Masaganang ANI Mataas na KITA

RICE COMPETITIVENESS
RCEF
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MECHANIZATION PROGRAM

05

Reference Manual on

Rice Milling

A Compilation of Resources

Philippine Center for Postharvest Development and Mechanization (PHilMech), 2020

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FOREWORD

The Philippine Center for Postharvest Development and Mechanization (PHilMech) is mandated to generate, extend and commercialize appropriate and problem-oriented agricultural and fishery postharvest and mechanization technologies and systems.

With this mandate, PHilMech works diligently at mechanizing the production or postproduction operations of all agricultural commodities available in the country. Rice is one of the major programs of PHilMech in terms of mechanization especially in the advent of free trade and the passing of the Rice Tariffication Law or the RA 11203. Through this law, the Rice Competitiveness Enhancement Fund or RCEF was funded where farmers are groomed to be as competent as its neighboring countries.

As stated in the law, PHilMech will receive 50 percent of the 10 billion peso-fund each year for RCEF Mechanization Program to facilitate the distribution of the machinery grants to qualified rice-producing farmers' cooperatives and associations (FCAs).

To support and make sustainable the program in mechanization, extension services like training courses, enterprise development and communication support have also been funded to educate, train and empower these FCAs.

In the area of communication support, the project aims at increasing the knowledge and interest of the farmers to adopt and utilize rice mechanization technologies in their production to postharvest operations.

One way to increase their knowledge is by producing helpful and comprehensive references on rice production and postharvest systems that can guide them toward the path of competitiveness. Thus, PHilMech, in partnership with the local manufacturers came up with the right and reliable operation and maintenance manual which our operators can use in the field.

The series of O&M manuals for machine operators include step-by-step pre-operation, actual operation and post operation procedures which the operators can easily use and understand. Moreover, it has maintenance procedures so the machinery grants received by farmers will be properly managed and preserved for its maximum efficiency and performance.

Baldwin G. Jallorina, Ph.D.
Director IV, PHilMech

TABLE OF CONTENTS

RICE MILLING

1. What is rice milling?

Rice milling is the process of removing hull, bran and brewer from the paddy, thereby producing an edible, white rice free from impurities.

Rice milling in the Philippines is mainly undertaken by four types of mills, namely, (a) the "kiskisan" type, (b) the "cono" type, (c) the rubber roll type and (d) the impact type.

2. What is the importance of rice milling?

Consumer preference dominates the process by which rice is milled. The appeal of milled rice was brought about by the consciousness that whitened rice is more palatable to eat than unpolished rice. Empirically, the majority of domestic consumer prefer well-milled rice even that of regular milled rice. In the last decade, the preference is slowly changing with some niche market for brown rice and other specialty rice with minimal processing such as brown rice hulling.

Grain type and variety is just one of the factors affecting the milling recovery for milled rice. Long grains which are considered slender are more susceptible to breakage and contribute to the reduction of milling yield. Grains types that are considered soft and immature does not tolerate well the mechanical stress during milling, which reduces milled rice yield. The degree of milling is proportional with milling recovery. The bran layer comprises at least 10 to 12 percent of the paddy, with 4-degree milling classification.

3. What are the technical terms used in rice milling?

- ***Bran*** – is the outer layer of the brown rice consisting of the aleurone cells covering the endosperm of the rice grain.
- ***Broken grains*** - are grains that break in the process of milling which have a size of less than eight-tenth (8/10) of the average length of whole grain.
- ***Coefficient of hulling*** – is the measure of the ability of the machine to remove the hulls
- ***Coefficient of wholeness*** – is the measure of the ability of the machine to remove the hulls without breaking the grain.
- ***Head rice*** – is the grain or fraction of grain with its length equal to or greater than eight-tenth (8/10) of the average length of the whole grain (PAES 206:2000).
- ***Huller or dehuller*** – is a component of a rice mill that removes the hulls (palea and lemma) from the grains.
- ***Hulling efficiency*** – is the product of the coefficient of hulling and the coefficient of wholeness of grains, expressed in percent (%).
- ***Input capacity*** –is the weight of palay per unit loading time into the hopper/intake pit, expressed in kilogram per hour (kg/hr).
- ***Milled rice*** - are grains obtained after the removal of hull and bran.
- ***Milling capacity*** – is the quantity of palay that the rice mill can process to a specified quality per total milling time, expressed in kilogram per hour (kg/hr).

- ***Milling degree*** – is the extent or degree by which the bran layer of the brown rice is removed as a result of whitening.
- ***Milling recovery*** – is the ratio of the weight of milled rice to the total weight of palay, expressed in percent (%).
- ***Milling recovery index*** – is the ratio of the milling recovery obtained in actual testing, to the milling recovery obtained from the laboratory test mill.
- ***Multi-pass rice mill*** – is a type of rice mill that employs a series of two or more whitening machines.
- ***Palay, paddy, rough rice*** - is the unhulled grain of Oryza sativa L., that is grain with the hull/husk enclosing the grain (PAES 206:2000).
- ***Percent head rice*** – is the ratio of the weight of grains that do not break in the process of milling and with a size of three-fourth (3/4) or more of the whole grain to the total weight of milled rice, expressed in percent (%).
- ***Percent head rice index***- is the ratio of the percent head rice obtained in actual testing to the percent head rice obtained from the laboratory test mill.
- ***Polisher*** – is an auxiliary device of a rice mill, which removes the remaining small bran particles on the milled rice and gives it a glossy appearance.
- ***Rice hull*** – is the outermost rough covering of the palay grain (palea and lemma) consisting of the empty glumes, floral glumes, and awn.
- ***Rice mill*** – is a machine that is used to remove the hull and bran of the palay to produce milled rice and consists mainly of hulling and whitening assembly.
- ***Cone "cono" type*** – is a type of rice mill having an under-runner stone disc huller and vertical cone whitener.
- ***Rubber roll type*** – is a type of rice mill using rubber roll huller and utilizes friction and/or combination of other types of whitener.
- ***Single-pass rice mil***l – is a rice mill that employs only one whitening machine.
- ***Well-milled rice*** – is a rice grain from which the hull, the germ, the outer bran layers, and the greater part of the inner bran layer have been removed, but part of the lengthwise streaks of the bran layers may still be present on less than 15 percent of the sample grains.
- ***Whitener***- is a component of a rice mill that removes the bran layer in the brown rice (PAES 206:2000).
- ***Abrasive type***- is a type of whitening machine consisting of a cylinder or cone coated with abrasive material such as emery stone or any similar materials enclosed in a perforated steel housing.
- ***Friction type*** – is a type of whitening machine consisting of a ribbed cylinder enclosed in a perforated steel housing.

4. What are the principles in rice milling?

Milling is a crucial step in post-production of rice. The basic objective is to remove the husk and the bran layers, and produce an edible, white rice kernel that is sufficiently milled and free of impurities with minimum breakage kernels. Most rice varieties are composed of 20 percent husk, 8 to 12 percent bran, 68 to 72 percent milled rice (IRRI, 2011). Total milled rice contains whole grains or head rice, and brokens. The by-products in rice milling are rice hull, rice germ and bran layers, and fine brokens. Milling is a term that describes the processes of converting paddy into rice. It includes the following basic operations:

- ***Pre-cleaning:*** removing foreign material such as particles of sand, stones, straw, seeds, etc. from the paddy.
- ***De-husking and husk separation:*** removing the husk from the paddy with a minimum of damage to the grain, and separating the husk from the paddy.
- ***Paddy separation***: separating de-hulled paddy (brown rice kernels) from any remaining paddy grains.
- ***Bran removal or whitening:*** removing all or part of the bran layer from the grain to produce white rice.
- ***Grading***: separation (or grading) of broken from unbroken rice. The broken rice is often separated into different sizes.

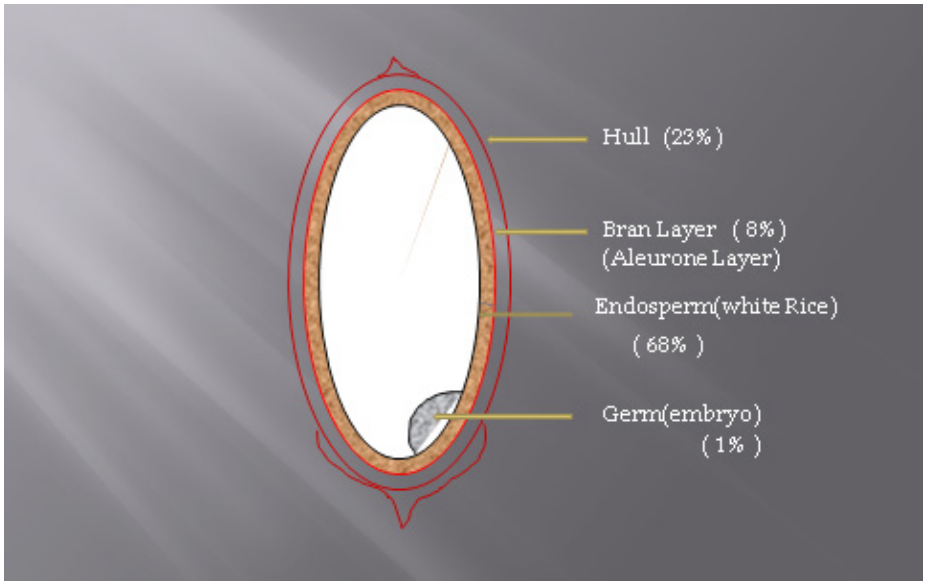

Figure 1. Major parts of the paddy

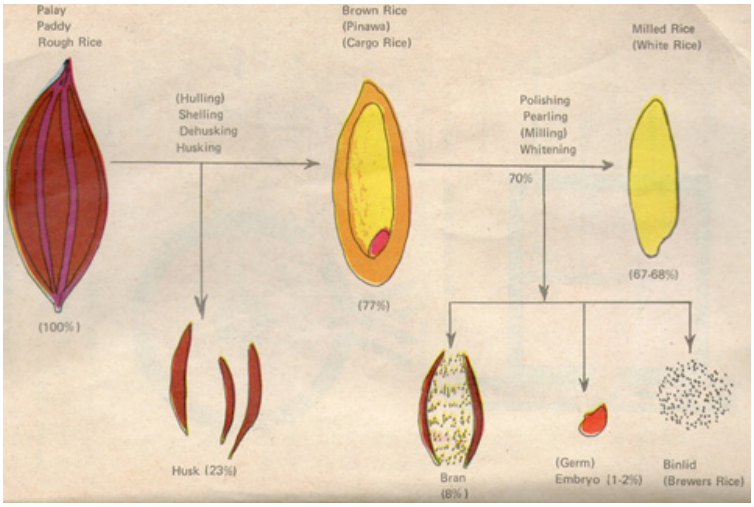

Figure 2. Diagram below shows the basic processes, products and by-products in milling paddy

5. What are the products and by-products of rice milling?

A. Rice hull - The most visible part of a rough rice or paddy grain is the husk also known as hull. This is formed from the two leaves of the spikelet namely the palea covering the ventral part of the seed and the lemma covering the dorsal portion. Both parts are longitudinally joined together by an interlocking fold. The interlocking fold of is the weakest point that easily breaks up when a twisting force is applied to the grain. The husk is formed mostly of cellulosic and fibrous tissue and is covered with hard glass-like spines or trichomes containing high proportion of silica. The presence of this make the husk abrasive and hard that affects efficiency and excessive wear-out of processing equipment parts e.g. dehulling machine parts, like rubber rollers and emery coated under-runner discs, bucket elevator cups, conveyors, and grain ducts. The calorific value of the hulls ranges from 3000 to 3500 kcal/kg making it as an important source of energy in agriculture such as fuel in the furnace for grain drying and steam boiler operations. It is also used as mulching materials and fertilizer in gardening. However, the most disturbing presence in rice hull is high proportion of silica which causes considerable damage to processing equipment through excessive wear of machine parts and interconnecting transfer facilities.

B. Bran - Immediately under the testa or tegumen layer is the bran layer or aleurone layer. This part is the main constituent removed in the whitening stage during milling. It has very low starch content but has a high percentage of oil, protein, vitamins and minerals. Because of its high oil, content, the bran is easily affected by oxidation when the oxygen in the air comes in contact with oil. In the milling process, the higher milling degree indicates a greater percentage of bran removed. Below shows the degree of milling as determined by the quantity of the outer layer removed from the brown rice kernels.

Degree of milling

1. Under Milled Rice - more than 40 percent presence of bran streak in sample grain
2. Regular Milled Rice - 15 to 40 percent presence of bran streaks in sample grains
3. Well Milled Rice - less than 15 percent presence of bran streaks in sample grains
4. Over Milled Rice - bran layers are completely removed

C. Germ (Embryo) - it is a part of the grain approximately 8 percent of the grain by weight depending on the variety. It is located at central bottom portion of the grain, where the grain has been attached to the panicle of the rice plant. Living organism in the grain which develops into a new plant. Respires by taking in the air, consumes food which comes from the starch in the grain itself while simultaneously releasing moisture and heat. This explains why grain during storage have the tendency to decrease in weight as a result of the loss in moisture and dry matter content in the endosperm. It is a by-product of milling separated by sieving or screening using sifter machines.

