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# DESIGN AND FABRICATION OF AUTOMATED COIR DRYER

[1*]Jerome NithinGladson G, [2a] Dhinesh B, [2b] Dinesh V, [3a] Elango L

1* Assistant Professor, Department of Mechanical Engineering, Saveetha Engineering College
2a, 2b, 3a UG Scholar, Department of Mechanical Engineering, Saveetha Engineering College

## ABSTRACT

Coir fiber is available in abandoned which can be used for variety of applications such as reinforced concrete and natural fiber materials mainly composites with its value added application and its low cost and easy availability the coir has been the used in various applications. The project aims to dry to the coconut fiber which is preprocessing stage by coir dryer machine. The project began with collection of information and data on user lifestyle and current process by which they perform their job. The current difficulties were analyzed. Interviews were held with users. A comparative bench marking study was done on similar processes used in other similar extraction processes. Along with this an ergonomic simulation was made to understand the user difficulties and manufacturing methods to get an overview to provide solution to the user to suit their requirement. Concepts were generated keeping benchmarked product in view. Five concepts were generated with different functions and operating processes for coconut fiber extraction machine. Final concept was selected by considering the users' operating environment and maintenance, which could be used in small scale coir industries and in the farm sector. Considering the users' needs and buying capacity, a prototype was fabricated. This machine works with gear mechanism, in which 2 barrels rotates in opposite direction to extract fiber from coconut. Validation was carried out with the user group and the feedback was positive. It was noticed that there is potential market for this product. Further work could be carried in terms of aesthetics, material and weight reduction by adopting advanced manufacturing techniques.

***Keywords: Coir fiber, Gear Mechanism, Drier, Thermal effects.***

## 1. INTRODUCTION:

Coconut fiber, or coir, is a low-value by-product of coconut production. In most countries coir is discarded as waste, sometimes it is used as a fuel, in few instances it is processed into products. Coconut production is largely the domain of small, poor farmers, mainly for the sale of copra. Coconut farmers, however, could earn an additional income if there were a demand for coconut fiber. Productive use of the fibrous material contained in the husk practically only takes place in India. As coir is a coarse, short fiber, traditional applications for coir are generally low-cost mats and nets, brooms and brushes, and filling for mattresses and upholstery.

## 1.2 PROBLEM IDENTIFICATION:

We and our friends discussed and found at that the industries felt difficulties to drying up the coir fibers during rainy seasons.The industries found difficulties to dry up the coir without shrinkage of coir fiber and avoid fire accidents in drying the coir fibers. After dried up the coir fibers the weight loss of the coir should be avoided and shrinkage is reduced.

## 1.3 OBJECTIVE:

Our main objective is to dry up the coir without any shrinkage of coir fiber and avoid weight loss during drying up the coir fiber the fire accidents during drying up the coir should be avoided by means of placing the sensor in coir dryer. Our objective is to dry up the coir in all seasons to increase the production rate of the coir fiber in industries.

The focus of the project was on coir wet processing technologies, and was directed towards the research and transfer of technologies that would encourage further demand or traditional coir products.

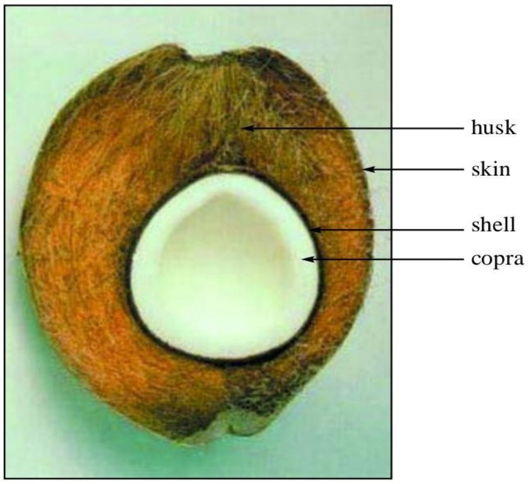



Figure 1 – Cross-section of coconut

## 2. COIR:

Coir fibers are extracted from the husks surrounding the coconut. In most areas coir is a by-product of copra production, and the husks are left on the fields as a mulch or used as fertilizer because of high potash content. India and Sri Lanka are the main countries where coir is extracted by traditional methods for the commercial production of a variety of products, including brushes and brooms, ropes and yarns for nets and bags and mats, and padding for mattresses. However, worldwide only a small part of the fibers available are currently used for these purposes (Table 2). The average fiber yield is dependent on geographical area and the variety of the coconut tree. In the south of India and Sri Lanka, for example, where the best quality fibers are produced the average yield is 80-90 g fiber per husk. Caribbean husks, by contrast, are relatively thick and may yield up to 150 g of fiber.

