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An Overview of Human Operated Rice Dehusking Machine

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Abstract- This paper discuss the innovations that took place in dehusking machines from the earliest times to the present and its future scope. The advantages and limitations of all mechanisms and their analysis are discussed in detail. This paper also comprises detail information aboutthe process carried out during rice dehusking and how the paddy or raw rice has to pass through different processes so as to obtain white polish rice.

Keywords: *Dehusking, husk, bran, manual operated rice mill, dal mill.*

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I. INTRODUCTION

Rice is one of the most important grain in India. It is the staple food of the people in the eastern and southern parts of the country. India is one of the world's largest producer of white and brown rice and produces 20% of the world rice production. As rice is the basic food crop and being a tropical plant, it flourishes comfortably in hot and humid climate. It is mainly grown in rain fed areas that receive heavy annual rainfall and thus it is fundamentally a Kharif crop in India(see Fig.1). It demands temperature of around 25^0 Celsius and above and rainfall of more than 100 cm. Rice is used in manufacturing of alcohol, starch, glucose, acetic acid, vinegar, acetone, oil and pharmaceutical products and diet foods.

A.Rice Dehusking Process

Rice dehusking isa process of removing the husk and bran from the paddy rice and producing head white rice grains that are sufficiently milled, free from impurities and contains minimum number of broken grains.

First process is ofHarvesting. It is a process of cutting and gathering of ripened rice crops. The rice crops are generally cut with the help of sickles and are then stacked at one place so as to allow them to dry in the sun for some days.

The next step is separating the grains from the stock (culm). This process is called as Threshing. Threshing is done by beating the crop with the sticks so as to separate the grains from their stock or the straw. In big fields, it is done with the help of threshers. These grains are called as Paddy rice. Paddy rice is the individual rice kernels that are in their natural, unprocessed state. Sometimes referred to as rough rice, it is harvested directly from rice fields or paddies and transported to a processing site.

The last step is Milling or Dehusking i.e. removing of outer covering (called husk) from the grains.Rice hulls (or rice husks) are the hard protecting coverings of grains on rice. In addition to protecting rice during the growing season, rice hulls can be put to use as building material, fertilizer, insulation material, or fuel.After removing the husk from grains the rice that is obtain is a brown rice. This outer brown covering is called as Bran. The bran is then removed by polishing the grains and thus resulting in a white colour rice grain.

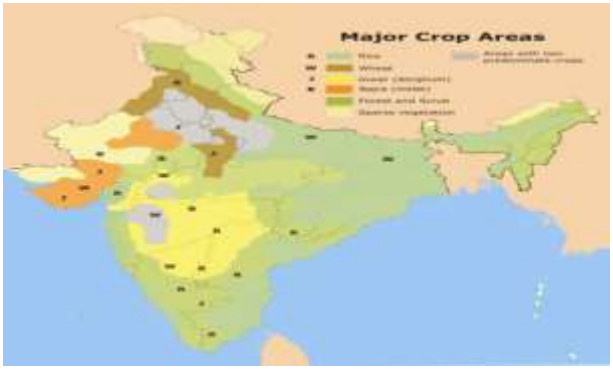


Figure 1.Major cropping areas in India. Rice shaded in light jade green indicates the most important and extensive growing areas in the east of the country [12].

II.CASE STUDY

This part provides case study information that will be referred to as ABC rice mill and DEF dal mill. In order to understand the process of rice and dal dehusking; ABC rice mill and DEF dal mill was visited. This case study is a part of a larger study that focused on design and development of dehusking machine. ABC rice mill has been promoted by the family of Mr. XYZ in the year 2007-2008 and is engaged in the activity of rice milling. Fig. 2 shows the Rice mill of Mr. XYZ.DEF dal mill has been promoted by the family of Mr. UVW in the year 1987 and is engaged in the activity of dal milling.

A. Process carried out:

Fig.3 shows the block diagram ofthe processes carried out during rice dehusking.