D. Endosperm (white rice) - ecndosperm or white rice is the final product in milling process. It is approximately 68 percent of the whole grain by weight depending on grain variety. In the milling process, the following are the term used for the product and by-products

Head rice –is the milled rice product separated by the rice graders such as, oscillating sieves, plansifters, rotary sifters and length grader machines during the milling operations. It is the grain or fraction of grain with length equal to or greater than 8/10 of the average length of grain.

Broken grains – are milled rice products that break in the process of milling and separated by graders that has a size of less than 8/10 of the average length of whole grain.

Brewer "binlid" – are milled rice chips, small pieces or particles of rice that pass through a sieve having round perforations 1.4 millimeters in diameter.

E. Other impurities - in the milling operations, foreign matters or impurities are removed to protect the processing equipment and to improve the quality of the product. Groups of impurities:

Large impurities consist of rice straw, panicles, bag strings, soils, stones and sometimes iron parts.

Small impurities consists of dust, sand, soil particles, weed seeds, insects and small stones.

Impurities are of the same size as the paddy grain. Can be empty grains, stones and iron particles.

6.What are the rice milling systems?

Rice milling system can be a single pass or a multi stage process. In a single-pass milling process, husk and bran removal are done in one pass and milled or white rice is produced directly out of paddy. In a multi-pass process, removing husk and removing bran to produce white rice are done separately by two or more independent machines. It is called multi-pass system when two or more whitening machines are installed and used. Because impurities and broken grains cannot be avoided during the milling process, different component and ancillary equipment are employed and installed, e.g. elevators, conveyors, pre-cleaner, de-stoner, paddy separator, dust collection system, graders and sifters.

Classification of the types of milling is categorized according to the flow of the grain in the machine. Rice mills with grains flowing in a single independent machine or of continuous flow from a series of machines with ancillaries but with one whitening machine is said to be a single-pass rice mills. Rice mills with multiple whitener in parallel and in series is classified as multi-pass, thus milling machines with two or more whitening components are generally called multi-pass rice mills.

A. Single-Pass Rice Mill

In a single pass rice mill, the processes of removing the hulls and bran layer are done in one passing inside milling machines with separate huller and whitener in one cylinder with steel fluted huller/whitener and screens; and in a rice mill machine with huller paddy separator and single whitener.

Single pass rice mill comes in a variety of forms, from a compact to a more complex configured layout of the different milling components. The most popular of the single pass rice mill employs the use of rubber roll as the primary hulling equipment and a steel-fluted roll as whitener.

An example of rice mill that removes hulls and bran in one action in a cylinder is the aged brand of Engelberg from US and Europe locally known as "kiskisan" and actually an adaption of coffee huller.

The "kiskisan" (steel roller) rice mill is one of the more popular and most patronized milling in the rural areas. It is predominant in the village level during the period of 1940-1990s. The mill is a steel friction type composed mainly of a metal cylinder with rectangular protrusions running along its whole length and a hollow cylinder casing. It uses very high pressure to remove the hull and bran from the grain in one cylinder resulting into many broken kernels, a low white rice recovery and head rice yields. The fine brokens are often mixed in with the bran and the ground rice hull which is ultimately used for animal feed. The poor performance of this rice mill in the Philippines has led some counties to discourage its use. However, this machine can also be used as whitener combined with other hulling machines.

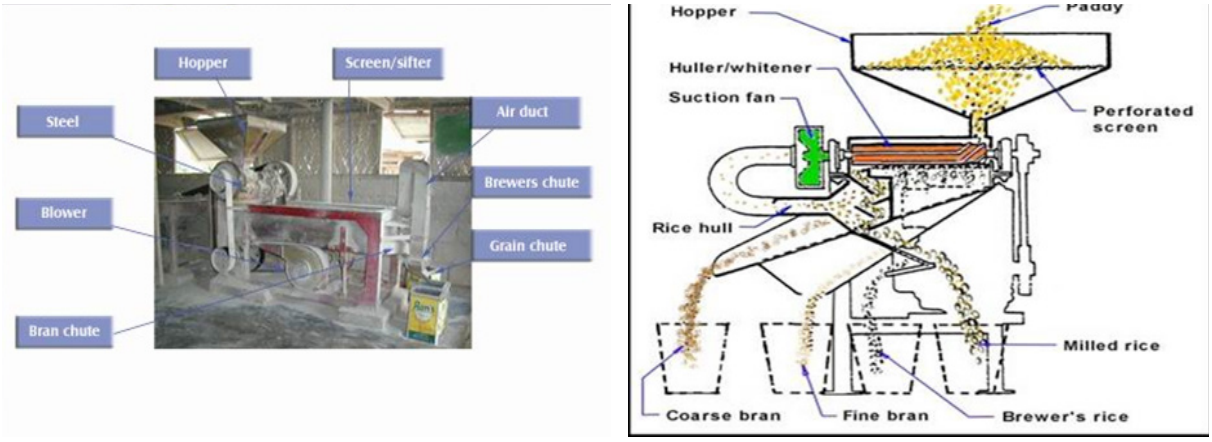

Figure 3. Principle of operation of kiskisan rice mill

Paddy is fed in the intake hopper with screen mesh to separate the impurities. Impurities retained in the screen are manually taken out. The screened paddy gets inside the chamber of steel fluted cylinder and metal screen. The hulling and whitening action is done in one process by a grain to grain friction and grain to screen friction with high pressure given by the counter weight placed at the end of the cylinder. The residence time of the grains in the cylinder which is controlled by the counter weights actually determines the degree of milling. The lesser the opening of the discharge gate of the cylinder the greater the residence time of exposure to friction of grains to each other and vice-versa. Below the cylinder is a suction blower that aspirates rice hull (ground hull included) and oscillating sifters that separates milled rice, broken, coarse and fine brans. Because of severe pressure applied inside the cylinder, temperature of grains rises and high percentage of grain breakage and cracks is manifested.

Another example of single-pass rice mill is they are the modern type of rice mills designed in a metal box where hulling process and the whitening process. The hulling process may use rubber roller or centrifugal impact while the whitening process may use the abrasive stone or a single fluted cylinder similar to steel roller of kiskisan type.

Figure 4. Single-pass rice mill

Figure 5. Single- pass rice mill (with added component parts)

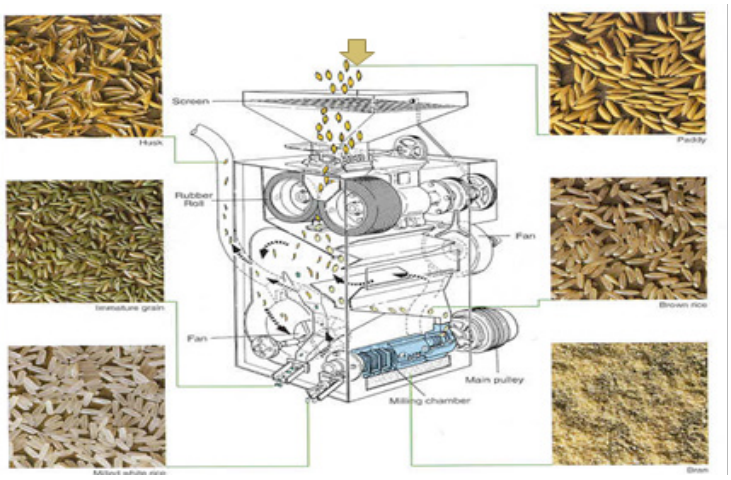

Figure 6. Diagram of modern single-pass rice mill

A.What are the principles of operation of single-pass modern rubber roller rice mill?

Paddy is fed in the intake hopper made of metal with built-in steel screen to separate impurities that goes with the paddy. Impurities are taken out from the hopper screen manually. The paddy goes into the huller removing the hull thru stripping action of two rubber rollers rotating in different peripheral speeds and directions at prescribed roller clearances of at least 50 percent of the paddy thickness. Below the huller is the aspirator that separates the hulls from the mixture of hulled and unhulled paddy. The hulled and unhulled paddy is brought to whitening chamber usually of friction type steel roller. The whitening process is done by principle of friction between and among brown rice kernels and unhulled paddy. The screen surrounding the cylinder also helps in the whitening process as the kernels slide on its surface. During the milling process the unhulled paddy that goes with the brown rice is also being dehulled and whitened at the same time. The hulls in the milling chamber are already being ground and being mixed with the bran. Milled Rice is collected in a separate outlet spout. Bran that is removed from this process is duct by a blower and collected also in a separate outlet spout.

B. Multi-Pass Rice Mill

This type of rice mill has a capacity that ranges from one ton per hour to as high as 10 ton per hour input capacity. It has two kinds the improved cono type adn the other one is the modern rice mill. The milling process actually combines a number of operations run by different machine components that produces higher quality and higher yields of white rice from paddy or rough rice. The processes involve:

1. pre-cleaning the paddy prior to dehulling;
2.removing the hull of the paddy;
3. whitening the brown rice by removing the bran layer;
4. polishing the whitened rice to have it gloss;
5. separating the broken grains from the whole kernels;
6. bagging and weighing the milled rice; and
7. managing the by-products (storing/marketing)

In the process, ancillary equipment and grain moving parts such as elevators to lift the paddy, conveyors, suction blowers for aspiration, cyclones, ducts, pneumatic compressors to regulate flow of grains and auto-weigher and baggers are other component parts of the multi-pass rice mill. Most of the modern multi-pass rice mills has its central panel board with built-in electrical controls and warning devices that controls all the operations of its component parts.

Table 1. Modern rice milling processes

Stage	Function
Pre-cleaning	Removing all impurities and unfilled grains from the paddy
Husking/Hulling	Removing the husk from the paddy
Husk Aspiration	Separating the husk from the brown rice/unhusked paddy
Paddy Separation	Separating the paddy from the brown rice
De-stoning	Separating small stones from the brown rice
Whitening	Removing all or part of the bran layer and germ from the brown rice
Polishing	Improving the appearance of milled rice by removing remaining bran particles and by polishing the exterior of the milled kernel
Sifting	Separating small impurities or chips from the milled rice
Grading	Separating small and large brokers from the head rice
Weighing and Bagging	Preparing milled rice for transport to the customer

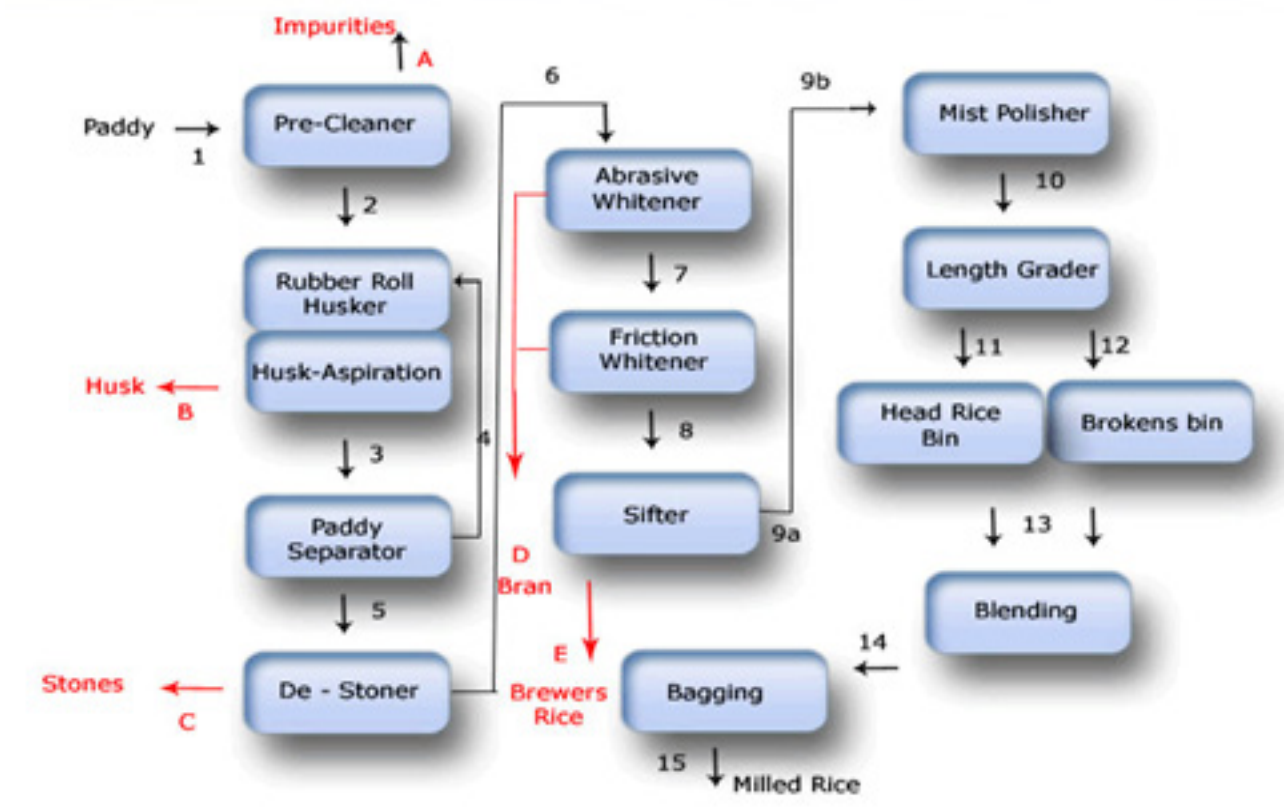

Figure 7. Typical low process of rice mill

Figure 8. Multi-pass rice mill processing center (Modern rice mill)

Figure 9. Multi-pass rice mill processing center (Modern rice mill)

7. What are the milling operations?

a. Pre-cleaning

Prior to the actual milling operation, the palay received from the farmer producer is cleaned in the pre-cleaning machine. Foreign matters or impurities are removed to protect the processing equipment and to improve the quality of the product. The impurities can be divided into three groups, namely: large impurities, small impurities, and impurities which are of the same size as the paddy grain. Large impurities normally consist of rice straw, panicles, bag strings, soils, stones and sometimes iron parts. Small impurities consist of dust, sand, oil, particles, weed seeds, insects and small stones. Impurities having about the same size as the paddy grains, stones and iron particles.

