Agriculture Engineering

5th Semester

Subject :AGRO PROCESS ENGG.

Chapter - 1.

Seed processing is a crucial step in refining post-harvested seed to its purest form for replanting purposes and human/animal consumption.

Flow Diagram Sowing Various Steps/ Operations in Processing

1 Receiving
Receiving of the seed into the handling and processing system

2 Storing
The uncleaned seed after receiving and before processing**.**

3 Drying
At the time of harvest, the seed normally contains very high moisture content i.e. above16% on average. In order to avoid any negative effects of high moisture, the seed has to be dried and the moisture content has to be reduced to 8-12%. If the seed is stored at high moisture content, it loses germination quickly and is infested with pest and diseases

4 Cleaning

In order to make the seed suitable for cultivation, impurities like weeds, immature seeds inert matters, infected seeds, other crop seeds have to be removed.

5 Grading

After cleaning, the seed requires grading. The grading is of the following types:

Length grading

The clean seed is further graded in this process from the point of view of its length and the immature/infected seeds or any foreign matter that may not have been removed in the cleaning process are removed in the length grading process.

6 Gravity Separating

Gravity separating is followed after length grading and is helpful in removing light and immature seeds having low germination.

7 Treating

Thisprocess is followed after gravity separating. In the process, a suitablefungicide a nd colour is used to protect the seed from fungus and various soilrelated diseases . The colour also gives a suitable appearance to the seed and proving that a check has been performed, confirming that all seeds have been uniformly treated.

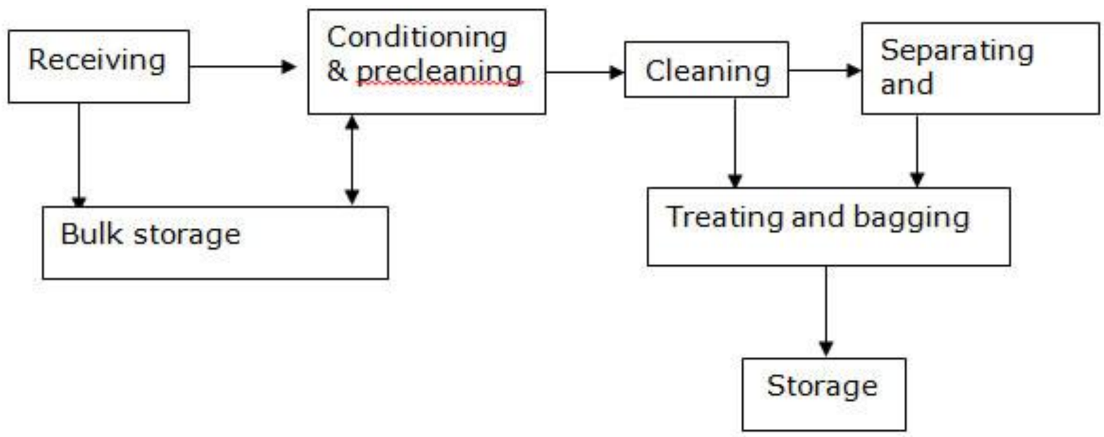
8 Packing

To avoid any moisture contents the processed seed is stored in bags which are stored properly.

http://eagri.org/eagri50/GPBR112/lec28.html

Movement of seed in a processing plant

Handling of seed at the processing plant adheres to a definite path irrespective of crop for easy management of seed which is sensitive at each and every step of handling and ready to lose or gain its quality all through the steps



Different Conveyors and Elevators

1. **Belt Conveyor**: -

A belt conveyor is an endless belt operating between two pulleys. The belt is flat for transporting bagged material. Horizontally the material can be transported to longer distance but there is a limit to carry the material on elevation.

2. **Bucket Elevator: -**
It consists of buckets attached to a chain or belt that revolves around to pulleys one at top & other at bottom. The capacities of bucket elevator may vary from 2 to 1000 ton/hr. the spaced buckets centrifugal discharge type is most commonly used for elevating the grains. The bucket elevator is a very efficient device for the vertical conveyance of bulk grains.

3. **Screw conveyor:-**
It consists of “V- shaped” trough in which a shaft with spiral screw revolves. The rotation of screw pushes the grain along the trough. The screw conveyor is used in grain handling facilities, animal feed industries other installations for conveying of products generally for short distances. The main parts of screw conveyor are screw blade, screw shaft, coupling, trough cover, inlet and outlet gates, bearing and drive mechanism.

4. **Pneumatic Conveyor:-**
It moves granular materials in a closed duct by a high velocity air system. The materials carried in pipelines either by suction or blowing pressure or
air stream. The granular materials because of high air pressure are comeged in dispersed condition for these air velocities in the range of 15-30m/ sec in necessary. The pneumatic conveying system needs a source of air blowing or suction means of feeding the product into the conveyor, ducts and a cyclone or receiving hopper for collection of product.

5. **Chain Conveyor:-**
Chain conveyors are made in a verities for a variety of purposes. They are slow moving conveyor often characterized by high power requirement. The drag or scraper conveyor is common type depending upon the use. The shapes are mounted between one or two chains driven end sprockets. The most common seed conveyor of this type is the outside portable elevator used for handling crop. The conveyor may operate horizontally or on a maximum inclined plane of 45° increased capacity of such a conveyor should be accomplished by larger flights than by increased seed.

6. **Vibrating Conveyor:-**
Conveyors or shakers more material through a metal trough at horizontal or near horizontal angles. The trough is mounted on rigid inclined toggles,
driven by a constant stroke eccentric and is transformed into an upward & forward pitching action by the inclination of the toggles. The result is a series of rapid pitching action which produce a total net movement of the seed toward the discharge and the trough.

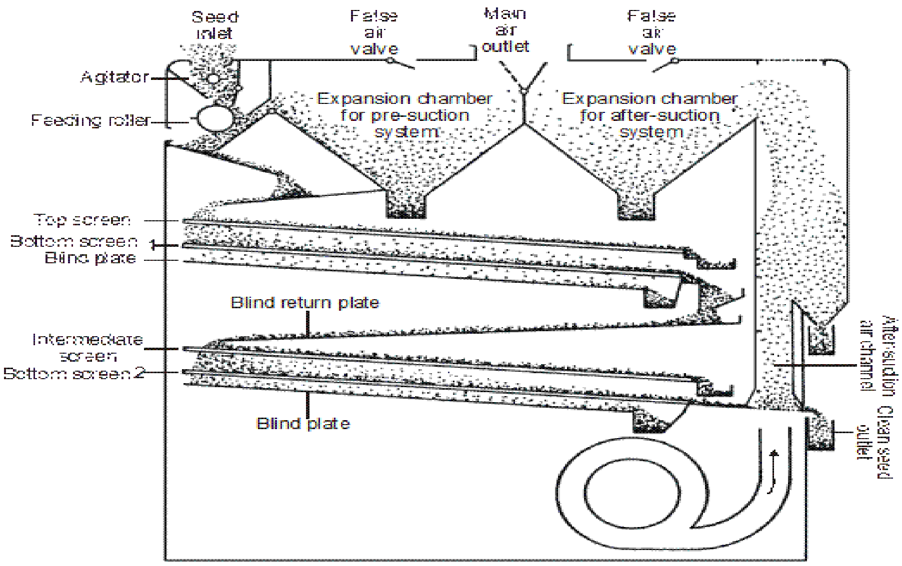
Equipments and machinery used in processing of seed of cereals and pulses (i.e. cleaners and graders)

http://agritech.tnau.ac.in/seed_certification/seed_processing_equipments.html

Seed processing equipments

I. Air screen cleaner

This is the most important machine of every cleaning plant. It uses screens and aspiration (air blow) for two separations. A coarse upper screen removes larger material, a lower fine screen stops the seeds and lets through fine matter and then the seed fraction passes through a transverse or nearly vertical air stream which can separate light impurities such as empty or partly filled seeds, husks and glumes from the seed. In most cases a number of sieves with different sized perforations are used and the cleaning is a process of gradually shifting out smaller particles. Factors which determine the quality and quantity of seed cleaned include (i) size of the perforations, (ii) the precision of the perforation, (iii) the angle at which the sieves operate, (iv) the amplitude and speed of movement of the sieves and (v) correct cleaning and maintenance of the equipment.



II. Cleaner cum grader

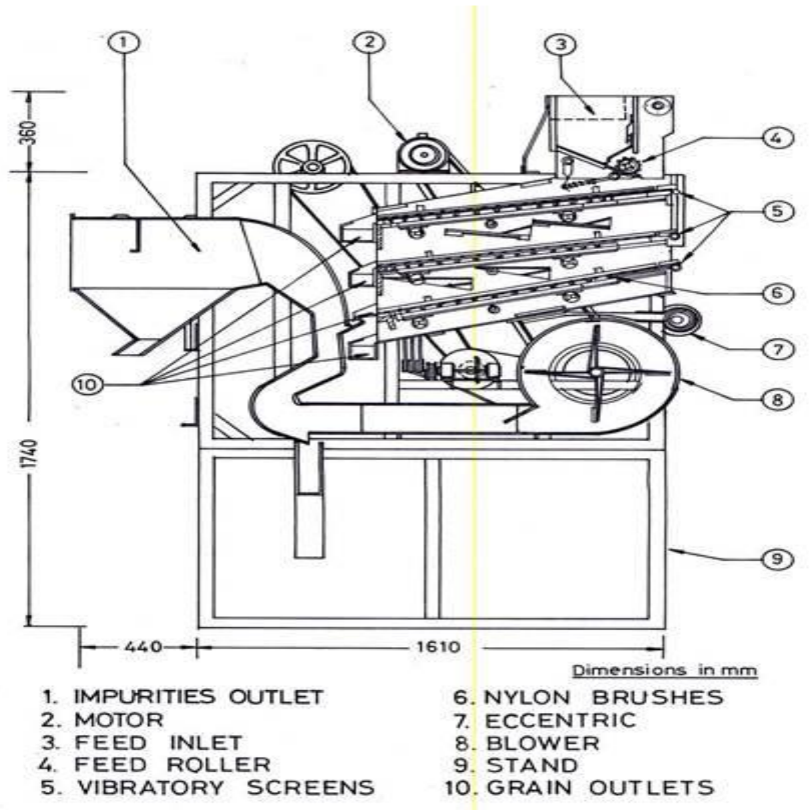
The dried seeds should be cleaned and graded with help of a cleaner cum grader. For large scale cleaning and grading the commonly available machine is the "Crippen Model Seed Cleaner cum Grader".

It consists of the following parts

- A hopper in the top for seed filling
- A fluted roller below the hopper to regulate the seed flow to the screen.
- Screen (or) sieves: Perforated metal sheet with specific size of perforation in which there are two types.
- Rectangular perforations for paddy and
- Round perforations for seed other than paddy
- Screen shaking unit : for oscillating the sieves to move the seeds on the screens
- Screen brushes to remove the blocked seeds
- Air blower with adjustments for air outlet
- Collecting outlet
- Air duct for directing the blown up light particles to outside
- Collecting bins.

Working principle

The seeds are fed into the hopper and they are guided to fall on the first sieve. The first sieve is a scalping screen which scalps all the foreign materials larger and heavier than seed and the entire quantity of seed passes through the first sieve. The second sieve is a cleaning sieve which removes all the unwanted particles larger in size than the seed. The third sieve is actually the grading sieve which size grade the seed lot and bring into a uniform size and which also screen the undersized, shriveled and immature seed, dust and dirt. The seeds are then rolled and passed through air column, where they are relived of the light chaffy and other materials by the blowing air.



Adjustments Fluted roller

the speed of this roller can be adjusted so as to increase (or) decrease the flow of seeds to the hopper of the sieves.

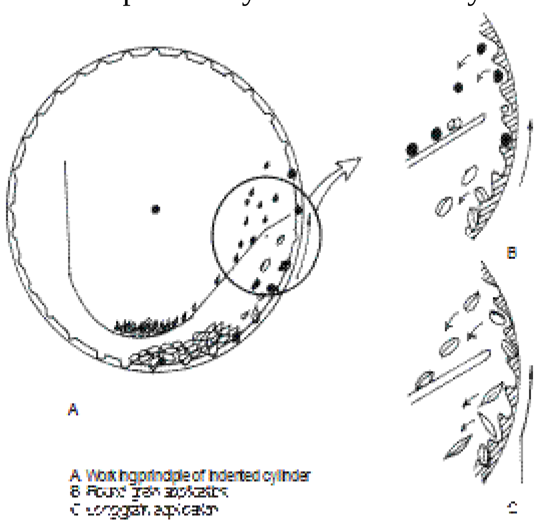
III. Disc separator

It consists of a series of discs, which revolve together on a horizontal shaft inside the cylindrical body. Each disc contains many undercut pockets. The seed enter the intake end of the separator and move through the open centers of the discs towards the discharge end of machine. As the discs revolve through the seed mass the pockets lift out short seed but rejects longer seed. Longer seeds are conveyed by flights on the disc spokes towards the discharge end of the machine where they go out through the tailings gate. The rate of seed travel through the open disc centers is controlled by conveyor or blades attached to the spokes of the discs. The disc separator makes a very precise separation. No factor other than seed length and shape affects its separation. Flexibility is obtained by varying size of the pockets.