1) The process starts by pouring the paddy rice into the pit.

2) The paddy is carried to various machines via Conveyors or Elevators.

3) The paddy rice is carried from pit to a Cleaner machine also called as Rice De-stoner machine via elevator. This machine has 5 graders (or more as per the requirement) that completely removes dirt, soil, stones, weed seeds, fragments of rice stalk, dust, husks, weevilled webs, and dead insects and other such impurities. This machine is provided with a separate aspiration machine for removing the dust and very light impurities from paddy. The paddy is allowed onto the sieve where the oversize materials are separated and the paddy automatically flows onto the other sieve. This sieve will separate the finer impurities like fine sand particles, dirt, soil, small stones, and other materials which are undersize than paddy. Likewise paddy will pass through other sieves and these sieves will separate the unwanted materials and impurities and allow only clean paddy to move further.

4) The clean paddy from this machine is carried by an elevator to the husker.

5) Husker is an automatic machine used for removing the husk from the rice grain. These machinesconsist oftwo rubber rollers which run in opposite directions with special cooling system to increase the rubber rollers life.Rubber rollers are used to reduce the amount of breakage of the grains and increasing the yield of the best quality head rice, but the rubberrollers tend to require frequent replacement, which can be a significant drawback.

Figure 2.Rice Mill of Mr. XYZ, Lakhani, Nagpur.

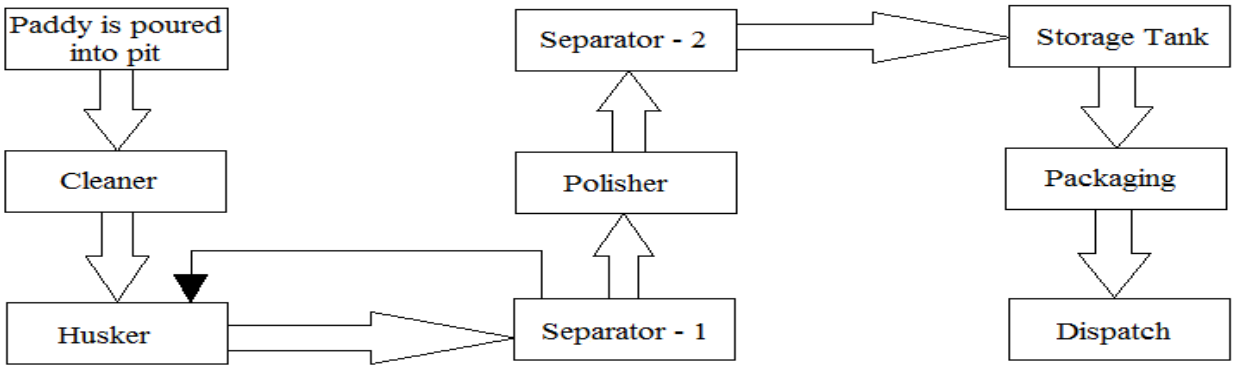


Figure 3.Block Diagram of Rice Dehusking.

Paddy enters the machine through a hopper. Sensors are fitted at a particular level. As soon as the paddy flows through the hopper and reaches the level of sensors, the sensor activates the feed shutter and the paddy flows through the shutter in between the two rollers. The rollers apply certain amount of pressure on the paddy grains due to which friction occurs between paddy grains and rollers and due to this friction the husk is separated from the rice grains as shown in fig 4.A blower is attached at the bottom of the husking machine which helps to separate the husk from rice by blowing off the lighter

husk and passing only the heavier rice grains to separator via conveyor. Rice thus obtained in this process is called as brown rice. The efficiency of the machine is between 80-90% and hence thebrown rice along with unwanted material is send to separator machine for separating the brown rice from unwanted material.