In the pre-cleaning process, impurities are separated from the paddy grains by making use of the difference in size and weight of the impurities compared to the average size and weight of the paddy. Impurities lighter in weight than the paddy grains are difficult to remove and it is presumed that these impurities will be disintegrated during the actual milling process. Weed seeds in general are small impurities and are normally processed, they will not be processed during the milling operation and will finally be mixed with end product, consequently degrading the white rice product.

- **Functions of a pre-cleaner**

A simple pre-cleaner used in rice mills usually contain an oscillating double screen bed with an aspirator. The first screen is a scalper that allow the grain to pass through but retains the straws. The second screen retains the grains but lets through broken grains and small stones or weed seeds. Air damper is provided and has to be adjusted to prevent the good grain from being sucked out. The capacity of the paddy pre-cleaner is usually based on the capacity of the rice mill. A typical pre-cleaner for a 3 ton/hr rice mill will have a 5 ton/hr cleaning capacity. Figures 10 and 11 show the flow diagram or process of pre-cleaning the paddy and the drawing of pre-cleaner machine, respectively.

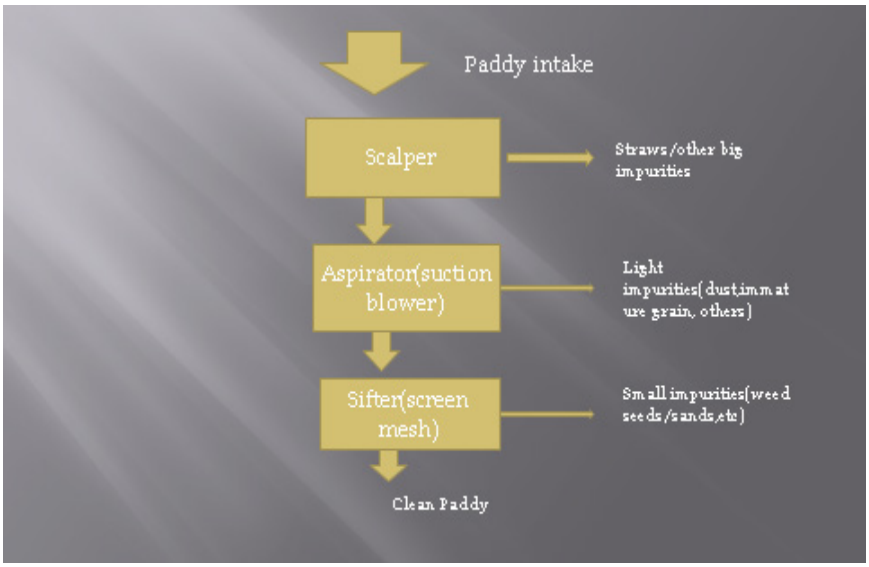

Figure 10. Pre-cleaning flow diagram

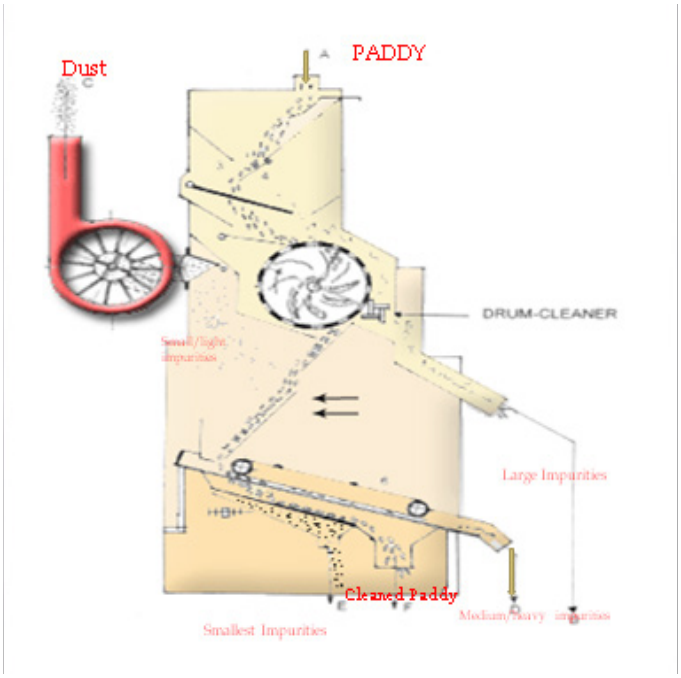

Figure 11. Scalperator-oscillating sifter type

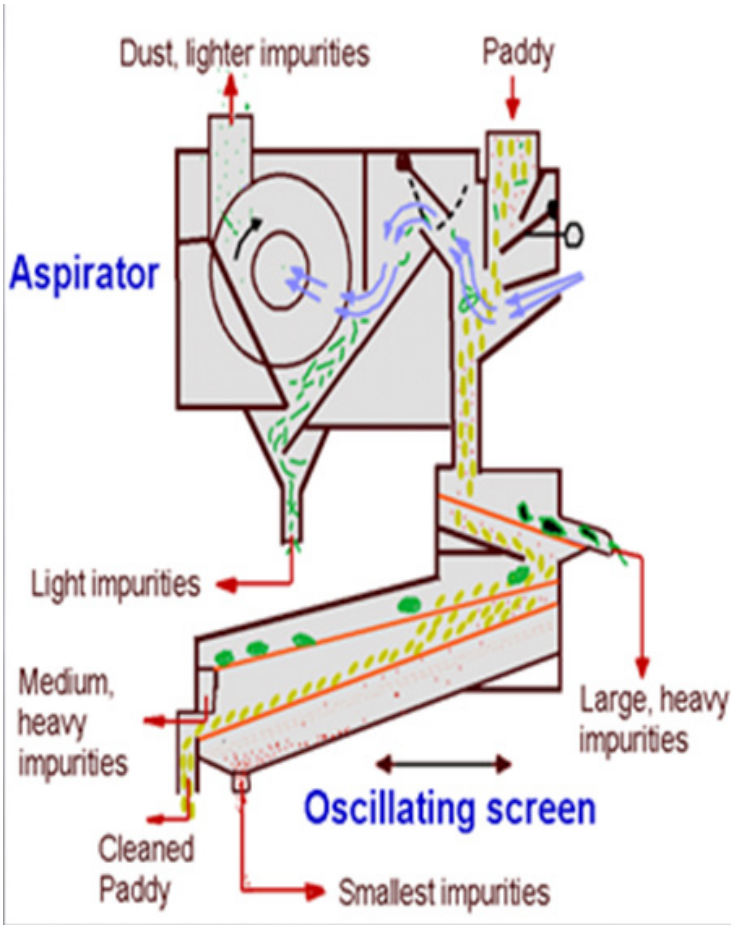

Figure 12. Aspirator-oscillating pre-cleaner type

b. De-stoning

As part of the pre-cleaning process, stones larger or smaller than the rice grains are separated by the cleaner sieves. However, stones of the same size as the rice grains require a type of separation that is usually accomplished with a specific gravity and forced-air separator known as a de-stoner. This machine is more often installed after the pre-cleaner machines separating the impurities thruough scalperator, sifters and aspirators. This machine can also be installed after paddy separator or after the polishing stage.

The destoner consists of a perforated deck mounted at an angle and operated by a reciprocating motion. A blower is arranged to push air through the deck as shown in Figure 13. Air coming through the deck stratifies the material according to specific gravity differences, while the reciprocating action of the deck separates the heavy stones from the lighter paddy. The heavy products are discharged from the high end of the deck, entirely separate from the light particles which are discharged from the low end.

Figure 13. Pre-cleaner with destoner machine

c. Hulling/Husking

Hulling or husking is the process of removing the hull of the paddy to produce the brown rice. The process subjects the grain to mechanical (shearing) and thermal pressures. Hence, it must be done with extra care to minimize breakage of the brown rice product.

There are hullers of different principle of operation and built of construction used in the industry. These are the under-runner stone disc huller, rubber roll huller, and the centrifugal-impact huller. Among these, the latter two is considered more efficient than the first one with roughly 3 kg more production of the brown rice for a given amount of paddy dehulled. Broken and cracked brown rice is also lower, using the rubber roll and centrifugal-impact huller.

• What are the types of paddy hulling/husking?

i. Under-runner stone disc huller. This huller is a standard component of the conventional "cono" rice mills. It consists of two circulars discs laid flat one on top of the other with grinding surfaces facing each other. The lower disc is mounted in vertical shaft and made to rotate while the upper disc is stationary. The clearance of the two discs is adjusted through the vertical movement of the lower disc shaft. The clearance adjustment also depends on the size of the paddy and this is normally set at half the length of the paddy for optimum efficiency. Hulling is affected as the paddy drops between the two discs. As the lower disc rotates, paddy hull is stripped off and discharge into an aspiration unit with oscillating sifter. The hull is thrown into the rice hull collector while the mixture of brown rice and paddy goes into the spout of compartment type separator. The hulling surface of the two discs is coated with abrasive stone materials such as emery, carborandum or the mixture of both. The abrasive nature of the surface has significant effect both on the quality and quantity of the brown rice produced. Hence, the clearance between the two discs and the abrasive property are important factors considered in the operation of this kind of huller.

Figure 14. Under-runner disc huller

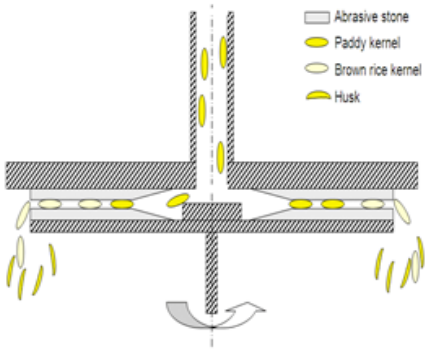

Figure 15. Cross-sectional diagram of under-runner disc huller

ii. The rubber roll huller. Figure 16 below shows the illustration of rubber roller huller. The machine has a pair of rubber rollers, each mounted on a horizontal shaft. One roller rotates clockwise and the other counter clockwise. The peripheral speed of one roller is 25 percent faster than the other one. One roller is fixed and the other one is adjustable or movable Its adjustment depends on the thickness of the paddy being processed. As a rule of thumb, this clearance is normally half the thickness of the paddy. The difference in speed of the two rollers of opposite direction causes the stripping action on paddy separating the hull from the brown rice. The resilient property of the rubber material allows it to absorb pressures imparted on the paddy during hulling, thus, contributing to a better efficiency. The actual photo of opened rubber roller head is shown in Figure 16 moreover, the diagram that illustrates how the paddy is de-hulled is shown in Figure 17.

The rubber roll diameter varies from 150 to 250 mm and the roller width from 100 to 250 mm (IRRI, 2011). Rubber roll hullers have aspirators in the base of the machine to separate the hull from the brown rice.

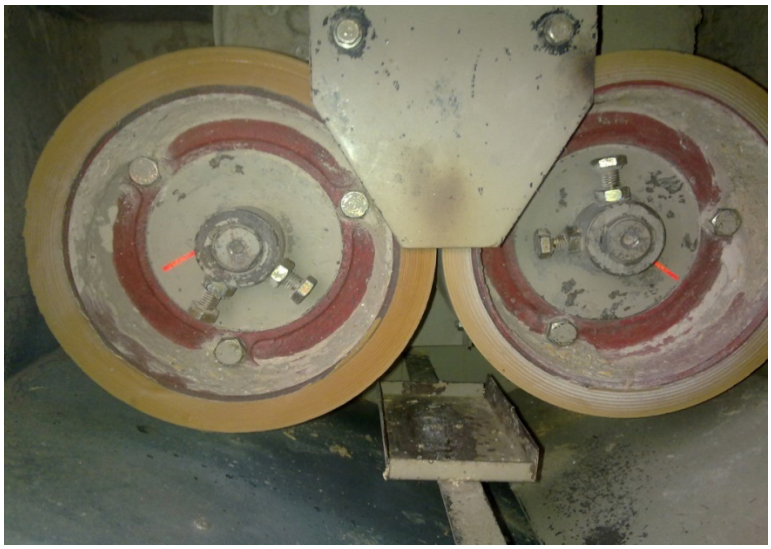

Figure 16. Inside a rubber roller hulling head.

