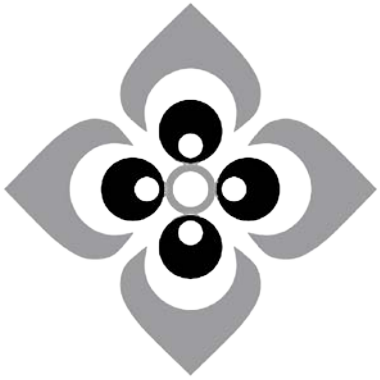

Consortium for Educational Communication

Module
on
Milling Systems – Paddy Milling

By
DR. ANU APPAIAH. K.A
Principal Scientist
Microbiology and Fermentation Technology
CSIR – Central Food Technologica Research Institute (CFTRI),
Mysuru 570020, Karnataka, India

TEXT

Introduction:

Milling is an ancient art. Its objective is to make cereals more palatable and thus more desirable as food.

Paddy or Rice is a annual grass which can be grown under a broad range of climatic conditions mainly as semi-aquatic crop. Cultivated rice is either *Oryza sativa L.* or *Oryza glabberrima*. *O. sativa* is the predominant species. *O. glaberrima* is grown only in Africa on a limited scale. In Asian countries 80–90% of the population is mainly dependent on rice as their staple diet. Rice is consumed in many ways in various countries. In addition to cooked rice, it is also consumed in the form of roti's, noodles, puffed rice, beaten rice, breakfast cereals (dosa, idli etc), rice cakes, fermented and unfermented sweet rice, and snack foods made by extrusion cooking. Rice is also used in making beer, wine, and vinegar.

In most Asiatic countries, rice is consumed in the cooked form and are normally served with vegetable or non-vegetarian curries/soups. There are many kinds of snack foods, prepared for more attractive taste, texture, and aroma. They are mainly served in special occasions, for some special tastes, and for convenience. Some rice snack foods are made from either sticky or glutinous rice (sweet or waxy rice) containing largely amylopectin (98% of total starch), but very little amylose (less than 2% of total starch), while others are made from both types. A typical glutinous rice flour contains 11.0–13.5% moisture, 1% ash (max.), 75– 80% total starch, 5.5–6.5% protein, and 0.5% total fat. Glutinous rice flour is often used in making snack foods since the sticky characteristics of high amylopectin content are necessary in many specialty rice foods. Another reason for application of glutinous rice in baked and popped snacks is that it expands readily and produces a more porous texture.

Paddy harvesting, threshing and handling: Paddy is harvested from the fields and thrashed to separate the straw from the grains. The grains are then transported to the mills for further processing. Paddy received in the mill generally contains moisture higher than that is safe for storage and hence needs to be dried. Moisture content of 18-25% is normally present in freshly harvested paddy. Moisture content of below 14% is considered safe for short periods of storage. For longer storage, the grain should be dried to 13% moisture or less. Drying process may be either through heat supplied by hot air or by the sun drying where the moisture from the grain evaporates, while the moving air carries away the evaporated moisture.

Paddy received in the mill must be first cleaned to remove the foreign matters before it can be properly stored. The foreign matter may be other plant/weed seeds, straw, chaff, sand, stones, dust, and pieces of mud and iron particles. If the paddy is not cleaned, they may cause deterioration of the paddy during storage or may damage or obstruct the conveyers and milling machinery. Cleaning also helps to reduce storage space. The first cleaning

operation of paddy after threshing is called 'scalping' **(Fig 1).** In this process based on the density of the particles they are separated.

Milling of Rice

Rice is mostly consumed as cooked whole grain, unlike other food grains. Milling technology is aims to obtain maximum amount of milled rice (out turn). Thus milling is designed to reduce breakage.

Rice milling systems range from the home scale to the large, complex modern rice processing installations. Paddy milling from home scale includes hand pounding equipments to village level hullers .These may be single hullers, battery of hullers, to emery sheller-cum-huller mills, emery sheller-cum-cone polisher mills and the modern rubber-roller rice mills.

The single huller mills are located at village levels or in localities where paddy is milled based on the customer requirements. The quantities are normally small and are milled to the requirements of the customers who bring the paddy and takes back rice for their own captive consumption. Hence, the capacity of these mills ranges from 250-750 kg per hour and they still handle the bulk of our country's production. The large capacity rice mills located in urban or semi-urban areas for commercial milling are of ½ to 4 tonnes per hour capacity where the paddy milling is normally carried out for commercial requirements.