Brown rice is unrefined version of white rice. According to a study conducted by the American Journal of Clinical Nutrition, brown rice is the top choice in terms of both nutritional and other inherent healthy benefits. It is better than white rice. Brown rice, unlike white rice, has the side husk and bran, requires lesser cooking time and is easier to digest as it is much "lighter" in the stomach. The side husk and bran provide "natural wholeness" to the grain and are rich in proteins, thiamine, calcium, magnesium, fibre, and potassium. For those trying to lose weight or those suffering from diabetes, brown rice can prove a healthful staple given its low glycemic rating which helps reduce insulin spikes. The conversion of brown rice into white rice by complete milling and polishing destroys 67% of the vitamin B3, 80% of the vitamin B1, 90% of the vitamin B6, half of the manganese, half of the phosphorus, 60% of the iron, and all of the dietary fibre and essential fatty acids.

6)The brown rice grains from husker machine reaches the Separator machine-1. This machine separates the brown rice from the mixture of brown rice and paddy. This machine works on the principle of gravity and thus separates the mixture into three parts (see fig. 5).

- Pure Paddy Rice.
- Brown Rice.
- Mixture ofbrownrice and paddy.

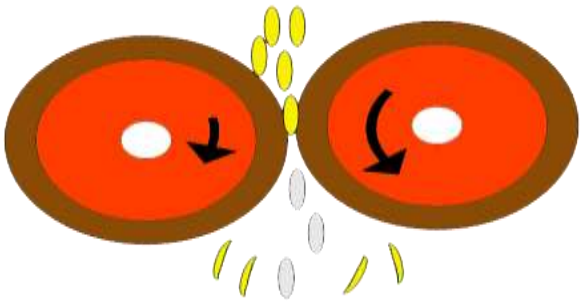
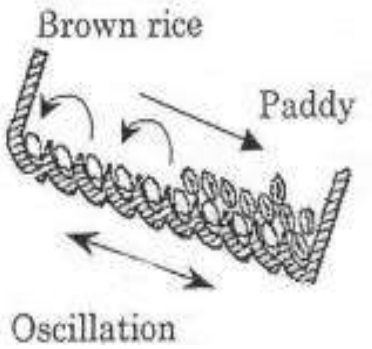


Figure 4.Diagram showing the process of removing husk from rice grains.



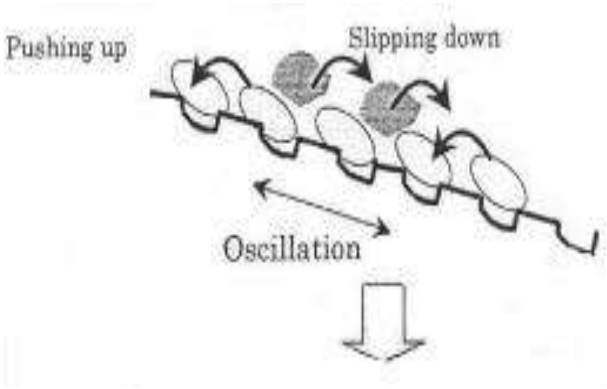


Figure 5.Principle of separating pure paddy rice, brown rice and mixture of brown rice and paddy in Separator machine-1.

The machine is provided with three outlets. From first outlet the pure paddy rice is send to husker machine for removing the husk. From second outlet the mixture of brown rice and paddy (i.e. the grain with only a part of husk being removed) is send to husker machine for dehusking process. From third outlet the brown rice is send to polishing machine via elevators. The machine is also provided with an aspirator that blows off the husk.

7)Polishing machine is a versatile machine which is used for giving better degree and quality of whiteness and gives better yield of head rice and also reduces the amount of broken rice. The polishing is achieved due to friction developed between the emery grains/stone and brown rice. Natural Emery is a very hard rock type used to make abrasive powder and is mostly made of Corundum. Emery grains along with magnesium oxide and magnesium chloride are applied to the Rice Sheller cone, in rice mills for polishing rice with minimum broken grains and faster output. The special rice polishing grade emery grains form a superior oxy-chloride bond and as a result the stone lasts longer. Water is sprinkled over the rice grains and then friction is applied via emery stones. This removes the bran from the rice grains and gives more shining and whiteness to the rice grains. The bran is then blown off by the aspirator.