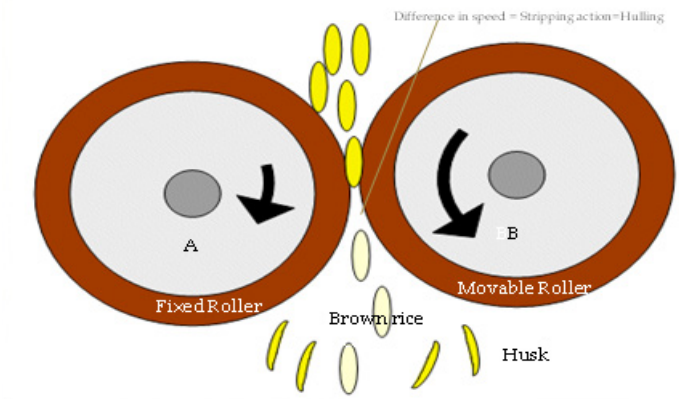

Figure 17. Illustration of rubber roller action on hulling paddy grains

iii. Centrifugal (Impact-Impeller Huller). One of the most advanced milling machineries works on the principle of centrifugal force and impact with the rotating disc which serves to accelerate the paddy being fed to the machine and a rubber ring which absorbs the force of impact created by the high velocity grain. The impact of the grain on the rubber ring breaks the hull open. The advantage over other existing rice mills is its ability to dehull different grain size uniformly and without damage due to breakage of fissures which is common in friction type machines. Another advantage, is that heating of grains does not take place as there is no grinding action involved. Milling recovery ranges from 63 to 68 percent. It is bracketed under high recovery machine group. The machine was actually introduced early in the 1980's but was not popularly accepted because of high cost of parts in the market. However, the principle is being reconsidered locally and now being improved by PHilMech.

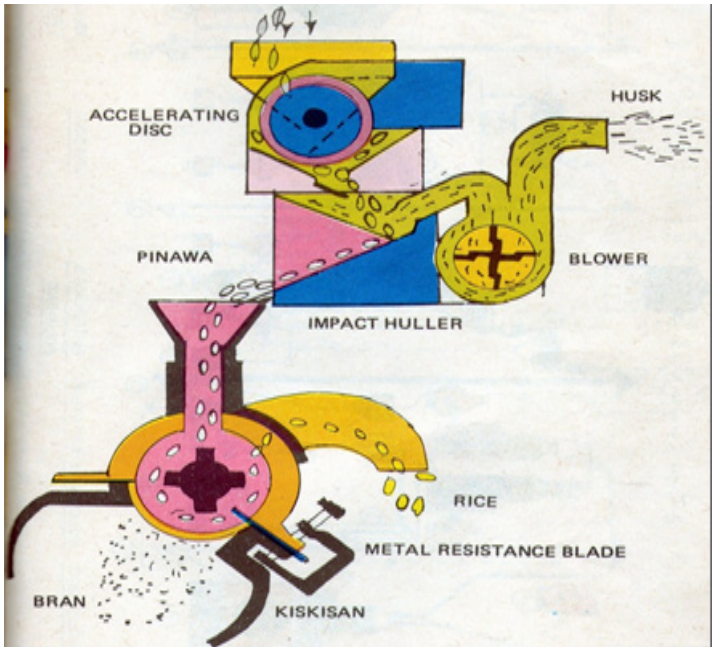

Figure 18. Diagram of centrifugal impact huller (combined with Kiskisan as the whitener)

d. Husk Aspiration

This husk aspirator consists of an oscillating sieve and an aspirator unit. The mixture of husk, brown rice, paddy, brokens, bran, immature grains and dust which are the product of hulling will pass through the oscillating sieve and separates the bran, dust and small brokens. The overflow from the sieve consisting of the mixture of husk, brown rice and paddy discharges to the aspirator as a film and separates the husk from the paddy and brown rice through aspiration. The final product is a mixture of brown rice and paddy discharges through a chute leading to the paddy separator.

e. Paddy Separation

From hulling and husk aspiration operation, a mixture of brown rice and paddy is fed into the paddy separation stage. The paddy must be separated before the brown rice goes to the bran removal stage. The unhulled paddy is returned to the husker for subsequent de-hulling. Separation is done considering paddy and brown rice have different characteristics:

- The average weight of paddy by volume is less than that of brown rice (specific gravity of paddy is lower than that of brown rice).
- Paddy rice has higher buoyancy than brown rice.
- The paddy grains are longer, wider, and thicker than those of brown rice.
- The coefficient of friction is different.

• What are the types of paddy separators?

i. Compartment-type paddy separator

The compartment-type paddy separator actually makes use of the difference in specific gravity and the difference in buoyancy of the paddy and brown rice kernels. It is an older design and has been in use for about 80 years. The main part is the oscillating compartment assembly in which the separation takes place. The steel or wood construction consists of a number of compartments in one or more decks (Figure 19). The number of compartments determines the capacity. One deck may have up to 10 compartments; 2 decks, up to 20 compartments; 3 decks, up to 50 compartments; and 4 decks, up to 80 compartments. The capacity of each compartment is about 40 kg/hr for long grain brown rice and 60 kg/hr for short grains.

Figure 19. Compartment–type paddy separator

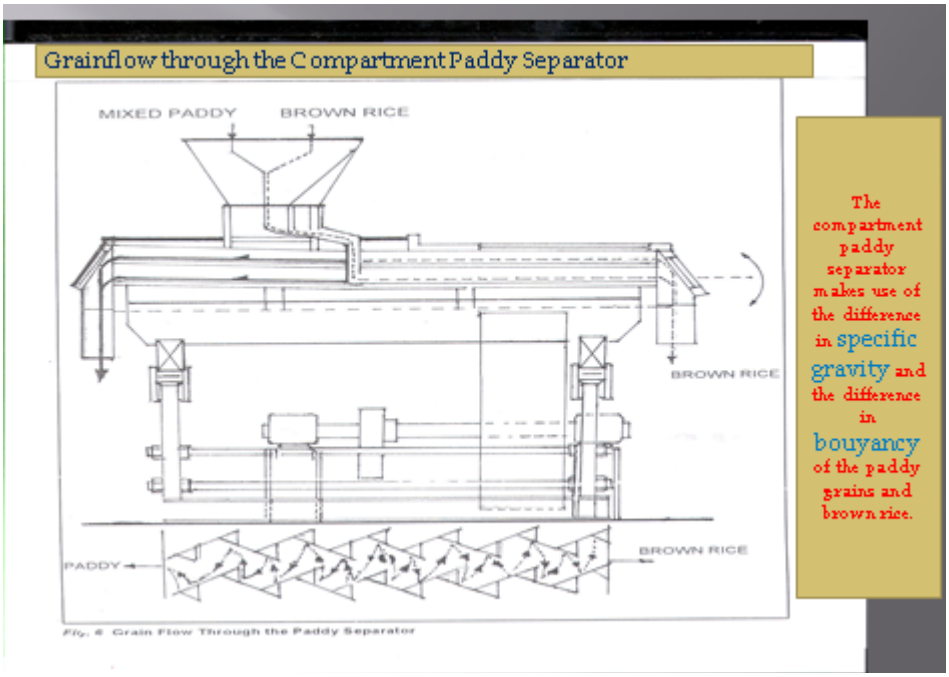

Figure 20. Diagram of compartment-type paddy separator

This type of separator has low power consumption, operating cost, and maintenance cost. The tray bottoms and compartment zigzags can be replaced locally as they wear out. The machine, however, is bulky, requires a strong foundation, and gets bigger space in the rice mill.

ii. Inclined-tray paddy separator

The tray separator has become widely used over the past 25 years. It consists of several indented trays mounted one above the other on a prescribed clearance depending on the design and capacity, all attached to an oscillating frame (Figure 21). The tray section moves up and forward, making a slight jumping movement.

Paddy moves onto each tray from the inlet hopper. As it moves across the tray, the brown rice separates from the paddy. The brown rice has a smoother surface and a greater bulk density and moves to the top of the tray where it is conveyed to the polishers. The paddy moves to the lower part of the tray where it is conveyed back to the huller. Some of the un-separated paddy and brown rice moves to the middle-most part of the tray where it is returned to the inlet of the separator. The table inclination is adjustable to meet different paddy varieties and conditions and to achieve maximum separation capacity.

Figure 21. Table tray selection

Figure 22. Paddy separator

Capacities vary with long and short grains. One model has 2,270 kg/hr for long grain and 3,180 kg/hr for short grain, and uses a 1-hp electric motor. Power requirements are small and about one-half of the horsepower requirements of the compartment- type separator. Designs are available with capacities ranging from 1.2 to 9.5 t/hr.

The all-steel construction, low horsepower requirements, and simple operation assure low operating and maintenance costs. The indented steel plates require replacement after long years of use. One advantage of the tray separator is the small space required. This makes the rice mill more compact and saves floor space.

f. Whitening

In the process of whitening, the silver skin and the bran layer of the brown rice are removed. There are two processes used to remove the bran layer from the grain, namely; abrasion and friction. The abrasion process uses a rough surface of abrasive stone with emery or carburandum material, to break and peel the bran off the grain. The friction process uses the friction between the grains themselves to break and peel off the bran.

There are three kinds of whitening machines that are widely used in the rice processing industry:

- the vertical abrasive whitening cone;
- the horizontal abrasive whitening machine; and
- the horizontal friction whitener.

Figure 23. Abrasive whitener

f.1. Vertical Abrasive Whitening Cone

This machine has been used in the paddy industry for many years and is manufactured in many countries. It is available with the cone directed either up or down with no difference in performance or capacity. The dehusked paddy (brown rice) enters at the top center and moves outward by centrifugal force to the edge of the metal cone. The cone has an abrasive surface and turns inside a cylinder covered with a wire screen. The clearance between the cone and screen is adjusted by raising or lowering the cone.

Figure 24. Vertical cone whitener

The peripheral speed of the cone has a prescribe speed making the speed of rotation of the shaft a function of the diameter of the cone. The larger the diameter of the cone, the lower the speed of the shaft. The abrasive surface of the cone can be replaced locally. The screens and rubber brakes can be easily replaced. The screens wear out the quickest, thus require frequent replacement.

In this type of whitener, removing all the bran in one whitening operation causes much breakage and reduces milled rice recovery, hence the installation of multi-pass whiteners is also done. Thus, producing the least amount of brokens and the largest total rice recovery, and is usually more economical. This kind of whitener is already phasing-out in the market because of the advent of the modern rice mills from abroad (China, Japan, Taiwan, etc.).

f.2. Vertical Abrasive Whitener

The vertical abrasive whitener can be installed as one component parts of modern multi-pass rice mill. It consists of abrasive stone of emery or carburandum materials built around a vertical shaft with slotted screen. The abrasive action is done on the abrasive roll and perforated screen cut and peel the bran layers from the grain.The brown rice rolls around up to discharge end of the whitener while the bran is being discharged in the perforated screen and brought to bran cyclone down to the container by air-suction blower.

Figure 25. Vertical abrasive whitener

f.3. Horizontal Abrasive Whitener

The horizontal abrasive whitener is more compact than the vertical abrasive whitener. The machine consists of an abrasive roll (emery stone attached to a steel shaft) operating in a cylindrical metal perforated screen mounted horizontally. Brown rice enters one end, and moves around the abrasive roll to the opposite end before discharge. The abrasive action is the same as that in the vertical abrasive whitener where the abrasive roll and perforated screen cut and peel the bran layers from the grain.

The intake hopper has a control that regulates the flow of brown rice into the machine and keeps the machine full during the entire operation. Running the machine partially full causes excessive breakage and uneven whitening. The pressure on the grain is controlled by an adjustable weighted discharge gate.

The newer models of horizontal abrasive whiteners use an airstream blown through the hollow shaft and then through the many small openings in the abrasive roller. The air passes through the rice and out the perforated screen. This keeps the rice temperature lower, thus reducing breakage and helping to remove the bran sticking to the grains or to the machine. The bran is collected after it leaves the machine. Special abrasive rollers with high durability and sharpness are used to obtain faster peeling of the bran without excessive pressure. One disadvantage of this type of machine is that the clearance between the roll and screen cannot be adjusted. When the roll wears down, it cannot be resurfaced and must be replaced with a new one.

Resistance pieces installed along the length of the perforated cylinder assist in slowing the tumbling speed of the grain and keeping the grain closer to the abrasive roll.

The airstream run through the abrasive roll actually assists in keeping the perforations clear.

Similar to the vertical whitener, multi-pass whitening is recommended with the horizontal machines. Often several horizontal whiteners are mounted in a stacking arrangement. This arrangement permits continuous flow from one machine to another without extra conveying equipment and conserves space in the mill. The power requirement of the machine is almost the same with vertical abrasive whiteners.

