy is also collected separately after aspiration. Units which employ both sieving and aspirating units are called Husk separators.

Husk Separator

Mixture of paddy, brown rice, brokens and husk are fed at the top of a vibrating sieve. The brokens pass through the perforations of the sieve. As the mixture of husk, paddy and brown rice overflows from the sieve, air is blown or sucked through the mixture. Husk is carried away by the air. Paddy and brown rice are collected separately. Different parts of the husk separator is shown in Fig. 10.14.

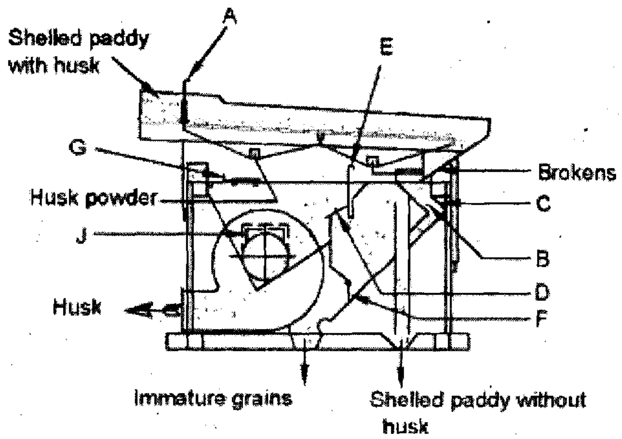


Fig.10.14 : Husk Separator

Husk Aspirator

Aspirators employ only the method of aspiration to separate husk, brokens and immature paddy from brown rice. Husk aspirators are available both in blowing and suction modes. Suction type husk aspirator is presented in Fig. 10.15.

Generally, husk aspirators are mounted just beneath the shellers for gravity feeding of the mixture.

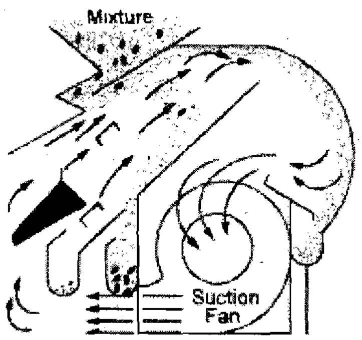


Fig. 10.15 : Husk Aspirator (Suction type)

PADDY-RICE SEPARATION

Shelling is never done to 100% level to avoid rice breakage. Also, since grains differ in size, so that the smaller grains tend to remain unshelled. Thus, the resultant product after dehusking and husk separation is a mixture of brown rice and paddy. To polish this mixture, higher milling pressure is required and this results in higher breakage and lower milling yield. Therefore, separation of paddy from the mixture is important and for this reason, paddy separators play a vital role in the rice milling process.

Separation is effected in the separator by taking advantage of the differences in density, size and surface smoothness (or roughness) of paddy and brown rice.

Two important kinds of paddy separators commercially used are: (a) Compartment type and (b) Tray type.

Compartment type paddy separator

The operating principle is based on the different behaviour of apparently similar bodies when moving over an inclined plane. The different speeds at which they gravitate are related to their specific gravity, shape, contact area and coefficient of friction. If a body is small, heavy, round and smooth, it slides down faster than the one which is bigger but light, flat and rough. The different parts of the compartment type paddy separator is shown in Fig. 10.16.

The machine applies this principle by spreading the mixture of paddy and brown rice over a sloping surface and giving equal, intermittent, obliquely upward thrust. The thrust so is regulated that it cannot push up the rounder, denser and smoother brown rice.

Flatter and rougher paddy grains of low density cannot however, overcome the upward thrust and move up the incline causing paddy and brown rice to move in opposite directions and fall off at the opposite sides of the sloping surface.

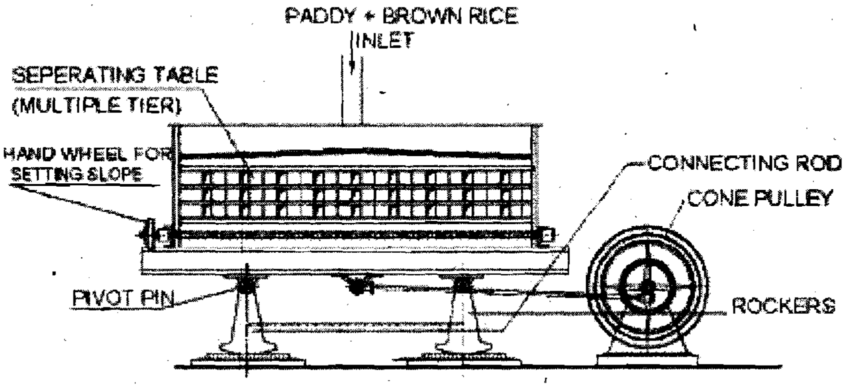


Fig. 10.16 : Compartment type Paddy separator

The compartment type separator consists of three main parts viz., feed box, table and the frame work carrying the drive mechanism. For efficient functioning of the separator the feed box should provide an even and constant supply of material to each compartment without stratification. The oscillating table is divided into zig zag channels and is inclined from one side to the other along the zig zag channels. Surface of the table is of smooth steel. The table oscillates cross wise i.e. perpendicular to the direction of channels. In the conventional system, the table frame is held by rockers to impart the reciprocating motion by an eccentric mechanism. Number of strokes of the table is varied by altering the number of revolutions of the drive shaft by sliding the flat belt on the cone pulley. In the improved compact versions of the separator, driving parts are mounted under the table itself and rpm is varied a variable speed gear. In another improved version, stroke of the table is made variable. The typical rockers are replaced by the rubber coated rollers and the table slides on these rollers. The slope of the table is altered by changing the position of the roller pivots using the hand wheel.

The mixture of brown rice and paddy is fed from the feeder to the centre of the channels. The impact of the grains on the sides of each channel causes the unhusked paddy grains to move up the inclined slope toward the higher end of the table. The dehusked brown rice slides down the slope to the lower side. The slope and stroke of the table are adjusted to ensure complete separation. Usually there are several decks one above the other to get the required working capacity.