Traditional rice milling machinery

Traditional rice mills include hand pounding equipments, single huller and battery of hullers, sheller-cum-huller and sheller mills.

Hand Pounding: A variety of implements are used for the purpose of hand pounding, the more common being: (a) mortar and pestle, (b) Dhenki and (c) hand stone (chakki)

Huller mill :The huller mill combines both dehusking and polishing process in one operation. Therefore the by-products, husk and bran are mixed together. The average milled rice recovery in the case of raw rice is low – 65% or less – breakage is high. Besides, it requires high power requirement per ton of paddy milled than other type of rice mills.

Battery of hullers : These mills consist of a battery of hullers. In addition, sieves for cleaning the paddy, reciprocating sieves for removing broken, aspirator to remove the husk and bran etc are added. The hullers work as parallel units to increase the capacity. As yield from huller is poor with raw paddy, these commercial mills are mostly found in areas where parboiled rice is eaten.

Sheller-cum- huller mill : A disc sheller (emery sheller, emery dehusker) is used for dehusking and the huller is used for polishing the dehusked (brown) rice **(fig 2**). After cleaning paddy in a sieve, the cleaned paddy is dehusked in a disc sheller and the husk is aspirated. The stock from the sheller is fed to hullers for polishing, often with a screen-type paddy separator in between. The mixture is then sifted and aspirated to remove bran and

small brokens from head rice. The outturn of rice form this mill is higher by 1-2% over the huller mill for raw paddy.

Sheller-cum-cone polisher mill : The disc Sheller-cum-cone polisher mill consists of a cleaner, disc sheller, aspirator to remove husk, paddy separator, cone polisher and broken rice separator. This mill gives more outturn of rice than hullers by at least 3% (for raw rice). In addition, the head rice yield is higher, breakage is reduced, bran and husk are separated, the rice is clean and free from paddy and the degree of polishing can be easily controlled.

Small Capacity Rice Mills : Paddy produced in Asian countries is still largely consumed by the farmers themselves. For this reason there is still heavy demand in Asia for a small capacity mill, where small quantities of rice can be milled.

Engelberg huller: The Engelberg huller is the most widely used for a small capacity rice mill **(Fig 3**). The huller consists of an 'iron ribbed cylinder' mounted on a rotating shaft and fitted in a cylindrical housing. The bottom half of the housing is fitted with a slotted sheet. It combines the dehusking and polishing processes into one operation.

Modern Rice Milling

Modern mill. means, efficient rice mill, a paddy receiving-cleaning-drying section, huge godowns or silos, parboiling-drying system, a huge husk furnace-cum – boiler, ash handling section, bran – handling-processing section, etc.

A modern rice mill as such is a much simpler when compared to wheat roller flour mill. Modern mill incorporates a rubber-roll sheller along with the full combination of a paddy separator, efficient polisher, grader, sorter etc. It is basically a rubber-roll sheller mill. Many a times a disc sheller mills is incorporated along with these combinations. The extra yield obtained by processing in modern mills is at least 2% in case of raw paddy and about ½ -1% in case of parboiled paddy as compared to disc sheller-cum-cone polisher mills. Head rice yields in the modern mills average about 5% more than those in sheller mills and 10- 15% more than in huller mills.

Operations and Equipments

The operations for milling of rice are as follows:

Cleaning – Removes foreign matter, such as sand, stones, straw, seeds and pieces of iron from paddy.

Dehusking – Removes husk from the paddy with a minimum of damage to the grain.

Husk separation – Removes the husk from the mixture obtained after dehusking.

Paddy separation- Separates dehusked brown rice from remaining unhusked paddy, the

paddy being returned for dehusking.

Polishing – Removes all or part of the bran layer from the brown rice to produce polished rice.

Grading – Separates brokens from unbroken rice. The brokens are separated into different sizes.

Sorting – Optical sorters sort discoloured, deshaped rice along with any other unwanted material.

Cleaning (Scalping): Cleaning is the first step in modern rice milling. It not only enables the production of clean rice but also protects the other milling machinery and increases milling capacity. Impurities that are lighter than paddy are removed by an aspirator. This prevents spreading of dust inside the building and creates hygienic conditions. Metallic (iron) impurities are removed by the use of a magnet. Impurities larger or smaller in size but heavier than paddy are removed by sieves. Vibrating or rotating sieves or a combination of both are used. Impurities that have the same size as paddy but are heavier than paddy are removed by specific gravity separators, namely destoners. Paddy is often subjected to a preliminary partial cleaning (scalping) prior to storage and main cleaning in the mill.