IV. Indented cylinder separator

The indented cylinder separator is a rotating, almost horizontal cylinder with movable, horizontal separating adjustments which are mounted inside it. Indent lines are there inside the surface of the cylinder. The indented cylinder revolves, turning the seed mass to give each seed a chance to fit into indent. Short seeds are lifted out of the seed mass and are dropped into the lifting and long seeds remain in the cylinder and are discharged out via., a separate spout at the end of the cylinder.

As the cylinder revolves, it creates centrifugal force which helps to hold the seed in the indent. Short seeds are held in the indent until the cylinder turns to the point where the indent is inverted enough for gravity to cause the seed to fall out of the indent. The length, surface texture and size of seeds determine how they fit into the indent, so that it can be lifted out of the seed mass. The speed of the cylinder creates centrifugal force which holds the seeds in the indent as it are lifted upward. Thus the shape and size of the seed to cause some seeds to fall out after being lifted only a short distance, while other seeds are lifted closer to the top of the cylinder before they fall out.



Working principle of the indented cylinder separator

As the seeds enter the cylinder, the small, short, easy to separate seeds are quickly removed. The center cylinder section removes the intermediate sizes of seeds still in the cylinder. All indents in a cylinder are the same size, only the progressively declining amount of material to be lifted causes this difference in separating action.

Adjustments

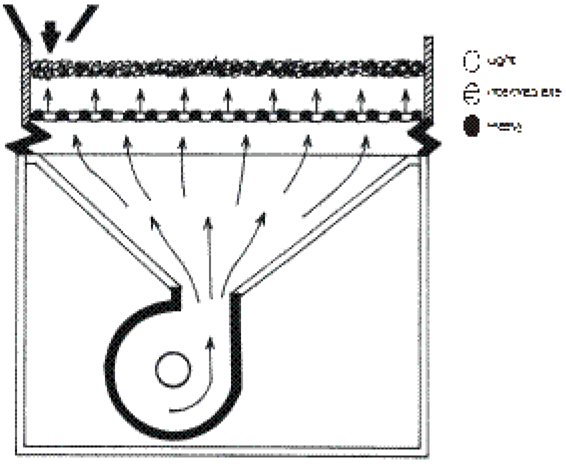
1. Cylinder speed 2) Size of the indent 3) Trough setting 4) Tilt of the cylinder 5) Adjustable retarder.

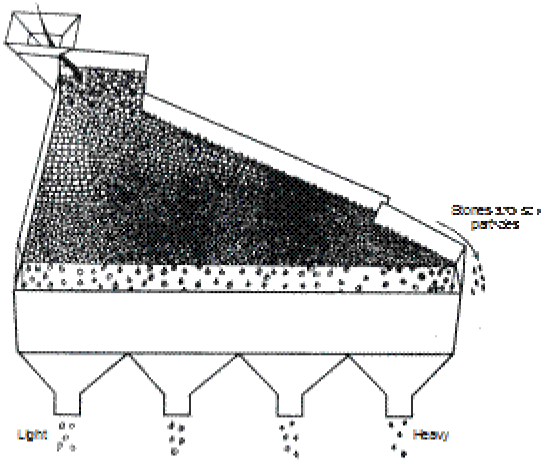
V. Specific gravity separator

Seeds of the same size and general shape can often be separated because they differ in specific gravity or relative weight. This difference is very useful in removing light, immature seeds or heavy sand and rocks to improve the purity and germination of crop seeds.

Lab Model

If seeds which differ in specific gravity (relative weight / unit of volume) are placed on substrate of intermediate density, seeds of higher specific gravity will fall down through the substrata, while seeds of lower specific gravity will be buoyed up the substrata. Here air is used as separation substrata.





Working principle of the specific gravity separator

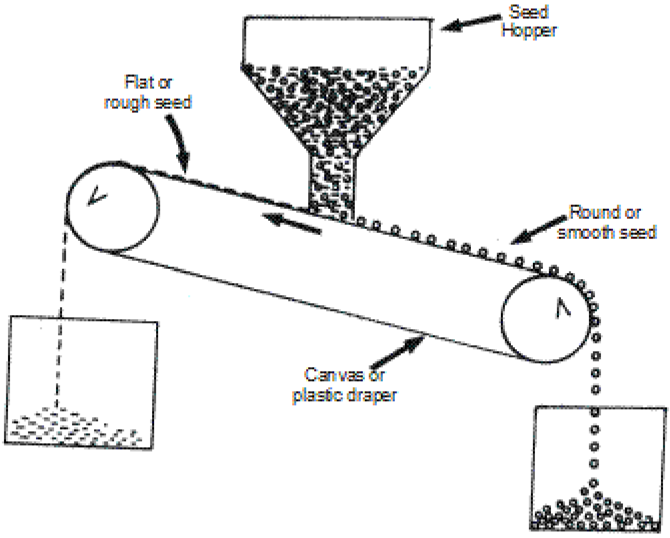
As seeds flow on the deck of the gravity separator, they enter a column of air coming up through the porous surface of the deck. The pressure of terminal velocity of the air rising through the deck can be controlled very closely to separate two kinds of seeds differing in specific gravity, the air is adjusted so that only the lighter seeds are lifted up off the deck surface. These lighter seeds are held up by air pressure and tend to float on the deck surface. The heavier seed possess a velocity greater than that of the air columns so they are not lifted and so will lie on the deck surface. The air column thus stratifies the seed mixture into vertical zones of relative weight with the heavier seed lying on the deck and the lighter seeds lifted up to the top of the seed mass.

Adjustments

1. Feed rate 2) Air flow 3) End slope 4) Side slope 5) Deck oscillation speed 6) Deck speed.

VI. Roll mill or dodder mill or Inclined Drapper Type Saperator :

It is used to separate the seeds based on surface texture and shape. This separator should be used only after the seed has been carefully cleaned and separated from the chaff. These are effective in separating seeds with a rough seed coat or shape angles from smooth seeds.



Working principle of the roll mill

The roll mill consists basically of two roller, covered with flannel or velvet, placed side by side, so that they touch each other down their entire length. The rollers are mounted on an incline and they turn in opposite directions. A curved adjustable shield is mounted above the rollers.

Separating action

The mixture of smooth and rough seeds is fed into the place, where the rollers touch each other, at the high end of the machine. As the rollers turn up and out, seeds that are rough or have sharp or broken edges are caught by the nap of the fabric covering the rollers. These seeds are thrown up against the curved shield. They strike the shield at an angle, bounce back down to the roller and are again thrown up against the shield. Smooth seeds bounce down the inclined position forward between the rollers, and discharge at the lower end of the machine. They are not affected by the fabric roller covering, and are not pitches over the side of the rollers.

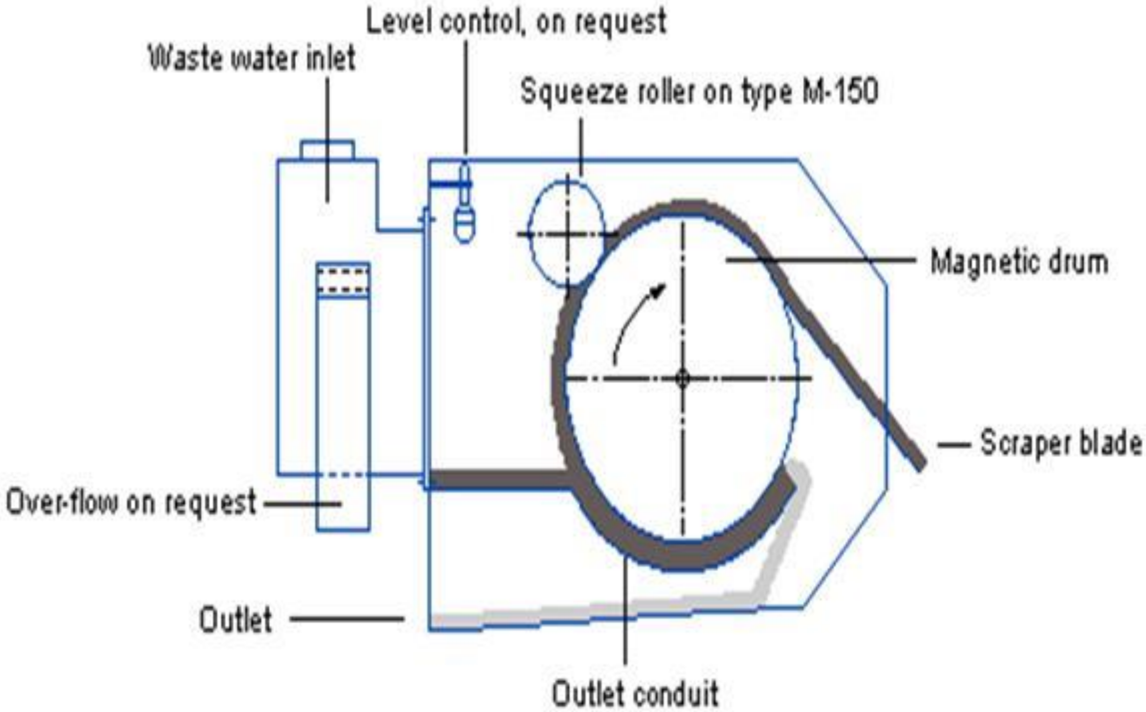
Adjustments

1) Rate of feed 2) Speed 3) Clearance between shield and rolls 4) The angle of inclination of rolls.

VII. Magnetic separator

The separation is mainly based on the affinity for liquids which is used for separation. Since seeds contains no free iron and are not attracted by a magnet they must be selectively pretreated with a magnetic material such as finely ground iron powder. Rough seed coats, cracked or broken seed coats, dirt lumps, chaff or seed with a sticky residue on the surface will hold the liquid and become sticky, so that iron powder will adhere to them. Smooth coated seeds will not absorb liquid. So no iron powder will adhere to them.

The seed are then discharged from mixing chamber and brought into contact with a powerful magnet, which removes the iron coated seeds. Most magnetic cleavers pass the seeds over a revolving drum which has a high intensity magnetic field. Seeds with an affinity for liquids which are now coated with iron powder are attracted by the magnet and adhere to the drum until they are removed by a brush or scraper. Seeds which are relatively free of iron powder are not attracted by the magnet and will fall into a separate discharge spout.



The first requisite of magnetic seed separation is that the seed to be separated must possess different seed coat characters. Crop seeds should have a smooth surface, while the seeds to be removed should have a rough surface which will retain liquid and can accept the iron powder. Success in separating the components depends upon the magnitude of seed coat differences and thoroughness with which the moistened seeds and the iron powder are blended.

VIII. Colour separator

Many large crop seeds such as peas and beans differ in colour between varieties. Colour variation may also occur due to immaturity or disease. Electronic colour sorting machines can separate such seeds by difference in colour and also remove mud balls and discoloured seeds in the same operation.

The electronic colour sorter views each seed individually with photo electric cells. The seed is compared with a selected back ground or colour range and is discharged from the machine according to its colour. If it is the great desired colour, the seed is discharged through the good seed spout. If its colour or shade falls within the reject range, a blast of compressed air deflects the seed and sends it in to the reject discharge spout. These are highly sensitive. Since the machine views each seed individually, capacity is low, but the initial cost is high and operating cost is less. The usefulness of machine is greater with large seeded crops.

IX. Spiral separator

The separator, which classifies seed according to its shape and rolling ability, consists of sheet metal strips fitted around a central axis in the form of a spiral. The unit resembles an open screw conveyor standing in a vertical position. The seed is introduced at the top of the inner spiral. Round seeds roll faster down the incline than flat or irregularly shaped seeds, which tend to slide or tumble.

The orbit of round seed increases with speed on its flight around the axis, until it rolls over the edge of the inner flight into the outer flight where it is collected separately. The slower moving seed does not build up enough speed to escape from the inner flight. Most spirals have multiple inner flights arranged one above the other to increase the capacity.

Delinting of Cottonseed

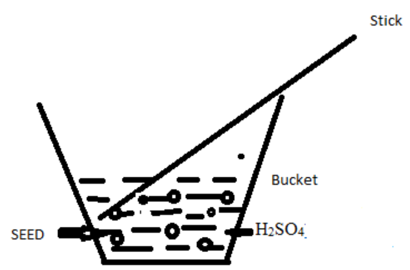
Cottonseed, as the by-product of cotton ginning operation, is covered with fibrous lint (linters). Removal of these linters by mechanical or chemical method is called delinting of cotton seed.

Methods of Cottonseed Delinting

Two general methods have been developed for removing the lint from cottonseed, which are removing the lint by acid and by delinter machine respectively.

Chemical method/ Acid Delinting

The acid delinting of cottonseed has been used extensively, particularly when the seeds are used for planting. Both sulfuric acid and hydrochloric acid have been used for acid delinting respectively. Due to the generation of heat from the reaction of acid with the moisture, the short cotton fibers on the seed would quickly disintegrate. The residue can be washed away with water. After washing, the seed need to be neutralized with soda ash, lime or anhydrous ammonia, which is regard as the wet acid method. However, the concentrated sulfuric acid is extremely corrosive to machinery and dangerous to handle. Some serious problems could emerge, like consuming a large amount of energy to dry the seed and causing soil and water pollution.



