Design and Fabrication of Areca Fiber Extraction Machine

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Abstract—This paper focused on fabrication of areca fiber extraction machine. This is basically removing fiber from areca husk. The areca husk is outer cover of areca nut which consists of fiber. These fibers are being extracted manually. This has several problems such as time consuming, low production rate, human error, low quality fiber, more workers and skilled labours. This paper aims to overcome these problems by fabricating areca fiber extraction machine which automates the fiber extraction process. This machine consists of 3 phase ac motor which is directly coupled to driven shaft. The driven shaft is enclosed in a casing which is designed in such a way that only dust is removed and fiber comes out of rectangular duct at lower side of casing. The driven shaft is supported by two bearings and has blades which are designed by modifying the blade design of coconut husk decorticating machine. Thus this machine will be helpful for rural entrepreneurs and farmers.

Keywords—Areca fiber, Blade, Extraction machine.

I. INTRODUCTION

Bio-fiber are defined as the fibrous material derived from the plant, tree, or shrub sources.[1,2] Natural fibers can be considered as naturally occurring composites consisting mainly of cellulose fibrils (fibers) embedded in lignin matrix (resin). These cellulose fibers are aligned along the length of the fibers, irrespective of its origin, i.e., whether it is extracted from bark or stem, leaf or fruit. It is interesting to note that natural fibers such as jute, coir, banana, sisal, etc., are abundantly available in developing countries like India. At present these fibers are used in a conventional manner for the production of, ropes, mats and matting, as well as in making fancy articles like wall hangings, table mats, handbags and purses.

The natural fibers have currently attracted the manufacturers attention [1,2]. These benefits can be classified into the following categories:

1) Environmental Aspects: Plant fibers are renewable resources, they need low energy requirements during production. Furthermore, natural fibers show carbon dioxide neutrality and their disposal can be done by composting.

2) Biological Aspects: They are natural organic products. There is no dermal issue for their handling compared to glass fibers and do not pose a bio-hazard upon disposal.

3) Production Aspects: Natural fibers are non-abrasive and exhibit great formability.

4) Component Weight Issues: Natural fibers are light weight (less than half the density of glass fibers).

5) Financial Aspects: Natural fibers are very cheap in comparison to glass fibers.

6) General Aspects: Natural fibers show a safer crash behavior in tests (i.e., no splintering). They are also available on a worldwide basis. In addition, they exhibit good acoustic and thermal insulating properties due to their hollow tubular structures.

A considerable speculation surrounds the origin of the areca nut palm. There seems to be no record of fossil remains of the genus areca, but the abundance of the palm genera discovered in the form of shells, leaves and stems from the tertiary period indicates that this genus was in existence as far back as that period.

II. PROBLEM DEFINITION

In early days to extract fiber, areca husk was soaked in water about 2 to 3 days, this wet areca husk is exposed to sunlight for drying. Effect of chemical treatment with sodium hydroxide NaOH of Areca fiber on mechanical properties was studied. Fibers were soaked in 5, 10, 15, 20, and 25% NaOH solution for about 12, 24, 36, 48, and 60 hours[1,2]. These fibers were further washed with water containing few drops of acidic acid. Finally, the fibers were washed again with water and dried. By doing this some biological activities takes place which makes areca husk soft and loosens fiber. These loosened fibers were extracted manually by hand. This way of extracting fiber from areca husk is time consuming and cannot be adopted in producing fiber in large scale. Also this method requires more labours and hard work.

In traditional method areca fiber is extracted by retting process. Retting process is employing the action of moisture and bacteria on areca husk to dissolve or rot away much of cellular tissues and other substances, thus facilitating separation of the fiber from areca husk. Basic methods include dew retting and water retting.
Dew retting is common in limited water resources area, but this is effective only in warm daytime temperatures and climates with heavy night time. In this procedure, the areca husk is spread evenly in grassy fields, where the combined action of sun, air, bacteria, dew produces fermentation, dissolving much of harder substances from areca husk. Within a week, depending upon climatic conditions, the fiber can be separated. Dew retted fiber is generally darker in colour and of poorer quality than water retted fiber.