Dehusking (Shelling): The object of dehusking is to remove the husk from the paddy with a minimum of damage to the bran layer and without breaking the brown rice grain.

Husk separation: A mixture of dehusked rice (brown rice), unshelled paddy from the sheller is subjected to sieving-cum aspiration to separate brokens and husk. Sieving prior to aspiration helps in separating.

Husk separator: The mixture of paddy, brown rice, broken and husk are fed at the top of a vibrating sieve. The brokens pass through the perforations of the sieve. As the mixture of husk, paddy and brown rice overflows from the sieve, air is blown or sucked through the mixture. Husk is removed by the air. The paddy and brown rice are collected separately.

Paddy separation: Shelling is never done to the level of 100% to avoid rice breakage. The grains also differ in size, so that the smaller grains remain unshelled. Therefore, a paddy separator is used to separate the remaining unhusked paddy from husked brown rice. The separated paddy is returned to the dehusker for dehusking while the brown rice is carried forward to the polisher. The separation is accomplished in the separator by taking advantage of the difference in physical density (heaviness), size and surface smoothness (or roughness) of paddy and brown rice.

Polishing: The brown rice is next polished to remove bran layers. Some amount of polishing is essential for easy cooking and storage, although excessive polishing reduces the nutritive value of rice.There are two types of polishers, one of emery and other of metal. The emery polishers (also called whiteners) polish the grains by abrasion with emery while the metal polishers (also called pearler) polish by friction between the rice grains. The emery polishers are again of two types – vertical (cone polisher) and horizontal.

Grading: After polishing operation, the milled rice contains, in addition to 'whole grains, broken grains of different sizes as well as some bran and dust. Separation of these materials is termed 'grading'. Bran and dust particles are removed by aspiration. Brokens may be separated either by a 'plansifter' or by a 'Trieur'.

Sorting: is normally carried out through an optical sorting system. The optical system sorts discoloured, deshaped and any broken rice left in the head rice. The final product normally contains 99% head rice with uniform colour and shape.

Modern milling control technologies

Conventional controls: Conventional controls are generally Single-Input Single-Output (SISO) Proportional Integral Differential (PID) controllers. These have been in use for many years and are especially effective when process dynamics are reasonably constant. The objective is to adhere to some measurable set point. Other control systems have been developed subsequently to handle complex process dynamics. These include:

- Feed forward control, which controls the feeding of paddy to minimise the disturbance of feeding.
- Ratio control, which helps in controlling one of the functions when the other functions can be varied.
- Cascade control, this is used to control the feeding of the partly processed paddy from one of the step to another step of process. Eg from cleaning to dehusking etc.
- Constraint control, these help in moving a process variable to help in deconstraining the process if there are any constrains.
- Dead-time or lagging compensated controllers, these systems help in slowing the process which helps in sampling and testing in between the milling process. This will help in uniform production.

Automation and its role within the milling industry: A survey on the use of Computer

Integrated Manufacturing (CIM) and Programmable Automation (PA) in the milling and baking industries suggests that:

the milling and baking industries do not have CIM developments.

• the number of such developments is slowing increasing, although slowly in rice milling when compared to wheat and maize milling

• Industry especially in India remains unconvinced about the benefits of CIM and PA

Benefits of CIM and PA for the milling industries needs to be made more clear.

The benefits of CIM includes quality improvement and improved production. Many CIM processes also have features that increase the hygiene of the process. In addition, it helps in product traceability and improves the process further based on rice varieties. These data's are used by the millers to ensure optimum quality for customers there by increasing the profitability. Improving control saves energy and improves product consistency by making the system run in a uniform speed. Processes may also be operated closer to optimum values or constraints. In many cases a simple control system will achieve the desired effect but others require a more sophisticated approach. This is true in paddy milling as each variety is of different shape and size. Advanced techniques are required in a number of situations. In addition simple controllers find it difficult to cope with significant time delays between controller actions and system responses and non-linear responses from the process. Finally, advanced controllers are required where the process is expected to be flexible

Process control equipment/methods may be divided into two principal subcategories, namely conventional controls and advanced controls.

In addition to these major groups, controllers incorporating specialist features are also available. Robust control techniques add functionality to controllers that are designed to work under all operating conditions. These are applied especially in safety critical applications. The type of controller employed in mills today fits into one or more of the above categories.