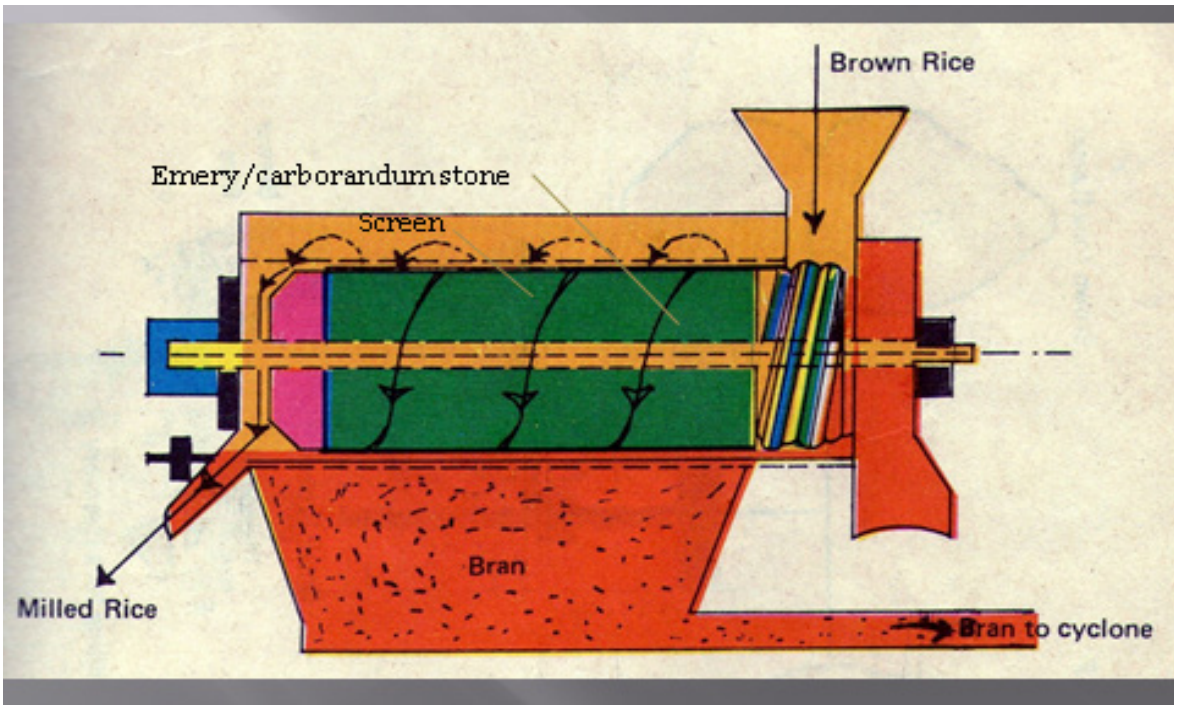

Figure 26. Diagram of horizontal abrasive whitener

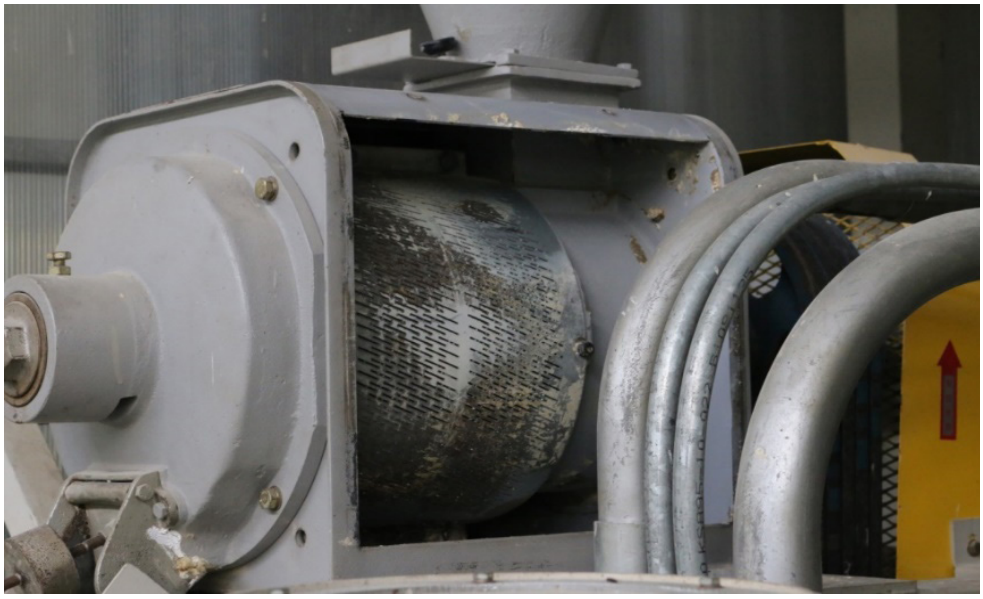

Figure 27. Open horizontal abrasive whitener

Figure 28. Slotted screen and abrasive stone of a horizontal abrasive whitener

f.4. Horizontal Friction Whitener

These are often called jet or pneumatic pearlers. Each of these machines uses the friction process in which the bran is peeled off by friction of the rice grains. Steel hullers are also used as friction-type whiteners.

In the friction whitener the grain kernels are forced against each other and a metal screen by a steel-ribbed cylinder rotating inside a metal-plated cylinder. The frictional forces created between individual rice grains and between the grains and the metal screen surface remove the bran layer from the grain. Friction polishers are always horizontal in design and apply more pressure on the grain than an abrasive whitener.

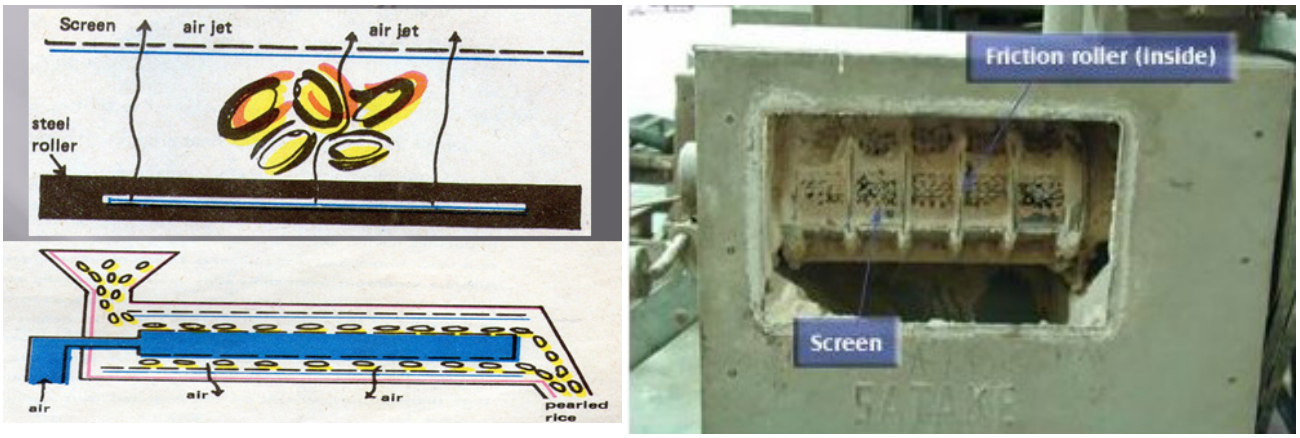

Figure 29. Friction-type whitener

Air is used to remove the bran as shown in the cross section in Figure 29. An airstream is blown into the hollow shaft, through the steel milling roller, through the rice, and out through the perforated screen. The airstream also cools the grain and reduces breakage. The major components of the friction whitener are the metal roller and the metal perforated screen. A feeding auger is used to force the grain into the milling cylinder. The clearance between the screen and the steel cylinder is adjustable. The pressure on the rice is controlled by a weight adjustment on the valve in the outlet spout.

When the friction-type whitener is used as a single pass whitener, the capacity is low and excess breakage occurs (similar in operation to the steel huller). However, it is more often used in a multi-pass operation. Like the horizontal abrasive whitener, the horizontal friction whitener may also be used in a stacking arrangement with one unit above the other. This arrangement conserves space and reduces the cost of conveying equipment. Horsepower requirements are about the same as those required for both the vertical and horizontal abrasive whiteners of the same throughput capacity.

g. Polishing

Polishing is the process of removing rice bran that still stick in the milled rice kernel after the whitening stage.

Some rice markets require glossy, highly polished rice. Vertical and horizontal polishers are available. In these machines, both the cones and drums (vertical or horizontal) are covered with leather strips; both with perforated screens and operated at a lower RPM. The vertical cone polishers are already being phased out in the market because of obsolency, non-availability of parts in the local market and high maintenance works. The principle of operation of this cone type polisher is similar to vertical cone whitener- it differs only on the leather strip material covering the cone.

There are three types of polishing machines that are used in the milling industry these are:

- horizontal polisher (leather strip);
- vertical cone polisher (leather strip type); and
- horizontal mist type polisher.

g.1. Horizontal Polisher (leather strip type)

The leather strips in the horizontal polisher repeatedly roll the whitened rice against the screen. Under slight pressure, the remaining bran is removed and the rice becomes shinier and glossier. This machine produces few brokens. Its power consumption is 30 to 40 percent less than that of whiteners. Most of these types are made from Japan and became popular in the 1970s.

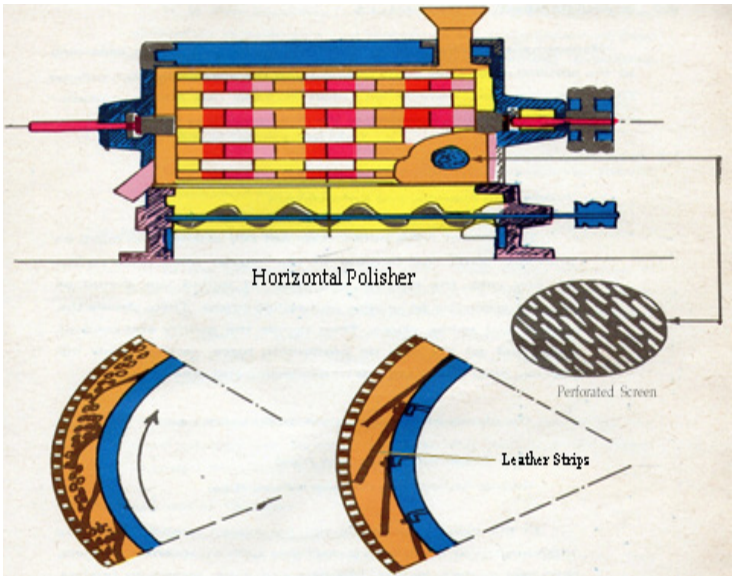

Figure 30. Horizontal polisher (leather strip type)

g.2. Vertical Cone Polisher

Below is a diagram of a vertical cone polisher. The principle of operation is similar to vertical cone whitener. From the whitener machine, white rice moves downward on spiral movement rolling with the built-in leather strips. Bran is captured by leather strips and thrown out of the perforated screens. The quality of white rice is glossy and of lesser breakage.

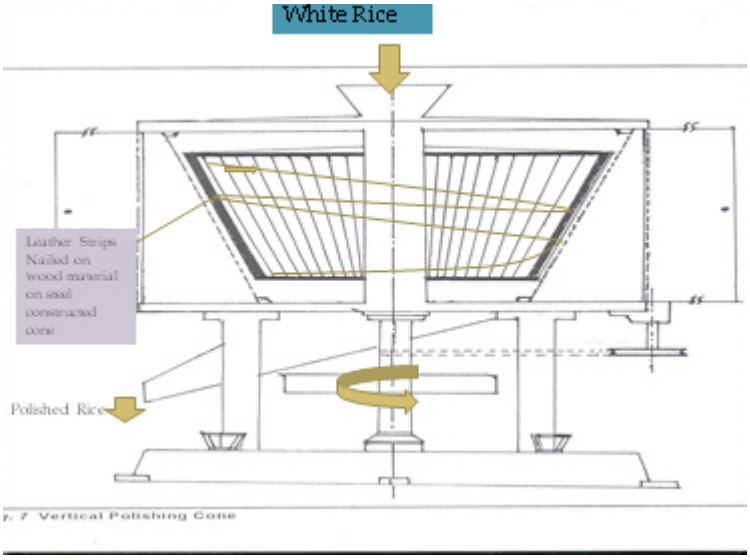

Figure 31. Diagram of vertical cone polisher (Leather strip type)

g.3. Horizontal Mist Type Polisher

For mills that produce premium or export quality rice, a mist polisher or humidifying rice milling machine is employed to brush off remaining bran dust and to create a characteristic gloss on the milled rice. In mist polishers, a controlled amount of water mist is injected, to polished the grain. Mist polishing improves the storability of milled rice because of the complete removal of the bran.