Water retting, the most widely practiced method, bundles of areca husk are submerged in water. The water, penetrating to the central portion areca husk, swells the inner cells, bursting the outermost layer. In this process of retting time must be carefully judged; under-retting makes separation difficult, and over-retting weakens the fiber.

The following are the problems involved in the manual method of extracting fiber

- Time consuming.
- More workers.
- Rate of production of fiber is very less.
- Depends on water resources and also climatic conditions.
- Human errors.
- Manual method of fiber extraction cannot be adopted for mass production.

III. PROBLEM SORTING

The following are the solutions to the problems faced in the traditional method.

- Time efficient.
- Only worker is enough to operate the machine.
- Rate of production is very high.
- Does not require any water resources for extracting the fiber.
- No Human errors.
- This method can be adopted for mass production of fiber.

IV. FABRICATION

1. Supporting unit was fabricated out of channel sections and equal angles are intended to provide the base of the machine. This carries four V shaped vertical columns of length 28.5cm and width 3.5cm. This provides sufficient stability to machine.

2. Two V shaped supports was welded to motor support made from mild steel of length 38.5cm and width 21cm.

3. A 3 phase, 5hp, 1440 RPM motor is fixed to motor support by means of four bolts.

4. Then casing of diameter 28.5 cm was fabricated from mild steel. For fabrication of casing 42 square rods of length 24 inches and width 1cm was welded in the circumference of the casing. In between two square rods a gap of 5mm is maintained, so that dust comes out through these gaps during fiber extraction process. The casing ring is provided with 2 bolts for opening and closing of casing.

5. For fabricating a U shaped hopper, a thin sheet metal made from mild steel was cut to a length equal to 13.5cm and width equal to 14.5cm. This hopper is welded to the casing at an angle of 33° with horizontal.

6. Then a shaft of diameter 2.5cm and length 76.5cm is fabricated from mild steel. This shaft is inserted inside the casing and is supported by providing two pillow block bearings on either side. Pillow block bearing with housing as shown in Fig. 2.

7. The blades are of rectangular shapes which were cut to length equal to 11.5cm, width equal to 5cm and thickness equal to 1cm. These blades were sharpened by surface grinding machine. Nine set of blades were welded to the shaft with 2 blades per set and a total of 18 blades. The blades were welded perpendicular to the shaft and distance of 7.5cm was maintained between two set of blades. Each set has 2 blades and angle between these blades is equal to 180°. The angle between two set of blades is equal to 90°. The design of blades is shown in Fig. 3.
V. COUPLING

The device used to connect two shafts together at their ends for the purpose of transmitting power is a coupling. Couplings do not allow the shafts disconnection during the operation, however there are torque limiting couplings which can slip or disconnect when some torque limit is exceeded. The primary purpose of couplings is to connect the two pieces of rotating element while permitting some degree of misalignment or end movement or both. Better selection, installation and maintenance of couplings, the maintenance costs reduces substantially and downtime.

A. Bearing

A bearing is a device that is used to enable linear or rotational movement, reduces handling stress and friction. Resembling wheels, bearings literally enable devices to revolve, which reduces the friction between the surface of the bearing and the surface it’s rolling over. It’s significantly easier to move, both in a linear or rotary fashion, when friction is reduced, this also enhances efficiency and speed.

VI. REQUIREMENTS AND DESIGN OF ARECA FIBER EXTRACTION MACHINE

Motor, Coupling, Bearings, Shaft, Blades, Casing, Square rods, Hopper, Duct, Mild steel support for motor and machine.

A. Selection of Bearing

The bearing selected to support the shaft is pillow block bearing. A pillow block, also called as a Plummer block or bearing housing, is a pedestal used to provide support to rotating shaft with the help of compatible bearings & accessories. Housing material for a pillow block is made of cast iron or cast steel.