Rice bran is a by-product of the conversion of brown rice to white rice. Bran is the hard outer layers of rice grain and is particularly rich in dietary fibre and essentialfatty acids and contains significant quantities of starch, protein, vitamins, dietary minerals and phytic acid, which is an anti-nutrient that prevents nutrient absorption. The bran has high oil content which makes it subject to rancidification which is also one of the reasons that it is often separated from the grain before storage or further processing. The bran itself can be heat-treated to increase its longevity.

8) The polished rice grains are send to Separator machine-2 through an elevator. This separator has an oscillatingsieve that separates the broken and head rice grains based on their size and length(small and big rice grains). The rice enters the machine through hopper and then flows over the sieve. The

sieve has different size holes that separate the broken and head rice grains.

9) The head rice grains from this separator are send to storage tank through conveyor for storage.

10) These grains are then packed in the gunny bags and are send to storage section.

B.Thus, from the Case Study, following facts were obtained:

1) The purchasing price of Paddy ranges from Rs. 1300-2600/quintal (as per the size and demand).
2) The selling price of finished rice is Rs. 4000-4500/quintal (varies from place to place and country to country).
3) The selling price of husk is Rs. 1500-2000/ton.
4) 5000 units/month (approximately) electricity is required.
5) The cost of entire setup ranges from Rs. 20-40 lacs (varies from industry to industry).
6) The output of the mill is 10-20 quintal/hr.
7) 6-10workers [4-8 helpers and 2 drivers] are required.
8) The cost of rubber rollers is Rs. 5000/pair.
9) Life of rubber rollers is 1500-2000 gunny bags.

C. Dal Dehusking Process:

Dal has an exceptional nutritional profile. It provides an excellent source of protein, particularly for those adopting vegetarian diets or diets which do not contain much meat. It is typically around 25% protein by weight, giving it comparable protein content to meats. It is also high in carbohydrates whilst being virtually fat-free. It is also rich in the B vitamins thiamine and folic acid, as well as several minerals, notably iron and zinc.Dal preparations can be eaten with rice, as well as Indian breads in North India. In India, it is eaten with rice and with a wheat flatbread called roti. The manner in which it is cooked and presented varies by region. In South India, dal is primarily used to make the dish called Sambar.

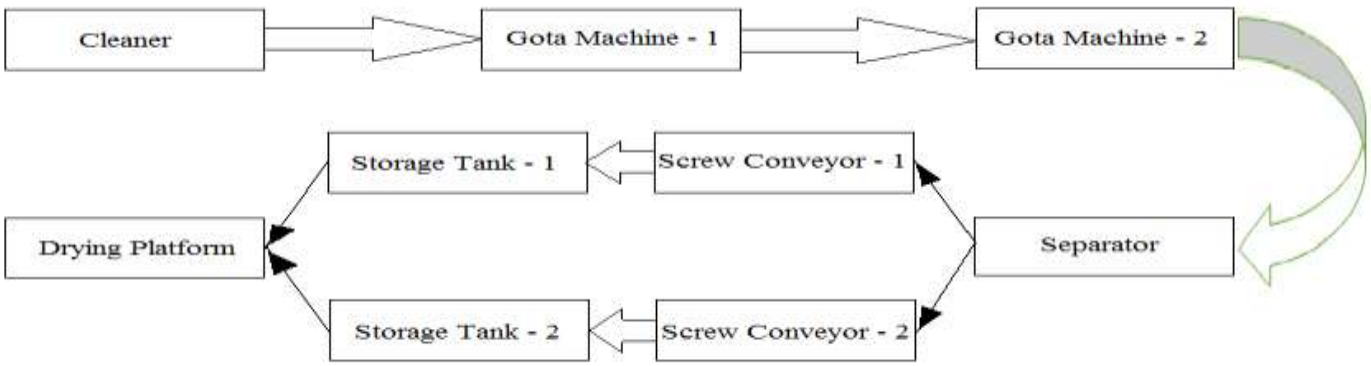


Figure6.Block Diagram of Dal Dehusking.