Mechanical delinting

It requires more energy than acid delinting, but it does not use any chemicals and can produce a small quantity of usable low grade lint as a by-product. Mechanical delinting is usually accomplished by high speed rotating sharp saws or abrasive surfaces to cut or rub the fibers off from the hull. The advantage of this type operation is that the fibers are not degraded during the operation and can be sold for various purposes. Also, since the seeds are to be subsequently crushed for oil or meal, the damage sustained by the seeds is not detrimental to their further use. The delinter machine also provides for the recovery of the lint after separation from the cottonseed. The movement and travel path of the cottonseeds during delinting process is controlled to ensure a high degree of efficiency in the removal of the lint.

Seed Processing Plant Layout Planning

Layout plan for construction of a seed processing plant should be carefully planned to ensure that the thorough seed cleaning, upgrading, seed treatment and other seed processing operations are carried out efficiently, without mixing and damaging seed lots, with a minimum of equipment, personnel, time and at minimum cost. The following factors should be considered in planning and designing a seed processing plant:

1. Kinds of crop seeds to be handled and kinds of contaminating crop and weed seeds usually present in the seed lots
2. Size of operation
3. Whether drying facilities should be required
4. Selection of suitable equipment
5. Location of the plant
6. Source of power for running machinery
7. System of seed delivery to processing plant and
8. Availability of labour

The key to efficient plant layout is a thorough knowledge of what needs to be done, and sound planning. First, the general sequence of processes involved between the time seeds enter the processing plant and the time they are cleaned, packaged and ready for shipment, must be charted. The sequence of operations depends upon the kind of crop and the initial quality of seed lot, type of contaminants, moisture content of the seed lot, etc. The layout planner must have an intimate knowledge of the seed to be processed, its physical characteristics, the contaminants in it, and also of the selection of machines used to bring the seed to acceptable marketing standards.

Seed Processing Plant Building Layout

Seed processing plant building will comprise of following components:

1. Receiving-cum-drying platform
2. Processing area
3. Auxiliary building

Receiving-cum-drying platform

This area will be utilized to receive the raw seed and to sun dry small lots of crop seeds. This area can also be utilized for storage of seeds on wooden palettes. The platform will be connected to processing shed through a rolling shutter.

Processing area

The processing area should be situated between the shed and ventilated storage building. The hall should be connected to ventilated flat stores through a covered gallery for easy movement of processed and packaged seed to seed stores. The hall should have a big rolling shutter in the processing plant to permit entry of seed processing equipment into the hall for installation.

Height will be kept to facilitate installation of the seed processing equipment and machinery. A sequence of processing machines to be installed is shown in Fig. 1. Floor of the processing hall should be above the ground level.

The shed should have sufficient provision for natural as well as forced ventilation in order to maintain congenial atmosphere inside the shed. The shed should accommodate seed scalping, seed processing and packaging equipment and will have sufficient space for weighing and packaging.

Auxiliary building

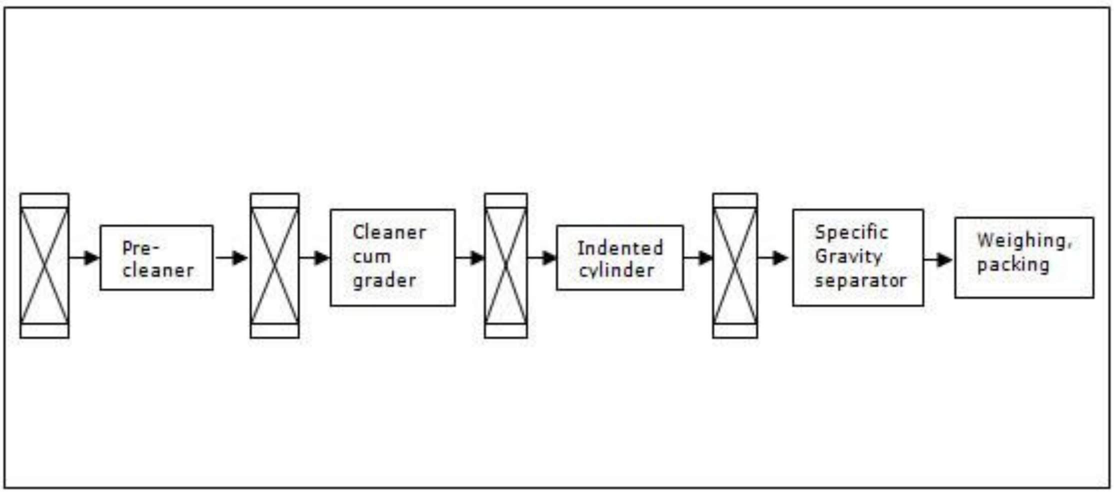
In addition to building discussed above, a provision should be made for generator room. Sufficient length of road should be provided to connect various functional buildings with each other and main highway. Boundary wall should be provided all around the complex for security reasons. Entire complex should have a good drainage system.

Provision for firefighting equipment such as extinguishers, water buckets, sand buckets etc. should be made to fight minor fire hazards.

The processing plant building should be constructed as per CPWD/PWD norms. It should have tubular trusses, AC sheets pitched hole roof, cement concrete flooring finished with water-proofing cement paint, aerated, ventilated, rat proof and bird protection. Sealed doors should be provided in these buildings. Buildings will be suitably planned to have interconnection for movement of seeds and materials.

Analysis of Operation

a) Processing sequence: After the machines needed have been identified, the next step is to determine the proper processing sequence. The seed separators, elevators, conveyors and storage bins should be so arranged that seeds flow continuously from beginning to end, and yet be flexible enough to bypass a machine or return to a part for re-cleaning.



b) Matching capacity: Equipment size of capacity must be carefully planned to prevent bottlenecks. When the overall operating capacity needs have been determined, all machines must be able to handle that capacity with some reserve capacity for problem lots. Surge bins can handle variations in individual machine capacities. But when differences are great, either larger models, or more than one machine installed in parallel flow, must be used to maintain uninterrupted flow.

c) Conveying: The type of conveying system is also a very important factor. The conveying system must be able to handle the capacity needed in a particular spot. And it must be carefully adapted to the seed handled.

Type of Layouts

There are three main types of processing plant layouts: multistory, single level and combination.

Multistory: In this system, seed is carried by elevators to the top floor and emptied into large bins. Cleaning machines are then arranged in a vertical series on the lower floors. Seed flows from one machine down into the next by gravity.

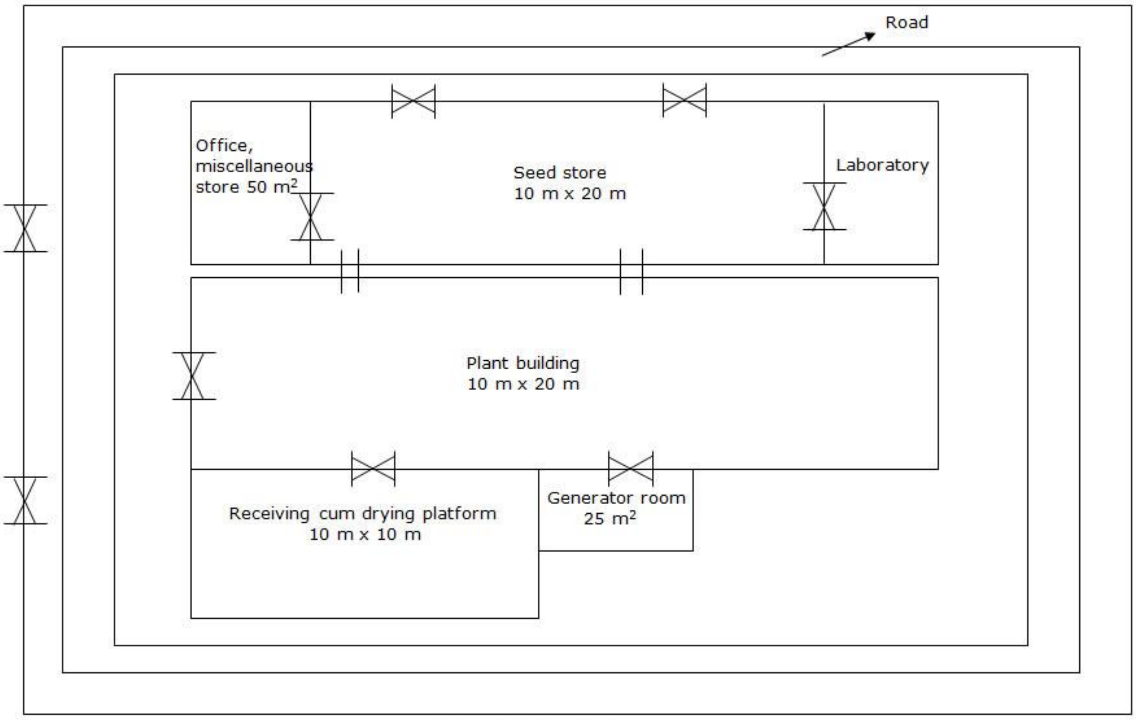
Single level: In the single storey plant, seed is moved from one machine to the next by elevators placed between the machines. A great advantage of the single level system is that one man can supervise the processing line without running up and downstairs. He can thus maintain closer supervision of all operations**.**

Combined designs: A compromise between the single and multistory system could also be adapted.

Planning

After the proper machines, elevator capacities, cleaning sequences, and lay out design have been selected, detailed layout planning can begin. Careful layout planning can identify and remedy bottlenecks and trouble spots before the plant is built, and thus prevent trouble later.

As the lay out or design develops, it should be drawn on paper. A good method is to draw lines of flow first and then convert these flow lines into machine lines. After appropriate revisions, detailed drawings can be made to show exact locations of equipment and distances. Scale drawings are the most widely used method of layout planning. Scale models and scale templates are also very effective, but are more expensive.



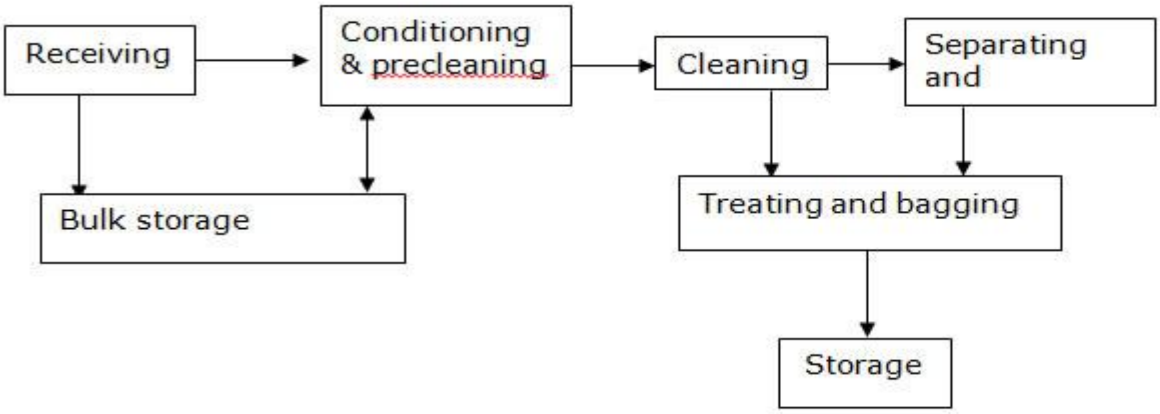
Building layout plan

Requirements in seed processing

1. There should be complete separation
2. Minimum seed loss
3. Upgrading should be possible for any particular quality
4. Efficiency
5. It should have only minimum requirement

Movement of seed in a processing plant

Handling of seed at the processing plant adheres to a definite path irrespective of crop for easy management of seed which is sensitive at each and every step of handling and ready to lose or gain its quality all through the steps.



SEED TREATERS

The application of Seed treatment materials on the surface texture of the seed coat in the form of dusts, slurries or liquids is called **seed treatment**. The equipment used to apply chemicals, in any form, to seed is classified as seed treaters.

They can be divided into two broad categories:

Commercial Treaters and Farm Treaters

1. Commercial Treaters:

Many seed treater are available that can apply a small amount of chemical and spread it uniformly over the surface of each seed.

(a) **Slurry Treaters:** The treatment material applied as a slurry is accurately metered through a simple mechanism composed of a slurry with each dump of seed into a mixture chamber where they are blended. Slurry treaters are adaptable to all types of seed.

(b)**The "Mist-O-Matic**" Treaters: These apply treatment as a mist directly to the seed. The treater is equipped with a large treatment tank, a pump and a return valve that maintain the level in the small reservoir from which the treatment cups are fed. The disc breaks drops of the treatment into a fine mist and sprays it outward to the seed. Just below the seed dump area to adjustable retarders designed to give a continuous flow of seed over the cone between the seed dumps. This is important since there is a continuous misting of material from the revolving disc.

2. Farm Treaters:

Several methods are used for seed treatment on the farm. Some of the following methods will give fairly satisfactory results:

(a) **Home-made drum mixture:** A simple mixture can be made by running a pipe through a drum at an angle. The drum is then mounted onto sawhorses. The seed and treatment are placed in the drum and it is rotated slowly until all the seeds are covered.