Husks are composed of 70 per cent pith and 30 per cent fiber on a dry weight basis. The ratio of yield of long, medium and short fiber, respectively, is on average 60:30:10. Based on these data and combined with the production data in Table 1, the maximum total world production of coir fiber (included short fibers) can be estimated to range between 5 and 6 million tons per year. Only a small part (less than 10 per cent) of this potential enters commercial trade. Continuousexpanding production of brown fiber reached 216 000 tons (70 per cent India, 27 per cent Sri Lanka) in 1996, while white fiber production (again, mainly in India) has remained stable at 125 000 tons.

### 2.2 COIR FIBER

The traditional production of fibers from the husks9, 10, 11,and 12 is a laborious and time-consuming process. This is highly polluting of surface waters13, 14,15 and results in the accumulation of large dumps of pith. After manual separation of the nut from the husk, the husks are processed by various retting techniques, and generally in ponds of brackish waters (for three to six months) or in salt backwaters or lagoons. This requires 10-12 months of anaerobic (bacterial) fermentation. By retting the fibers they are softened and can be decorticated and extracted by beating16, which is usually done by hand. After hackling, washing and drying (in the shade) the fibers are loosened manually and cleaned.

Traditional practices of this kind yield the highest quality of (white) fiber for spinning and weaving.

Retted fibers from green husks are the most suitable fibers for dyeing and bleaching. For the production of more coarse brown yarns, shorter periods of retting may be applied. These find an increasing outlet in geotextile applications,

Alternatively, mechanical processing using either defibering or decorticating equipment can be used to process the husks after only five days of immersion in water tanks.

Crushing the husk in a breaker opens the fibers. By using revolving "drums" the coarse long fibers are separated from the short woody parts and the pith. The stronger fibers are washed, cleaned, dried, hackled and combed. The quality of the fiber is greatly affected by these procedures.

Fig 2. Coir Fiber

**2.2COIR PITH**

As a by-product of coir fiber extraction large quantities of pith are obtained, which have been accumulating at production sites over the years. The extraction of 1 kg of fiber generates more than 2 kg of coir pith. Recently, however, the product has gained commercial interest as a substitute for peat moss in horticultural substrate cultivation. Low susceptibility to biodegradation and a highly porous structure enables coir pith to absorb large volumes of water (more than 50 per cent by weight), which makes it highly suitable in a potting mixture. For horticultural use, the product has to meet specific chemical and biological standards of pH, electrical conductivity and elemental composition. Repression of sodium and potassium from the cation complex of the coir may be desirable for many sensitive horticultural products. Technical information to describe microbial contamination and product safety is another concern for users. Exports of coir pith from India have increased from less than two per cent of the volume produced in 1997 to almost four per cent in 1998. Coir pith is also supplied from other production areas (e.g. Sri Lanka, the Philippines and Indonesia), and the penetration of coir pith into markets for horticultural and garden substrates is gaining interest.

**3. DESIGN DEVELOPMENT**

This section details the design process of the device, including conceptual designs, concept selection and preliminary analysis.

**3.1 CONCEPT GENERATION**

• It was clear to me that the final product would involve a slow speed motor with blower fan and the heating coil is placed horizontally to blow up a hot air. This device is powered by direct current source using wires and cables. The smoke sensor is placed to avoid fire accidents during drying up the coir fiber.

**3.1.1 STRUCTURE**

• Our design concept involved a slow speed motor which is connected to a blower fan to produce air. The design is inspired by MSME projects and by the industrial visit to the coir industry. The motor is placed outside of the wooden box.

• The wooden box is placed after the motorized fan the wooden box is made up of plywood to withstand heat. The heating coil is placed horizontally in the inside of the wooden box. The heating coil is wounded closely in all directions to avoid a flow of normal air. The heating coil is connected to the normal power supply unit. The motor and the heating coil is connected to the power supply and its operated by switches.

• The smoke sensor is placed above the wooden box and it is connected to the automated switch. The temperature of the coir fiber is known. If the smoke occurs during drying up the coir fiber the smoke sensor sensed and switch of the motor by automated switch.