Tray separator

This machine works on the principle of the differences in the size, specific gravity and surface roughness of paddy and brown rice. The tray or deck type separator (Fig. 10.17) will have indented decks. These decks are inclined at a fixed slope in lateral direction and inclination along the longitudinal axis is adjustable. The trays oscillate. The tray section moves up and forward, making a slight jumping movement.

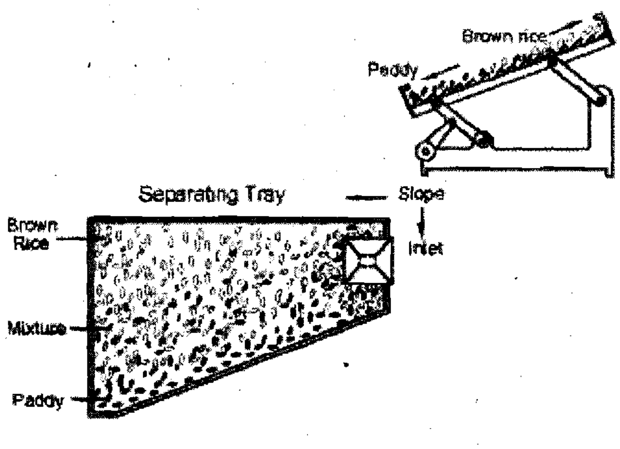


Fig. 10.17 : Tray type separator

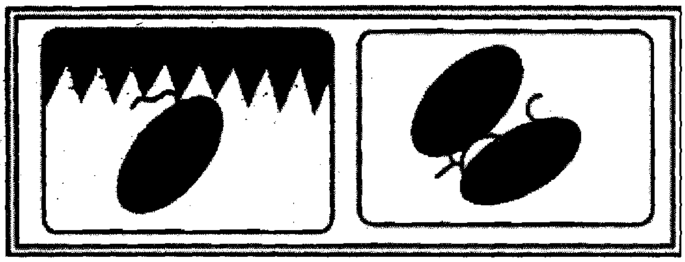
When the mixture falls on the tray at the top corner from the inlet hopper, smoother, smaller and heavier brown rice tends to move down wards and paddy floats up due to the motion of the tray. Further, brown rice being smaller is caught in the indentations and move upwards with each jump of the tray. Free flowing paddy slides downwards and is discharged there. Unseparated paddy-brown rice mixture remaining in the middle portion is discharged in between and is returned to the feed hopper for recirculation. The tray inclination is adjustable to meet different grain sizes and conditions.

Separation efficiency of paddy separators depends on the speed, stroke, feed and inclination. They have to be properly set and monitored for optimal performance. Improper setting would result in brown rice going with return paddy or return paddy going with brown rice, or both, affecting capacity of the plant and the yield and quality of milled rice.

Paddy collected from the separator is called return paddy, for it has to be returned to the sheller. The return paddy grains are shorter (if in disc sheller) or thinner (if in rubber-roll sheller) than normal paddy. Hence, it is preferable to shell it with closer clearance between the discs or rolls. Brown rice is carried forward to the next stage viz., debranning or polishing.

DEBRANNING

Objective of polishing is to remove, to a greater extent, outer layers of brown rice viz., the pericarp, tegmen and aleurone layers, as well as germ – collectively called bran. Bran is rich in pigments, fat, fibre and ash. Debranning is essential for easy cooking and digestion, although excessive polishing reduces the nutritive value of rice. Removal of the outer layers of bran is called whitening. Bran obtained during these stages would have more fibre. Polishing is the next step wherein the rice is made to get the polish/ finish/glaze. Bran obtained during these stages is likely to have more oil (initially), and starch (scoured endosperm). 'Whitening' is also called primary polishing and 'polishing' (also called pearling) is called secondary/final polishing.



Abrasion type **Friction type**

Fig. 10.18 : Principles of debranning

The principle of polishing is quite different from than that of dehusking. Husk, though encloses the caryopsis quite tightly, it does not adhere to the grain. But, bran layers wrapped on the endosperm are deeply embedded and fused together.

Also, rice has a unique conoellipsoid shape which generally also would have ridges and furrows on its surface with varying depths of bran layers covering it. Therefore, bran cannot be removed layer-wise on all sides at any degree of milling. The extent to which these layers are removed is indicated by 'degree of milling' of rice. This is calculated as the percentage by weight of brown rice removed as bran during milling.

There are two types of polishers, one of emery and the other of metal. The abrasive (emery) polishers (called whiteners) polish the grains by abrasion with emery while the friction (metal) polishers polish by friction between the rice grains. The manner of removal of bran from abrasive and friction rollers differs. The abrasive roller acts as a blade to cut and remove small bits of the bran layer from the brown rice. The process is similar to cutting off an orange skin little by little in small pieces with a sharp razor blade. But in friction type machines, bran is removed in rather big flakes just like peeling of the skin of an orange.

Friction, cutting, grinding and impact forces may be present in varying degrees in all the types of polishing machines. It should not be misconstrued that in Friction type of polisher only frictional forces are acting and in abrasive polisher only abrasive forces would be present, though that would be the predominant one.

Abrasive type of polishers

In these units, brown rice is scraped against an abrasive surface and the outer part is cut away as if scraped off by a knife; meanwhile each grain rubs against each other and against other parts of the milling chamber and bran layers are taken off. Abrasive polishers are of two types – vertical and horizontal.

Vertical type abrasive polishers

a. Cone polisher

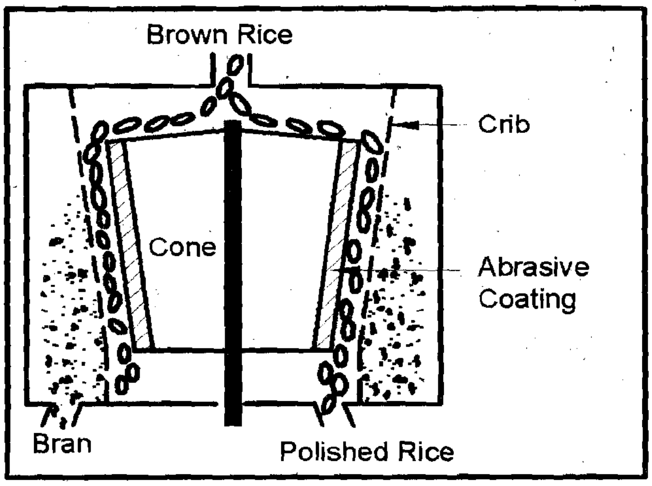


Fig. 10.19 : Cone Polisher

The whitening cone consists of an inverted truncated cast iron conical rotor covered with an abrasive material like emery. Mounted on a vertical spindle, the cone revolves inside a crib (Fig. 10.19). The crib is lined with steel wire cloth or perforated metal sheets and is provided with vertically and equally spaced rubber brakes, which protrude into the interstitial gap between the cone and the crib. As the rotor shape is conical, this allows for gap adjustment between the cone and the crib by moving the cone up and down.

