Design of Lever Operated Coconut De-Huskingmachine

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Abstract- Coconut (Cocos) grows in more than 80 countries in southern and south-western Africa, Latin America and Asia. "Cocos" is old Spanish/Portuguese language and means "grinning face", which refers to the facial expressions at the "top" of the coconut's hard shell from which it sprouts. Coconut production plays an important pole in the national economy of India. However without the knowledge of proper de-husking of this nut, all the benefits of this fruit are wasted. Here we discuss those methods.

Keywords – de-husking, methods, lever operated, multifunctional.

I. INTRODUCTION

The coconut tree (Cocosnucifera), is a member of the family arecacea (palm family). It is the only accepted species in the genus Cocos. The term coconut can refer to the entire coconut palm, the seed, or the fruit, which, botanically, is a drupe, not a nut. The spelling coconut is an archaic form of the word. The term is derived from 16th-century Portuguese and Spanish coco, meaning "head" or "skull", from the three indentations on the coconut shell that resemble facial features. Found throughout the tropic and subtropics area, the coconut is known for its great versatility as seen in the many uses of its different parts. Coconuts are part of the daily diets of many people. Coconuts are different from any other fruits because they contain a large quantity of "water" and when immature they are known as tender-nuts or jelly-nuts and may be harvested for drinking. When mature, they still contain some water and can be used as seed nuts or processed to give oil from the kernel, charcoal from the hard shell and coir from the fibrous husk. All the parts of the coconut palm, except the roots, are used in a peasant's household, so it is no wonder that this tree has also been called 'Tree of life'. De-Husking is required for the proper utility of coconut which is described further.

COCONUT DE-HUSKING METHOD

Mechanical De-husker: Shown in fig 1.2

1. *Farmers* – A skilled husker can manually split and peel about 2,000 coconuts per day
2. *Households* – 1-2 coconuts per day
3. *Hotels* – 10-20 coconuts per day

Automatic De-husker: The main users of this type of application practices are by Oil extracting, fertilizer and food industries, etc. with the use of coconuts in mass quantity every year. These machines can process 2,000 coconuts per hour as shown in figure 1.1.


Fig 1.1


Fig1.2

II. USER STUDY

User study is done by observations of coconut de-husking in remote locations, villages, where farmers used to de-husk the coconuts by manual. The Steel spear is the tool used by farmers to de-husk the coconuts. An experienced worker can de-husk approximately 1000-1500 nuts per day with the use of this tool. Other than Steel spear, Lever operated de-husker is well reaching user in rural market and it is used more often by farmers. Pedal operated De-husker is refined design of lever operated coconut de-husker and it is designed for the application of farmers. This will help farmers in reducing de-husking time and increase in productivity. It is portable in design and height of the de-husker can be adjusted as per user requirement. The availability and marketing of this product is not reaching user in rural areas.

Coconuts in the husk are very bulky. The de-husked fiber is being transported in trucks or carts to the fiber/ coir industries for the fiber extraction process.

III. LITERATURE SURVEY

A. DETAILS OF PATENTS CHANDRA DINANATH

A machine specifically designed to remove the husks from the coconut fruit including a plurality of rollers rotating in opposite directions effectively toward one another wherein each roller includes a plurality of penetrating spikes sharpened to penetrate and effectively engage the husk portion of the coconut fruit (Figure 4.1). The interaction of the rollers in combination with the gripping action of the spike serves to tear away the husk from the nut leaving the nut intact. This invention relates to a machine for removing the husk from the nut portion of a coconut fruit in a manner which leaves the nut intact and insures that the husk is separated from the fruit and from the de-husking machine itself.

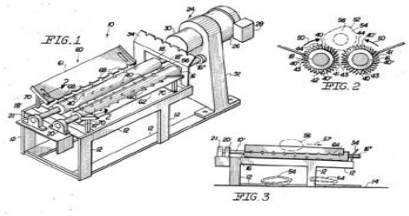

Fig. 4.1 US Patent US 4708056 A

B. *GILLES DURAND*

A machine (Figure 4.2) for removing the fibrous casing, said fill, the coconut, characterized in that it comprises: a system of continuous operation does not require stopping for loading the direction of chains pins guided nut which cause three rotary blades are designed to cut the floss after its ternary system and allowing the lifting of the three posts Boure by letting out the retractable nuts.