Fig.6 shows the block diagram ofthe processes carried out during dal dehusking.

1) Raw dal / Chilka (Skin) dal / Paddy is first poured into the pit.

2) It is then carried to the Round Chalna via Elevator / Conveyor.

3)This Round Chlana has 4 outlets (or more as per the requirement), first outlet is used to remove excess dal (sometimes more amount of dal is carried to the machine so before going to the next machine excess dal is removed), second outlet is used to remove dirt and other impurities, third outlet removes Mulan and fourth outlet removes big stones. The clean dal from this machine is carried by a conveyor to the Gota Machine 1.

4)In this Gota machine, a roller made of Carborendum+Cement+Salt is fixed. The roller is rotated and the dal is passed through the gap between roller and side wall of the machine. Due to friction the chilka is loosened. Then the dal is send to another Gota Machine 2.

5)In Gota Machine 2 the same process is repeated. Then it is send to separator machine.

6)In Separator machine, there are 2 sieves that separate the round / desired dal and broken, crushed, powdered dal. The desired dal is then send to screw conveyor.

7)The screw conveyor is filled with the dal and then it is filled with Linseed oil. The level of oil should be such that the dal is completely immersed into it. The dal is left there for 12 hours and after 12 hours the dal is taken out and is kept in sun for drying. The entire process from step 1 to 7 is repeated thrice (twice with oil and lastly with water in screw conveyor)in case of Tur dal whereas the process is repeated twice (with water in screw conveyor) in case of Chana dal. After this process the chilka is removed. Dal is then send to storage tank.

8)From storage tank the dal is either send to drying platform for drying or directly to the packaging section for packing dal in the gunny bags.

D. Thus, from the Case Study, following facts were obtained:

1) Capacity of entire setup is 10 tons/day (both tur and chana dal).
2) The cost of entire setup was 25 lacs (At the time of establishment). Today's cost will be approximately 3 crore.
3) The purchasing price of raw dal is Rs.5000/quintal for tur dal and Rs. 3000/quintal for chana dal.
4) The selling price of finished dal is Rs. 70/kg for tur dal and Rs. 45/kg for chana dal.
5) The cost of rollers is Rs 40000/-.
6) Life of rollers is 3000 quintals.
7) For 1 quintal of tur dal, 500gm of oil is required.
8) ½ inch gap is maintained between roller and sides of the machine.
9) 70% (and 2% is impurities) is the accuracy of machine in case of Chana dal.

Figure 7.Traditional method of rice pounding in mortar and pestle.

more percentage of broken grains.Another drawback was that it required more human efforts and hence cannot be used for large scale production [1].

In order to overcome above drawbacks automated machines were developed. These machines are capable of performing all operations of dehusking and are able to use for large scale production. These machines are mostly power driven and are used in almost all the rice mills.Figure 8 shows a modern automated rice husking machine.

The main advantage of using these machines is that they reduce human efforts, reduce the percentage of broken grains, by-products are free from sand and other impurities, high husking efficiency, reduces production time and useful for large scale production.

Although these machines have many advantages, there are certain drawbacks such as the machines are very costly, the rubber rollers used are also very costly, requires frequent maintenance, runs on electricity and so continuous power supply is required, it can be used only for dehusking large quantity of paddy, if used at small scale more amount of energy is lost and hence cannot fulfil the requirements of individuals, requires more space, etc.

