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OPTIMIZATION OF ABRASIVE WHEEL HULLING FOR ANDHRA TOOR DAL

R. W. Patil[1], A.B.Tupkar[2] & Dr. S.V.Deshmukh[3]

Abstract- This paper illustrate the optimization and use of new type of abrasive wheel hulling of Andhra toor Dal, which also would be used for the purpose of seed decorticating and pulse making. Presently Toor Dal mills are operating on very large scale and not able to fulfill the demand of Toor Dal for manufacturing Toor Dal (dal) needed for rural people. Conventional processes that are being previously practiced have a many factors which reduced the efficiency of the processes. The horizontal wheel arrangement gives maximum contact area for dehulling. Farmers currently sell their product in raw form, which produce is passed through a network of intermediaries that includes several layers of traders, processing mills, and wholesalers/retailers. Farmers are systematically exploited in this process due to asymmetries in information and inefficiencies in this chain. Ultimately, the farmer receives less than 1/3 of the retail price for processed dals. It is widely agreed that "poor market linkages", "weak infrastructure", and "many layers of intermediaries" hinder the growth of India's countryside, wherein over 2/3rd of the population lives. Abject poverty is unfortunately the norm, not the exception, for the majority of Rural Indians. The creation of a small-scale dal mill and surrounding procurement & marketing capabilities would allow farmers to engage in value addition and thereby receive more equitable returns for their hard work. Beneficiaries could participate in the venture and stand to see a 15-50% improvement in incomes. All above objectives will help us to increase the efficiency of the machine. We are going to optimize this machine considering these objectives & design this mechanism with introduction of motor as prime mover. This will make it simple in construction & use for agriculture purpose with minimum cost.
Index Terms: hulling, decorticating, roughness.

1. INTRODUCTION

Now a day, it is a need of an hour to improve the farm machinery, so the government is also now interested in the research and development of agriculture equipments. Our proposed machine is simple in construction and easy to operate and maintain. it consists of horizontal grinding wheel which is covered with emery coating, surrounded by a drum through which the husk is discharged. The shelled pulses will pass through a conical hopper at bottom, below which they are collected. It will run on electric motor. Arrangement will be made for collection of de husked and split pulses, undehusked
and split pulses, undehusked pulses and broken pulses. This proposed machine will offer dust free operation, does not cause pollution, retains proteins, natural shine etc. considering the above importance the optimization of abrasive wheel hulling of Andhra Toor Dal mill is our aim. As far as proposed machine is concerned the machine must have the ability to decorticate Toor Dal and make its pulses. Toor Dal is one of the major factors in vidarbha’s economical aspect. As Toor Dal is principle source of proteins and is integral part of Indian diet. At the same time, pulses occupying a premier position next only to cereals as the daily food item in India. Conservation of pulses can be done mainly through the development of superior milling procedure and equipment. Dry whole seeds of pulses possess a fibrous seed coat. The seed coat is often indigestible; therefore pulses are mainly consumed after dehulling to improve their palatability and taste. The Andhra Tur as named by the merchants has two fold impact, on the farmers side they had given lesser prices (nearly Rs. 1000 less per quintal) and the reason behind this is said to be the hulling potential as said in local language ‘Utara’ (i,e, the percentage of whole grain dal in hulled dal) is less ac compared to the other variety of Toor Dal. Therefore overall productivity is less. Our aim in this proposed research is to find out the optimum conditions so as to increases the productivity of this variety of Toor Dal. So ultimately the benefit would the higher productivity and higher remuneration to the local farmers for their crop.

2. NEED FOR DEHULLING:

Semi-arid regions in developing countries such as India, Africa, etc. For example, can only support the cultivation of cereals such as toor Dals, sorghum, millet and maize. As a result, a significant percentage of the population in many parts in Maharashtra depend on toor Dal for their daily meal. Other crops such as wheat and bajri contribute to the daily diets of population. Rural women have traditionally improved the organoleptic quality of foods prepared from cereals by processing the grains to remove the outer layers (the pcricarp and testa). The pericarp (bran) contains mainly fibre, whereas the testa contains anti-nutritional substances, such as polyphenols, which give a bitter taste to the grain and inhibit the digestion of

[1] Department of Mechanical Engineering, Bapurao Deshmukh College of Engineering, Sewagram, Wardha (Maharashtra), India.
[2] Department of Mechanical Engineering, Bapurao Deshmukh College of Engineering, Sewagram, Wardha (Maharashtra), India.
[3] Department of Mechanical Engineering, Bapurao Deshmukh College of Engineering, Sewagram, Wardha (Maharashtra), India.