• The smoke sensor, slow speed moor and heating coil is internally connected to the switches by wire to dry up the coir fibers. When the motor, heating coil and smoke sensor is switched on the wet coir is loaded to the wooden box when the hot is started to flow the coir fibers will started to dry. When the water content in the coir is dry up the coir will throw out by the flow of air. It is fully automated process to drying the coir fibers with less consumption of time period.

### 3.1.2 DESIGN GOALS

• Our main aim is to overcome the fire accidents during the time time of drying the coir fibers in the machine. Our device maintain the optimum temperature of the coir fibers during drying the coir fiber in the machine.

• As previously the industries felt difficulties while drying the coir the shrinkage in the coir fiber may occur and the over weight loss in the coir is also occur. Because of weight loss they exporting rate of the coir fiber is reduced by large amount.

• Our project mainly aims to overcome the shrinkage of the coir and weight loss because of maintaining the drying temperature constantly to overcome this difficulties.

• To overcome the main difficulties like manpower and drying the coir in rainy seasons. Our project is fully automated and it is used in all the seasons with less consumption of energy.

• Coconuts thrive in wet tropical climates, where monsoon rains prevent drying of wet processed products in the open air for much of the year. Therefore, it is essential for industrial productivity and export markets that suitable drying equipment be available at the various stages of production, to enable producers to continue to supply markets. Suitable drying equipment should meet criteria for throughput, reliability, ease of use and cost effectiveness.

• Suitable drying technologies for coir products should be cheap and effective. The more sophisticated technologies in use in modern food industries such as vacuum-drying, freeze drying, microwave drying or radio-frequent drying are neither practical for bulky fiber products nor likely to be economically viable. Drum drying is a conductive drying technique with efficient heat transfer, in which contact time with the hot drum is important. It is especially suitable for flowing powders. Hot air drying is the most obvious method for drying coir fibers, where drying rate can be controlled by air temperature and velocity of materials flow. In a fluid-bed dryer (or, alternative, spouted, pneumatic or vibrating bed dryers) the contact of the fibers with the air is improved by stirring the material, which results in a higher heat transfer coefficient to the product. The efficiency of theprocess is largely dependent on the cost of energy for generating the hot air.

• The CFC/FAO project set targets to develop a cost-effective drier for coir fibers based on low cost energy use. The CDA project team in Sri Lanka undertook this work. Domestic exporters recommended requirements for a commercial drier capable of handling a fiber throughput of two tonnes per hour, and with moisture reduction from 50 per cent to 15 per cent in a single pass.

## 4.THERMAL PROPERTIS

• Drying kinetics of coir fiber was studied and the properties of compressed coir pith discs were analyzed. Coir fiber particles were oven dried in the range of temperatures from 100 to 240 °C and the rehydration ability of compressed coir fiber was evaluated by finding the volume expansion. The optimum drying temperature was found to be 140 °C. Hot air drying was carried out to examine the drying kinetics by allowing the coir fiber particles to fluidize and circulate inside the drying chamber. Particle motion within the drying chamber closely resembled the particle motion in a flash dryer. The effective moisture diffusivity was found to increase from 1.18 × 10−8 to 1.37 × 10−8 m2/s with the increase of air velocity from 1.4 to 2.5 m/s respectively. Correlation analysis and residual plots were used to determine the adequacy of existing mathematical models for describing the drying behavior of coir pith. The empirical models, Wang and Singh model and Linear model, were found to be adequate for accurate prediction of drying behavior of coir pith. A new model was proposed by modifying the Wang and Singh model and considering the effect of air velocity. It gave the best correlation between observed and predicted moisture ratio with high value of coefficient of determination (R2) and lower values of root mean square error, reduced Chi square (χ2) and mean relative deviation (E%).

• Coir fiber samples of 700 ± 5 g each were oven dried at temperatures in between 100 and 240 °C at intervals of 20 °C. In industrial practice, the final moisture content of coir pith before compaction was found to be 15 ± 5 % (w/w, dry basis). A preliminary investigation was carried out to find the suitable range of final moisture content based on the volumetric expansion (VE) of the compacted discs. The highest volume expansion was recorded with the coir pith samples having final moisture content in the range of 12–23 % (w/w, dry basis). Therefore a final moisture content of 17± 1 % (w/w, dry basis) was selected and the drying time for each experiment was recorded. The dried samples were then compressed under 1500 psi using a hydraulic press, into the form of discs. The volume expansion of these compacted discs was measured in order to determine the optimum drying temperature.

