Design and Development of a Coconut Dehusker for Small Scale Coir Industry and Marginal Farmers

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ABSTRACT

India is the world's third largest producer of coconut after the Philippines and Indonesia. India alone accounts for about 70% of the world production of coir and coir products. The total output of coir and coir products in India is estimated to be around Rs.1500.00 crore including exports of Rs.350.00 crore. All the parts of coconut orchard such as coconut husk, shell, copra, coconut water are useful. Coconut husk is used in coir industry, shell as a fuel, copra as food, coconut water as nutritious liquid. There are many farm equipment's and tools which are developed for the post harvesting operation of horticultural crops. The dehusking of a coconut is regarded as the most time consuming, tiring, and difficult operation to perform and involves much human drudgery.

Many attempts has been done to perform coconut dehusking manually as well as mechanized. Dehusking with traditional hand tools like machete or a spike depends on the skill of worker and involves training. Nowadays there is shortage of such skilled workers. The mechanized or the power operated machines are developed to eliminate the drawbacks of manual tools. Such manual tools and machines are developed all over the world and a very few have become popular, rest got vanished due to their limitations. The reasons for the failure of these tools include unsatisfactory and incomplete dehusking, breakage of the coconut shell while dehusking, spoilage of useful coir, greater effort needed than manual methods, etc. This present work aims to design and develop a semiautomatic coconut dehusking machine with eliminating the above mentioned drawbacks of the existing tools and machines. The machine conceived shall have main parts like deshuking unit mounted on a frame with electric motor as a power source along with speed reducing unit. The dehusking unit shall have a pair of cylindrical rollers with tynes (cutting pins) on its surface. These rollers will rotate in opposite direction with different speeds so that the tynes will penetrate into the husk and tear it away from the shell. The proper tearing of husk from shell occurs when the coconut offers good mesh with the tynes and it depends on the depth of insertion of nut into rollers and profile of tynes. As coconuts varies considerably in size and shape there is a need of adjustment in distance between pair of rollers for desired depth of insertion. Also the suitable profile of tynes is required for effective dehusking. These tynes shall be attached to the cylinders with fasteners so that replacement can be easily done.

Keywords: Tynes, Dehusking Unit, Peeling Strength, Penetration Strength, Coir Industry.

I. INTRODUCTION

Coconut (cocos nucifera) is one of the world's most useful and important perennial plants. The coconut fruit is made up of an outer exocarp, a thick fibrous fruit coat known as husk; underneath is the hard protective endocarp or shell [2].

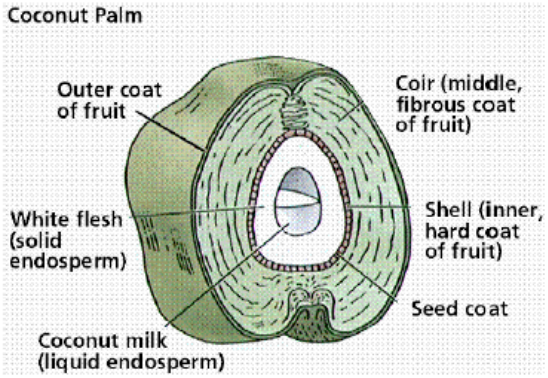

Fig. Parts of Coconut

The coconut palm is widely cultivated in the tropics. India is the world's third largest producer of coconuts after the Philippines and Indonesia. Other producers are Thailand, Malaysia, Papua New Guinea and the Pacific Islands. With coconut plantations extending over more than a million hectares, India produces about 5500 million nuts a year. Copra produced in the country is about 0.35 million tons and India accounts for about 50% of the world trade in coir. Coconut plantations are mostly concentrated in the coastal and deltaic regions of south India. In India, the crop is produced mainly by small and marginal farmers who number about 5 million. The average size of holding is as small as 0.25 hectares. With agricultural labour problems worsening and water resources dwindling, more and more plantation acreage is being converted from arca to coconut since the latter is easier to grow and more remunerative [6].

Coconut production plays an important role in the national economy of India. According to figures published in December 2009 by the Food and Agriculture Organization of the United Nations, India is the world's third largest producer of coconuts, producing 10,894,000 tons in 2009.

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Traditional areas of coconut cultivation are Kerala (45.22%), TamilNadu (26.56%), Karnataka (10.85%), Andhra Pradesh (8.93%) and also Goa, Orissa, West Bengal, Pondicherry, Maharashtra and the island territories of Lakshadweep and Andaman and Nicobar [1].

Almost all the parts of coconut are useful. The meat of immature coconut fruit can be made into ice cream while that of a mature coconut fruit can be eaten fresh or used for making shredded coconut and livestock feed. Coconut milk is a refreshing and nutritious drink while its oil is use for cooking and making margarine. Coconut oil is also very important in soap production. The shell is used for fuel purpose, shell gasifier as an alternate source of heat energy. The husk yields fibres used in the manufacture of coir products such as coir carpets, coir geo-textile, coir composite, coir safety belts, coir boards, coir asbestos and coir pith [2]. Coir is a versatile natural fiber extracted from mesocarp tissue, or husk of the coconut fruit. Generally fiber is of golden color when cleaned after removing from coconut husk. Coir is the fibrous husk of the coconut shell. Being tough and naturally resistant to seawater, the coir protects the fruit enough to survive months floating on ocean currents to be washed up on a sandy shore where it may sprout and grow into a tree, if it has enough fresh water, because all the other nutrients it needs have been carried along with the seed.