Brown rice that enters at the top of the rotor moves outwards by the centrifugal force to the annular space and is dragged along by the rough surface of the rotating cone. The rubber brakes tend to stop it and cause it to pileup against their sides. While pressed up against the brakes, grains undergo a strong swirling and revolving movement because of their oval shape and smooth surface.

Grains are scoured by the abrasive surface of the cone and also by the friction as grains are rubbed against the surrounding ones as well lining of the crib. The grains revolve around the cone in the gap until their own weight causes them to sink lower and lower. Finally the rice is discharged at the bottom of the cone.

The bran layers are allowed to pass through the openings in the crib. Bran, because of its high oil content 'lubricates' the grains making scouring and rubbing less effective. Therefore, bran is to be removed from the polishing zone, as it is produced.

Construction

A cone polisher as shown in Fig. 10.20 consists of an inverted cast iron, frusto-conical rotor, which is hollow inside with outer surface covered by an abrasive compound. The rotor revolves concentrically, on a vertical spindle inside the crib lined with perforated sheet metal or wire cloth. The crib is divided into sections by rubber blocks or brakes placed vertically at equal distances all round and protruding into the gap between the cone and the crib surfaces. The extent to which the rubber blocks protrude into the milling chamber and their parallelism with the cone surface is adjusted by the hand wheels secured to the crib. Adjustment also is necessitated by the wearing out of the rubber blocks. The spindle is driven by an electric motor by means of pulleys and belts. It revolves on the ball bearings and rests on a thrust block. On the spindle shaft, is mounted a pinion which drives the crown wheel supported by a set of rollers. This will scavenge bran coming out of the milling chamber.

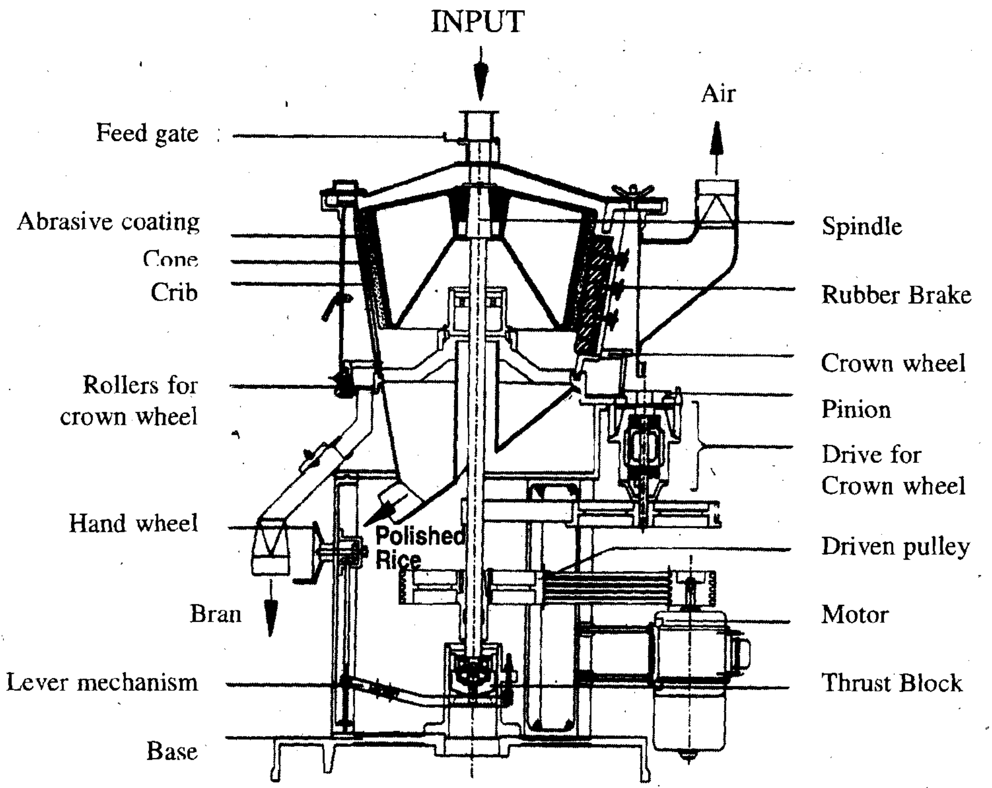


Fig. 10.20 : Constructional details of Cone Polisher

The diameter, cone height and rpm are adjusted such that the force resulting from centrifugal force and gravity causes the grain to spiral down for scouring of the rice all around.

Generally, a series of cones are used to polish rice in stages to get the required degree of milling. These whitening cones are a common feature in the plants meant for milling parboiled paddy, though they are also used for milling raw paddy.

Vertical polisher

Vertical polishers (Fig. 10.21) are divided into two groups according to the direction of flow. The first has rice grains moving downward. The second has rice grains being pushed upward.