It may be seen from the list above that many different types of conventional controller exist to cope with most simple process requirements. However, whole process control does not fit into this category of control requirement and so advanced control techniques must be investigated in the future in order to increase process efficiency.

Conclusion: Rice being a major crop of the world is still a crop of the Asian countries. Majority of the crop is used as cooked rice and products are mainly produced from the cuts

and bits produced during milling. Hence, during paddy milling the main emphasis is the production of unbroken head rice or out turn. As paddy is mainly used in Asian population the milling needs to be at the village limits. This has led to the development of rice milling systems ranging from the home-scale to the large, complex modern rice processing installations. Large modern mills which produces uniform sized and coloured rice are becoming popular. However automation of rice milling is still not in use in our country.

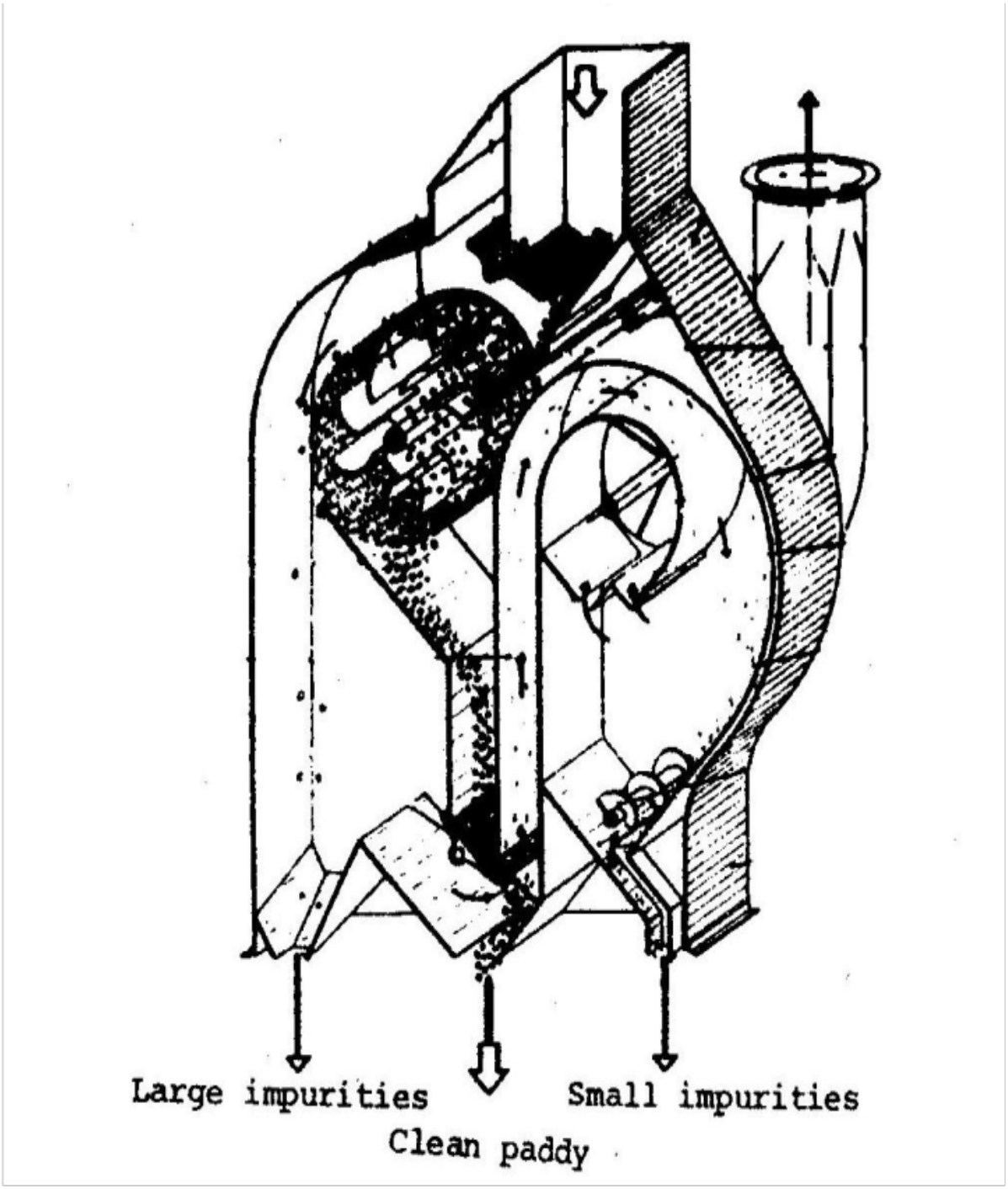

Fig 1 Scalper –cleaner

Source FAO of UNO booklet

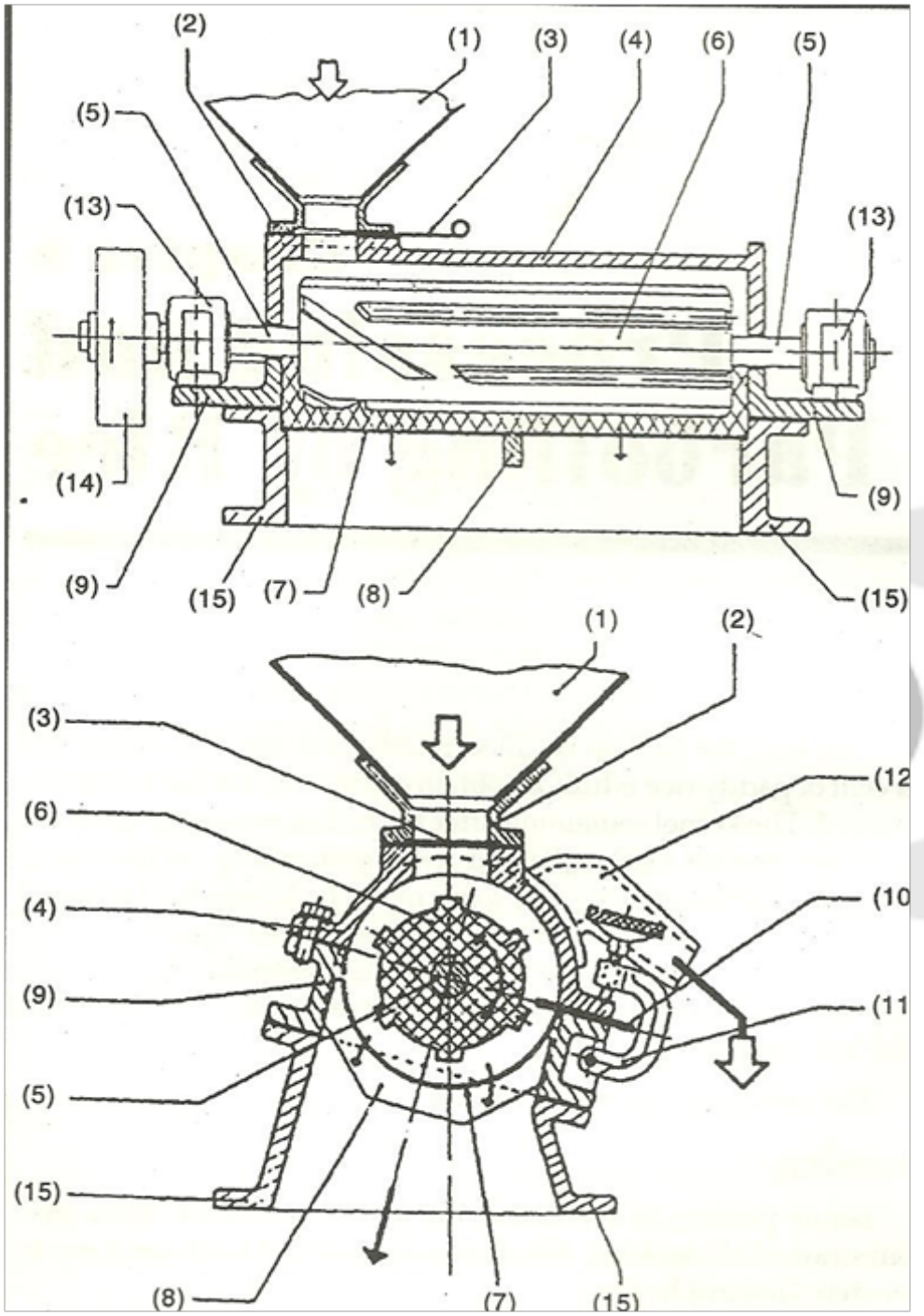

Fig. 2: The Engleberg Paddy Huller

Key: 1) Hopper, 2) Hopper seat, 3) Feed-granulation gate, 4) Cover, 5) Cylinder shaft, 6) Cylinder shell, 7) Screen, 8) Screen holder, 9) Frame, 10) Frame, 11) Cover clamp, 12) Outlet clamp, 13) Bearings, 14) Pulley, 15) Frame.