(b) **Grain Auger**: Liquid materials can be dipped onto the seed as they enter a grain auger or screw conveyor. By the time seed have left the auger, the liquid is spread well over most seeds.

3. **Shovel:** Seed are spread on a clean, dry surface, 4-6 inches in depth. The proper amount of treatment is diluted with water and sprinkled evenly over the seed. Mixing is accomplished with a shovel or scoop by turning the seed at-least 20 times.

Chapter - 2.

RICE MILLING SYSTEM

Milling of Rice (Definition)

Milling of paddy is the major operation in paddy processing. It removes husk and outer layer of bran so as to produce acceptable white rice with minimum breakage and impurities.

Milling is a crucial step in post-production of rice. The basic objective of a rice milling system is to remove the husk and the bran layers, and produce an edible, white rice kernel that is sufficiently milled and free of impurities. Depending on the requirements of the customer, the rice should have a minimum of broken kernels.

Parboiling – Basic concept and Principles

Paddy Grain Structure:

The structure of paddy grain shows that the endosperm which covers the major volume of rice grain, is mainly composed of polygonal starch granules. The void spaces are filled with air and moisture. The presence of voids and cracks developed during maturity, causes breakage of rice during milling. Such a breakage may be eliminated by gelatinizing the starch which will fill the voids and cement the cracks.

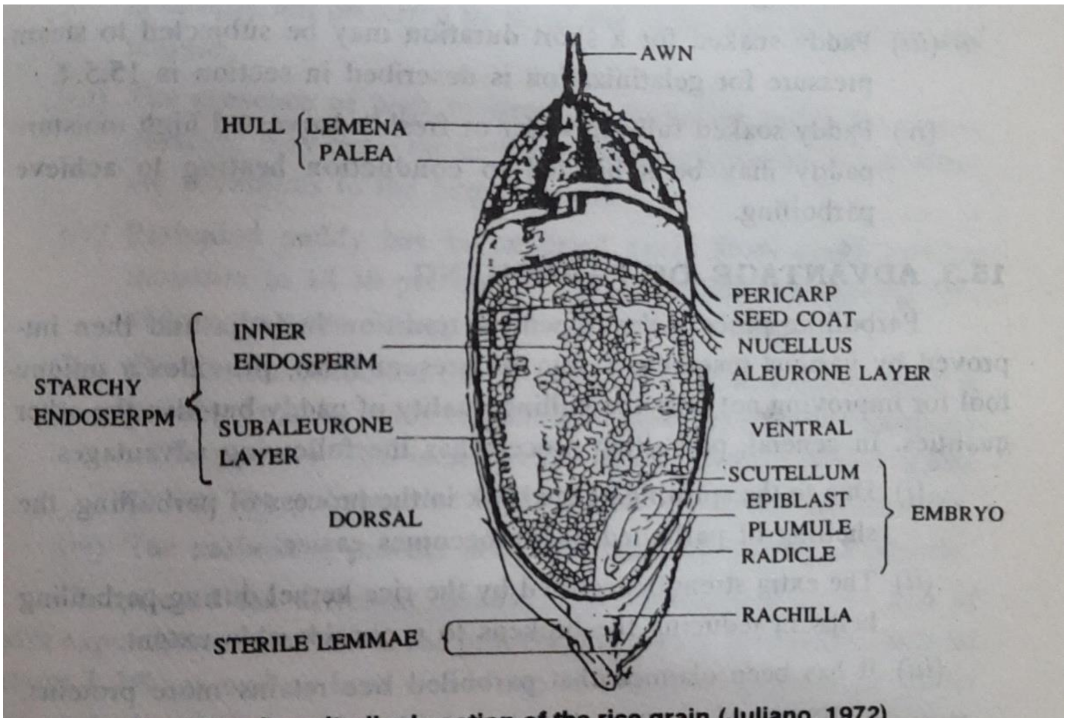


Fig. 15.1—Longitudinal section of the rice grain (Juliano, 1972)

Swelling of starch granules may be achieved by soaking paddy in cold or hot water. During hot soaking, energy supplied in the form of heat weakens the granule structure by disturbing hydrogen bonds, giving more surface for water absorption by starch granules. This permits further hydration. This phenomenon is called Gelatinization of starch. The temperature at which gelatinization takes place is known as gelatinization temperature which is specific for each variety.

Principles of Parboiling :

Theoretically, soaking of paddy can be done at or below its gelatinization temperature. The lower the temperature used, the slower is the process of soaking and vice-versa. But it should not be more than 75degree centigrade, otherwise paddy will get cooked.

Parboiled paddy may be dried in shade, or in sun, or with hot air. Shade drying gives an excellent milling quality but rapid drying in the sun or with hot air gives high breakage during milling.

Advantages of Parboiling:

1. The shelling of parboiled paddy becomes easier.
2. Extra strength acquired by the rice kernel during parboiling.
3. It had been claimed that the parboiled rice retains more proteins, vitamins and minerals than raw milled rice of the same variety.
4. It is more resistant to insect infestation during storage as compared to raw rice.
5. It can withstand overcooking without becoming pasty.
6. Rice bran from parboiled rice is of superior quality.

Disadvantages of Parboiling:

1. The heat treatment during parboiling, causes a destruction of some natural antioxidants.
2. Parboiled rice takes more time to cook.
3. It may cause the development of micotoxins in rice which are hazardous to the human health.
4. It add an extra drying cost to the total processing.
5. The shelled parboiled rice is harder, therefore, more difficult to polish.

Methods of Parboiling:

1. Traditional methods: (a) Single boiling, (b) double boiling
2. Modern methods : (a) Central Food Technological Research Institute (CFTRI) method(Indian)

(b) Kisan continuous method

(c) Pressure parboiling method

(d) R P E C method (Hot soaking)

(e) Sodium chromate (cold soaking) and single boiling.

Traditional methods:

The traditional process consists of soaking in water at room temperature for 24-48 hours or more, steaming in kettles and drying in the sun.

a)Single parboiling method: Paddy is soaked in ordinary water for 24-72 hours and then soaked paddy is transferred to cylindrical iron kettles for steaming which is done in small batches under atmospheric pressure. The parboiled paddy is then dried in the sun before milling.

b)Double boiling method: In this method, first steam is injected into raw paddy in the steaming kettle before soaking. This hastens the soaking process. Hot paddy raises the temperature of soak water 45°C to 50°C, which aids in reducing the soaked time to 24 hours only. Therefore, soaked paddy is steamed as in the single boiling. Sometime, the soak water itself is heated to about 50°C before dumping the raw paddy in it. In that case, the first steaming of raw paddy is not required.

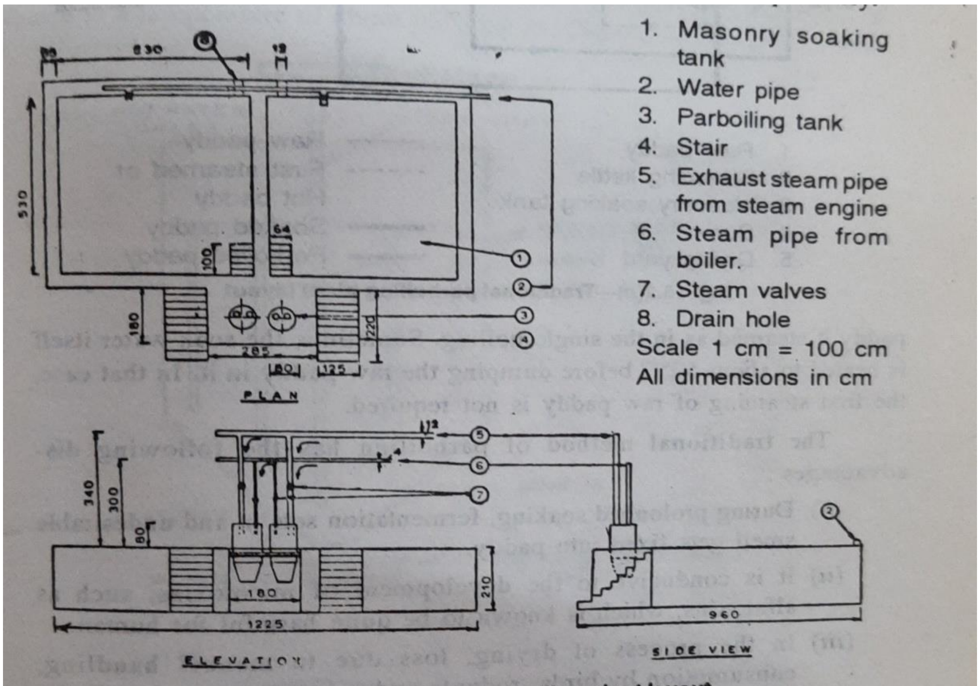


Fig. 15.2(a)—Traditional parboiling plant layout

Modern Methods

1. **CFTRI Method**

In this process, parboiling tanks are filled with clean water and then the water is heated to a temperature of about 85 degree centigrade by passing steam through the coils already placed inside the tank. Sometimes, hot water is prepared in a separate hot-water tank before being pumped into the tanks as shown in fig.

The second process saves time and increases the capacity. Paddy is dumped into hot water as quickly as possible. In fully automatic system the paddy can be lifted up by an elevator to be dumped into the parboiling tanks for soaking. The resulting temperature of paddy-water mixture in the tanks after dumping paddy stays around 70°C. After letting the paddy soak for 3-3.5 hours, soaked water is drained out and water discharge valve kept open to remove the water that condenses during steaming. Soaked paddy is exposed to steam heat by letting in steam at a pressure of about 4 kg/cm² through the open steam coil.

After completing the steaming operation, steam paddy can be drawn off for drying by opening the bottom door. If a mechanical dryer is to be used, parboiled paddy is conveyed to the dryer by a conveyor and an elevator. Mechanical drying is preferable to the sun-drying in this method in order to save the space and to minimize the cost of production.

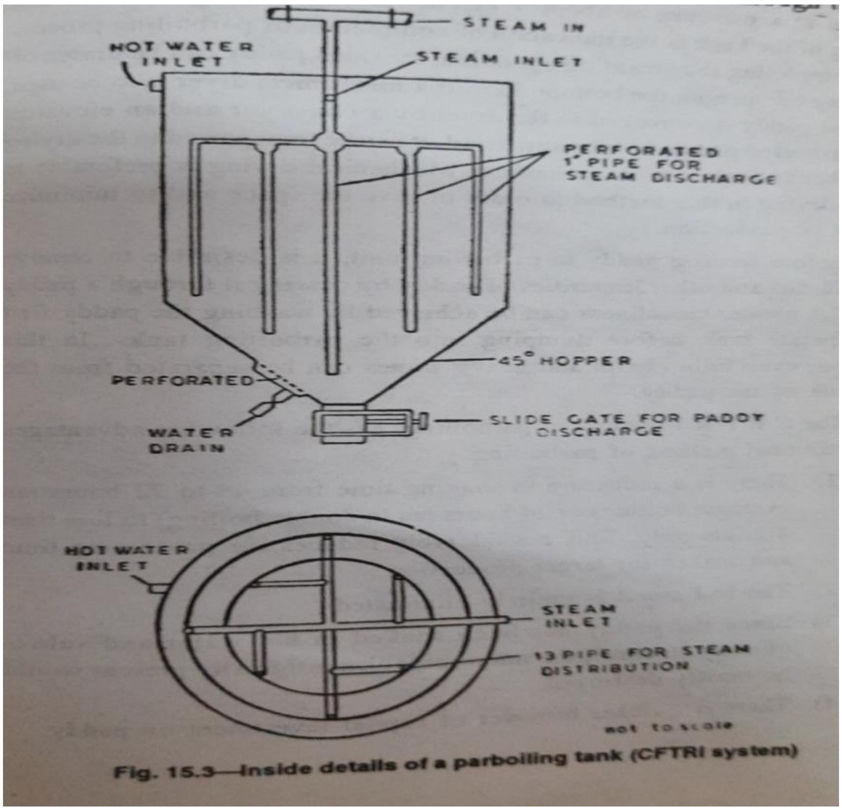


Fig. 15.3—Inside details of a parboiling tank (CFTRI system)

2. **Kisan Continuous Parboiling Method**:

In this process, the hexagonal tank with 12 compartments is filled with hot water into which paddy is discharged from an elevator head. These compartments are filled in a sequential order starting with No.1 first, and leaving an interval of 15 minutes between successive compartments filling. By the time the 12th compartment is filled, the first one is ready for steaming.

By opening the discharged gate, water and paddy can be taken to the dump pit below the tank. This pit has a perforated floor plate which permits water to drain out. From this pit a screw conveyor of capacity 2 tonnes per hour carries the soaked paddy for steaming. Since each compartment contains only ½ tonne, the pit would be empties in 15bminutes.Thus a series of quick batches emptied from the hexagonal tank is succession, give rise to a continuous feed to the parboiling unit.