Pillow blocks are usually referred to the housings which have a bearing fitted into them and thus the user need not purchase the bearings separately. Pillow blocks are usually mounted in cleaner environments and generally are meant for lesser loads of general industry. These differ from "Plummer blocks" which are bearing housings supplied without any bearings and are usually meant for higher load ratings and corrosive industrial environments. However the terms pillow block and Plummer block are used interchangeably in certain parts of the world.

The fundamental application of both types is the same which is to mount bearings safely enabling their outer ring to be stationary while allowing rotation of the inner ring. The housing is bolted to a foundation through the holes in the base.

Various seals are provided to prevent dust and other contaminants from entering the housing. Thus the housing provides a clean environment for the expensive bearings to freely rotate, hence increasing their performance and duty cycle. Bearing housings are usually made of grey cast iron. It has wide inner race.

B. Selection of Coupling

The coupling is selected based on following basis
- Type of driven machine and operating hours /day.
- Speed and power absorbed by the driven machine.
- Diameter and length of the shafts to be connected.

The bush type coupling is selected as shown in Fig.4. It is a rigid coupling. Coupling two shafts together sounds like a simple task, but the reality is somewhat different. Shafts are invariably misaligned to a greater or lesser extent, and the application requirement may be for accurate transmission of torque or, for example, some loss of accuracy here may be an acceptable downside to using a lower-cost coupling.
The type of coupling that is best suited to a particular application will also depend on the space available, shaft diameter, the torque, power and speed to be transmitted, the life expectancy required from the coupling, electrical conductivity (or insulation), the operating temperature range, and the nature of the shaft misalignment which may be radial, angular or a combination of the two.

Rigid couplings, having a split cylindrical body that is clamped to the two shafts, are simple and robust, easy to install and can be readily adjusted. Of course, being solid they cannot tolerate any misalignment.

Rigid couplings are the most effective choice for precise alignment and secure hold. By precisely aligning the two shafts and holding them firmly in place, rigid couplings help to maximize performance and increase the expected life of the machine.

D. Blades

Blades used in the areca fiber extraction machine are of rectangular shape. The blade is made from mild steel as shown in Fig. 5. The rectangular blades are cut according to the required dimensions as given below.

Length of blade = 11.5cm
Width of blade = 5cm
Thickness of blade = 1cm

E. Blades on drive shaft

There are 18 blades welded to the driven shaft. The blades are welded perpendicular to the driven shaft. Each pair of blades are at an angle of 180° as shown in Fig. 6. The adjacent pair of blades are at an angle of 90°. The distance between two blades is 7.5cm. The blades are made from mild steel. The pair of blades nearer to the duct opening is meant for throwing away the fiber from hopper side to duct opening and it has flap welded at right angle to the blade at the top. The diameter of the shaft used is 2.5cm. Hopper side to duct opening and it has flap welded at right angle to the blade at the top. The diameter of the shaft used is 2.5cm.
F. Design of Hopper

The Hopper is fabricated as per below dimensions and as shown in Fig. 7.

- Width of hopper = 14.5cm
- Length of hopper = 13.5cm
- Inclination of hopper with horizontal = \( \sin^{-1} \left( \frac{7.5}{13.5} \right) \)
  \( = 33^\circ \)

![Figure 7. Hopper](image)

G. Design of Duct

The areca husk is fed into the hopper and the fibers come out of the duct. The duct is also made of mild steel. The blades nearer to the duct are provided with flaps to guide the fiber through the duct as shown in Fig. 8.

![Figure 8. Design of duct](image)

H. Design of Casing

The casing is the most important component in the design of machine. The casing is made from 42 horizontal square rods of 24 inches length. The gap between the horizontal square rods is of 5mm and these gaps are provided in the casing to remove the dust from the areca husk as it comes with contact of blades. The casing is fabricated as per dimensions mentioned below and as shown in Fig 9.