Although coconut is of immense economic importance to both the industrialist and rural dwellers, separation of its husk from the nut (dehusking) constitutes the first, most difficult and dangerous operation in its processing. The use of cutlass which is the popular traditional method for coconut dehusking poses threat and danger to the life of people involved, since on the process of dehusking, some cut their hands, and face as the cutlass usually bounces back on hitting the husk. The use of metal spike was later developed to overcome these negative features of dehusking of the fruit with matchet but this later development focused only on extraction of coconut meat even though accident, time and energy consumption was reduced . The search for a device that will enable effective recovery of other products of this fruit such as the milk, shell and fibre continued due to the importance of these coconut by-products in modern technological applications.

However, rural small scale farmers constitutes the major source of coconut fruits to the nation and the budget of this category of farmers cannot carry the huge investment requirement in both electric generator and costly motorized coconut dehusking equipment which are mostly of foreign origin. Also, the problem scarcity of petroleum based fuels such as petrol and diesel in this country since 1993 makes the operation of this electric powered equipment difficult. Thus, most Nigerian coconut farmer still use the crude method of dehusking by cutting with cutlass despite the adverse features of this technique. It is therefore of economic sense if a manually operated machine that can dehusk the fruit without nut breakage and distortion of the extracted fibre length is developed from standard and locally sourced materials to ensure affordability to rural based small scale coconut farmer of this nation and other developing nations in both acquisition and maintenance. Hence, objective of this study is to develop a coconut dehusking machine that can dehusk the fruit without nut breakage and distortion of the extracted fibre length for rural small scale farm-holders.[2]

II. LITERATURE

Hand operated coconut dehusker is widely used there to dehusk the coconut. Such a tool consists of two blades one is fixed to the upright column and the other is movable. The movable blade is attached to the handle. As force is applied on the handle the jaw rotates which helps in dehusking. While dehusking the coconut is impaled onto the blades in closed position, and then handle is lifted up to dehusk.

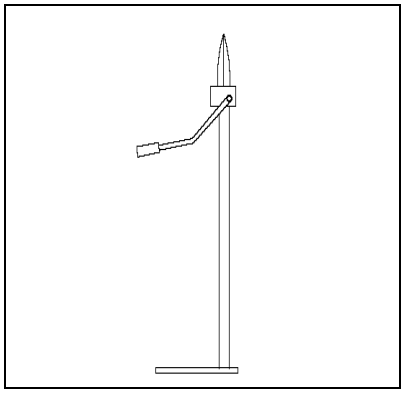

Fig. Coconut Husking Tool

The Coconut Dehusker is a manually operated tool. It consists of three set of blades each consisting of 3 blades. Upper unit is having 2 set of blades and lower half is having one set of blades. The upper one set of blades will first penetrate the husk, and then other upper set of blade will peel the husk away. This coconut dehusker comprises of three sets of three jaws. By operating these jaws the coconut is dehusked.

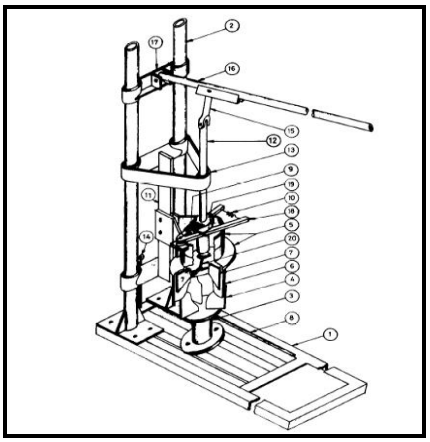

Fig. Hand operated Coconut Dehusking Machine

Young coconut is highly nutritious and is one of the most popular export fruit varieties in Thailand. The fruit structurally comprises green skin, exocarp of fibre, shell enclosing flesh and juice. The ‘‘Nam Hom’’ cultivar is generally preferred by consumers because of its taste and aroma. Maturity and development of the young coconut fruit strongly affects the fruit quality. The juice and the flesh of the immature fruit are, respectively, sour and oversoft (jellylike) while those of the overmature fruit are, respectively sweet and hard. Both of these stages are not favoured by consumers. The mature fruit is characterised by pleasantly sweet and

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slightly sour juice and moderately soft flesh, which the consumers love. There are several changes in physical characteristics, mechanical strength, sound, and physiological properties that change with the maturity of the young coconut fruit and are sensed by competent fruit growers. Such experience is personal and unavailable to the public. Young coconuts sold to fresh markets are usually trimmed of their outer husk so that the coconut looks attractive and can be easily opened.