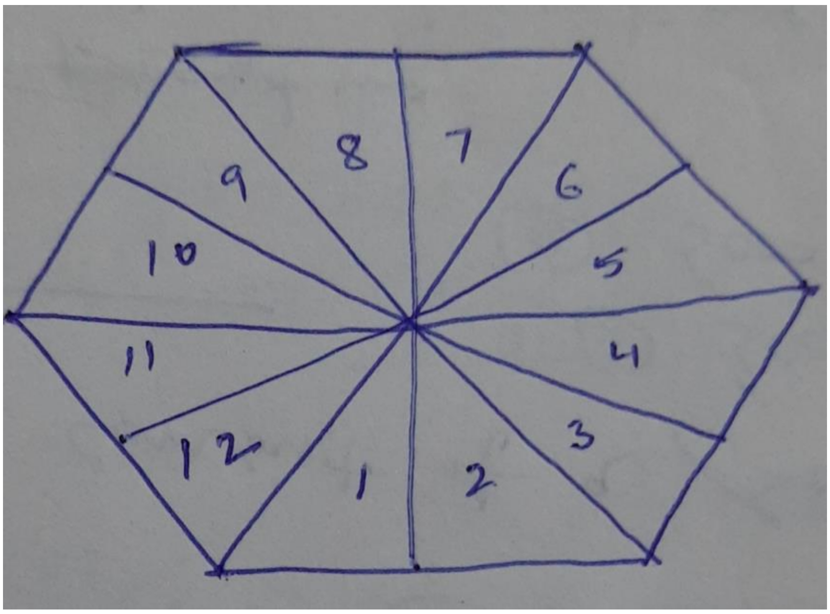


Fig. Hexagonal Tank in Kisan Continuous Method

3. **Pressure Parboiling:**

The principle of the method is the penetration of moisture inside the paddy in water vapour phase under pressure and bringing the gelatinization of the kernel. Paddy is soaked for 40 minutes at a temperature of 85-90° C and then steamed under pressure for 18 minutes. The entrapped air inside the rice kernel will be driven out by the penetration of water vapour and thus avoids the presence of white bellies in resultant rice. It is claimed that whole parboiling operation is completed in 1 to 1 ½ hours only.

The main advantages were reduction in soaking time; increase in shelling efficiency (nearly 80% of paddy hull splits during steaming) and milling out turn as grains become resistant to breakage.

4. **R E P C Method:**

The Rice Process Engineering Center (RPEC) method consists of soaking paddy in water at 2-3 ° higher than its gelatinization temperature for a suitable period depending upon the paddy variety. During soaking process paddy absorbs moisture as well as heat. Gelatinization of starch mostly takes place during latter part of soaking. Then, the soaked or say parboiled paddy is taken out and either dried in sun or through mechanical dryers.

Advantage- This method might be economical because it eliminates the steaming process.

5. **Sodium Chromate Method:**

The process consists of soaking paddy in 0.05 % sodium chromate (Na_2CrO_4) solution is well enough to control the putrefactive changes for 30 days. The rest of operations i.e., steaming and drying are done in traditional way and there is no extra cost involved in the operations. There is absolutely no smell in the soaked paddy, resultant rice and bran.

COMMERCIAL RICE MILLING SYSTEMS

Commercial milling systems mill the paddy in stages, and hence are called multi-stage or multi-pass rice mills. The objective of commercial rice milling is to reduce mechanical stresses and heat buildup in the grain, thereby minimizing grain breakage and producing uniformly polished grain. Compared to village-level systems, the commercial milling system is a more sophisticated system configured to maximize the process of producing well-milled, whole grains. The rice milling facility comes in various configurations, and the milling components vary in design and performance. “Configuration” refers to how the components are sequenced.

The flow diagram below shows a modern commercial mill catering to the higher end market (Fig. 8). It has three basic stages, the husking stage, the whitening-polishing stage, and the grading, blending, and packaging stage.

Modern rice milling processes consist of:

Pre-cleaning - Removing all impurities and unfilled grains from the paddy.

Husking - Removing the husk from the paddy.

Husk aspiration - Separating the husk from the brown rice/unhusked paddy.

Paddy separation - Separating the unhusked 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 ran particles and by polishing the exterior of the milled kernel ·

Sifting - Separating small impurities or chips from the milled rice.

Length grading - Separating small and large brokens from the head rice.

Blending - Mix head rice with predetermined amount of brokens, as required by the customer.

Weighing and bagging - Preparing milled rice for transport to the customer.

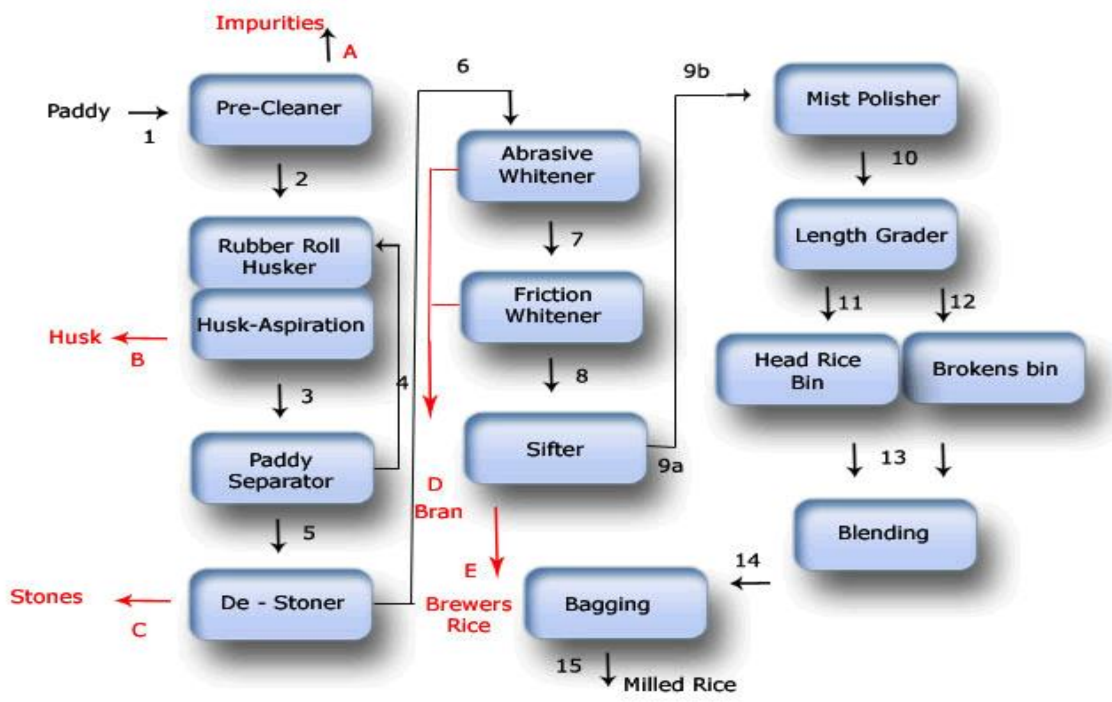


Fig. 8 Flow chart/diagram of a modern commercial mill

THE HULLING OF PADDY

The objective of a hulling machine is to remove the husk from the paddy grain with a minimum of damage to the bran layer and, if possible, without breaking the brown rice grain.

The most common machines used in hulling paddy are the Under- Runner Disc Sheller, The Rubber Roller Sheller and huller.

Hulling machines are known by different names, such as shellers, hullers, de-huskers, huskers, and hulling mills. Most commonly of these machines are called "hullers".

THE UNDER-RUNNER DISC HULLER

The under-runner disc huller consists mainly of two horizontal cast- iron discs, partly coated with an abrasive layer (Fig. 14). The top disc is fixed in the frame housing; the bottom disc rotates. The rotating disc is vertically adjustable (2) so the clearance between the abrasive coating of the disc can be adjusted (3). This adjustment depends on the variety of paddy, the condition of the grain, and the wear of the coating.

The paddy is fed into the centre of the machine through a small hopper. A vertically adjustable cylindrical sleeve (1) regulates the capacity and equal distribution of the paddy over the entire surface of the rotating disc. By centrifugal force the paddy is forced between the two discs and under pressure and friction most of the grain is dehusked.

The adjustment of the clearance between the discs is rather critical and requires continuous rechecking to avoid excessive breakage or insufficient huller efficiency. Quite often, the effective width of the abrasive coating is made too large, causing unnecessary breakage of the grain. The peripheral speed of the disc should be about 14 m/s.

The main advantages of the disc huller are its operational simplicity and its low running cost; moreover, the abrasive coverings can be remade at the site with inexpensive materials. The main disadvantages are grain breakage and the abrasions to outer bran layers.

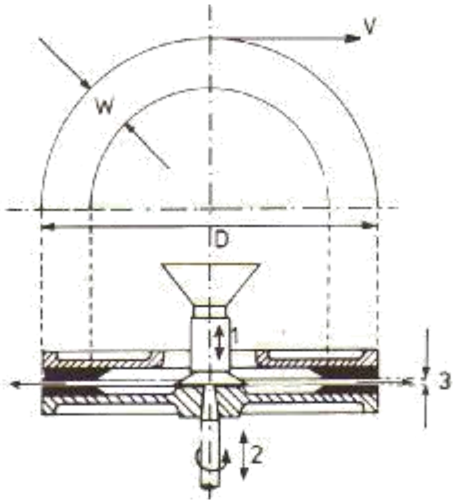


Fig. 14.The Under-runner disc huller.

RUBBER ROLL HULLER

The rubber roll sheller /huller is by far the most important technology used today for hulling rough rice. The rubber roll paddy husker, often referred to as a huller or sheller (Fig. 16), consists of two rubber rolls rotating in opposite directions at different speeds (Fig. 17). One roll moves about 25%; faster than the other. The difference in peripheral speeds subjects the paddy grains falling between the rolls to a shearing action that strips off the husk. The clearance between the rolls is adjustable and is kept at less than the thickness of the grain.

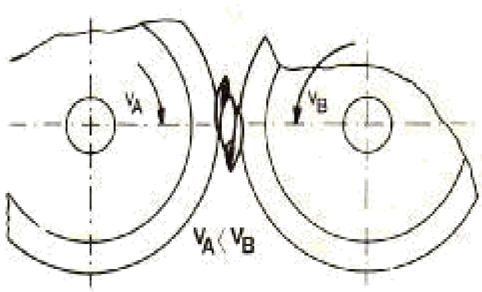


Fig. 16.Rubber roll Sheller

Fig. 17.Dehusking principle of rubber roll huller.

Compared with the disc sheller, the rubber roll offers many advantages. It reduces grain breakage and the loss of small brokens; it does not remove the germ; sieving the husked products is unnecessary; it reduces the risk of damage to the grain and machine by unskilled operators; it increases hulling efficiency; and it does not require a beard-cutting machine.

The main disadvantage is the cost of replacing the rubber rollers as they wear. That is offset, however, by the reduction of breakage and increased total rice outturn.

The machine is complex and consists of many moving parts to have rollers operating at different speeds. Manufacturers use chains, belts, and gear drives. Horsepower requirements are slightly less than those for the disc sheller.

For optimum performance, the grain should be evenly distributed over the full width of the rolls. Otherwise, the roll surface wears out unevenly, reducing efficiency and capacity. Unevenly worn rolls can be corrected by turning them on a lathe.

Hullers:

Almost all the huller rice mills are having one or more hullers with winnower grader. The huller consists of a solid fluted cylinder rotating at 700 to 800 rpm within a hollow stationery cylinder in the lower half of which is the perforated iron sieve with slots of 1.5 to 7.5 mm. The flute on the cylinder is so arranged as to carry the paddy to the centre from the feeding end, get it milled by scouring action at the centre of the cylinder and then to carry it to the other end where the milled rice is discharged. The hullers are used first for shelling by keeping a wide clearance between the cylinder and the blade. The grader is fitted with two or three sets of sieves for grading the rice into various fractions.

Advantages of Hullers:

The conventional steel hullers have the following advantages:

1. Investment required for unit capacity is extremely low.
2. It needs very small space to be installed.
3. It is very simple in design.
4. It can be used as whitener or polisher also.

Disadvantages of Hullers:

The conventional steel hullers have the following disadvantages:

1. It gives low heat yield, and large large broken.
2. Germs, bran and husks get mixed together.
3. Separation of paddy from rice cannot be achieved in the machine.
4. Power consumption per tonne of paddy is quite high.

WHITENING AND POLISHING

Whitening: In the process of whitening, the silver skin and the bran layer of the brown rice are removed.

Polishing: In the process of polishing the whitened rice, the bran particles still sticking to the surface of the rice are removed, and the surface of the rice is slightly polished to give it a shinier appearance. Polishing, therefore, always takes place after completion of the whitening process.

Some confusion exists about the words used for these processes. Whitening is sometimes called "polishing" or "milling". Polishing is sometimes called "refining" or "grinding".

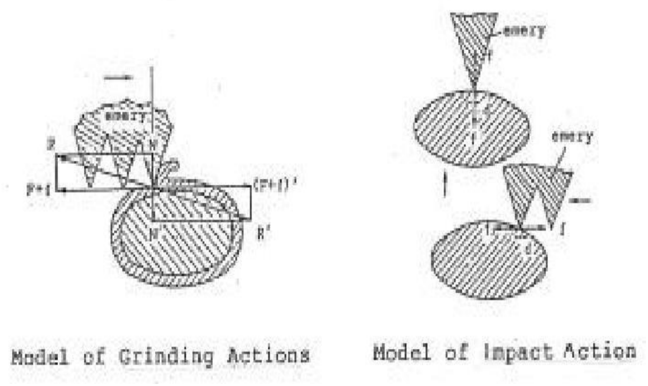


Fig. 25 Abrasive process of bran removal.

