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Design and Fabrication of a Prototype Of Ragi (Finger Millet) Threshing and Winnowing Machine

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Abstract: **Ragi (finger millet) is an important cereal and fodder crop which is extensively cultivated in southern Asian countries like India, Malaysia and Nepal and is known for its high drought tolerance and nutritional properties. Thus, there is a requirement of cheap, affordable, easy to maintain and economical ragi processing machine which is designed and aimed specifically towards farmers with medium to small holdings. The design and fabrication of such a machine has been carried out in Vemana Institute of Technology. The machine was being designed to replicate the manual beating method of ragi for threshing. Power was derived from an AC motor and was transmitted to a central shaft carrying the crushers via a V-belt drive. The central shaft is supported via pillow block bearings from the frame. When the central shaft rotates, the crusher arrangement also rotates inside a closed drum, and the unprocessed ragi is threshed on the obstructers, hence separating the seed from its husk.**

Keywords: Blades/crushers, compatible sieve arrangement, static obstruction, V-belt drive.

INTRODUCTION:

Millet is one of the oldest human foods and believed to be the first domesticated cereal grain. It is the staple food of millions of people in drier parts of tropical Africa. Millets are good sources of minerals such as calcium, iron, zinc, copper and manganese. It has been reported that the air-dried grain of millet contains approximately 12.4% water, 11.6% protein, 5% fat, 67.1% carbohydrate, 1.2% fibre (referred from the research conducted by G.B Adebayo, G.A Otunola and T.A Ajao on Relationship Between Nutritional Qualities of Millets and Temperature, Advance Journal of Food Science and Technology). The major Finger millet growing states are Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, Jharkhand, Maharashtra and Uttaranchal. Finger millet is the staple food for millions of people in India and Africa. Finger millet is also an ideal food for patients suffering from diabetes. The grains are rich in calcium and iron besides rich in carbohydrates and proteins. It ensures nutritional security in most parts of semi-arid tropics of India. With the changing environmental conditions (which is adversely affecting the productivity of agricultural lands per acre) and booming population (which is increasing the demand of high nutrition crops), there is a need of efficient processing of the harvested crops in order to maintain a good supply chain, from the field to the customer. But due to accessibility issues of post processing agricultural machinery to the farmers with medium to small holdings, it is necessary to develop a viable option to counter this problem. Designing a simple, affordable and easy to maintain machine may help in better time and resource management of farmers, hence increasing their efficiency and profit. Modular designing of the machine will result in easy maintenance and repair of the machine, which may be an attractive characteristic to the farmers thinking of buying the machine. The project, ragi threshing and winnowing machine, is based on the same principle. Attempts have been made to replicate the slow but effective manual method of beating the crop, hence separating the seed from the husk. It is done by providing multiple blades/beaters on a rotating shaft, which is then placed inside a drum. The lower part of the drum has a sieve structure, which results in separating seeds from the separated husk.

Some of the advantages of the machine is the simplicity, maintainability and economic. However, the drawbacks of the project are the varied challenges yet to be overcome to convert it to a successful commercial product.

II. COLLECTION OF DATA:

Two methods of Finger millet threshing were identified and studied, these are:

Manual Hand Beating:

Fig.1. Manual Hand Beating of Ragi with a Stick with Soft Soil as Base

A man/women with previous experience in threshing is selected as a power source as shown in Fig.1. The unprocessed ragi was kept in a heap and constantly beaten with a long stick. After some duration of time, due to this threshing action, the ragi would get separated from the husk. This was an effective but slow method of processing any produce.

Stone Roller:

Fig.2. Threshing Done by a Stone Roller Powered by a Tractor

The unprocessed harvested ragi was first evenly spread on a surface. Animal power was used as power source to pull the stone roller, but was preceded by tractor in recent times, as shown in Fig.2, which would carry out the threshing action and the seed separated from the husk after several given repetitions of this process. Some of the drawbacks were some amount of wastage due to the seeds crushed into the soil due to uneven distribution of weight on top of the seeds.

III. DEVELOPMENT OF PROTOTYPE FINGER MILLET THRESHER

Initial Design and its Consequent Rejection:

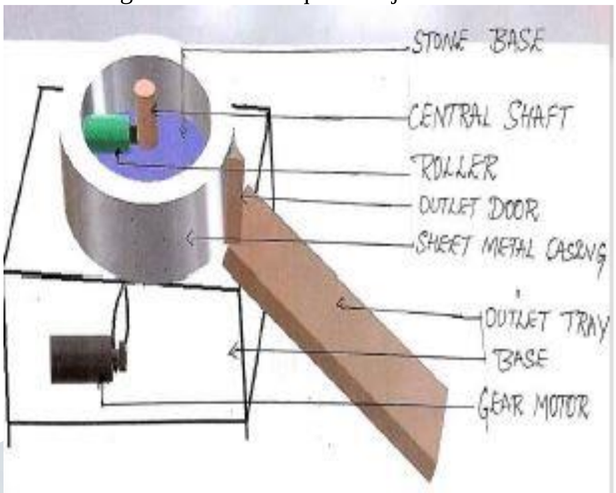

Fig.3. Initial Concept

Based on the data collected, an attempt was made to replicate the motion of the rollers on the ragi crop. The design was based on the heavy roller suspended from a central shaft. The roller would rotate on a stone base which would provide the necessary abrasive surface for the seed to separate from the husk.