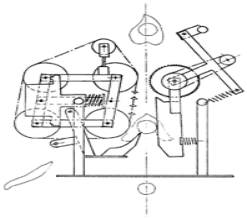

Fig. 4.2 EP 0188949 A1

SUMMARY OF LITERATURE REVIEW ON COCONUT FIBER EXTRACTION MACHINE

Literature study is carried out based on the existing patents on coconut fiber extraction machine, study gives opportunity to develop a compact coconut fiber extraction machine which could be used in remote villages so that unutilized husks from such areas could be tapped and fiber could be made available to the Coir Industry directly.

IV. CONCEPT GENERATION & SELECTION

After all the necessary study and understanding the customer needs, based on the major requirements concepts are generated. For generating these concepts or proposal ready considered all the points jotted out in QFD and product design specification (PDS).

Five concepts generated with various factors which meets the demands like functionality, safety and cost. Final concept selected for the working prototype manufacturing. This concept selected based on the dot selection method.

CONCEPT-1, HANDLE OPERATED

Manual operated coconut fibre extraction machine is considered as first concept, here handle is used to rotate, for which gears assembled, one gear will give drive to other gear, and Barrel rotates in opposite direction with the help of these gears. Coconut with untapped husk is placed in between barrels. Round coconut shell is removed by hand after the operation and separated fibre material is collected in sack below as shown in Figure 4.1.

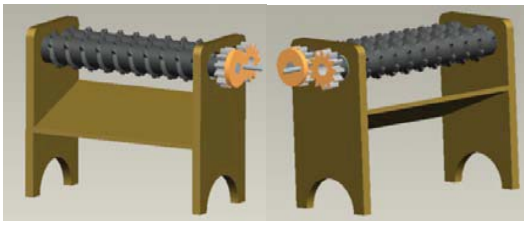

Fig. 4.1 Concept-1 Handle operated

CONCEPT-2, SEWING MACHINE TYPE

As name indicates in this concept sewing machine type paddling mechanism is attached to the base of the machine, with the help padding drive is given to gears. Handle is also used to start rotation, one gear will give drive to other gear, and Barrel rotates in opposite direction with the help of these gears. Coconut with untapped husk is placed in between barrels. Round coconut shell is removed by hand after the operation and separated fibre material is collected in sack below as shown in Figure 4.2.

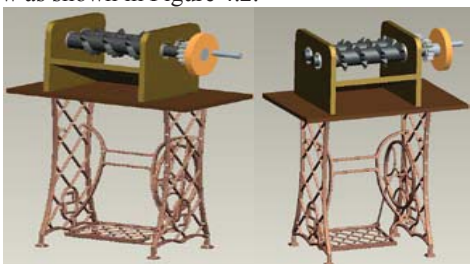

Fig. 4.2 Concept-2 Sewing Machine Type

CONCEPT-3, CYCLING TYPE OPERATED

As name indicates in this concept cycling type paddling mechanism is attached to the base of the machine, with the help padding drive is given to gears. Paddle with chain gear will give to drive to small chain gear sprocket, small chain gear sprocket is attached with large wheel, and large wheel will give drive to the smaller wheel with the help of belt drive, which is connected to gears. Barrel rotates in opposite direction with the help of these gears. Coconut with untapped husk is placed in between barrels. Round coconut shell is removed by hand after the operation and separated fiber material is collected in sack below as shown in Figure 4.3.

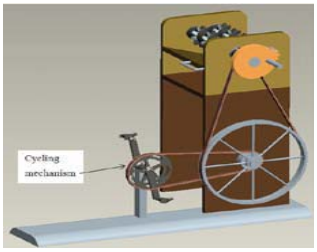

Fig. 4.3 Concept-3, Cycling Type

CONCEPT-4, MOTOR OPERATED TYPE-1

Motor operated type-1 coconut fibre extraction machine, in this type motor is attached at the base, smaller pulley at the motor end gives drive with the help V-belt to bigger pulley which is connected to gear. One gear will give drive to other gear, and Barrel rotates in opposite direction with the help of these gears. Coconut with untapped husk is fed from one end in between barrels and round coconut shell is moved automatically towards other end and is collected in the tub after the operation and separated fibre material is collected in sack below.

In this concept helical serrated teeth is engraved / Brazed on barrel surface to remove fibre and to give linear motion to coconut shell to exit. Helical serrated teeth play the major role in this type as shown in Figure 4.4.