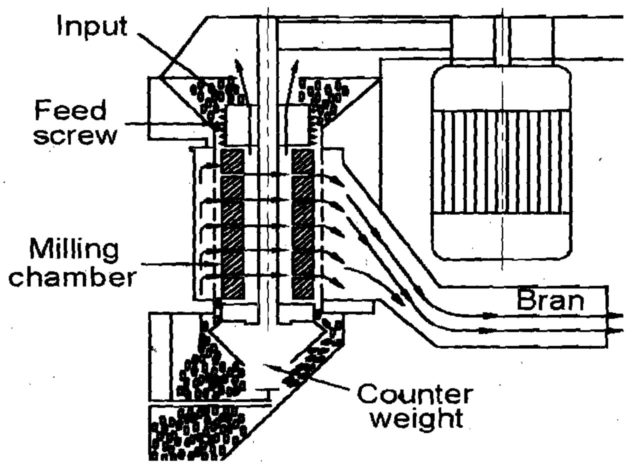


Fig. 10.21 : Vertical Polisher

In the polisher that pushes the rice grains upward, the rice grains are conveyed by a horizontal conveying screw and then pushed up with a screw roll in the abrasive section. In the vertical down flow type machines rice flows down by gravity. They are then polished by a cylindrical emery grindstone. The pressure on the grain is controlled by hanging different weights on the discharge gate. The grindstone (abrasive cylinder) is formed in the same way as for the horizontal abrasive mill. Air is sucked through the mill stock as it is polished. This prevents heating, reduces breakage, and keeps dust out of the mill.

Although there are large differences in their constructional features, the basic polishing method is the same as that used in the horizontal mill.

Horizontal type Abrasive polisher

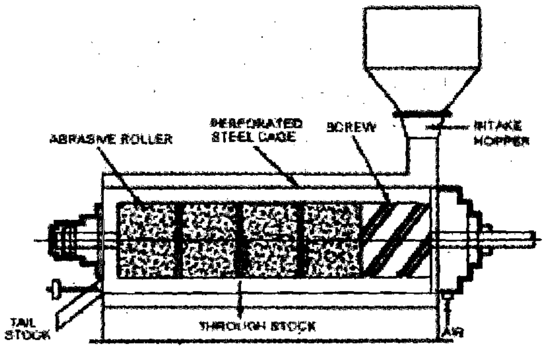


Fig. 10.22 : Horizontal Abrasive Polisher

Horizontal type Abrasive polisher is presented in Fig. 10.22. This consists of an abrasive cylinder/discs attached to a steel shaft rotating in a perforated cylindrical, metallic screen mounted horizontally. These polishers are also called primary polishers.

Brown rice fed into the system passes through the clearance between silicon carbide abrasive roller and the perforated steel cylinder towards the discharge end. As the grain passes through the space between the roll and the perforated screen, bran layers are peeled off from the grain. Bran passes out through the screen and polished rice is discharged through the outlet.

The pressure on the grain is controlled by hanging different weights on the discharge gate. Resistance pieces attached to the perforated steel cylinder help to alter the flow rate and the grain density inside the milling chamber. Angle of the resistance pieces can be adjusted from outside even when the machine is in operation. The angle of resistance pieces against the abrasive rotor can be adjusted from 0 to 90 degrees. By changing the angle, rice movement in the whitening chamber and the resistance to grain flow can be altered.

Friction type polishers

Vertical friction polisher

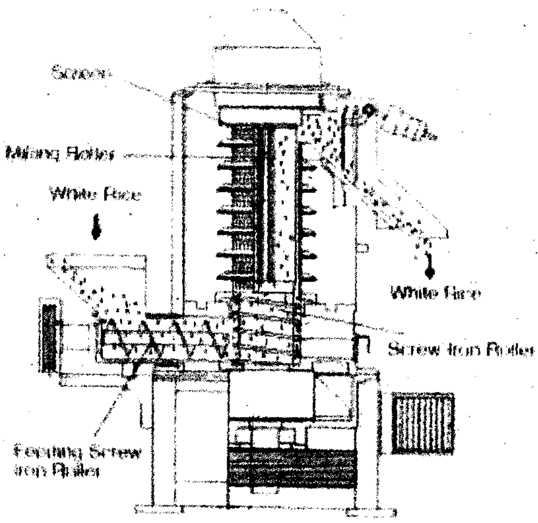


Fig. 10.23 : Vertical friction Polisher

The Fig. 10.23 shows the Vertical Friction Polisher. The machine consists of a cylindrical steel roller rotating inside perforated screen. Semi-polished rice is fed into the milling chamber by the feed conveyor. Pressure inside the milling chamber (degree of milling) is adjusted by putting loads at the outlet gate. Rice passes from bottom to top and is whitened by friction. Polished rice is discharged at the outlet. Bran removed is sucked through as it comes out. This high pressure air lowers the operating temperature at the milling chamber, makes removal of bran easier and reduces breakage.

Horizontal friction polisher

The machine consists of a cylindrical steel roller rotating inside a hexagonal perforated screen. The cylinder has a long slit along its length and a hollow shaft for passing air. The clearance between the screen and cylinder is adjustable by opening or closing the screen. The Horizontal Friction Polisher is shown in Fig. 10.24.

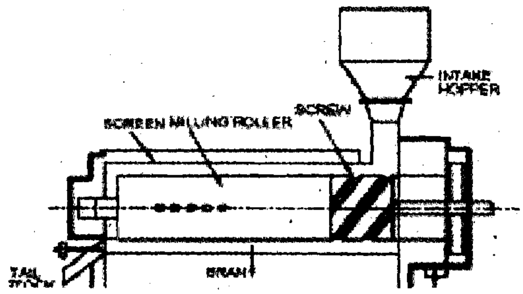


Fig. 10.24 : Horizontal Friction Polisher

The pressure on the rice is further controlled by hanging weights on the discharge gate. A strong stream of air is blown by a centrifugal blower through the hollow shaft and long slit of the cylinder. The air helps in separating the bran and removing the heat generated by the friction between rice and rice.

Generally, the abrasive polishers are used as primary polishers and the friction polishers as the final polishers. The percentage of bran removed in the primary polishers is the greatest. Adhering bran particles are removed in the friction polishers.

Operation: Stepwise polishing in several polishers gives minimum breakage during milling, thus increasing total and head rice recovery. Keeping the abrasive roller uniform and in balance reduces grain breakage. When parboiled rice is milled, the bran tends to stick to the screens. In this case, the quantity of aspirated air is increased to overcome choking of the screens. The bran coming out of the polisher should be checked often to make sure that it does not contain broken rice, not to speak of head rice.