- Diameter of the casing = 28.5cm
- Length of casing = 61.8 cm
- Width of square rods = 1cm
- Gap between square rods = 0.5cm

![Figure 9. Casing design used in the machine](image)

I. Dimension of Support

The supports will give stability to the machine and can withstand vibration. The support is of v shaped and totally 4 supporting rods are used in fabrication of machine. The support used in fabrication as shown in Fig 10.

![Figure10. Supports of the machine](image)

VII. DESIGN CALCULATIONS

A. Bearing Calculations

Bearing pressure, \( p = \frac{W}{L \times D} \)

\[
1.2 \times 10^6 = \frac{W}{(0.0388 \times 0.025)}
\]

\[
W = 96.926N
\]

\[
W = 9.88 \text{ Kg}
\]
Where,
\[ W \text{ weight in kg (Load on Bearing)} \]
\[ L \text{ is the length of bearing in m} \]
\[ D \text{ is the diameter of bearing in m} \]
Velocity of Shaft,
\[ V = \pi \times D \times N / 60 \]
\[ = (\pi \times 0.025 \times 1440) / 60 \]
\[ = 1.88 \text{ m/s} \]

Power lost due to friction,
\[ P = \mu \times W \times V \]
\[ = 0.09 \times 96.926 \times 1.88 \]
\[ = 16.39 \text{ W} \]

Where,
\[ \mu \text{ is the coefficient of friction which is 0.0-0.12 for pillow block bearing.} \]

The designed and fabricated fiber extracting machine as shown in Fig. 11.

**VIII. FIBRE EXTRACTION**

**A. Initial Preparation**
Areca husk was crushed and soaked in water and was dried for 2 days. The crushing is done manually by moving heavy vehicle over areca husk which removes dust and also weight of husk is reduced which helps in extracting areca fiber from areca husk.

**B. Working Principle**
Dried areca husk was soaked in water for about 2-3 days. The soaking process loosens the fibers and fibers can be extracted easily. The fibers were extracted by using areca fiber extracting machine. Areca husk is fed into the machine through hopper and comes into the contact with blades. Blades are fixed on the rotating shaft. The driven shaft is fixed in casing by two bearings at either ends of the casing. The motor is directly coupled to the shaft. The rotary action of the blades breaks the husk and differentiates them into coarse fibers and fine fibers.

The fine fibers are the individual fibers and coarse fibers are the clusters of fibers. The individual fibers and the dust come out from the casing from the gap in between horizontal square bars. The coarse fibers come out through the opening provided at the lower side of the casing.

The clusters of fibers are fed again into the machine and the process is repeated to get individual fibers. The fibers are thus extracted. An external fan is used to avoid contact with dust particles from areca husk during fiber extraction. The motor frame and casing frame are placed on rubber mat to avoid noise and vibration.

**C. Details of Areca Fiber Obtained**
The extracted fiber are collected and shown in Fig. 12. The fiber diameter are measured. The fibers diameter varies from 0.21 to 0.56 mm for randomly selected 100 fibers as shown in figure 13. The fibers are selected randomly with dried condition.

From this distribution curve the mean diameter of the areca fibers is found to be 0.385mm. The calculated average diameter of the areca fibers is 0.39305 mm.
From this it can be conclude that the mean diameter and the calculated average diameter are the same and are equal to 0.39mm. Therefore the average diameter of the areca fibers varies from 0.39 ± 0.12mm.

IX. CONCLUSION

- The overall performance of 5hp electric motor driven areca fiber extraction machine was satisfactory by considering the quantity of fiber produced.
- Areca fiber extraction machine is cost efficient and hence can be adopted for small scale commercial production of areca fiber.
- This machine can produce areca fiber which is 10000 times that of manually produced. Hence production rate is high.
- The areca fiber obtained was of good quality with diameter varying from 0.39 ± 0.12mm and length varying from 5-6cm.
- Areca fiber obtained can be used in packaging items, preparation of composites

REFERENCES