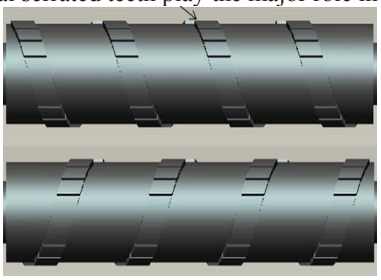

Fig. 4.4 Concept-4, Motor Operated Type-1

CONCEPT-5, MOTOR OPERATED TYPE-2

Motor operated type-2 coconut fibre extraction machine, this is also same as concept-4, motor is attached at the base, smaller pulley at the motor end gives drive with the help V-belt to bigger pulley which is connected to gear. One gear will give drive to other gear, and Barrel rotates in opposite direction with the help of these gears. Coconut with untapped husk is fed from one end in between barrels and round coconut shell is moved automatically towards other end and is collected in the tub after the operation and separated fiber material is collected in sack below.

In this concept cutting pins has been press fitted on indexed hole on barrel surface as shown in figure, cutting pins helps to remove fiber and to give linear motion to coconut shell to exit. Cutting pin indexing angle and distance plays the major role in this type as shown in Figure 4.5.

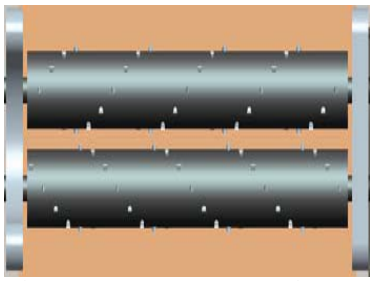

Fig. 4.5 Concept-4, Motor Operated Type-2

FINAL CONCEPT, LEVER OPERATED MACHINE

This is a totally new concept which involves the use of lever to de-husk the machine. Here the gear system and a long lever are used to perform the de-husking operation. The long lever is used in order to increase the torque applied and hence performing the de-husking operation effectively. Secondary operations can also be provided in this machine for example cutting and scrapping action can be performed.

Fig 4.6 Final Concept, Lever operated machine

DESIGN DETAILS

DESIGN OF SHAFT AND DEHUSKING TOOL

- Total force required = 60 kg X 9.81 = 588.6 N
- Total torque required to de-husk, **T = f X r** = 588.6 X 0.36 = 211.896 Nm
- Actual torque required, T = 211.896 X 2 = 423.792 Nm (Considering FOS = 2)
- Power obtained, $\mathbf{P = \frac{2\pi NT}{60}} = \frac{2 X \pi X 30 X 423.79}{60} =$ 1331.38 Watts
- Speed of the roller unit = 30 rpm

  From Design Data Hand Book (DDHB), Mild Steel Materials
- Density = 7850 Kg/m^3
- Yield strength, σ_y = 378 MPa
- Ultimate strength, σ_u = 585 MPa
- Young's modulus, E =210 GPa
- Shear modulus, G = 81 Gpa
- Poisson's ratio, ϒ = 0.3

DESIGN OF SHAFT

Assume, FOS = 2

- Working or Allowable normal stress, $\boldsymbol{\sigma} = \frac{\sigma_y}{FOS} = \frac{378}{2} =$ 189 N/mm^2
- Allowable stress in shear, $\boldsymbol{\tau = 0.5\,\sigma}$ = 94.5 N/mm^2
- Torque, M_t = 423792 Nmm
- General expression for torsion is, $\frac{M_t}{J} = \frac{G\theta}{l} = \frac{\tau}{r}$

  For strength, $\frac{M_t}{J} = \frac{\tau}{r}$

  $$\frac{423792}{\frac{\pi}{32}d^4} = \frac{94.5}{\frac{d}{2}}$$

  Therefore diameter of the shaft, d =28.37 mm

  For stiffness or rigidity, $\frac{M_t}{J} = \frac{G\theta}{l}$

  $$\frac{423792}{\frac{\pi}{32}d^4} = \frac{81X10^3X(1X\frac{\pi}{180})}{280}$$

Diameter, d = 29.48 mm ≈ 30 mm (From T 14.6 of DDHB)

Therefore diameter of the shaft, d = 30 mm

Therefore for the safer design of the machine we consider the standard shaft diameter as 30mm.

DESIGN OF TOOL

- Diameter = 10.5 mm, Length = 60 mm, Load = 588.6 N
- Bending Stress due to bending load, $\sigma_b = \frac{M_b}{I}C = \frac{588.6X60}{\frac{\pi}{64}X10.5^4} X \frac{10.5}{2}$ =155.37

  Therefore σ_b = 155.37 N/mm^2
- Shear stress due to torsional load, $\tau = \frac{M_t}{J}C$

  $= \frac{423792}{\frac{\pi}{32}X10.5^4} X \frac{10.5}{2}$

  Therefore τ = 1864.47 N/mm^2
- Maximum normal stress, $\sigma_{max} = \frac{\sigma}{2} + \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2}$