protein from the grain . Phytic acid, which is present in the bran and germ of toor Dal combines with mineral elements such as calcium, iron, sodium, zinc, and magnesium, to form insoluble compounds (phytates) thus making them unavailable for human nutrition . The presence of high concentration of c-glycosyl flaveres in undehulled toor Dal changes test of food. Many of these various anti-nutritional factors can be substantially reduced by dehulling. Most producers and consumers of toor Dal face a daily task of dehulling and pulverizing the grains manually before being able to prepare the daily meal. Traditionally, toor Dal are dehulled (a) To remove the outer layers, which contain primarily fibre, the presence of which affects cooking quality and taste and texture of the product, and adds bulk to the daily meal. (b)and To remove sources of bitter taste (polyphenols or tannins) that are often found in the outer hull or in the testa layer immediately under it.

3. MILLING FACILITIES AVAILABLE:

3.1 Traditional Method:

Fig.1: dehulling of toor Dal using a chakki

The dehulling operation involves two steps;

1. Loosening the husk from the cotyledons.
2. Removing the husk from the cotyledons and splitting them using a roller machine or stone chakki (quern).

Before dehulling in chakki, pigeonpea seed is soaked in water for 2 to 14 hours. Some farmers treat the seed with oil before dehulling. Processing of Red gram is generally known as Dal milling or dehulling. Milling means removal of the outer husk and splitting the grain into two equal halves. Dal milling is one of the major food processing industries in the country, next to rice milling. The efficiency of conversion of grain to Dal by traditional methods of milling is low and the resultant product especially that from the wet method is inferior in cooking quality. The average Dal yield varies from 60-70 percent (theoretical value 85 percent), i.e. a net loss of 30-40 percent during the conversion of Red gram into finished Dal by traditional methods. In modernizing the Dal milling industry, the Central Food Technological Research Institute (CFTRI), Mysore, has recommended an improved method of Dal milling.

3.2 Floor Mill:

As like dal mill, floor mill is also used for hulling of tur by people in rural India, by adjusting gap between the wheels. Initially they soak tur in water for 1 days, after soaking tur has to be dried for 2-3 days then it will be ready for hulling process. Then in this process tur has to be passed through floor mill 2 times. This process is economical for farmers as the hulling cost is less than dal mill. But in this case the efficiency is 60-65%. That means losses of 40% will be there.

Fig.2: Floor mill

The losses in the hulling process, if carried out in the floor mill consist of various sub parts. Pulses get contaminated with floor previously milled in mill, due to insufficient gap between grinding wheels grains get powered and due to very high speed of wheels, proper splitting cannot be guaranteed.

3.3 Mini Dal Mill:

Features: The mini dal mill consists of a feed hopper at the top of the unit with a feed regulating mechanism. When the pulses fed in between the two discs, they split into two halves due to shearing action and fall down through an outlet chute. The abrasion discs are the main component in milling of grain legumes. Depending upon the grain to be milled, the material of the abrasion discs
are to be changed. For splitting to dal, the rotating discs should be cast steel with serrated teeth and the rubber disc serves as the statiopary disc. For flour making, the two discs are to be provided by means of cast steel with serrated teeth arrangements.

3.4 Existing Dal Mill:

Fig.3: Mini dal mill

Features: It is a 2.0 hp three-phase electric motor operated equipment for dehusking and splitting of toor Dal, black gram, green gram and lentil. It consists of emery/corundum roller, feed hopper. The product to be milled first soak in water (pre-conditioning), sun dried and later on fed into the unit to achieve complete milling in two passes.

Fig.4 Dal mill

4. FEATURE OF DEHULLER'S PERFORMANCE:

Laboratory and field studies indicate that the performance of abrasive disk dehullers depend on:

- Speed of rotation of the disks.
- Physical characteristics of the disk surface such as roughness and hardness.
- Number and diameter of disks in the barrel, reflecting the total surface area available for dehulling.
- Spacing between disks and their angle of inclination to the shaft.
- Distance between the end disks and the end plates of the barrel.
- Clearance between the periphery and the barrel.
- Presence or absence of aspiration during dehulling.
- Roughness of the inner surface of the barrel.
- The rate at which grains are fed into the dehuller in the continuous mode, and the quantity of grain in the dehuller in the batch mode.
- Residence or retention time of the grain in the dehuller.
- Physical characteristics of the grain being dehulled.