Recently, polishing units which have a combination of both abrasive and friction types in series, in a single machine, have been developed. They eliminate the use of intermediate elevator and surge bins and are more compact in structure.

Water jet polisher

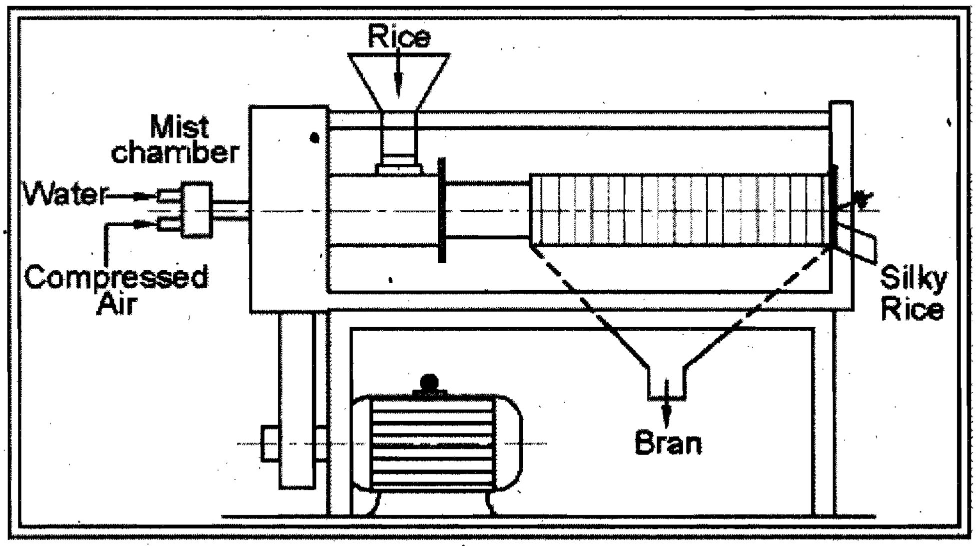


Fig. 10.25 : Water Jet Polisher

There is an increasing demand for fully polished, white, smooth, shining, glossy, silky rice. Although an inferior appearance may not reduce the nutritional or functional value of rice, consumer will be pleased and satisfied with a product that looks delicious. A Water mist polisher/ silky rice polisher (Fig. 10.25) was developed to meet this demand.

Polishing unit is very similar to the friction type polisher. Main differences are in the milling action. Milling chamber is elongated to almost twice the length of the friction units. Water and compressed air tubing are fitted to the hollow shaft. Milled or semi-milled rice is fed into machine. Rice is forced to move quickly in a circular motion around its feeding axle, rubbing against each other at high pressure and very high speed. As rice grain is rubbing against each other at very high speed so breakage is minimal. Due to high pressure and friction, grain temperature increase rapidly. Surface of rice will gelatinize. During polishing, part of rice surface rubbed against each other so some surface with dust and bran is rub off, hence rice is cleaner. After rice surface is gelatinized, it will be a thin layer of shiny dried gelatinized starch. This thin layer has smooth and glossy touch. Rice has a shiny appearance.

Bran separation

In conventional mills, a reciprocating sieve is used for separation of brokens from bran. In the modern mills a pneumatic bran separator is adapted. A pneumatic bran separator separates rice germs and brokens from bran and also conveys the bran pneumatically (i.e., by air). It consists of a powerful centrifugal fan which aspirates the bran from the polisher and delivers it to a cyclone. A blower and an auxiliary cyclone aspirate the bran from the outlet of the main cyclone. Thus fine bran is separated from coarse materials (germs and brokens).

Grading

After polishing operation, the milled rice contains, in addition to 'whole grains', broken grains of different sizes as well as some bran and dust. Separation of these materials, termed 'grading', must now be done. Bran and dust particles are removed by aspiration. Brokens may be separated either by a 'sifter' or a 'Plansifter' (Fig. 10.27) or by a 'Trieur' (Fig. 10.27). In sifters, grading is based on differences in breadth or thickness of brokens and wholes. Trieurs work on the differences in the length of grains.

Plansifter

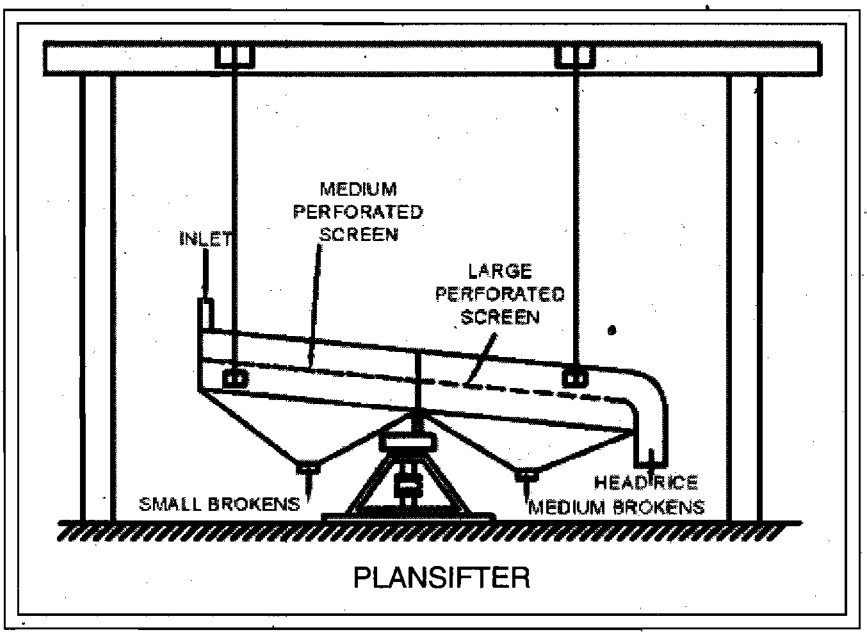


Fig. 10.26 : Plansifter

It is a single or double decked sieve which is given a swinging (gyrating) motion produced by an eccentric. It consists of two sheets of different perforations (first small and then large) to separate two grades of brokens from the polished rice. The grain moves across the swinging sieve in a continuous spiral path. A plansifter (short for planetary sifter) being of sieve type, cannot separate all broken grains from head rice. Big brokens remain along with head rice, while small brokens (less than half the size) are removed. Sieves of the grader should be kept free from clogging for maximum removal of brokens.