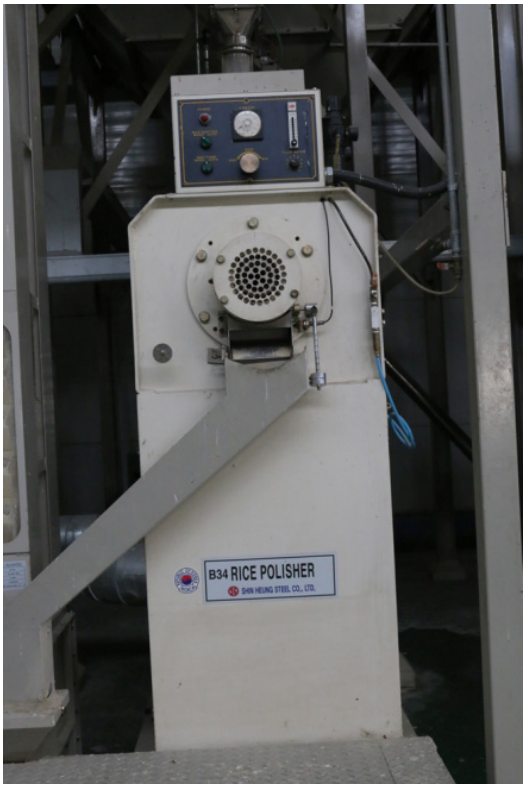

Figure 32. Horizontal-type mist polisher

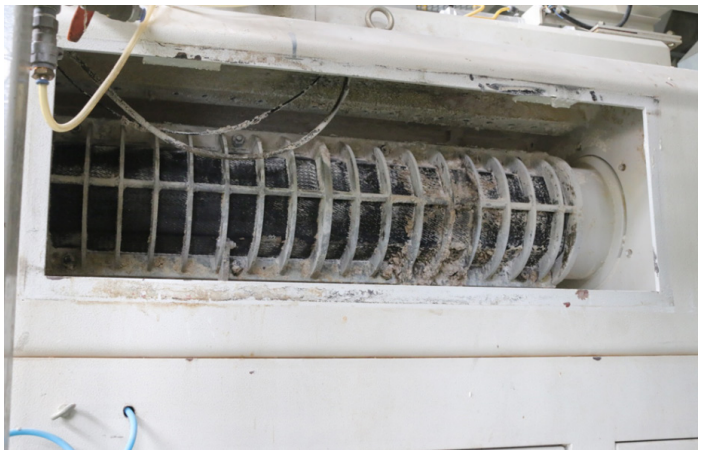

Figure 33. Open view of a type of mist polisher

Figure 34. Horizontal-type mist polisher

h. Rice Grading

After the whitening and polishing operations, the head rice is still mixed with different sizes of broken rice, bran, and dust. Separation of these particles after whitening is termed "grading".

The degree of grading is determined by the rice market or consumer preference. Many rice markets do not require any grading; others require a sophisticated grading system that will produce clean, bran-free rice with no brokens. Most rice markets will accept a small percentage of brokens but demand clean and bran-free rice.

Bran and dust particles are separated by air aspiration. This may be in the form of a blower pulling an airstream through a column of rice, similar to that used in a cleaner, or a special aspirator installed just for this purpose.

Small brokens and germs are separated by a vibrating or rotary sieve. The vibrating sieve oscillates and is similar to that used in cleaners. A rotary sieve, termed a rotary sifter or plansifter, is the same perforated sheet moving in a circular motion.

Simple plansifters can be made with one, two or more trays, each tray having a different perforation: the largest perforations for the top tray; the smallest perforations for the bottom tray.

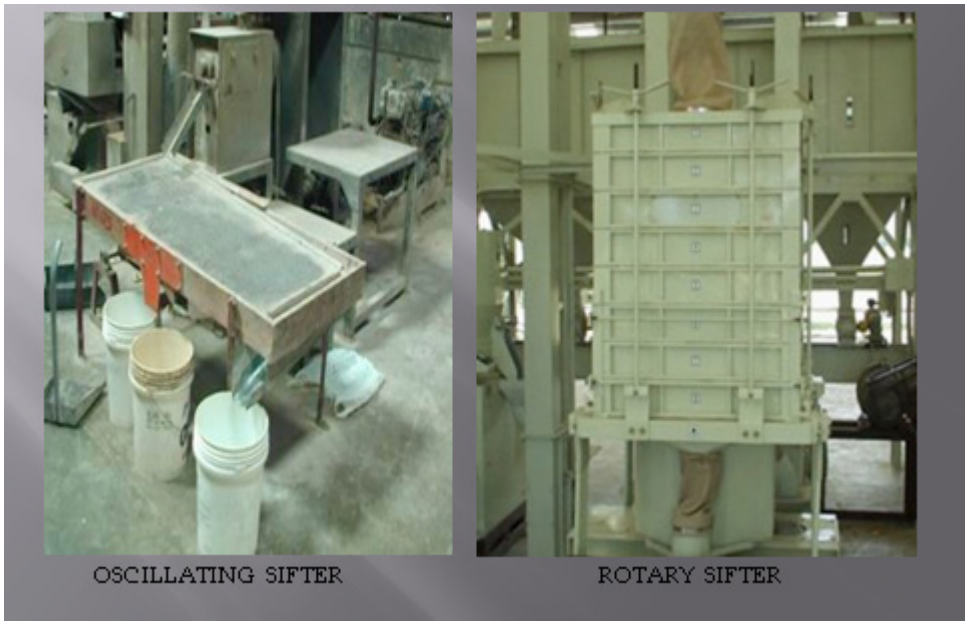

Figure 35. Types of milled rice sifter

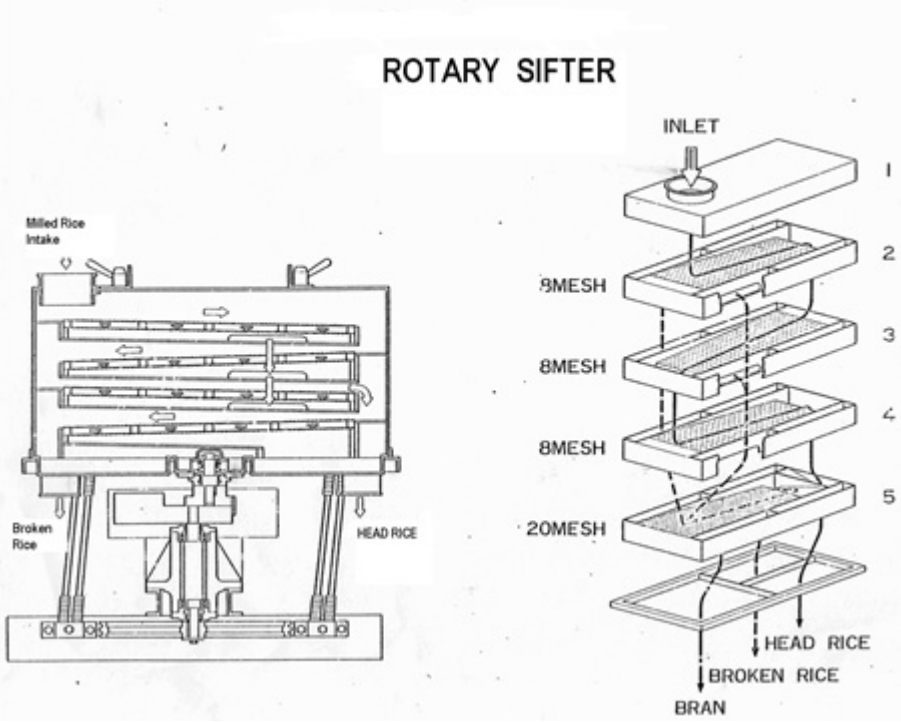

Figure 36. Diagram of a rotary-type sifter (Satake)

In large capacity rice mills so-called high capacity plansifters are used. These very compact machines consist of two, four, six, or eight rectangular steel boxes or sections that hold a large number of trays that have different mesh wire screen sieves. These are often used to produce rice for the most sophisticated markets.

Oscillating or rotating sieves are not used to separate large brokens because their perforations are the same diameter as unbroken rice. Because the length of the brokens differs from the length of the unbroken rice, length separators may be used. These are called Trieurs, rotating cylinders, length graders or drum graders.

An indented cylinder is installed at a slight incline. The inside of the cylinder has a catch trough and screw conveyor to catch and remove the brokens. The head rice remains in the lower part of the cylinder and are discharged at the low end of the machine.

Figure 37. Rice grader (Oscillating type)

Figure 38. Length grader

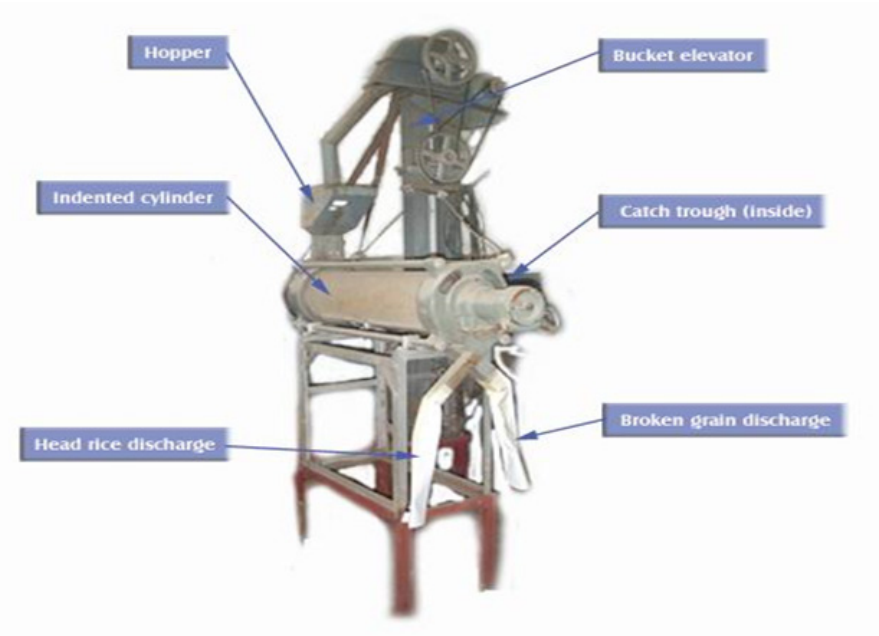

Figure 39. Triur-type length grader

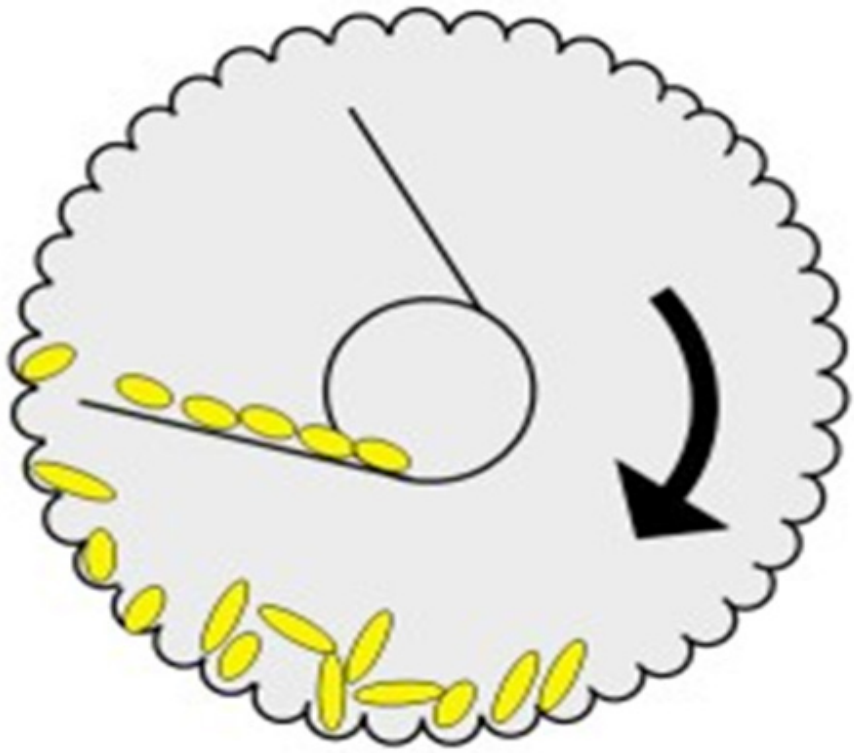

Figure 40. Illustration of length grading principle

i. Color sorting

The machine that is used to further enhance the quality of milled rice recovery from milling is called color sorter. It separates discolored grains from white milled rice. It has photo sensors supported with air-gun of pneumatic system that separates dark colored grains as it passes the columnar rail of the machine. The Figure below shows the diagram of the machine (Satake rice mill).

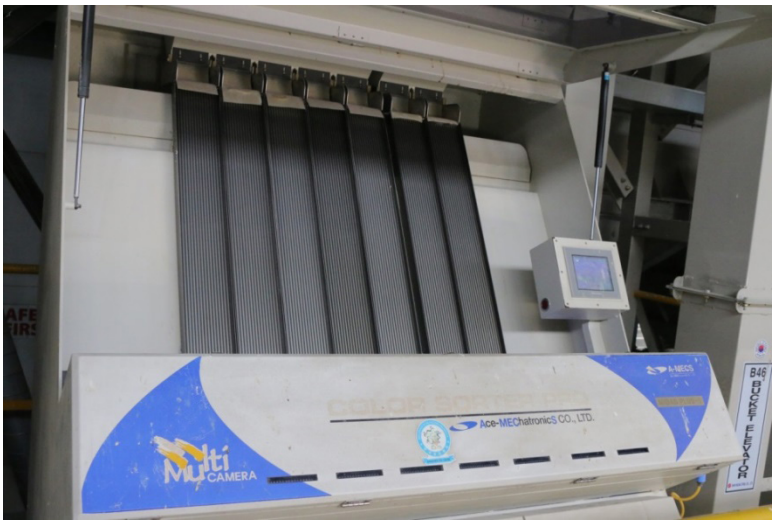

Figure 41. Satake rice mill

j. Weighing and bagging

Milled rice is sold in bags. The standard milled rice bag is made of polypropylene woven bag that can contain 50 kg. The NFA requires the use of color-coded bags for the different grades of milled rice and specifies the markings. The basic bagging bin, platform scale, and a bag closing-sewing machine.