5. COST-EFFECTIVE ASPECTS

Tur is one of the major agricultural products in Vidharbha region. The selling price of tur is about Rs.3500/- per quintal from farmers to the traders. And the market price of toor Dal increases due to cost incurred in its processing of converting from tur to dal . The selling price of toor Dal after all processes is about Rs 7000/- per quintal. The traditional process which are used for hulling the tur are Use of traditional dal mill,Floor mill,Dal mill. The hand mill used for hulling dal is outdated now .Generally the floor mill are most popular means of decorticating and milling. The cost of milling on the floor mill is about Rs 250/- per quintal. But main thing is the efficiency of the floor mill is not more than 60%. It means nearly 40% of the product goes waste. Also a gap between the grinding wheel should be adjusted frequently for milling the dal . If the adjusted gap is more than the output will be not proper and if it's too narrow, seeds will be crushed. Another way of dal processing is the mini dal mill. They give the efficiency higher than the floor mill nearly 75%. But the cost of milling is about RS. 300/- per quintal. The efficiency about 75%. Even if the efficiency is larger but the initial investment for dal mill is RS.150000/- and it is not available in remote rural area so the people have to come to the town .This adds extra transportation cost in the price of toor Dal .

6. METHODOLOGY

From the review of traditional processes and machineries available in market for decorticating toor Dal, we have a clear view of the plan of working that will lead the way towards the efficient working model.

Following are the point which covered in the plan of work:

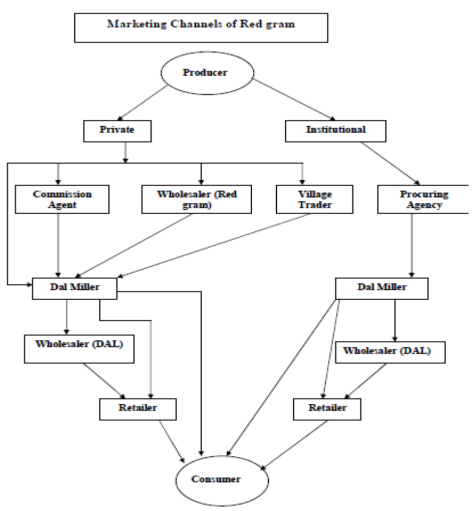
1. Use of emery powder of different numbers.
2. Speed adjustment mechanism.
3. Gap adjustment mechanism.

6.1 Use of emery

The actual process of decorticating and hulling will be done mainly with the help of roughness of emery. After taking interview of several people who have actually worked on same project, we come to conclusion that the emery having grades 24 and 30 may give optimum result. So taking idea into consideration, we decided to produce two different wheels of grade 24 and 30 emery pasted on it and taking output of each wheel on varying speed and gap. An abrasive which is too hard or too coarse can remove too much material or leave undesired scratch marks. Excessive abrasion or the presence of scratches may:

- Diminish or destroy usefulness (as in the case of scratching optical lenses and compact discs or dulling knives).
- Trap dirt, water, or other material.
- Increase surface area (permitting greater chemical reactivity such as increased rusting which is also affected by matter caught in scratches).
- Erode or penetrate a coating (such as a paint or a chemical or wear resistant coating).
- Overly quickly cause an object to wear away (such as a blade or a gemstone).
- Increase friction (as in jewelled bearings and pistons).

A finer or softer abrasive will tend to leave much finer scratch marks which may even be invisible to the naked eye (a "grain less finish"); a softer abrasive may not even significantly abrade a certain object. A softer or finer abrasive will take longer to cut as tends to cut less deeply than a coarser, harder material. Also, the softer abrasive may become less effective more quickly as the abrasive is itself abraded. This allows fine abrasives to be used in the polishing of metal and lenses where the series of increasingly fine scratches tends to take on a much more shiny or reflective appearance or greater transparency. Very fine abrasives may be used to coat the strop for a cut-throat razors, however, the purpose of stropping is not to abrade material but to straighten the burr on an edge. The final stage of sharpening Japanese swords is called polishing and may be a form of super finishing.



6.2 Speed adjustments

As the wheels would be motor driven, we will have to adjust the speed of wheels. With very high speed, toor Dall will be converted into powder and with very low speed decorticating would not be proper. After taking views into consideration of peoples who actually worked in dal mill, and studying the literature related to decorticating machine, the speed of 100 to 140 rpm will give optimum result which would be given to wheel. As this much low speed motor is not readily available, we going to incorporate the controller to vary the speed of motor as per our requirement.

6.3 Gap adjustment mechanisms

Along with emery grade and speed of motor, gap between wheels is also an important parameter to be considered in project, more the gap no seed will be decorticated and run out as it is from machine, less the gap either machine would be jam or seed might be crushed. So the third and important parameter to be considered in project is the gap between wheels. We are going to make movable the upper wheel out of two wheels in order to adjust the gap. As the lower wheel is rotating with motor, it will be difficult to move it when it is rotating or working. So instead of lower, we are working with upper wheel to adjust gap, we are providing a simple nut and bolt arrangement to adjust the gap between the wheels.