Trieur cylinder

This is a slightly inclined rotating cylinder having indentations, like small pockets or cockles, all along its inner body. Rice from the polishers is fed to the raised end of the cylinder. As the rice passes along the slowly rotating cylinder, the broken grains sit nicely in the pockets and are therefore picked up by the rotating cylinder. But as the cylinder rotates upward, these broken grains finally fall out at a higher point and are caught by a collector trough

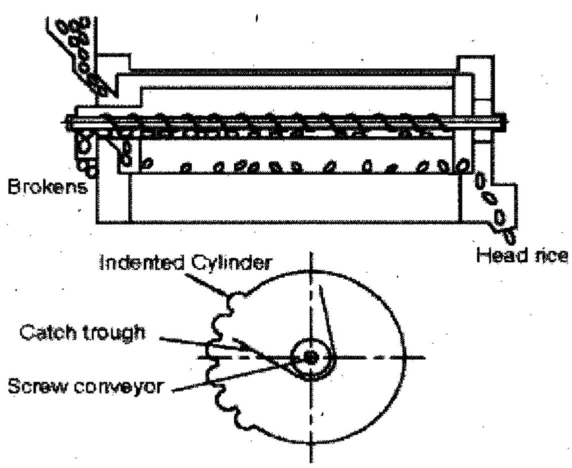


Fig. 10.27 : Trieur Cylinder

fixed inside the cylinder and are discharged separately. A screw conveyor is used for this purpose of discharging broken grains. Whole grains, being too long, cannot sit into the small pockets. Hence they move down the cylinder undisturbed as it rotates. Whole and broken grains are thus separated into two streams. By adjusting the size of the indentations and the position of the trough, broken rice of different sizes can be separated according to their length. In commercial practice multiple cylinders of different indentations are employed for separation. Broken rice is later combined with whole rice in specific proportions to suit market requirements. Basmati rice is usually exported/marketed as 100% whole length rice depending upon the requirements of the importer.

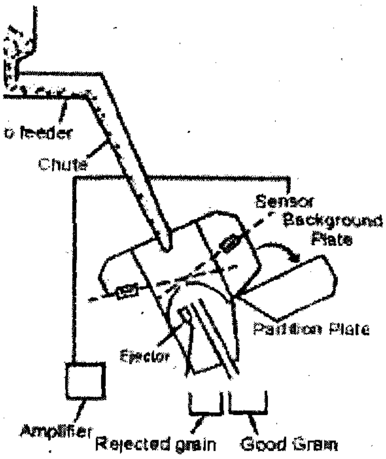


Fig. 10.28 : Colour sorter

Colour sorter

The colour sorter (Fig.10.28) is a photoelectric particle separator. The chute – type colour sorter that is now in wide use was first developed in the United Kingdom. Toward the end of the 1880s, it was discovered that the electrical conductivity of selenium oxide varies with the amount of light present. This fact provided the basis for the colour sorter.

A solenoid air valve (ejector) is connected electrically to a sensor that distinguishes, on the basis of reflected light, the background from the rice grains falling from a conduit shaped chute; the ejector discharges any grains that are discoloured.

Sorter efficiency and accuracy have been significantly improved by taking advantage of the progress in the electronic circuits.

Rice grains are fed in a channel to fall one grain at a time. Each grain is then compared with the set standard. Should there be any deviation in the colour of the rice grain from the set colour, then the ejector blows a jet of air thus pushing the discoloured rice grain from the mass. It is possible to set the colour to any desired shade, thus making it possible to colour sort the rice grain to a uniform hue.

We have so far discussed different operations and machinery involved in the process of rice milling. A modern rice mill would have all the unit operation machinery working in sequence. From the days of manual pounding of paddy to the hullers and modern rice mills and the state of the art ultra modern PLC/ computer controlled rice mills, the progress witnessed in the field of rice milling is phenomenal. With this progress, there is a continuous improvement both in the milling yield and quality of rice produced by the mills. This also has contributed in upgrading the quality of oil-rich rice bran. This has pushed up the production of good quality, edible grade rice bran oil contributing much to the oil pool. Many of the mills also use paddy husk as a source of thermal and electrical energy and are operating as self sufficient, zero-energy plants.

10.5 LET US SUM UP

Rice milling is the final and most important process to produce edible rice from paddy. Since we cook and consume rice grains which are in the whole form, importance during milling is given to see that the brokens produced are as less as possible.

You have read the use of Engelberg huller which is the only "Single step" mill for small scale milling of paddy. While doing so, you have come across the pros and cons of this simple machine. Even though this machine is easy to operate and maintain, average rice recovery is low and by-products (husk and bran) are mixed. In a modern rice mill, the unit operations include Cleaning, Dehusking, Husk separation/ Aspiration, Paddy separation, Polishing and Grading. Cleaning of paddy is undertaken to remove impurities like sand, stones, straw, seeds of other grains and pieces of iron. You have got to know the working of a Closed type double action cleaner, Drum type cleaner and Sieve separator. To remove stones from paddy, a destoner is used which could be either of pressure type or vacuum type. Working principles of these two machines have been discussed. To remove tramp iron or ferrous impurities, a magnetic separator is used. So, paddy cleaned and destoned is sent to the next section that is, dehusking. Disc shellers, Centrifugal shellers and Rubber roll shellers are the machines used for the purpose, which have been described in the previous pages.

After dehusking, the husk has to be separated from the mixture which is done by using husk separators. Since husk is lighter than paddy or brown rice, it is easily separated by using a current of air. After husk separation, a mixture of paddy and rice is obtained. If this mixture is sent as it is to the polishing machines, then the operator would exert pressure on the rice and paddy grains in such a way that the paddy grains get dehusked and debranned. Whereas this pressure is okay for paddy, it is more for rice and may get broken. Hence to reduce the milling pressure and for better process control, paddy is separated from brown rice, and only brown rice is taken for polishing. Paddy separation can be achieved by making use of the differences in the physical properties of paddy and brown rice. Hence there are two different machines for the purpose. Compartment separator makes use of the differences in the specific gravity and coefficient of friction. The tray separator makes use of the differences in the size and specific gravity.