  $= \frac{188.37}{2} + \sqrt{\left(\frac{188.37}{2}\right)^2 + 1864.47^2}$

  Therefore σ_{max} =1943.77 N/mm^2
- Minimum normal stress, $\sigma_{min} = \frac{\sigma}{2} - \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2}$ σ_{min} =- 1788.40 N/mm^2
- Maximum shear stress, $\tau_{max} = \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2}$ τ_{max} = 1866.08 N/mm^2

THEORIES OF FAILURE FOR SHAFT

- Bending stress, $\sigma = \frac{M_b}{I}C = \frac{588.6X60}{\frac{\pi}{32}d^4} X \frac{d}{2}$

  $= \frac{1.8X10^5}{d^3}$N/mm^2
- Torsional shear stress, $\tau = \frac{M_t}{J}r = \frac{423792}{\frac{\pi}{32}d^4} = \frac{21.6X10^5}{d^3}$N/mm^2
- Maximum principal stress, $\sigma_1 = \frac{\sigma}{2} + \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2}$

  $= \frac{1.8X10^5}{2d^3} + \sqrt{\left(\frac{1.8X10^5}{2d^3}\right)^2 + \left(\frac{21.6X10^5}{d^3}\right)^2}$

  $\sigma_1 = \frac{22.02X10^5}{d^3}$ N/mm^2
- Minimum principle stress, $\sigma_2 = \frac{\sigma}{2} - \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2}$

  $= \frac{-20.71X10^5}{d^3}$ N/mm^2
- Maximum shear stress theory, $\tau_{max} = \frac{\sigma_1 - \sigma_2}{2}$

$$= \frac{10.76X10^3 + 10.98X10^3}{\frac{\pi}{32}d^3}$$

$$= \frac{64.6X10^3}{d^3} \text{ N/mm}^2$$

- The design equation, $\tau_{max} = \frac{\sigma_y}{2XFOS}$

$$\frac{64.6X10^3}{d^3} = \frac{378}{1X2}$$

Therefore diameter, d =28.37 mm

- Distortion energy theory, $\left(\frac{\sigma_y}{n}\right)^2 = \sigma_1^2 + \sigma_2^2 - \sigma_1\sigma_2$

$$\text{i.e.} \left(\frac{378}{2}\right)^2 = \left[\frac{32.32X10^3}{d^3}\right]^2 + \left[\frac{-10.74X10^3}{d^3}\right]^2 - \left[\frac{32.32X10^3}{d^3}\right]\left[\frac{-10.74X10^3}{d^3}\right]$$

Therefore diameter, d = 27.06 mm

- Total energy theory (Haigh's theory), $\left(\frac{\sigma_y}{n}\right)^2 = \sigma_1^2 + \sigma_2^2 - 2\sigma_1\sigma_2$

Substituting values in the above equation we get d= 26.42mm

Therefore diameter, d = 26.42mm

- Maximum normal stress theory, as $\sigma_1 > \sigma_2$, the design equation is $\sigma_1 = \frac{\sigma_y}{n}$

$$\text{i.e.,} \frac{32.32X10^3}{d^3} = \frac{378}{2}$$

Therefore diameter, d = 22.84mm

From the above calculation, we found that the shaft may undergo failure if it is below 22.84 mm diameter. So for the safer design we choose 30 mm standard diameter of shaft. Hence the design is safe.

V. APPLICATIONS & ADVANTAGES

Applications

The application of the Coconut de-husking machine is purely employed in the field of Agricultural forms where the coconuts are growing in more numbers. Also, it can be used in the field of coconut oil and coconut powder production factories for continuous husking of coconut palm.

Advantages

- Does not require the use of direct human force as in the normal. Instead it involves the use of roller mechanism and applying force with leverage.
- The sharp edged tools are used to enhance the force at the side of the coconut to put pressure.
- It is user friendly, rapid and can be operated safely.
- Small enough to be either carried by two workers or rolled into place.
- Can be conveniently assembled or disassembled.
- Removes husks of various shapes and sizes.
- The coconut shell of any thickness and hardness can be removed easily.
- Can be operated by anyone regardless of age.
- Simple and easy maintenance.
- Does not require lengthy training for the operation and the machine can be understood easily
- Portable.

VI. CONCLUSION

Coconut tree is called "the tree of life" for many reasons as mentioned above, but in order to utilize it efficiently the coconut fruit should be de-husked. The coconut de-husking machine is required to de-husk it efficiently and with the application of multi operational lever operated de-husking machine it's simpler and cheaper. It also allows performing multiple operations like scrapping and cutting.

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