From the literature review it was found that many specialists are working on developing manually operated rice mills that can overcome the drawbacks of both automated machines and mortar and pestle. These machines are mostly pedalled and hand operated and does not depend on electricity (see Figure 9).T.H. Surendranath Singh developed a pedal operated rice mill thatconsists of a front and rear pedestal in which sitting arrangement is provided on rear pedestal, forward pedestal is provided with rice huller mechanism and a rear pedestalis provided with a freely rotatable crank operated by a pair of pedals provided sufficiently below the seat. The forward pedestal is provided with a means for mounting a bigger crank to be operated by the smaller crank. A winnowing fan is used to provide a current of air when the flywheel is operated. It also consists of a sieve plate so as to let the husk to pan through and to retain the dehusked rice[1].

III. DEVELOPMENT OF DEHUSKINGMACHINE

In earlier days the farmers used to dehusk the rice by pounding the rice in mortar and pestle as shown in figure7. The mortar was made up of stones or wood that consists of a pocket or a block into which paddy rice was kept. The paddy rice was then pound with the help of a long wooden log of 5-6ft called pestle by one or two workers. The upward and downward movement of the pestle induces force on grain against grain that removes the husk and some bran layer. Due to pounding the percentage of broken grains was more. The cleaning was done by winnowing and gravity separation by hand [1]. In Bengal (West Bengal, India and Bangladesh), this is called Dhenki. This process is still used traditionally in the villages for personal use. This is because it preserves the brown rice coating that is perceived as a healthy part.

The drawback of this process was that the mortar and pestle were made of wood and thus large amount of trees were required to cut in order to meet the requirement of millions of rural people.The rice grains obtained by this process contain

A. Need for human energized Grain Mill

1) The problem with traditional rice pounding method is the excessive human efforts, breakage of rice, requires more time to finishing whereas the power operated Baby hullers, consuming electrical energy up to minimum of 2-3 HP or diesel operated hullers up to 10

HP are available ; big rice mills are very costly& located far away [1].

2) Most of the mills are located far away, so farmers are required to carry their paddy over a long distance. Also they have to wait for a long time for their turn or due to load-shedding.
3) Developing countries of the world like India are facing problems of non-availability of power in rural areas and unemployment among unskilled workers; urge engineers to harvest energy from non-traditional sources & should be eco- friendly. Such type of equipment's can easily find their place where there is no power supply.
4) These machines are environment friendly i.e. non-polluting.
5) A group of 4 to 5 families in a village may be catered for their daily demand of rice.

B. Advantages of Human operated rice mills

1) Best alternative source of energy.
2) Low maintenance cost.
3) Human power is easy to use and there is no need of special training.
4) No air pollution takes place as there is no combustion of fuel.
5) Human operated machines are self-dependent source of energy [9].

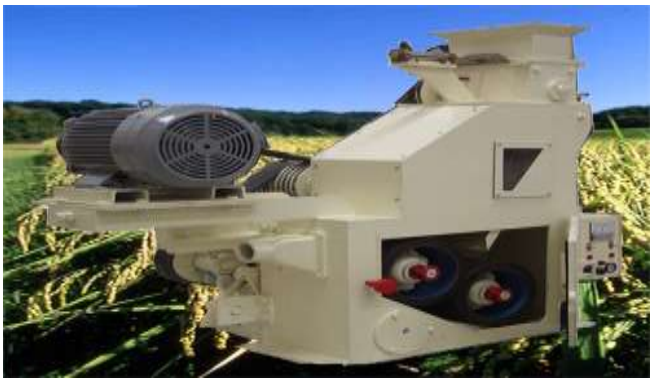


Figure 8.Modern automated rice husking machine.

Figure9.Pedal operated rice mill [1].

TABLEI.SUMMARY OF VARIOUS THRESHER PERFORMANCES DATA [2].