Figure 42. Storage tank of milled rice

Figure 43. Bagging and weighing of milled rice done in commercial combined rubber roller-cono rice mill

Figure 44. Auto-bagger and auto-weighing machine of milled rice

k. Other Ancillary Equipment used in Milling Operations

k.1. Dust Collection System

All fine dust and small particle products from pre-cleaner machines, elevators, huller, and de-stoner up to the last processing equipment, dust collection system is installed. The use of pneumatic system using air-compressor, metal ducts and cyclones is installed as part of the ancillary equipment of large multi-pass commercial rice mill. The ideal capacity of the blower used is 2 m_3 of air per cubic meter of grain at 25 mm static pressure. The critical locations are grain elevators, pre-cleaner and de-stoner.

Figure 45. Pneumatic system (Air-compressor equipment)

Figure 46. Dust collector (Cyclones)

8. What are the operation and maintenance procedures for rice mill?

- **Preliminary Operations**

A. Determining grain quality

The quality of milled rice produced in a milling facility is affected by the quality of the raw paddy used during milling. Grain quality is paramount to the efficiency of the milling system. There is need to determine the grain quality prior to milling. It will also aide in the required adjustment and condition of the milling facility.

a. Grain purity
- Weigh a determined amount of fresh paddy sample, preferably 1 kg
- Aspirate the samples
- Weight the clean sample
- Determine grain purity by obtaining the ratio of the clean sample to the fresh sample of paddy

b. Moisture content
- Obtain sufficient amount of grain sample from different locations
- Using secondary method or by using electronic moisture meter, determine the moisture content of the grain. The optimum moisture content of the grain recommended for milling is at 14 percent.

c. Potential milling yield
- Obtain sufficient amount of grain sample for analysis.
- Weigh 250g of clean sample for test hulling, and determine the weight after hulling. The resulting output is called the brown rice.
- Using the weight of the brown rice, place the sample into the test whitener, and obtain the weight after whitening.
- The amount of time depends on the degree of milling desired. For regular milling, set the timer to 60 seconds; for well milled, set the timer to 75 seconds.
- Obtain the resulting weight for the milled rice.
- Separate the grains classified as whole and obtain the weight, which is called the head rice yield.
- Compute for the milling efficiency and head rice recovery. The required computations are found in PAES for rice milling.

B. Making service records

a. **Service checklist** as provided by the manufacturer

b. **Service factor**. Planning for replacement and scheduling of stock inventory for consumable components is influenced by the service factor of each machine. Paddy grain is highly abrasive.

Table 2. Making service records

Component	Service Factor, No. of Cavans
Rubber Roll (Size mm x mm x mm)	Input Capacity (kg/hr)
64 x 152 x 60/73	350 - 400
102 x 165/222	450 - 700
152 x 222 x 174	850 - 1000
203 x 220 x/254	1700 - 2200
254 x 254	
Whitener screen	
Polisher Screen	
Bucket Elevator Cup	

SOURCE: PAES 214:2004

C. Setting operating parameters and maintenance for milling machinery

a. Pre-cleaner

•Tray-type

The equipment is generally an oscillating tray with perforated or screen that separated grain from impurities larger than the grain itself. Some large capacity pre-cleaners are equipped with bouncing rubber balls and act to dislodge the clogged pores of the perforation. The oscillation ranges from 150 to 200 RPM. The common impurities removed are chaffs, leaves and twines. Paddy grains dried in mechanical dryers are cleaner than those dried in pavements.

• De-stoner

The primary purpose of the de-stoner is to remove small stones that pass through the pre-cleaner and mix with the paddy grain. These stones ruin the hulling equipment. The ideal location of this equipment is after the pre-cleaner stage where cleaner paddy enters the hulling equipment. A secondary de-stoner is placed after the huller. The purpose of installing a secondary de-stoner is to eliminate damage to the whitening and polishing equipment.

Figure 47. Grains with stones removed from the de-stoner

• **Aspirator**

Unfilled grains affect the capacity of the huller. Milling facilities with aspirator exhibit higher milling capacity and better grain quality than their counterpart without such equipment. A terminal velocity of 1.7 to 1.9 m/s should be maintained to remove efficiently the unfilled grains and other light impurities.

• **Dust collection System**

Fine dust and particles present in the grain during drying are removed and collected. The ideal capacity of the blower used is 2 m^3 of air per cubic meter of grain at 25 mm static pressure. The critical locations are grain elevators, pre-cleaner and de-stoner. A separate cyclonic dust collector must be used for the purpose.

b. Huller

• **Rubber roll**

The RPM of the adjustable roll should run 25 percent faster than the fixed roll. The recommended RPM is dependent on the diameter of the rubber roll where larger diameter runs at lower RPM as compared with smaller diameter rubber roll. The rubber roll should have a service factor where for every 2g reduction in weight of the rubber roll, the volume of brown rice processed should be about 60 kg. The normal servicing of the rubber roll is every 8000 cavans of input paddy. The grain diameter determines the clearance of the rubber rolls. The recommended clearance is half of the diameter of the grain.

• **Steel huller**

Except for large stones and metal fragments finding its way into the hulling chamber, the service factor of the steel huller will last for a long time.

• **Under-runner**

When there is chipping of abrasive components set up standard clearance based on manufacturer's manual. Check-up RPM of each component of the machines

• Centrifugal huller

The recommended RPM varies from 3000 to 4000 RPM. This is to ensure hulling ratio close to 80 percent with grain moisture content of 14 to 14.5 percent. The impact ring is made from could be made of polyurethane or rubber. The degree of breakage and paddy variety dictates the type of huller ring used.

c. Paddy separator

The separation of hulled grains to unhulled grains is optimized by means of an adjustable screw that changes the degree of inclination of the indented tray. The inclination varies from paddy variety-to-variety; thus it is recommended to check the inclination during the milling operation (refer to manufacturer's manual).

d. Whitener and polisher

Correct moisture content during milling is the key factor for an optimized operation of the whitener and polisher. High grain moisture content tends to clog the pores of the screen cover. During the removal of the bran, grain temperature is elevated and excess moisture in the grain tends to evaporate. These water vapor mixed with the fine bran coagulates and causes caking and fouls the pores thus impeding the process. It is best to keep the moisture content of the grain at 14 percent for efficient whitening and polishing.

e. Ancillary equipment

Among the ancillary components, the elevator is the most dominant and hardly the most easy to optimize. The shaft RPM at the head ranges from 200 to 250. Belt tensions must be maintained with a slack of 3 cm.

f. Electrical equipment

Electrical components and equipment depend on the voltage and current of the power supply. The frequency cycle plays a dominant role in electrical motors where RPM is affected. If possible, a frequency shifter should be installed in the control panel to correct frequency anomalies.

D. Good housekeeping practices

a. Select and classify grain materials according to the prevailing standard in the grain industry.
b. Check the by-product collection system; check and clean the pneumatic system including the cyclones and receiving boxes.
c. Apply of 5S before and after the milling operations.

E. Workplace safety

a. Wear protective clothing
b. Provide of safety equipment
c. Guard the machine

9. How to evaluate and test the performance of rice mills?

Below are the formula used in determining the performance of a rice mill (Adopted from PAES 207:2000).

1. Input capacity (kg/hr) = $\frac{\text{Weight of input paddy (kg)}}{\text{Total loading time (hr)}}$

2. Output capacity (kg/hr) = $\frac{\text{Weight of milled rice (kg)}}{\text{Output time (hr)}}$

3. Milling capacity (kg/hr) = $\frac{\text{Weight of clean paddy (kg)}}{\text{Total operating time (hr)}}$

4. Milling recovery (%) = $\frac{\text{Weight of milled rice (kg)}}{\text{Weight of clean paddy (kg)}} \times 100$

5. Coefficient of hulling H_c

$$H_c = 1 - \frac{\text{Weight of unhulled paddy (kg)}}{\text{Weight of clean paddy (kg)}}$$

6. Coefficient of wholeness, W_c

$$W_c = \frac{W_s}{t_s}$$

Where: W_s = the weight of the whole brown rice

t_s = the weight of the total hulled samples

7. Hulling efficiency, H_e (%)

H_e = (Coefficient of hulling) x (Coefficient of wholeness) x 100

8. Percent head rice (%) = $\frac{\text{Weight of head rice (g)}}{\text{Weight of milled rice (g)}} \times 100$

9. Broken rice (%) = $\frac{\text{Weight of broken rice (g)}}{\text{Weight of milled rice (g)}} \times 100$

10. Brewer's rice (%) = $\frac{\text{Weight of brewer rice (g)}}{\text{Weight of milled rice (g)}} \times 100$

10. How to troubleshoot rice mills?

Table 3. Troubleshoot a single pass rice mill (cause and remedies when single-pass rice mill malfunction)

Malfunction	Cause	Remedy
Hard to start electric motor	Belt too tight	Loosen belt tension
Low feeding rate	Shutter/feeding gate is closed or partially closed Feeding roll is loose Presence of chaffs and other impurities	Open the feeding gate to desired opening Tighten the nut of the feeding roll Remove the impurities
Presence of hull and unfilled grains in the brown rice output	Low aspiration air	Adjust the blower opening for the aspiration Adjust the air vent setting
Output rice is under-milled or over-milled	Counter-weight is light or too heavy	Adjust the counter-weight to desired setting
Presence of bran in the milled rice output	Clogged whitener screen; Whitener blower is not working Moisture content of grain is high	Remove the screen and brush-off the clogged pores Tighten the screws or replace the belt Dry the grains to correct moisture of 14%
Presence of rice hull in the bran outlet	Clogged blower ducting Filled rice hull compartment	Remove the ducting and check for clogging Remove the rice hull periodically

Table 4. Trouble shooting a multi-pass rice mill

Problem Encountered	Cause	Remedy/Solution
Paddy Receiving Area: Malfunctioning of slide gate opening	Over -feeding	Gradual input of paddy Check the solenoid valve and have it repaired or replaced with new one.
Paddy clogging at the bottom of elevators.	Worn-out bucket cups Torn/Worn-out Flat-belt Sliding Flat-belt Worn-out elevator ducting	Patch worn-out parts or Replace bucket cups Join the cut flat belt using belt clip; or replace flat-belt Apply flat-belt grease Patching of worn-out duct surfaces.
Presence of impurities at the paddy huller temporary bins	Worn-out perforated screens	Patch-up screens; replace worn-out screens. If the original part is not available in the market, replace it by local materials.
Inaccurate reading of auto-weighing machine	Dirty control unit or sensor: Corroded and dirty PCB of sensor.	Check the PCB connection using multi-tester. Clean the corroded portion and reconnect the broken line by soldering.
Abnormal noise of electric motor	Worn-out bearing or bushing	Dismantle the electric motor and replace the bearing or bushing.
Components: Electric motor stop working	Controls circuit breaker, magnetic contactor, overload relay are malfunctioning; Burnt electric winding;	Reset the controls replace if it did not work; rewinding of stator or simply replace the motor.
Malfunctioning of paddy storage slide gate	Defective solenoid valve	Replace solenoid valve.
Abnormal vibrations of huller and low hulling efficiency.	Misalignment of shaft or worn-out bearings; worn-out pulleys or v-belts; drop in pneumatic air-pressure;	Dismantle main shafts and pulleys and have it aligned in the machine shaft; replace the worn-out bearing and v-belts; check the pneumatic system-adjust the air-compressor gauges.
Grain clogging at the hulling section because of Un-regulated grainflow	Worn-out grain stopper	Patching of grain stopper
Malfunctioning of aspirator	Worn-out grain spreader-distributor	Patching or replacement of sieves and repair of grain spreader.

