Design and Fabrication of Pulverising Unit for Maximum Absorptivity of Raw Banana Fiber

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Abstract. Women in the developing world lack awareness of basic sanitation during their menstrual days. Moreover, the sanitary pads available in the market are so expensive that it is unaffordable to them. Efforts are made to give the women the knowledge of basic sanitation during the menstrual days and also to make the sanitary pads affordable to them. One such method to make sanitary pads affordable is to use frequently available materials as the absorbing substance. This paper discusses one such novel approach of using raw banana fiber as the absorbing material that can be used in sanitary pads. The minimum requirement of any sanitary pad is the factor of absorptivity, or the ability to absorb liquid to a sufficient degree. The paper also includes optimization of the blades of pulverising unit for maximizing the absorptivity of absorbent fiber.

1. Introduction
In developing countries like India, women suffer from reproductive diseases due to the use of unhygienic substances by women during their menstrual days. The reason for using such substances is due to their ignorance of basic sanitation and also due to expensive sanitary pads available in the market which is unaffordable to them. Efforts are made to give the women the knowledge of basic sanitation during the menstrual days and also to make the sanitary pads affordable to them.

One such method to make sanitary pads affordable is to use frequently available materials as the absorbing substance. The property of absorptivity is one of the parameter considered during the manufacture of sanitary pads. In view of reducing the cost of sanitary pads, readily available materials like raw banana fiber is considered as the absorbent material in the sanitary pad [1]. The banana fiber is ground in a pulverising unit and is made into fine powdered [2]. The blades of the pulverising unit are also optimized for the maximum absorptivity of the banana fiber.

1.1. Pulverising Unit
In the pulverising unit, the raw banana fibre in the form of strands is converted into strands of smaller lengths, in the range of 8-15 mm. This is achieved through the rotation of circular cutters of about 5 cm diameter, fixed onto a single shaft, kept in a circular chamber with a slot on top [3]. A circular mesh kept below the shaft helps in allowing only strands below a particular limit to pass through. The pulverised strands are then fed to the caking unit by a variable screw feeder arrangement.
1.2. Feeding Unit

The feeding unit involves an Archimedes screw, which is essentially a screw of variable pitch. It consists of an axis with helical blades lying in a channel with a semi-circular or even closed circular cross section. An Archimedes screw is a screw conveyor contained within a tube, turned by a motor so as to deliver material from one end of the conveyor to the other. For the feeding unit, emphasis was given to the factor of variable pitch. An efficient mechanism was needed for the transport of the raw banana fibre from one end of the shaft to the other. Hence, the arrangement consisted of a screw with one end at a diameter of 15 mm and the other at a diameter of 8 mm.
2. Design of pulverising unit

The basic objective of the pulverizing unit is to grind the banana fibre to strands of smaller length. The design of the pulverizing unit involves a circular cutter, fixed onto a single shaft, kept in a circular chamber with a slot on top. The present design of the pulverising unit is based on the comparative study conducted on various other pulverizing mechanisms used to grind similar materials like banana fiber.

Table 1.1: Pulverising unit design parameters

| Design Components   | Design Values   |
|---------------------|-----------------|
| Power of motor      | 2 HP            |
| Length of the shaft | 100 mm          |
| Diameter of Shaft   | 20 mm           |
| Dimensions of Casing| 120 x 150 mm    |
| Blade Diameter      | 4 inches        |
| Length of Spacer    | 10 mm           |
| Torque              | 10 Nm           |

3. Methodology

In order to optimise the number of blades of the pulverising unit for the maximum absorptivity, experiments were conducted by varying the number of blades and the output grain size of the fiber was recorded. The efficiency of the process was also calculated by measuring the weight of banana fiber grains that comes out of the pulverising unit. The input weight of the banana fiber is 50g.

Comparisons were also made between the number of blades and the absorptivity of the banana fiber grains.

4. Results & Discussion

4.1. Number of Blades vs Grain Size

Table 4.1 gives the comparison of the number of blades and grain size. It also gives the variation of number of blades and the efficiency of the pulverising unit.

| No of blades | Grain size(mm) | Efficiency(%) |
|--------------|----------------|---------------|
| 4            | 25.5           | 40            |
| 5            | 14.3           | 62.9          |
| 6            | 4.5            | 79.5          |
| 7            | 3.9            | 58.4          |

Table 4.1. Data indicating variation of output and grain size with number of blades
From the table, it is observed that the fiber grain size decreased with increase in the number of blades. The reason for this phenomenon is due to the large space between the adjacent blades when the number of blades are less. Due to which there is not much cutting take place which results in long fiber strands coming out of the unit.

The efficiency of the pulverising unit increased with increase in number of blades. The maximum efficiency is obtained as 79.5% for the number of blade as 6. When the number of blade was taken as 7, the efficiency dropped to 58%. This is because the strands get tangled between the blades due to their close proximity which results in a bottleneck that prevents the ground grains to come out of the pulverising unit.

4.2. Number of Blades vs Absorptivity
Absorptivity is defined as the amount of water absorbed by a material under specified test conditions, commonly expressed as a weight percent of the test specimen. Being the base of a sanitary napkin, it is expected that any raw material would have to be a very good absorbent. The water absorption technique used for the absorptivity of banana fibre is ASTM D570 [10]. This was done by testing the existing samples taken on the basis of the number of blades and to find the extent of absorptivity obtained in each situation by keeping the sample in water for a time period of 10 minutes and then checking for the change in weight of the sample. The specimen was submerged in water at room temperature and the samples were taken out periodically and weighed immediately. The weight of sample before and after absorption was taken to calculate the percentage of water absorption.

| No of blades | Grain size(mm) | Absorptivity(%) |
|--------------|----------------|----------------|
| 4            | 25.5           | 18.7856        |
| 5            | 14.3           | 24.1347        |
| 6            | 4.5            | 27.2539        |
| 7            | 3.9            | 28.7581        |

Table 4.2. Data indicating variation of number of blades and grain size with absorptivity
5. Conclusion
This paper focuses on developing low cost sanitary pad which is affordable to women. For this purpose one of the most readily available raw banana fiber is used as the absorbent material. The pulverising unit and the feeder unit were designed and fabricated for using banana fiber as the raw material. Various experiments were conducted to obtain the optimum number of blades for the maximum absorptivity of the banana fiber specimen. Based on the experiments comparisons were made on the various parameters like number of blades, grain size and absorptivity and an optimum design is obtained.

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