7. OPTIMIZATION OF MACHINE PARTS

7.1 Frame

The whole machine setup is built up on metallic frame made from mild steel. Various sections of mild steel used to build the frame wherever needed. The base of frame is made from C-channels of sections 120x60x60 mm of total thickness 5 mm. The base of frame is square of 650x650 mm dimension. The backside of frame is made from mild steel channel of 70x30x30mm of 5mm thickness. The overall dimension of is 1300 mm high and 650 mm wide. This frame provides housing for motor mounting. Motor is mounted on two mild steel angles of 35x35x5 mm. The LHS and RHS side supports of frame are made from mild steel angles and mild steel channels of 40x40x5 mm and 75x35x35 mm respectively. The gap adjusting screw is mounted on top cover frame which is made from 40x40x5 mm angles of 650x650 mm square dimension. Two cross shaped plates are welded over it to support the gap adjusting screw and to guide the other four screws so that disc slides in horizontal manner.

7.2 Drum and bottom hopper:

When tur is fed to the grinding wheels via hopper, after dehulling and splitting when dal comes out from wheel it is spread all around due to centrifugal force. To guide the pulses in a particular direction so as to fill them in container or sack, we have provided a sheet metal drum around the grinding wheel. The sheet metal drum around the emery wheel is made from mild steel sheet of 0.8 mm. The diameter of the drum is 450 mm and 400 mm height. For manufacturing the drum from mild steel sheet, the rectangular piece of 1414 mm long and 400 mm i.e. Circumference = $\pi x D = \pi x 450 = 1413.71 \approx 1414$ mm (length), Width = 400 mm, Under the drum, a conical hopper is provided. So that all pulses splitted in the grinding wheel will fall down into hopper through the cylinder. The cone's base diameter is equal to the diameter of the drum i.e. 450 mm and the height of the cone is 230 mm. A hole of 75 mm is cut on the apex of cone to make the outlet for the seeds.

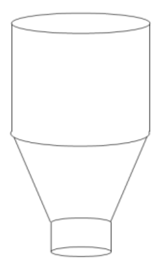


Fig.6:Assembled drum

7.3 Emery wheels & Wheel preparation:

To prepare the grinding wheels, we took four discs cut from mild steel plate. The overall thickness of plates is 11 mm. The reason behind selecting thick plates is, while cutting discs from plates using flame cutting, thin plates get bend and disc formed from them wobbles while rotating. So the discs of 375 mm diameter are cut first and then turned on lathe to make them round. Then the facing of the discs is done to reduce the thickness of discs from 12 mm to 8 mm. This is done to reduce weight of discs.

Fig.7: wheel preparation

7.4 Pulley drive:

In order to transmit the power from prime mover i.e. D. C. Motor to grinding ARAT wheel, the pulley drive is used. Smaller pulley of 100 mm (4 inch) diameter is mounted on motor shaft. The larger pulley of 300 mm (12 inch) is mounted on grinding wheel shaft. The belt section used is 'B' of 54 inch length. Total speed reduction achieved using pulley drive is 3:1.

7.5 D. C. Motor:

To provide power to the wheels, D.C. motor is used as a prime mover. As we have to find out optimum speed for the dehulling, a controller is also incorporated with it. With the help of controller speed of the motor can be varied. The motor specifications are as follows:

Motor specifications:

Power: 0.5 Hp = 0.37 Kw, Voltage: 220 V,Current: 2 Amps

Type: Shunt motor, Speed: 1500 RPM

7.6 Taper roller thrust bearing:

As the total weight of metal discs, emery powder is considerably high; so we have provided a taper roller thrust bearing at the base of shaft. The reason behind using thrust bearing is, as all loads along with shaft's self weight is acting axially on shaft. So to provide free rotation of shaft the bearing is used. The bearing number Used is 30206, Where, 02 denotes Roller bearing, 06 is for shaft diameter i.e. 06x5 = 30 mm

Fig.7: Taper roller thrust bearing

8. CONCLUSIONS

Our paper is based on the overview on optimizing the dehulling process of Andhra toor Dal. The reason behind selecting the Andhra toor Dal for project is that, tur is one of the major agricultural products in our Vidarbha region. Our project will help farmers to relive from the problem of low efficiency dehulling from the traditional processes. Firstly we have studied about various traditional and existing methods for dehulling, we collected all relevant data about toor Dal and dehulling processes. After studying various aspects of optimizing the dehulling process, we selected the few parameters such as: emery grade, gap between the wheels and speed of rotation of wheels. Experiments to be done on these parameters to find out the most favourable settings to get desired output.

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