Polishing involves the removal of bran layers which may be brought about either by abrasion with an external rough surface or due to friction between rice grains itself. Cone polisher makes use of an abrasive surface to scratch off the bran layers. Horizontal or vertical abrasive polishers also do the same but the constructional features are different. Under friction type polishers, Vertical friction polisher or horizontal friction polishers fall under this category. A further development of friction polisher is to use air with mist of water for giving a glossy finish to rice grains. The bran removed during polishing in modern rice mills is pneumatically separated. From this bran, brokens are separated. A reciprocating sieve is used in conventional mills for the purpose. The mixture of whole rice (head rice) and brokens is subjected to sieving either in a reciprocating sieve or a planetary sifter (plansifter) or trieur cylinder to remove brokens according to their size.

Head rice, in modern mills, is subjected to sorting according to colour to get rice grains of uniform colour and hue. Milled rice thus obtained is packed either in plastic woven sacks or gunny bags or in unit packs for marketing. Prior to any set up, a pre-investment economics is done to determine the viability of the plant. An example of such an economics is also presented in these notes.

In these notes, the salient features of each operating machine and their sub-types are dealt with in isolation. However, in any rice mill, the entire operation is continuous. In other words, paddy is fed to an elevator at the input end and after each unit operation (like cleaning, dehusking, paddy separation, polishing, grading); the material is transported to the next machine for processing. The layout of the mill could either be on a single floor or multi – storeyed. In a single floor layout, the use of material transport systems (like elevators) is high. In the multi – storeyed layout, gravity is made use of in addition to elevators, but the building cost is higher.

What has been presented in these notes is only the tip of the iceberg. Rice milling encompasses many more features and attributes. The references provided would serve as excellent reading material for the interested reader.

10.6 KEY WORDS

Abrasive polisher : A machine used to remove bran from brown rice, using abrasive action between the kernel and the emery stone. Also called whitener.

Aspiration	:	A process of cleaning by moving a large volume of air through a thin layer of grain, to separate particles lighter in weight than grain.
Aspirator	:	Machine used to separate particles lighter than grain by moving through a thin layer of grain.
Bran	:	The outer covering of rice kernel after the husk is removed. It is removed during polishing.
Brown rice	:	Dehusked rice grain obtained after dehusking paddy. Also called unpolished rice, dehusked rice.
Carborundum	:	An artificial abrasive, whose hardness is about two and a half times that of emery. Chemically, it is Silicon Carbide.
Cyclone separator	:	Large, round, tank like structures, used to separate particles carried in an air stream.
Degree of polishing	:	Expression used to indicate the amount of bran removed in the milling process. Represents per cent by weight of brown rice removed as a fine powder during polishing. Also referred to as degree of milling (DoM).
Dehusking	:	The process of removing husk from paddy during milling. Also referred to as shelling.
Destoner	:	A machine that separates stones from grains. Usually used to separate stones of same size as the grain. Also called Stoner.
Dockage	:	Chaff, immature grains, other seeds, sand, stones or other impurities found in a sample of grain.
Emery	:	Naturally available abrasive material used in polishers.
Friction polisher	:	Equipment used to polish brown rice using friction between the rice grains. Also called pearler.
Grading	:	The separation of broken rice grains from the unbroken rice and separation of broken of different sizes.
Head rice	:	Kernels of milled rice obtained when paddy is milled. It is the total rice produced minus brokens.
Head yield	:	The amount of head rice obtained when paddy is milled. It is the total rice minus the brokens.
Husk	:	Outer covering of paddy grain. Also called hull.
Huller	:	Engelberg huller, widely used as a small capacity rice mill. Removes both husk and bran from paddy in one operation.
Milled rice	:	Rice obtained from paddy after the husk and bran have been removed. Also called polished rice.
Milling yield	:	Amount of milled rice obtained from paddy after the milling process. When used as a general term, it means brown rice yield, total milled rice yield and head rice yield.
Paddy separator	:	Machine used to separate the mixture of paddy and brown rice obtained after shelling.
Parboiled rice	:	Rice obtained from parboiled paddy (paddy that has been soaked, then steamed and dried).

Polishing or Whitening : The process of removal of bran from brown rice. Also called whitening, pearling, milling.

Raw rice : Rice milled from paddy, which has not been parboiled.

Screen : A perforated metal sheet having round/ oblong/ rectangular openings or wire mesh having square or rectangular opening.

Sheller : Machine used to remove husk from paddy.

Shelling : The process of removing husk from paddy. Also called dehusking.

Sifter : Machine used for sieving impurities smaller or larger than paddy grains.

Total milling yield : Total rice, including head rice and broken rice milled from paddy. Usually expressed as a per cent of paddy milled.

Check Your Progress

Note: a) Use the spaces given below for your answers.

b) Check your answer with those given at the end of the unit.

1. Explain the need for milling paddy.

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2. Describe the steps involved in rice milling, with a suitable flow chart.

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3. Explain the concept of cleaning paddy.

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4. With a neat sketch, explain the working of pressure type Destoner. Highlight the features of Pressure & Vacuum type of Destoners.

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5. Explain the process of dehusking of paddy in a centrifugal sheller.

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6. How does a rubber roll sheller work? Enumerate the factors responsible for effectiveness of the sheller.

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7. Describe the Compartment type paddy separator used to separate paddy and rice from the mixture of the two.

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8. How does a Tray type paddy separator work?

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9. Explain the working principle of Vertical cone type polisher.

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10. Explain the working principle of Horizontal Abrasive polisher.

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11. Explain the working principle of Horizontal Friction polisher and Water jet polisher.

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12. How is rice graded and explain briefly methods used to grade milled rice.

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13. For export quality rice, milled rice is subjected to colour sorting. How does this machine work?