The two processes used to remove the bran layer from the grain are abrasion and friction. Note that the abrasion process uses a rough surface, which is an abrasive stone, to break and peel the bran off the grain (Fig. 25). The friction process uses the friction between the grains themselves to break and peel off the bran.

Three kinds of whitening machines are widely used in the rice processing industry: (1) the vertical abrasive whitening cone; (2) the horizontal abrasive whitening machine; and (3) the horizontal friction whitener (the horizontal jet pearler).

VERTICAL ABRASIVE WHITENING CONE

A typical vertical abrasive whitener is shown in Figure 27.

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 about 10 mm by raising or lowering the cone. The peripheral speed of the cone should be about 13 m/s. Making the speed of rotation of the shaft a function of the diameter of the cone, the larger the diameter of the cone, the speed of the shaft must be lower. The screens wear out the quickest and require frequent replacement.

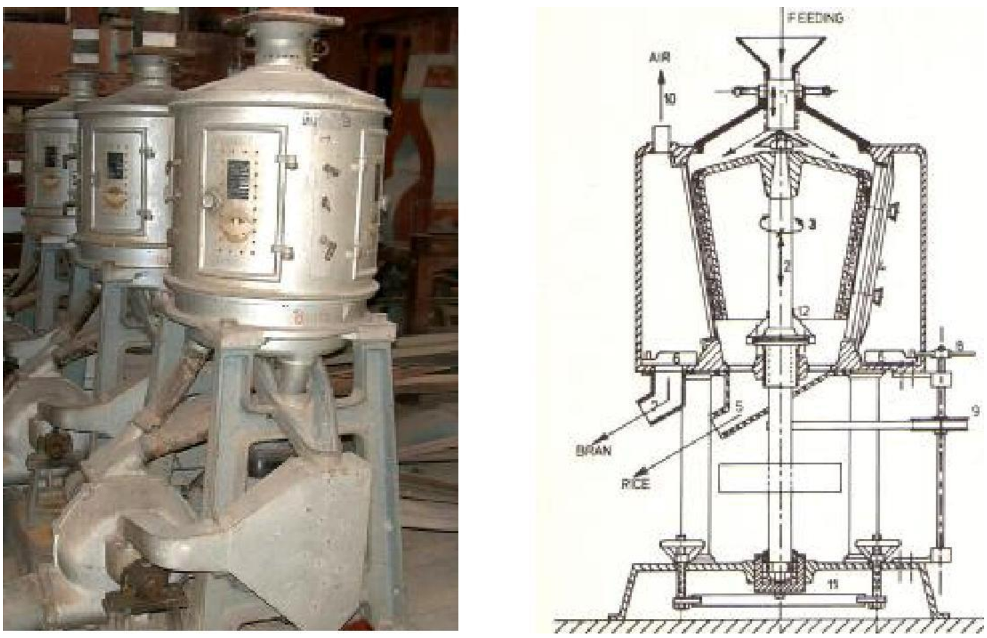


Fig. 27.The vertical abrasive whitening cone.

Removing all the bran in one whitening operation causes much breakage and reduces total rice recovery. Therefore, most modern rice mills use multipass whiteners. For example, a capacity of 1,200 kg/ hour can be obtained by l) a single pass with one 1,000-mm cone, 2) a double pass with two 800-mm cones, or 3) a multipass with three 600-mm cones. The last produces the least amount of brokens and the largest total rice recovery, and is usually more economical

Multipass whitening produces higher rice mill recovery because there is: (1) an increased head rice yield; (2) a reduced percentage of large brokens, and (3) a reduced percentage of small brokens (Fig. 28).

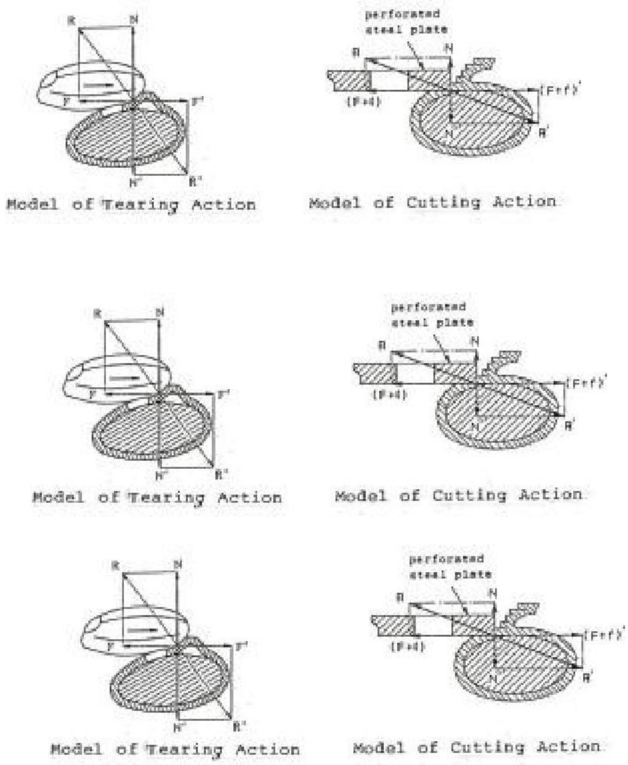


Fig. 28.Multipass whitening increases rice mill recovery by reducing the amount of rice

HORIZONTAL ABRASIVE WHITENER

A typical horizontal abrasive whitener is shown in Figure 29. It 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 (Fig. 30). Brown rice enters one end, and moves around and 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 (Fig. 30) 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.

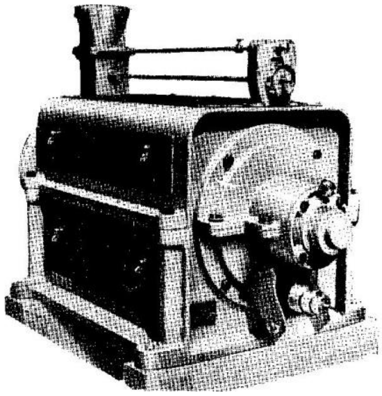


Fig. 29. Horizontal abrasive whitener.

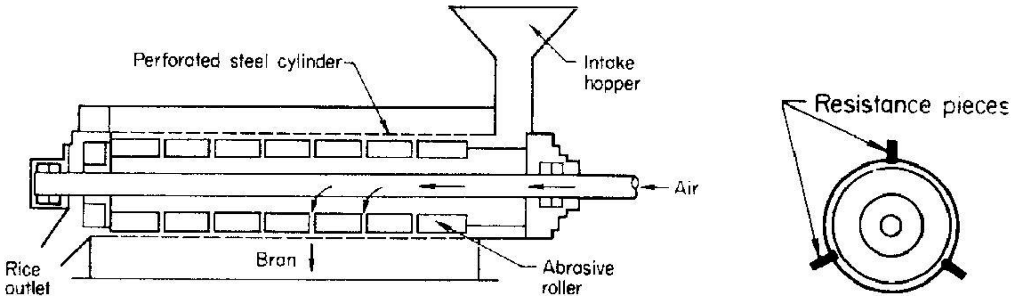


Fig. 30.Cross section of horizontal abrasive whitener.

The airstream through the abrasive roll is particularly useful in the milling of parboiled rice. Bran on parboiled rice tends to stick to and cake up the perforations in the screen. The airstream assists in keeping the perforations clear.

<u>Utilization of BY-Product of Rice Mill</u>

In rice mills, during processing of paddy-rice, the by-products generated are

(i) Rice husk= 20-24%

(ii) Rice bran= 4-6 %

(iii) Rice germ= 1-2 %

(iv) Small broken =2-3%

It is necessary that rice by-products may be used so as to generate extra income to mill owners. Economic utilization of milling by-products is a great incentive to millers.

1. **Rice Husk:** (i) It contains about 15-18% silica and is low in nutritional value and adds very little to the soil ass fertilizer.
   (ii) Husk can be used for production of hot gases, steam and running boilers and steam engines.
2. **Rice bran and Germ:** Rice bran is a source of proteins, oil and nutrients. It is also rich in vitamin'E' and other nutrients and has advantageous effects in lowering blood cholesterol level.
   Rice germ is richer in protein and fat, but lower in fibre than bran. Flour is prepared from rice germ which is used as cattle and poultry feed.

3. **Rice bran Oil:** (i) Crude rice bran oil of high acid value is used for making solidified oil, stearic and oleic acid, glycerine and soap.

(ii) Crude oil can also be confined with glycerine to make neutral oil.

(iii) Oil can also be sulfonated to make lubricants. Such lubricants are used in textile or leather finishing.

4. **Paddy husk Ash:** The husk ash can be used for the following:

(i) Manure
(ii) Active carbon
(iii) Production of sodium silicate
(iv) Production of cement
(v) Ceramic industry
(vi) Production of furfural

MINIMIZING BREAKAGE OF RICE

There are various reasons including careless handling, storage, drying and milling which cause breakage of rice in milling. The most significant and avoidable reasons are as follow:

1 Optimum Harvest Time: Harvesting should be done immediately after the attainment of maturity between 19 and 23% of moisture.

2 Controlled Drying: Paddy should be dried under controlled conditions preferably in a hot air mechanical dryer.

3 Milling at a Suitable Moisture Content: The lower the moisture content the stronger the kernel but not below 14% moisture. Best milling is done at 14% m.c.

4 Proper Storage: It should be done to avoid weakening of the kernel by the insects.

5 Use Rubber Roll Shellers and Emery Polishers: Both of these machineries cause less pressure and heat on the kernel which are responsible for breakage .

6 Constant Feed Rate: Machines should not be overloaded.

7 Degree of Milling: Undue pressure should not be created by restricting the flow of rice at the outlets.

8 Pre-milling Treatments: Parboiling is the most appropriate pre-milling treatment to minimize breakage.

Chapter-3
PULSE MILLING

Pulse Milling Processes

1. Domestic level Processes:

- In eastern parts of India alternate soaking and sun drying method is in use. Pulses are soaked in water for 6-8 hours, water is then drained off and the grains are spread in thin layer and sun dried for two days. The dried pulse is then milled by hand operated stone chakki. One woman can produce about 5 kg of dhal per hour. Two passes of pulse is normally required for husk removal up to 80-90%.

2. Commercial Scale methods:

- Some of the commercial scale methods are described below.
- **Wet milling method**: This method of processing is being adopted by comparatively smaller units. This method is mostly practiced in southern India.
- The milling quality of above method was found to be good and on an average 72% dhal recovery is reported.
- **Dry Milling Method:** This method of milling is mostly adopted in the central and northern India. Dhal produced by the dry method is said to cook better while dhal produced by wet method tastes better but takes time to cook

Wet milling method

Raw grain(Pigeon-pea)

↓

Cleaning by sieves ← → Chaff, dirt etc.

↓

Soaking in water for 4-12 hours in cement tanks, then water is drained off

↓

Mixing of red earth to form a paste @ 2-3% level. Grains are then heaped for 16 hours.

↓

Drying under sun in thin layers for 2-4 days, heaped in night to retain night

↓

Dehusking and splitting by a emery coated vertical chakki about 95-98% of the grains are dehusked and splitted.

↓

Gota ← Grading by services ← → husk, powder, chuni and small brokens

↓

De-husked split dhal

Dry Milling Method

- Raw Pigeon-pea
- ↓
- Cleaning and grading by sieves → chaff, dirt etc.
- ↓
- Pitting or scratching by emery roller → dust, chuni
- ↓
- Grains with cracks in the husk are mixed with edible oil like linseed @ 1.5 to 2.5 kg/t of pulses in an anger mixer, then held for 12 hours
- ↓
- Oiled grains are spread in 5-10 cm thick layers for sun-drying, heaped in nights, after 2-4 days of drying on last day the grains are sprayed with 3-5% water and heaped overnight.
- ↓
- Milling by 1st roller. About 40-50% of grains are dehusked in the process
- ↓
- Dhal separating sieves → hush, chuni, brokens
- ↓
- Whole dehusked grains
- ↓
- Sun drying and addition of water
- ↓
- Dehusking and splitting in 2nd roller
- ↓
- Sieving
- ↓
- Grade I dhal
- This method of milling is mostly adopted in the central and northern India.

Factors affecting pulse milling outturn

Theoretically the endosperm of pulse accounts for maximum 87-89% of the whole grain legumes. But in practice it is not achievable. Some of the important factors responsible for lower recovery of dhal are given below:

1. Grain Parameters

- Type of grain
- Species of grain legume
- Chemical constituents
- Moisture content of the grain endosperm
- Shape of grain
- Size –bold, small
- Seed coat surface texture
- Thickness of gum layer

2. Machine Parameters

- Size of roller
- Peripheral speed of the roller
- Texture of abrasive material
- Hardness of the abrasive material
- Clearance between the roller and cage
- Inclination of the roller
- Outlet position

****

Chapter – 4.