Type of Thresher	Speed (rpm)	Production rate (Kg/hr)	Average Seed Loss (%)	Mechanical Damage (%)
Hand Operated	100-150	20-30	13	0
Foot Pedal (treadle)	140-180	40-50	10	0
Prototype Hand Powered	120-180	40-80	06	0
Prototype Foot Pedal	180-220	0-100	05	0
Prototype Motor Power	400-750	200-400	0.5	1.5

On further study it was found that there are two types of portable dehusking machines, hand/pedal operated and motor operated. Based on production rate, mechanical damage and seed loss both types of dehusking machines were analysed by byOlumuyiwa B. Ajayi, Buliaminu Kareem, Olanrewaju R. Bodede andOluwasiji F. Adeoye and the following results were obtained from the analysis as shown in Table 1 [2].

From the analysis it was observed that the hand operated machine has less speed and thus less production rate. The foot pedal machine has more speed and production rate than hand operated machine while the motor operated machine has the maximum speed and production rate than other machines. Also less the speed more will be the seed loss and thus this has become the major disadvantage for both hand and pedal operated machines. However, mechanical damage is more in motoroperated machine as at high speed impact force is high. Thus, this reduces the market price of rice and also the wearing of machine parts and rubber rollers increases. This is not the case in hand and pedal operated machines as they are operated at less speed [2].

IV. MULTI – GRAIN DEHUSKING MACHINE

From the literature review and case study it was observed that all the machines available are single – purpose machines and can dehusk only a single grain. Thus, these machines are seasonal machines that depend on seasonal crop and if farmers want to dehusk more than one grain, then they have to take their grains to another mill for dehusking purpose. Thus, it becomes necessary to design and develop a hand or pedal operated machine that can dehusk more than one grain by doing simple adjustment with the mechanism. The machine will be a multi-grain dehusking machine which will not depend on a single seasonal crop but will be useful in all

seasons for dehusking multiple grains. Figure 10 shows a conceptual design of such multi – grain dehusking machine.

Multi-Grain Dehusking Machine will be a compact machine which will consist of a hopper, a hand operated mechanism, a pair of detachable rollers, a winnowing fan and different grade sieves. A gear train will be used to run the entire mechanism.

Grains will be fed from the hopper into the machine. A lever will the attached to one of the roller. As this lever is rotated, the rollers will the rotated and thus the rollers apply certain amount of pressure on the grains due to which friction occurs between grains and rollers and due to this friction the husk is separated from the grains. A winnowing fan will be attached at the bottom of the roller mechanism which helps to separate the husk from grains by blowing off the lighter husk and passing only the heavier grains to sieve. The sieve will be provided with a horizontal motion due to its motion it will allow only the grains to pass through it thus separating the husk and the grains. The grains will be collected in a vessel.

V. CONCLUSION AND RECOMMENDATIONS

Instead of using pounding method for dehusking rice grains, pedal or hand operated machines must be implemented as they reduce the human efforts and also reduce the percentage of broken grains. Automated machines can be used for large scale production as their production rate is more and has less seed loss but these machines are very much costly; poor farmers cannot afford to buy them. Also, since these machines are big and heavy, they are not portable and so farmers are required to carry their paddy over a long distance and are required to wait for a long time for their turn or due to load-shedding.

Figure 10.Conceptual Design of Multi-Grain Dehusking Machine.

Hence it is necessary to reduce the limitations of hand and pedal operated machines so that these machines can be effectively used by poor farmers on large scale. As the use of fuel by industries is increasing day by day, its storage is going to end one day and hence it becomes necessary to find out the alternates source of energy. Human power can be one of the alternative source of energy as it fulfils the requirement of renewable source of energy [9].

Since all the machines available are single purpose machines, thus, it becomes necessary to design and develop a hand or pedal operated machine that can dehusk more than one grain. This machine will be very helpful for farmers as well as for small group of families in a village tocater their daily demand of rice or any other grain. Multi-grain dehusking machine will not depend on a single seasonal crop and will be useful in all seasons for dehusking multiple grains.

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