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10.8 ANSWERS TO CHECK YOUR PROGRESS

1. Rice milling → final post – harvest process before cooking. Is a process to produce milled rice. Paddy → outer rough, inedible woody covering → husk. Removal of husk → inner kernel → brown rice → some soft outer layers called bran. Process of removing husk and bran (partially or fully) from paddy → easily used by consumers. Dehusking → Debranning. Debranning essential for easy cooking and digestion →Rice cooked and consumed in whole form. Loss of kernel integrity → brokens. More brokens → quantitative and qualitative loss of edible rice.

2. Paddy → Cleaning → Dehusking → Brown rice + Paddy + Husk → Husk separation/ Aspiration → Brown rice + Paddy → Paddy separation → Paddy back to dehusking, Brown rice → Debranning/ Polishing → Milled rice + Brokens → Grading → Head rice & Brokens.

   Cleaning removes foreign matter such as sand, stones, straw, seeds & other grains, pieces of iron from paddy. Dehusking → removes husk from paddy, minimum damage to grain. Husk separation → Removes husk from mixture. Paddy separation

→ Separates brown rice and paddy from mixture. Paddy separated → dehusking for removal of husk. Brown rice taken to polishing section. Debranning/polishing → Removes all or part of bran layers. Multi stages better than single stage → more pressure in single stage → more brokens. Grading → to improve market value, remove brokens from head rice. Brokens → different sizes.

3. Process of separation of impurities from paddy stock. Foreign matter → contaminants mixed during field stage handling & transportation. Cleaning required → to produce clean rice → to protect milling machinery → improves milling capacity. Cleaning uses differences in physical properties of paddy & impurities. Based on size impurities → larger, smaller and same size of paddy. Give examples of large, small & paddy size impurities. Lighter impurities → aspiration, hygienic work environment. Ferrous impurities → magnetic separators. Same size impurities but heavier than paddy → Destoners. Large and small impurities → sieves or size separation. Many types of cleaners available: a) Closed type double action cleaner, b) Drum type cleaner, c) Sieve separator.

4. Destoners used to remove impurities of same size of paddy but heavier than paddy → differences in density between paddy and impurities. Destoners of two types: 1) Blowing type (pressure type), and 2) Suction (Vacuum) type. Pressure type destoner: Reciprocating perforated deck mounted at angle → required quantity of air blown from below the sieve. Air stratifies materials according to their densities. Heavier stones/ impurities → remain on deck → carried backward to top end of deck → discharged. Paddy floats on air cushion → slides down incline. Separation adjusted by regulating rate of feed, volume of air and sieve inclination. Vacuum type Destoner: Working principle similar to Pressure type destoner → Air sucked from top of deck. Grains fed uniformly → feeder. Oscillating deck motion and air flow allows for collection of lighter materials. Stones separated by countercurrent of air. Valves used for discharge of stones. Screen inclination and air volume → adjusted → to suit different grains. Available with air recycling system.

5. Draw sketch. Consists of high speed rotating impeller disc → stationary rubber rim. Paddy fed at centre → Centrifugal action → grains thrown against rubber rim → husk cracked due to impact → Some breakage occurs → raw paddy. Small capacity range → preferred for parboiled paddy only.

6. RR Sheller → two rubber rolls → opposite directions → different peripheral speeds → one roll fixed another movable laterally → adjust clearance between rolls. Rolls → spring loaded, newer machines pneumatically loaded. Paddy falls in gap → compression and shear strips off husk. Rolls cooled → blowing air. High shelling percent in RR shellers compared to others. Compression and shear forces should be optimum → No roll to roll contact → heat generation → wear and tear of rubber → discolouration of grains. Circumferential speed of rolls → speed differential between rolls → Pressure between rolls → Roll hardness → Gap between rolls → Feeding rate and uniformity, Life of rubber rolls versus age.

7. Operating principle based on different behaviour of apparently similar bodies when moving over an inclined plane. Separation based on differences in specific gravity, shape, contact area and coefficient of friction. Small, smooth, round heavy rice → slides down faster than bigger light, flat and rough paddy→ machine gives uniform, equal, intermittent oblique thrust along smooth compartments, hitting zig zags→ causes separation → construction of separator→Feed box, table and frame→mixture fed on to the centre of channels→ table oscillates → Impact of grains on the sides of channels moves paddy up the incline and brown rice slides down the incline effecting separation.

8. Works on the principle of differences in size, specific gravity and surface smoothness of paddy and rice → mixture spread on trays with dimples→ indented trays oscillate with jumping motion→ smaller brown rice caught in dimples moves up with each

jump of the tray reaches one end→ free flowing paddy reaches other end → Mixture that comes in between which is recycled.

9. Whitening cone consists of inverted, truncated CI conical rotor coated with emery → rotates inside a crib (wire cloth or perforated sheet) provided with rubber brakes→Gap between cone and crib can be adjusted→Brown rice forced to the annular space by centrifugal force→ grains made to spiral down the cone→scoured by abrasive→ brakes create swirling of grains→bran passes through the crib and whitened rice is collected separately.

10. Consists of a horizontal abrasive cylinder rotating inside a perforated, metallic screen→ brown rice/ semi polished rice fed into the annular space→ Pressure on the outlet controlled by hanging weights → resistance pieces control the flow pattern of grains in the chamber→ As grains pass through the chamber they come in contact with abrasive roller → bran peeled off, passes through the screen → polished rice collected at the outlet.

11. Horizontal friction polisher: Final polisher→ cylindrical steel rotor rotating inside a hexagonal perforated screen→ pressure in the milling chamber adjusted by tailgate loads → Air blown through the hollow shaft→air helps in separating bran and cooling→ gives shining to grains. Water jet polisher: Construction is very similar to friction polisher→ longer shaft→ water and compressed air forced through the hollow shaft→ Due to high pressure and friction temperature of rice increases→ surface of rice gelatinizes→produces a thin layer of shiny dried starch→ smooth and glossy surface → also called silky rice polisher.

12. Grading → Separation of whole rice from brokens →by sifter (reciprocating)→ plansifter → description of plansifter→lengthwise separation→ trieur cylinder→ description → colour grading (sorting) to remove discoloured grains

13. Photoelectric particle separator→ construction→ rice grains fed in channels one by one → photo sensors view the rice → compare with set standard→ejector blows air separates discoloured grains in case of deviation.