WHEAT MILLING

WHEAT MILLING PROCESS

- **Introduction**
- Wheat is the principal food grain in many countries of the world. It is one of the most important cereals and is used as staple food in the form of flour. In India, a large proportion of wheat is used as the familiar Atta and Maida (white flour)
- **Flour Milling**
- The objective of modern flour milling is to obtain the maximum amount of white flour from the wheat endosperm without any bran or germ content.
- The yields of white flour and byproducts from white flour milling are about 70% and 30% by weight, respectively. Wheat consists of bran (12%), germ (3%) and endosperm (85%)

Modern flour milling With its six Operations

- Receiving, drying and storage of wheat,
- Cleaning,
- Conditioning,
- Milling into flour and byproducts,
- Packaging and Storage of finished products, and
- Blending.

Of them the most important operations namely, cleaning, conditioning and milling have been discussed here.

- **1. Cleaning**
- Wheat is thoroughly cleaned to remove all fine impurities and the dirt sticking to the surface of the grain. Small pieces of sticks, stones, sand etc., are removed by aspirations. The seed of other food grains, defective grains and weed are removed by disc separators.
- **2. Conditioning/Hydrothermal Treatment**
- The Conditioning of wheat can be done either at room temperature or at high temperature. But the temperature of wheat grain should not be raised by 47°C otherwise the gluten quality will be affected which deteriorates the baking quality of flour.
- The rapid rate of heating weakens the inter molecular bonds in various parts of the grain to a considerable extent resulting in easier separation of bran, more effective grinding of endosperm and stronger the action on proteins and enzymes.

- **3. Grinding (Milling)**
- Milling of wheat is carried out by roller mills. The roller milling system is mainly divided into the break roll and reduction roll systems.
- The surface of the reduction roll is smooth and the surface of the break roll is corrugated. In the break rolls, the bran is cracked, the kernel is broken open. The endosperm adhering to bran is milled away successfully in a few steps. Generally a series of four sets o break roll are used. The above operations are continued until the desired products are obtained.
- **4. Storage of Finished Product**
- The flour and the mill feed are bagged in waterproof bags, stitched and stored in cold, dry conditioned in flat godowns.
- **5. Blending**
- Here, constituents are mixed together to produce different flours. For instance, a blend of wheat bran and white flour produce whole wheat flour.

- **Packaging:**
- The action of putting a product into a package or forming a package around a product which is concerned with protection, economy, convenience and promotional considerations.
- The aim of packaging is to protect the product during handling, transportation and storage until the consumer finally uses it. The shelf life of a product is based on the protection required for the product under ideal packing and storage conditions.
- **Blending:**
- The method of laying on different tints so that they may mingle together while wet and shade into each other insensibly e.g. all fruits and vegetables are not suitable for jouncing. You would not get much juice out of banana, but they are excellent for making smoothies-This is where blending comes in.

Components, Operation and Performance of Wheat Mill

1. **Break roll**

   Break roll consist of twin pairs of corrugated steel rolls. The one roll of a pair revolves faster than the other, differential speed being in proportion of 2.5 to 1.

2 Break shifting system

- This can be divided into two parts- plan shifters and purifiers
- Plan shifter.
- Plan shifter is a scalping system removing large bran pieces adhering with endosperm at the top. The next series, which are finer, remove the bran and germ. The next layer of still finer sieve removes the endosperm middling and the bottom rough flow.
- Purifier.
- The middling containing finer bran particles are removed by purifier before they move to reduction roll.

3. **Reduction roll**

- The reduction roll comprises of two smooth rolls. The rolls in the reduction system are further divided into course rolls and fine rolls depending on the clearance between the rollers.
- It is possible to grind flour into very fine particles by gradual grinding. But under high grinding pressure the starch is ruptured and this should be avoided.

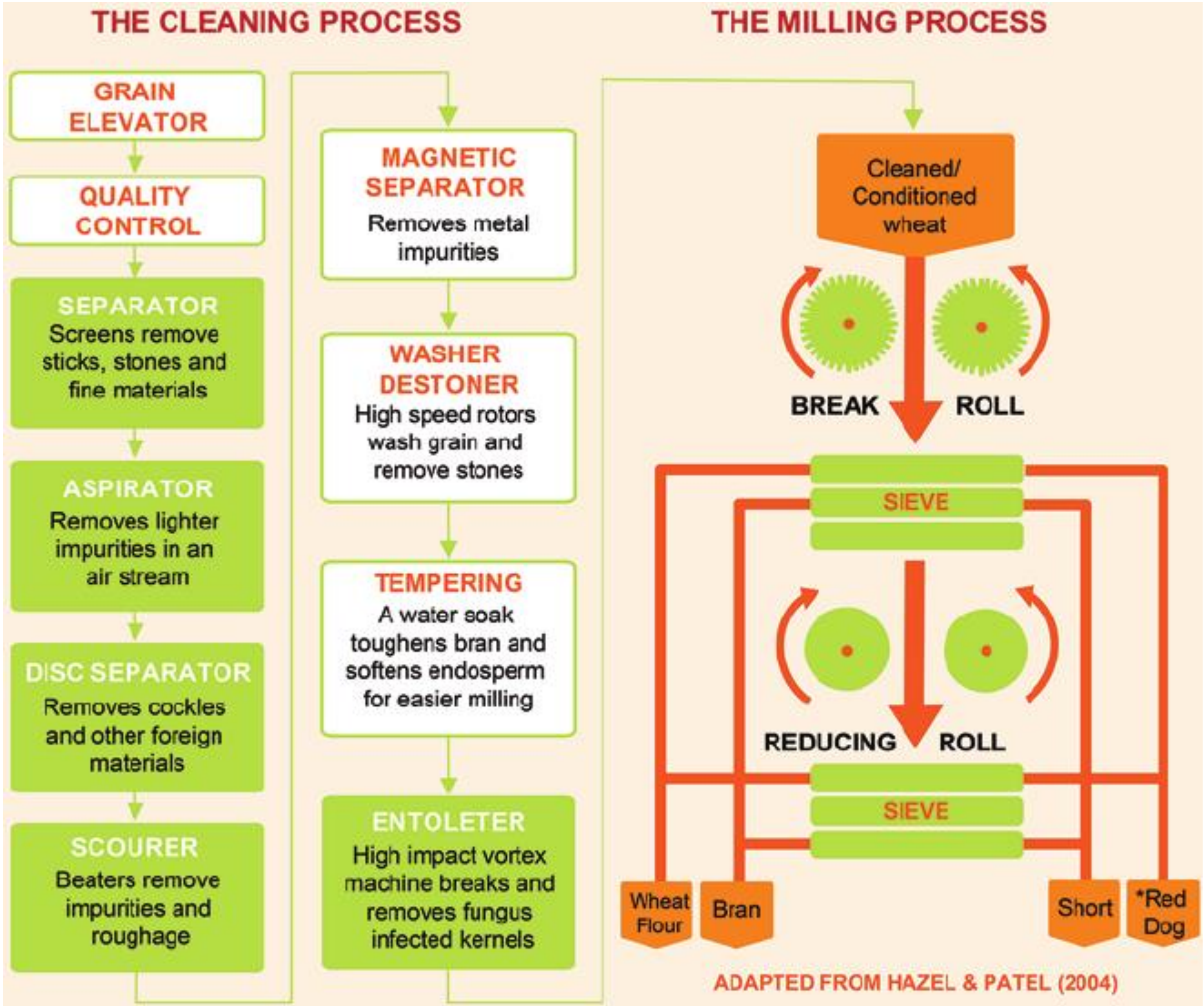
4. **Reduction sifting system**

- The same plan sifting system is used here.
- After each reduction the product is separated by plan shifters where the finished flour is sifted by 120 mesh sieve (silk) and removed and oversized material is sent back to the reduction rolls for further processing.

5. **Scratch system**

- If the mill is function properly, i.e., good release of endosperm is obtained on the break rolls, the scratch system can be bypassed, if not, the scratch system is employed to maintain proper release of endosperm from bran. The scratch system is an extension of the break system and thus used as stand-by system only.

Modern Wheat Mill



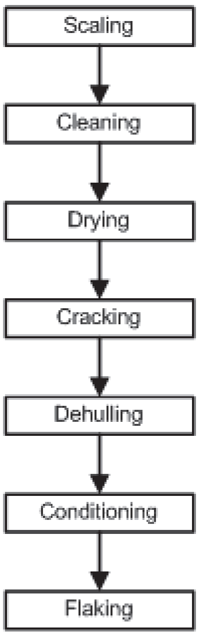
Chapter – 5

Oil mill

An oil mill is a grinding mill designed to crush or bruise oil-bearing seeds, such as linseed or peanuts, or other oil-rich vegetable material, such as olives or the fruit of the oil palm, which can then be pressed to extract vegetable oils, which may used as foods or for cooking, as olive chemical feed stocks, as lubricants, or as bio-fuels. The press cake - the remaining solid material from which the oil has been extracted - may also be used as a food or fertilizer.

Unit operation of oil mills

The main unit operations used are shown in Figure 2:
scaling, cleaning, dehulling (or decorticating), cracking, drying, conditioning (or cooking), and flaking.
Although cooking operation is not included in the flowchart, it is a very important step in the processing of oilseeds. The flowchart below may be altered depending on raw material to be processed.



Unit operations for raw materials preparation

Oil Expression:

It is the process of mechanically pressing liquid out of liquid containing solids.

Screw presses, roll presses and mill, collapsible plate and frame filler presses, disk mill are some of the examples of filler presses, disk mill are some of the examples of wide range of equipment used for expression liquids.

The advantage of the mechanical expression system over chemical extraction is that it gives the liquid free of dissolved chemicals and thus a safer process.

Oil Extraction:

It is the process of separating a liquid from a liquid-solid system with the use of solvent.

The process gives a higher recovery of oil and a drier cake than expression. It is capable of removing nearly all of the available oil from oilseed meal or flakes. Apart from giving higher yields of oil the extraction process provides meal of better preservation qualities and with higher protein quantities.

Oil Expression Devices

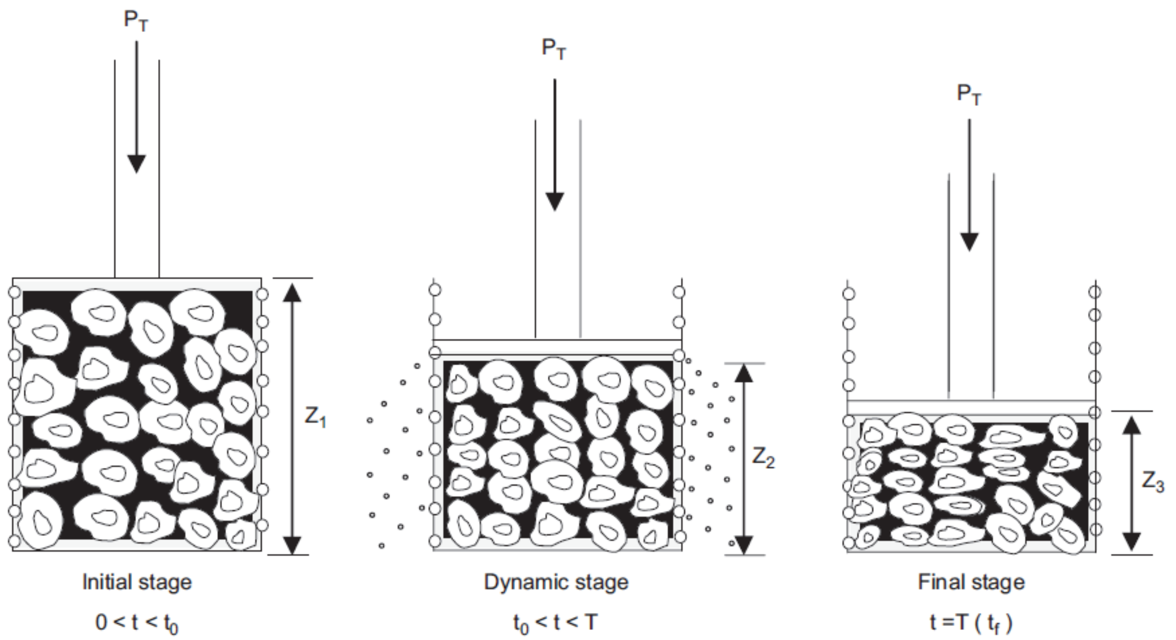
a) Ghani

The Ghani consists of a large mortar and pestle, the mortar being fixed in the ground and the pestle being moved within the mortar by animal traction (donkey or mule) or (more commonly) a motor. Oilseeds are placed in the mortar and the pestle grinds the material to remove the oil. The oil runs out of a hole in the bottom of the mortar and the cake is scooped out by hand.
This method is slow and requires two animals, replacing the tired one with another after about 3-4 hours of work. Motorised ghanis are faster than manual or animal types but are more expensive and their higher capital and operating costs will require a larger scale of production for profitability.