Drawbacks of the Design:

The design was rejected as the design requirements were contradicting each other. The design demanded the roller to be heavy to be able to impart a load on the seeds, but a heavy roller, which was attached to the central shaft in a cantilever manner, would result in a bending force to be developed which may increase the requirement of maintenance due to the possibility of premature failure. Also, the components were difficult to acquire such a stone base with a central hole, a heavy but soft roller, etc. Since the surface area of contact with the crop was very less, the rate of processing of the crop was also quite slow. So the design did not meet most of the requirements that we had set up in the initial phase of designing.

Present Design:

Since the first design, which was based on the roller method which was analysed during collection of data, the design was

Fig.4. Present Design with Internal and External Arrangements

Then based on the method of beating of the unprocessed ragi. This motion was replicated using a series of dynamic beaters and static beaters/obstructions as shown in Fig.4. While the unprocessed ragi was loaded from top, the blades would thresh the ragi on the obstructions, which would result in separation of the seeds from the husk. The seeds would then get separated and "filter" through the sieve, collected and stored. The separated husk would be blown away from an opening given. V-belt drive is used for the power transmission system in this design. A multitude of crops can be processed by manipulating the sieve size. One of the major advantages is all the serviceable parts are kept easily accessible, which would result in easy maintenance and reduced overhauling time.

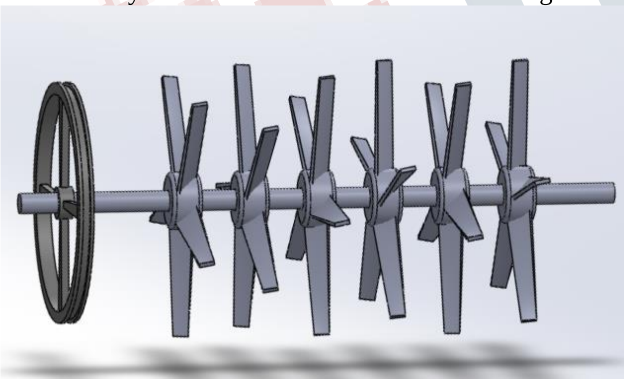

Fig.5. Shaft Pulley with Hub and Blade Assembly

SPECIFICATIONS OF THE MODEL:

1. External Dimensions: 0.76m x 0.54m x 1.15m
2. AC motor: 0.25 HP, 0.18kW, 1420 RPM
3. Central Shaft: ϕ 0.025m x 0.60m
4. Blade: 0.135m x 0.03m x 0.002m
5. Pulley Diameter:
   - Shaft Pulley(D1): ϕ0.30m
   - Motor Pulley(D2): ϕ0.06m
6. Rotational Speed at The Larger Pulley: 280 rpm
7. Number of Hub Arrangement: 6 Nos.
8. Number of Blades on Each Hub: 5 Nos

NOMINAL DIMENSIONS:

Diameter of Drum, d = 0.342 m
Length of Shaft, L = 0.620 m
Length of the drum, L1= 0.495 m
Length of the obstructers = 0.120 m
Diameter of the obstructers = 0.015 m
Distance between the centers of two pulleys = 0.615 m

The belt length was calculated from the distance between centers of two pulleys and diameter of pulleys using equation number 21.38, based on the reference of "Design Data Handbook by Dr. K Lingaiah as L = 1.819 m.

The volume of drum is found out using the standard formula (V = (π x d^2)/4 x L_1) to be 0.045 m3.

The usable loading volume of drum is reduced by 20% of the total volume (V- 20%V) to 0.036 m3. This is the effective loading area of the machine. The 20% is taken as the volume covered by the components inside the drum itself, like the central shaft, blade and hub assembly, etc. So this is the volume that is available to accommodate the unprocessed ragi. Varying this volume by varying the dimensions of the drum will result in change of threshing rate of ragi.

EXPERIMENTS CONDUCTED:

While testing was conducted, the machine was loaded several times with 1 kilogram of unprocessed ragi. After processing, an average of 750 grams of processed ragi with 200 grams of husk was recovered in 3 minutes. According to these test values, for processing 1 quintal (100 kilograms) of unprocessed ragi, the machine will take 300 minutes or 5 hours.

IV. RESULTS AND DISCUSSION:

However, this is not the optimum rate of processing the ragi with this machine as the rate also depends on the moisture content. According to various sources, the optimum moisture content of ragi for processing is 22% (our test material was more than this value).

Fig.6. The "clumps" of Unprocessed Ragi

Fig.7. The Processed Ragi after Threshing

Fig.8. The Husk after Threshing

Since one of the initial objectives of the design was easy maintenance, hence, we went ahead with a modular design. For example, in case of damage to a blade/crushers, only that set of blade and hub arrangement can be replaced instead of all the sets, resulting in simplicity and overall maintenance cost reduction. Simple screw mechanism has been provided for replacing or overhauling the parts.

Fig.9. The Blade and Hub Assembly held on the Shaft using Screw Attachment

3. Also, the machine is designed in such a way that most of the breakdowns occurring can be easily overcome by a simple toolbox on field itself.

V. CONCLUSION

During conceptualization of the project, the aim was to make a simple, affordable, robust and easy to maintain ragi threshing machine. Most of the boxes have been ticked. However, there are still some problems to be ironed out like the winnowing mechanism, better efficiency and refinement of the model. These shortcomings can be overcome in further editions and refinements. Although the machine is working as expected, there is still work to be done to bring the rate of processing the ragi to acceptable values for industries. With further modification, the machine can be converted to a multicrop thresher by carrying out some minor changes. But still, there's a long way to be covered to convert this model from a "project" to a "product".

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