Continuation...		
Inefficient paddy separation	Dirty feeder control unit; separator trays are not in correct angle or slope.	Clean and Adjust the control feeder; adjust the angle or slope of separator tray
Inaccurate separation of immature grains at the thickness grader	Dirty grain control feeder; worn-out screens.	Clean and adjust the control feeder; replace the screen if it is already worn-out.
Inefficient de-stoning process	Defective belt or loose belt causing slippage and low RPM; high or low blower pressure	Replace defective belts; adjust loose belts; check the blower motor for possible defects on bearing or bushing.
Inefficient whitening of rice	Worn-out abrasive stone or slotted metal screen; worn-out variable resistance metals	Replace worn-out abrasive stone and slotted screen including variable resistance pieces. Variable resistance must be replaced when its width is worn-out by about 1/3.
Excessive rise of milled rice	Insufficient air volume intake; worn-out	Check the looseness of v-belts of air-blowing fan; replace worn-out screwed iron roller; check the regulator of grain intake. Clean perforated screen; check for belt tightness of suction blower; clean cyclones.
Inefficient bran collection	screwed iron roller; over-loaded abrasive rollers	Tighten v-belt; adjust grain flow rate; clean conveyors and spouts
Miling machines stop due to excessive load	Perforated screen is clogged; cyclone is clogged with bran; insufficient supply of air from suction blower. Screw conveyor drive belt is slipping; excessive flow rate; excessive regulation of resistance pieces; adherence of bran in the screw conveyor; bran adherence to spouts	
Inefficient polishing	Disaligned or worn-out metal screen	Alignment of metal screen; replace worn-out metal screen
Overflowing of mist by water pump of mist polisher	Worn-out pneumatic hose; defective flow meter	Replace pneumatic hose or flow meter.
Inaccurate reading of auto weigher at the bagging and weighing area.	Damaged or defective load cell	Conduct checking and replace load cell

Continuation...		
Inefficient sifter	Dirty or defective screens.	Dismantle and Check the screen perforations or mesh- if it is already worn-out replace with new one or remedy by patching.
Inefficient or not functioning color sorter	Malfunctioning of grain ejector	Check the ejector sensor using tester; replace defective electric and glass fuses, diodes or bulbs.
Low efficiency of length grader	Grader drums are not aligned; dirty indented cylinders	Check the correct grain clearances, alignment and angle of rotation; clean the whole grader cylinder.
Poor separation of broken, headrice, and brewer rice.	Clogged screens; brushes are not moving freely or worn-out already; excessive feeding rate; low RPM	Clean the screens; mend or patch up-screens if worn-out; replace the defective brushes; tighten or simply replace belts; adjust feeding to required rate. Replace, clean or repair screen depending on the degree of damage as examined; reset frame packing; set the correct screen framing.
Size of separated grains is not uniform	Damaged screen or frame packing; clogged screen; screen frames are not fitted	
Abnormal sound during operation	Loose screen frame lock handle; damage screen oscillating part; no lubrication	Tighten the handle; replace damage screen frame; lubricate all bearings, pulleys, and other moving parts.
Irregular oscillation or vibration of the machine	Damage or deform screen; screen frame lock handle is loose; worn-out bearings; base is not level	Replace screen with new one; tighten frame lock handle; replace worn-out bearings; make level adjustment
Frequent tripping of magnetic contactor, circuit breaker at the main control panel	Stuck-up magnetic contactor and circuit breaker contact points; dirty contact points because of arcing.	Clean magnetic contactors and circuit breakers or replace with new one if it is already burnt-out. Run the gen-set in case of power failure; check the primary power line fuse-cut-out- replace the fuse; check the transformer terminals for voltage and current flow- if busted refer it to technician for thorough check-up and repair.

Continuation...		
Miling operations suddenly stop	Power failure; Main circuit breaker malfunctions; breakdown transformer; busted fuse cut-out of the primary line outside.	Check the LED lights if busted have it replaced with new one; check the condition of siren –if busted replace it.
Warning signal for machine troubles not functioning	LED lights are busted; busted siren	
Milled rice with presence of stones	Defective abrasive stone whitener—stone grits of abrasive roller disband or dissolved during whitening action and goes with the milled rice.; defective de-stoner operation	Replace abrasive stone; check the mal-functioning of moving parts of de-stoner machine.
Presence of white bran at the bran collecting box	Over adjustment of resistance pieces or whitening screen that peel off much bran including the starchy surface of endosperm from the brown rice resulting to overmilling of rice.	
Presence of broken grains and unhulled grain at the rice hull collector	Defective rubber roller; Defective pneumatic system; Defective aspirator- blower; Defective sieve screen.	Replace or adjust clearance of rubber roller manually if pneumatic system is malfunctioning; check the air-compressor motor and its control mechanism and make adjustment or repair; replace screen.

11. What are the routine works in the operation of multi-pass rice mill?

Once a rice mill system has been set up correctly, it should be regularly checked as part of a regular preventive maintenance program.

Things to do in the inspection before and during the operations.:

A. Check, maintain, adjust and repair each machine component before operation.

B. Make sure the facilities, machines, dust chamber of residual products are clean to avoid residual grains or foreign substances.

C. Check the power supply. Check the gauges in the central control panel room based on the standard set in the manual.

D. Only the authorized and trained technicians or mechanical operator should operate the rice mill machines.

E. The authorized operator should understand the entire process and should be aware of how to handle the machines based on the Operation manual provided by the supplier.

F. Check the rotation or operation direction of each machine.

G. Check and adjust the tension of operating devices such as the V-belts, and chain.

H. Check all bearings, bushings and other parts that needs lubrications or greasing.

I. Check the alignment of bucket belts of elevators. Make adjustment if necessary.

J. Undertake dry-run of the rice mill machines. Observe each of the component machine parts during the operation and make adjustment or repair if it manifests abnormalities in the operation.

K. Check if the fixing bolts and gates of the pulleys and sprockets are operating properly. If not properly working, make adjustment repair or replacement.

L. Check and clean the grain residues in all the elevator buckets, temporary bins, grain storage tanks.

M. Place the warning sign on the control panel when doing preventive maintenance.

N. The control panel board electrical controls, such as, relay, magnetic contactors, circuit breakers, gauges and other related controls and switches must be properly cleaned after each operation. Use appropriate contact cleaners.

O. All technicians, operators, and labor crew must wear proper and safety uniform in accordance with Occupational Health and Safety Standard.

P. During the operation do not allow unauthorized personnel and uneccessary items or subtances inside the rice mill areas.

Q. The authorized operator should always check the control panel board. If any unnecessary sounds occur from the machine, the operator should stop the operation and investigate causes and make necessary repair or replacement of observed deficiencies.

R. Maintain the logbook for the observation of the operator during the operations.

S. Make fire extinguishers available near the control panel board and other strategic locations in the plant when fire breaks out.

12. What are the rice mill safety considerations?

A. How to plan for emergencies?

What are the emergency circumstances common to the rice mill facilities?

- Explosion
- Fire
- Entrapment
- Flammable liquid or gas leak
- Chemical release or spill
- Structural failure
- Power failure
- Natural disaster

How to plan for emergency

- Ensure prompt notification of the emergency
- Provide for immediate response
- Promote the well-being of the community
- Come up with the emergency action plan
- Involved five department and recue squad
- Familiarize with the location of the following:

  - Fire hydrants and water supplies
  - Facility entry and exit points
  - Gas and power lines
  - Stored chemicals, including the types of chemicals stored and amounts stored
  - Confined spaces, including their particular type

B. What are the elements of an emergency response plan?

- Employee alarm systems
- Response duties of each employee
- Evacuation procedures
- Designated safe areas outside the facility
- Plan to communicate with the news media

Emergency escape routes must be clearly shown on floor plans and workplace maps. Employers must know that their employees know the emergency escape routes.

Employees must have access to at least two means of escape from bin decks. Employees working in tunnels or in grain or feed elevators must be provided with at least one means of emergency escape. Grain elevators constructed after March 30, 1988, must provide at least two means of emergency escape.

C. How to train for emergencies?

The type, amount and frequency of training vary, depending upon the tasks employees are expected to perform. Although training must be provided to employees at least annually, safety meetings and drills should be conducted at more frequent intervals.

Regardless of the specific type of facility, training should include:

- Hazard recognition and prevention (fire, explosion, etc.)
- Proper use of fire extinguishers
- Emergency reporting procedures
- Personal protective equipment
- Preventive maintenance hazardous spill response
- First aid

D. What are the drills and exercises?

Drills and exercises provide a measure for the state of readiness and effectiveness of an emergency response plan. Drills should include:

- Audible emergency communications
- Fire response and control
- Spill control and cleanup
- Emergency shutoffs Emergency rescue
- Medical first aid response
- Management of off-site personnel
- Monitoring and evaluation

E. What are the sources of explosions and fires?

Grain dust explosions are the number one cause of injury, death and property damage in the grain and mill industries. As the number of rice mill facilities has increased, and, as the volume of grains handled in a given facility has increased, the number of dust explosions has also increased.

For a dust explosion to occur in a grain elevator or mill, the following key elements must exist simultaneously:

- Grain dusts, as the primary fuel
- Oxygen
- An ignition source
- A confined space

When the first three elements come together, in an explosive mixture, the rapidly expanding heated gases build until the pressures exceed the strength of the confined space. Conditions under which a grain dust explosion occurs result from the following:

- A complex combination of dust particle sizes
- The concentration of dust particles in the air
- The energy of the ignition source
- The moisture content of the dust (or percent of relative humidity of the air)
- The actual composition of the dust
- When these conditions are present and the concentration of suspended dust exceeds the lower explosive limits of that particular dust, an explosion results.
- When grain is moved, grain dust is produced. The more that grain is handled, the more dust is produced. The more dust produced in a confined space, the greater the chance of exceeding the lower explosive limit of the dust.
- As grains move from input to output, there are several points where the grain is subjected to mechanical stress. Each of these points leads to the production of grain dust. Without proper precautions, each major dust site will permit the formation of a dust cloud. All dust clouds have the potential to reach explosive levels.

F. What are the following training for the operators?

In accordance with Rule 1030 of OSHS, the employer must provide each employee initial and, at least, annual training. In addition, the employer must provide training when changes in job tasks expose the employee to new hazards. The training must address the following topics:

- Safety precautions associated with the facility
- Hazard recognition related to dust accumulation and common ignition sources
- Preventive measures related to dust accumulation and common ignition sources
- Specific safety procedures and practices appropriate to the employee's job, including, but not limited to, the following:

- Cleaning procedures for milling equipment
- Housekeeping procedures
- Hot work procedures
- Preventive maintenance procedures
- Lockout/tag-out procedures

All employees assigned to special tasks such handling of flammable substances must be well trained to perform these special tasks.

G. What are the preparation for the fire prevention and protection?

Fires represent a major concern to grain and feed mills. Fires result from many different causes. The end result of a fire, however, is always the same—personal injury, death or loss of property. In the grain industry, the primary concern is not that the facility will burn, but that the fire may initiate an explosion.

Establishing a program to prevent fires from starting. This is important in the feed and grain industries because of the potential for explosions and the track record of this industry for fires. A comprehensive fire prevention program addresses all work activities in which the conditions for starting a fire are present such as hot work, electrical machinery, belts and drives, and grain dryers.

The fire prevention and protection program must have:

- Prevention policies, practices and procedures designed to keep the conditions necessary for a fire from coming together
- Hot work permits
- Lockout/tag-out policies
- Design specifications for storage of flammable materials
- Severity reduction—policies, practices and procedures designed to reduce the spread of fire and bring the fire to a quick end
- Emergency plans
- Alarm systems
- Portable fire extinguishers
- First aid
- Recharging portable extinguishers
- Removal of debris to an appropriate waste site
- Equipment and facility repair

The success of such a comprehensive fire prevention and protection program has been demonstrated in many industries, such as the oil industry, in which fire is a serious threat. In each successful program, responsibilities rest primarily with management but are shared with the employees. Employee involvement in the design, implementation and evaluation stages of the program is a central element in a successful program.

H. What are the fire protection equipments?

- Explosion Suppression Systems should be used in unusually hazardous areas such as elevator legs, boots and head, or in areas such as bins, distributors and tanks.
- Portable Fire Extinguishers, all buildings within a facility must have fully charged and operable portable fire extinguishers. If employees are expected to use portable extinguishers or other fire fighting equipment against incipient fires, they must be trained to use the equipment. Training must include the following:

    - Correct type of extinguisher to use on different classes of fire
    - Proper techniques for use of the equipment to extinguish a fire

If employees are not expected to fight fires and are not trained to do so, they must be instructed to evacuate the facility in accordance with OSHS Rule 1948 rather than fight fires.

I. What is the Automatic Sprinkler Systems?

Automatic sprinkler systems are recommended in areas containing combustible materials. The automatic sprinkler systems must meet the requirements in OSHS Rule 1943.

J. Fire Hydrants

All rice mill facilities should have adequate public or private fire hydrants on site. Each fire hydrant should have an adequate water supply.

L. What are the considereations on firefighting?

In a grain dust fire, it is critical to avoid the use of extinguishing methods that will spread the dust into suspension or dust cloud. The formation of a dust cloud during a fire could result in an explosion. Water from a hose under high pressure can throw up large quantities of dust. Water under low pressure, such as a fog or fine mist, is less likely to create a dust cloud.

The first steps in fighting a fire are determining the contents or materials burning in the fire and the extent (size) of the fire. The following are basic considerations for firefighting:

- Equipment that is operating should be shut down.
- Portable extinguishing equipment should be available in areas where the potential for fire is high.
- Employees must be trained in the use of any firefighting equipment that they are expected to use.
- Appropriate alarm systems should be in place in accordance with OSHS Rule 1948.
- A fire should be isolated. If personnel cannot isolate the fire, they should evacuate the area.
- Extinguishing methods must be appropriate for the fire.
- Warm or burning materials must be removed as soon as possible.
- Equipment should be restarted only after the fire area has been inspected and cleared by qualified personnel.

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