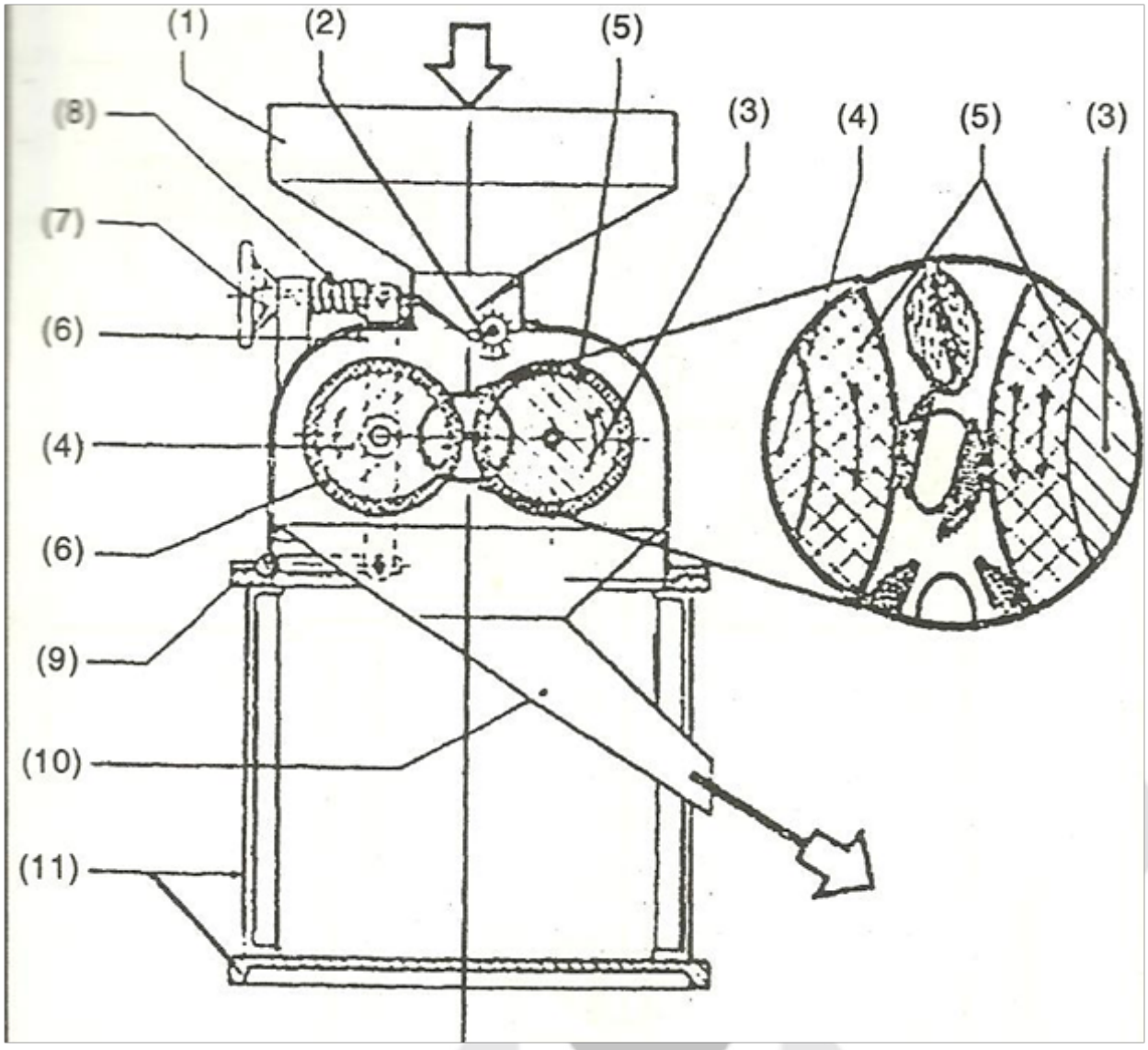

Fig. 3. A Rubber-Roller Dehulling Machine

Key: 1) Hopper, 2) Feeding roll, 3) & 4) Drive rolls, 5) Rubber coating, (6-8) Pressure adjustment system, 9) Housing, 10) Delivery spout, 11) Stand