• Equilibrium moisture content of coir pith for the given drying conditions of 140 °C and air velocities in the range of 1.4–2.5 m/s was found to be 12.73± 0.65 %. At the beginning, coir pith was available as lumps and these lumps were found to break within the initial period of drying due to the fluidization and circulating effect. This behavior is relatively similar to particle motion and drying within a flash dryer. Free moisture is available in two forms; within the lumps and around the surface of particles. indicates that moisture content linearly reduced with time but a clear difference could be observed for the initial stage of removing free moisture and the second stage of removing the bound moisture.

| **Temperature (°C)** | **Volume expansion** | **Drying time (min)** |
|---|---|---|
| 240 | 3.8 | 32 |
| 220 | 4.12 | 36 |
| 200 | 3.96 | 47 |
| 180 | 4.16 | 58 |
| 160 | 4.41 | 71 |
| 140 | 5.61 | 105 |
| 120 | 5.72 | 195 |

Table 1 Volume expansion of coir fiber dried under different drying temperatures

• Volume expansion of compacted coir fiber discs was found to be significantly affected by the drying temperature. An optimum temperature of 140 °C was identified for the drying of coir fiber by considering both volume expansion and drying time. Effective moisture diffusivity was found to increase from 1.18 × 10−8 to 1.37 × 10−8 m2/s with the increase of air velocity from 1.4 to 2.5 m/s respectively. Typically used mathematical models for thin layer drying with exponential functions were failed to describe the drying behavior of coir fiber. However, Wang and Singh model and Linear model gave good correlations. A new mathematical model was proposed and it was found to have the best correlation as compared to the other mathematical models used in this study. Model constants for the proposed model were found to be quadratic functions of air velocity. Since the experimental setup of this study closely simulated the particle motion and heat and mass transfer in flash drying due to induced fluidization and circulation, the new model has a great potential in designing and modeling of the flash drying of coir fiber.

• The effective moisture diffusivity was calculated using) and the values are summarized. Moisture diffusivity has increased from 1.18 × 10−8 to 1.37 × 10−8 (m2/s) with the increase of air velocity from 1.4 to 2.5 m/s.

## 5. FINAL DESIGN DESCRIPTION

• It is a motorized blower set up with heating coil to dry up the coir fiber without any shrinkage of coir fiber. It also controls the fire accidents during the time of drying the coir fibers.

• The smoke sensor plays a major role to avoid fire accidents in the time of drying the coir fiber in the machine. It is a user friendly setup ad it is operated easily by the unknown people also.

### 5.1DESIGN DETAILS

• The design consist of a wooden box for the user to load the wet coir fibers. If the switches are on it is dry up the coir fiber and throw the dryed coir in the out without any shrinkage and weight loss.

### PART SELECTION

| Component | Selection |
|---|---|
| Wooden box | 200 X 310 mm of thickness 10mm |
| Slow speed motor | 130rpm |
| Fan | 300mm(radii) |
| Heating coil | 2 fully wounded coil |
| Base plate | 170X140mm |
| Smoke sensor | 5mm IR diode |
| Wire | 2m |

• The wires are connected to the slow speed motor, heating coil, smoke sensor by means of that power is transmitted and the machine is operated by the user easily.

### 5.2DESIGN CALCULATION

Drying temperature of air=100 to 240 °C.

Optimum temperature=140 °C.

Effective moisture diffusivity= 1.18 × 10−8 to 1.37 × 10−8 m2/s Velocity of air=1.4 to 2.5 m\sec at the interval of temperature=20 °C Moisture content before=15 ± 5 % (w/w, dry basis)

Final moisture content=17 ± 1 % (w/w, dry basis) Coir sample=300g

DR = Mt+dt −Mt÷dt 1

Where, DR=drying ratio

MR=mt-me÷m.-me… 2

Where,

MR=moisture rate

mt= moisture content at time m.=initial moisture content

effective moisture deffisuvity

Deff= effective moisture dffusivity M=mas

R=radius of the sphere =40mm

MR=15-18\16-18

MR= 1.5 at the time period of 25min

Effective moisture diffusivity=0.289m\s at a velocity of 1.4m\s Moisture ratio=1.5 at the time period of 25min

### 5.3 DESIGN MODELING

• The 2d cad model is designed in the modeling software “AUTO CAD”.

• The coir is dryed by means of the hot air flowing inside the wooden box for particular period of time.

Figure3 Design Lay out

• The design clearly shows that the setup of coir dryer machine in the AUTO CAD software.

• The smoke sensor located above the wooden box is sensing a smoke and avoid a fire accidents.