The oilseeds and subsequently the expressed oil are held in a scooped circular pit in the exact centre of a circular mortar made of stone or wood. In it works a stout, upright pestle which descends from a top curved or angled piece, in which the pestle rests in a scooped-out hollow that permits the pestle to rotate, eased by some soapy or oily lubricant. Today the single angled piece takes the form of two shorter pieces pinioned or chained together. The bottom of the lower angled piece is attached to a load-beam; one end of the load-beam rides around the outside of the barrel, while the other is yoked to the animal. The load-beam is weighted down with either heavy stones or even the seated operator. As the animal moves in a circular ambit, the pestle rotates, exerting lateral pressure on the upper chest of the pit, first pulverizing the oilseed and then crushing out its oil.

b) Hydraulic Press

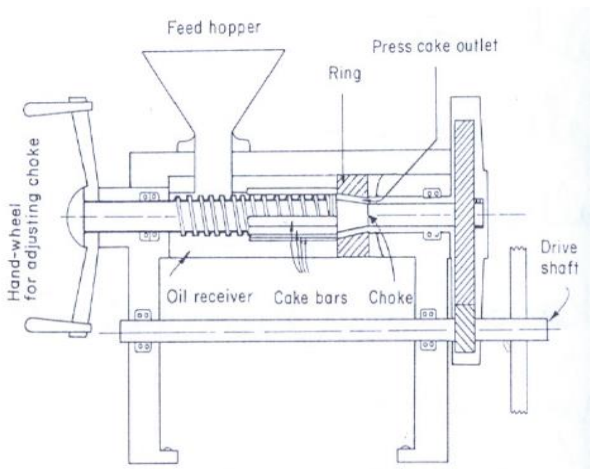
Oilseeds were processed in manual presses, where layers of grains were placed into the equipment, separated by filter cloths and filter press plates and force was applied via a hydraulic cylinder. When the oil has stopped flowing, the workers opened the machine, removed the mass of crushed grain and put more fresh material. At the beginning of the twentieth century the vegetable oil industry worked basically with the hydraulic presses but even making use of a hydraulic cylinder, work with this type of equipment was considered labor intensive.



Stages of hydraulic expressions

c) Continuous mechanical pressing (screw press)

Among the physical processes for the extraction of vegetable oils, the continuous mechanical pressing emerges as the best technology to serve small farmers. That´s because this type of equipment associates both small scale and low cost when compared to the other methods cited. Another important advantage is the possibility of using cake resulting from the pressing as fertilizer or animal feed, since it is free of toxic solvents. The operating principle of this equipment consists a helical screw which moves the material, compressing it, and at the same time, eliminating the oil and producing the cake. Optimization of the continuous mechanical pressing consist of defining the optimum parameters, such as temperature and moisture content of grain, or adjustments on the press, in order to reach optimum yields of oil, using a minimum value of pressure applied by the press.



Screw press machine

d) Solvent extraction

In the solvent extraction process, the solvent is added to the well prepared materials. It is then followed by the diffusion of oil solvent mixture to the surface of solid for recovery of oil. The most commonly used solvent in the Indian Plants is the n-hexane.

Three systems of solvent extraction operations are in use, namely, batch, semi continuous and continuous systems. The continuous system has certain advantages over the batch system, as it can be used for the production of oil from various oil seeds and meal and rice bran as well. But the capacity of the plant is higher and the initial investment is high.

The batch type is believed to be exclusively suitable for rice bran oil extraction. It is popular due to its simplicity in operation and low cost of installation. The solvent extraction method is described below:

Pretreatment of bran prior to extraction is an essential step for either batch or continuous system. Pretreatment consists of either direct steaming or drying of bran. Pretreatment of bran reduces amount of fines and moisture content and thereby increase the particle sizes, aids the release of oil from bran, imparts hardening effect to bran particles better extractability lower filtration time and it eliminates the problem of fines.

In the continuous system the steam treated bran is pelletized in the pelletizing equipment to enlarge the particle size of the bran to 6 to 8 mm pellets. But it is a very costly method due to requirement of high electrical power per unit mass of pellets.

Chapter - 6.

ANIMAL FEED PROCESSING

Animal feed is food given to domestic animals in the course of animal husbandry. There are following are the types of animal feeds:
1. Compouned Feed:
The commercial pelleted food produced in a feed mill and fed to domestic live stock.
2. Fodder:
Food given to the domestic live stock including plant-cut and carried to them.
3. Forage:
Growing plat eaten by the domestic live stock.
4. Organic feed:
Such as rice hulls, wheat middlings and corn cob meal.

Animal feed making machines
http://www.fao.org/docrep/x5738e/x5738e0j.htm

Feed Milling Processes

https://www.youtube.com/watch?v=7_tzDTsLVkE

Machines used for making Animal Feed

Dry feeds may be ground, sifted, screened, mixed, compressed, expanded, texturized, coloured and flavoured. By one or more of these processes, a wide variety of ingredients can be prepared into a standardized product

GRINDING
Hammer mills are mostly impact grinders with swinging or stationary steel bars forcing ingredients against a circular screen or solid serrated section designated as a striking plate (Figure 1). Material is held in the grinding chamber until it is reduced to the size of the openings in the screen. The number of hammers on a rotating shaft, their size, arrangement, sharpness, the speed of rotation, wear patterns, and clearance at the tip relative to the screen or striking plate are important variables in grinding capacity and the appearance of the product.
Heat imparted to the material, due to the work of grinding, is related to the time it is held within the chamber and the air flow characteristics. Impact grinding is most efficient with dry, low-fat ingredients, although many other materials may be reduced in size by proper screen selection and regulated intake.

MIXING

Feed mixing may include all possible combinations of solids and liquids. Within each ingredient are differences in physical properties. For solids there are differences in particle size, shape, density, electrostatic charge, coefficient of friction as represented by the angle of repose, elasticity and, of course, colour, odour, and taste. Mixing may be either a batch or a continuous process.

Horizontal Mixers

1 Continuous ribbon mixers

The continuous or "twin-spiral" mixer consists of a horizontal, stationary, half-cylinder with revolving helical ribbons placed on a central shaft so as to move materials from one end to the other as the shaft and ribbon rotate inside. Capacity can be from a few litres to several cubic metres. The speed of shaft rotation will vary inversely as the circumference of the outer ribbon; usually optimum between 75-100 metres per minute. Since material travel is from one end to the other, either end may be used for discharge. These mixers may be inverted for cleaning.

2 Non-continuous ribbon mixers

Non-continuous or interrupted ribbons are similar to the continuous ribbon mixers except that short sections called "paddles" or "ploughs" are spaced in a spiral round the mixer shaft. Action is different from that of continuous ribbon mixers, and may be more satisfactory for mixing liquids with dry solids. These mixers are made in a wide variety of sizes with travel of the outer diameter of paddles from 100 to 120 meters per minute.

Vertical Mixers

Vertical mixers may consist of a cylinder, cone, or hopper-shaped container, with a single or double screw (auger) located vertically through the centre. The screw operates at speeds of 100 to 200 rpm and vertically conveys incoming materials from the bottom (generally the intake) end, like a screw conveyor, to the top where they are scattered and fall by gravity. This sequence is repeated several times until a blend is attained (usually from 10 to 12 minutes). These mixers may also be loaded from the top. Results show that vertical mixers are not efficient for uniform mixing of solids and liquids or for materials of quite different particle size or density. This unit is difficult to clean and there may be inter-batch contamination.

PELLETING

The transformation of a soft, often dusty feed into a hard pellet is accomplished by compression, extrusion, and adhesion. The general process involves passing a feed mixture through a conditioning chamber where 4 to 6 percent water (usually as steam) may be added. Moisture provides lubrication for compression and extrusion and in the presence of heat causes some gelatinization of raw starch present on the surface of vegetative ingredients, resulting in adhesion. Within 20 seconds of entering the pellet mill, feed goes from an air-dry (about 10-12 percent moisture) condition at ambient temperature, to 15-16 percent moisture at 80-90°C. During subsequent compression and extrusion through holes in a ring' die, friction further increases feed temperature to nearly 92°C. Pellets discharged onto a screen belt of a horizontal tunnel drier or into a vertical screened hopper are air-cooled within 10 minutes to slightly above ambient temperatures and dried to below 13 percent moisture.

Layout of feed Milling Plant

A number of manufacturers supply ranges of feed milling equipment and will advise on the selection of suitable models if provided with full information on the proposed operation. This must include the proposed capacity of the mill, the types of raw materials available, the types of livestock feed to be produced, and the characteristics of the power supply available. The chosen site for feed production should be readily accessible 20 to transport, as near as possible to raw material sources and to the livestock owners, free from flooding, and with suitable power and water supplies available. There are no set specifications for the layout of a feed milling operation, each being designed according to individual circumstances. The planning of larger mills requires the services of skilled engineers and draughtsman, but small mills can usually be assembled from modules supplied by equipment manufacturers. Several manufacturers sell 'Mill+ Mix' units which can be used for meal production, provided no difficult raw materials are to be used. In recent years there has been increasing interest in the concept of 'packaged' or 'containerized' feed mills where items of machinery are assembled within a space frame and wired up to a control panel at the factory. The unit is then shipped as a whole within a container. On arrival it is placed on a level (concrete) base, and the electricity supply connected to the control panel.

RAW MATERIAL, STORAGE AND SELECTION

In most circumstances the raw materials coming into a feed process area will have been requested by the nutritionist as being necessary to meet the nutrient requirements of the diet to be manufactured. In developing countries raw materials will normally be delivered or collected from a supplier in hessian, jute, cotton, paper, or possibly loosely woven polythene sacks. A standard size of sack may not be used f or each consignment and care should be taken to check-weigh as many bags as possible since, for many small-scale operations, a weigh bridge for weighing a lorry before or after unloading may not be available. Bags are often man-handled, although the use of a small sack truck will considerably ease t he burden of carrying heavy materials within a feed mill area. In some circumstances, and especially with larger feed mills, raw materials may be delivered in bulk, necessitating appropriate handling and storage facilities. In order to ensure a continuous supply of raw materials at the mill, when some may only be seasonally available on the market, and to take advantage of price fluctuations, some form of storage will be necessary. The particular method chosen for raw material storage will depend on the local circumstances, but in areas where labour is cheap and plentiful and capital funds scarce, it is likely that storage in bags will be preferable. Raw materials should arrive in good condition and in sacks which have not been used for the storage of fertilizer, pesticides or chemicals. Contamination by string, large pieces of metal, wood or stones which could cause extensive damage to machinery can normally be removed on a coarse metal grid fitted over the sack tipping-in point of the feed mill, and permanent magnets will normally remove any tramp ferrous metal which may enter the system, particularly before entering the grinder, mixer or pelleter. Storage areas must be waterproof and well-ventilated, and provide protection against infestation by insects and vermin which can quickly cause substantial losses in weight. If materials are to be stored in bags they should be kept in a building having a concrete floor. The roof and walls need only to be lightly constructed provided that they are pest and waterproof. The bags should be stacked a few inches above floor level and away from walls. Raw materials may also be stored in bulk either in silos constructed from concrete or steel or in bins formed with partitions in conventional stores. Bulk storage normally entails a greater investment i'tl capital equipment but lower operating costs. If raw materials are to be stored in this way it is essential that the bin manufacturers are informed of the raw materials to be handled, since some raw materials which have poor flow characteristics tend to form bridges of material in the bin base thus preventing their discharge. In general, raw materials of low bulk density have poor flow characteristics and those of high bulk density have good flow characteristics. Raw materials which have poor flow properties normally require large diameter augers for their transfer. Raw materials will vary from country to country and from region to region and will have widely ranging bulk densities (weight for a given volume). These differences in bulk density must be taken into account when determining the space required for the storage of raw materials and finished products.. The proper storage of raw materials and of finished feeds is not only essential to prevent physical losses, but is also an important aspect of quality control which will be discussed in more detail later. Where the construction of stores is to be undertaken.

OTHER REQUIREMENTS

For the successful manufacture of compound feeds several other requirements must be fulfilled: these are discussed below.

Buildings The buildings to house the manufacturing plant will depend to a large extent on the particular circumstances of the mill, but generally they must be capable of being kept clean, and provision should be made for keeping the dust level as low as possible since it can affect the operation of machinery. Excessive dust is also a fire and explosion hazard. In some environments, machinery can be housed in a light structure and where the climate is suitable it may even stand in the open. However, consideration may need to be given to local building regulations and to special precautions necessary for occasional adverse climatic conditions, for example, hurricanes. A concrete floor which can be swept is usual, but should be laid down to the manufacturer's plans as some pits and floor fixings may be required. Where flooding may occur, as during a monsoon period, the floor must be above the high level water mark. The machinery usually has its own supports which are supplied by the manufacturer or can be made locally to his specifications.

Power The power to drive feed milling equipment is generally obtained from electrically driven motors. Some small-scale processes can be undertaken by hand or by using direct driven machinery. Grinders, mixers and pelleters can be obtained which are driven by petrol or diesel engines directly, or from a tractor power take off (PTO). However, for most situations, electric motors provide the simplest and most convenient method of driving machinery. If grid ('mains electricity') is not available, a diesel-generating set can be used instead so that electricity is produced independently of the grid.

Electricity supply For small processes with a connected motor load of a few kilowatts (that is, the sum of the motor powers), operation from a single-phase electrical supply might be possible. However, it is normal for industrial/commercial premises and sometimes for agricultural premises to have a 3-phase supply. lt is essential to determine the likely electrical load for the machinery and then to determine what type and quantity of electricity can be made available.