• The heating coil is placed horizontally to produce a hot air to dry to the coir fibers.

• The smoke sensor is connected to the automated switch by which it is automatically switched off when the fire is occurs.

• The wires are internally connected and it is fully safe from the hot air and avoid fire accidents.

• The switch 1 is operated manually and switch 2 is operated automatically by means of automated switch.

## 6.FABRICATION

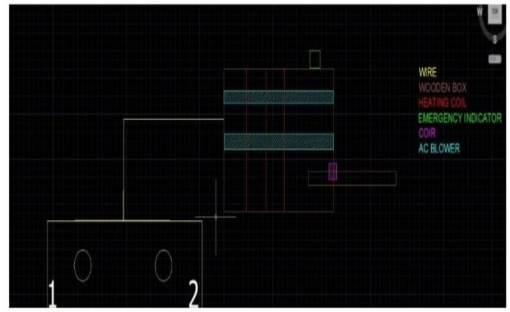
• The structure outlines the manufacturing process and it is a futuristic device to be used in the industries. It may be change the coir industries production drastically by means of this dryer.

### 6.1 CONSTRUCTION

• Once the ply wood was take for 200X110mm for a thickness of 10mm it is cutted by using saw and clamped by the nails at the corners. During clamping the nails the strength of the fiber is checked after that the nails are hamered to create a wooden box of required dimensions.

• The wooden box is drilled for the accurate dimension of the motor in the left face also the wooden box is drilled at the top for loading the coir fiber by the user.

• The motor is fitted with the blower fan of 300mm radii and the motor is connected to the switch by means of wire. The heating coil is placed horizontally inside the wooden box and the end of the coils are connected to the




same motor wire, in which the motor and heating coil is operated by a same switch named switch1.

• The smoke sensor is placed at the top of the wooden box and it is sensing the smoke inside the wooden box. The smoke sensor is connected to the switch 2 and it is a automated switch. When the smoke occurs inside the wooden box its automatically sensed and switch off the motor and stop the flow of air, by which the fire accidents in the drying process is reduced.

• The steel plate is placed below the wooden box it is placed by means of dragging mechanism. The steel plate is used to collect the dryedcoi fiber and it is dragged by wearing gloves because it have some heat by the flow of hot air.

| SI.NO | COMPONENTS | COST(RUPEES) |
|---|---|---|
| 1. | Slow Speed Motor | 2500 |
| 2. | Blower Fan | 400 |
| 3. | Smoke Sensor | 300 |
| 4. | Wooden Box | 400 |
| 5. | Wire | 200 |
| 6. | Switch | 100 |
| 7. | Heating Coil | 600 |
| 8. | Fabrication | 500 |
| **TOTAL** | | **5000** |

• The wooden box is fully covered without an air gap the hot air does not flow outside. The hot air produced fully used for drying the coir without any wastage of air.

• The temperature of the heating coil is maintained constantly from 140 to 200c by means of that fire accidents are avoided.

## 7. COST ESTIMATION:

## 8.CONCLUSION

• Implementing this system we can increase the production rate of coir in all the season it reduce the man power in industries By developing these project the production rate of the coir in very good quality to sale. The main usage of the project we can control the damage of the coir such that shrinkage and weight loss.

• A substantial part of the initial targets for the project to develop technologies to produce better quality and more attractive coir products with better consumer acceptance have been achieved. Although there is still work to be carried out as a follow up to the various project team activities, much more is now known of the chemical and biochemical aspects of wet processing of coir as the result of CFC/FAO project investments.

• Investment by the coir trade in the industrial drying of coir will become attractive only when the additional costs can be covered within the prices for coir and coir products prevailing in the market. This is directly related to the supply of products with confirmed specifications of quality required of markets.

• Costs of alternative technologies are high, and have generally not been introduced. R&D costs are equally high, and funds are difficult to raise for this traditional fiber commodity, since earnings from fiber production remain marginal. The majority of fiber producers operate on a small-scale at a village level and 39 are unable to contribute towards the costs of R&D programmes. The public sector may need to provide for industrial continuity, and also to encourage traders and others to develop and exploit novel markets that could provide a measure of security for smallholders and small-scale processors.

• Based on the Design concepts and development, output of the product. This product can de-fiber 100 coconuts per hour and it will be good for Farmers and small scale coir industries.

• About the market, this model is compact with good range of productivity with low cost and safety an avoid fire accidents during the time of dry up the coir fiber by this device.

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