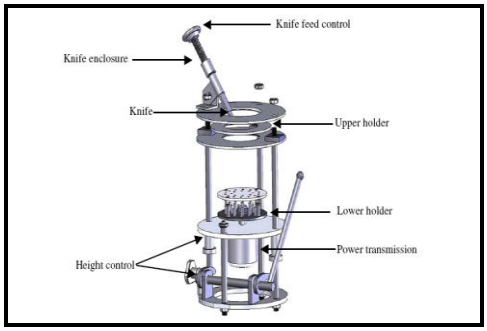

Fig. Young Coconut Dehusking Machine

C. P. Waters et. al**.** have developed a very simple concept to dehusk a coconut, by making use of a pair of tongs with pointed tips. His work relates to improvements in coconut husk removing tools. The tool developed have pivoted pair of tongs, these are provided with the handle and tips are pointed. The tips are inserted into the husk by manual force. After the handle are pressed together so that the tip which is inserted into fiber tries to move away by removing the fiber from the shell. It is highly efficient and inexpensive but still in this there is a lot manual force involved as well as it can result in injury to the worker.

Edward Hill et. al. have developed a simple yet effective tool to dehusk the coconuts. The husking of coconuts is a laborious, time-consuming and somewhat risky undertaking. No set formula seems to exist for handling this operation, but usually it is carried out with a knife or machete. These can be dangerous especially in dealing with a coconut due to its being ungainly. Additionally, it required considerable time to do the job, so that it has not been a profitable operation. This work provides a relatively simple tool for husking coconuts and one which does not pose risks and can be achieved easily quickly and without the necessity of prior training. The tool includes wedge blades which are forced into the husk and then one of the blades is shifted away from the other, thereby to tear loose a portion of the fibrous husk. This is repeated until the entire husk is forced from the seed. The entire operation can be accomplished quickly and easily.

III. MATERIALS AND METHODS

The developed coconut dehusker is consisting of the following parts,

1. Electric motor as a power source
2. Power transmitting gear train
3. Cylindrical Rollers
4. Threaded conical tynes
5. Swiveling Plates
6. Swiveling Plate Vertical Support
7. Shaft and Bearing Assembly
8. Gear Box
9. Cylinder intermediate distance adjustment mechanism
10. Supporting Frame

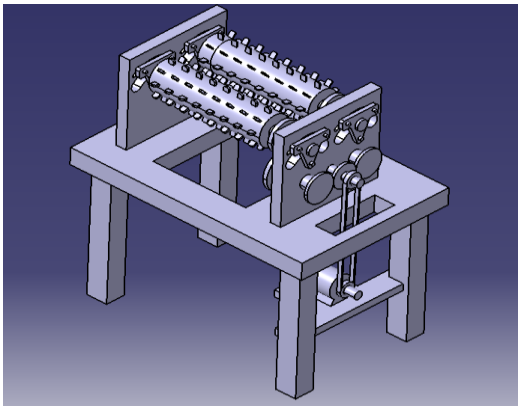

Fig. Cad Model of Coconut Dehuking Machine

Table. Materials and their composition.

Sr. no.	Description	Material	Composition
1.	Cylindrical Roller	EN24	Carbon- 0.36% Silicon- 0.20% Manganese- 0.45% Sulphur- 0.040%
2.	Roller Shafts	Stainless Steel	Carbon- 0.15% Silicon- 0.50% Manganese- 1.00% Sulphur- 0.03%
3.	Bearing Supports	EN24	Carbon- 0.36% Silicon- 0.20% Manganese- 0.45% Sulphur- 0.040%
4.	Frame	MS	Carbon- 0.29% Manganese- 0.80%

These elements mentioned above will be placed over the supporting frame. To transmit the power from motor to cylindrical rollers gear and pulley transmission system shall be incorporated. The dehusking unit is consisting of cylindrical rollers attached with tynes (cutting pins) over the surface. The coconut is placed in the intermediate distance between rolling cylinders. The rollers will rotate in such a way that there will be tearing of coconut fiber from the shell. With proper meshing of fiber with tynes effective dehusking is achieved with consuming lesser time.

The shape and size of coconut is considered while designing the machine. From the studies conducted on the green and dry coconuts collected from the midlands of the two districts of Ernakulam and Kottayam of Kerala, India, the physical properties of coconut are as follows.

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Table. Physical Properties of Coconut

Particulars	Dry Coconut
Shape	Ovoid
Length, *mm*	210-270
Diameter, *mm*	160-206
Weight, *kg*	0.62-1.25
Shell Diameter, *mm*	80-120
Husk Thickness - at pedicel end, *mm*	62
Husk Thickness - at apex end, *mm*	34
Husk Thickness - 1/4th distance from pedicel end, *mm*	32
Husk Thickness - 1/2th distance from pedicel end, *mm*	24
Husk Thickness - 3/4th distance from pedicel end, *mm*	28

The force estimates using a Universal Testing Machine are as follows:

Table. Force Estimates of Coconut Husk

Condition of coconut	*Force for piercing (kg)*	*Force for peeling (kg)*
Raw (green colour)	230–250	35–40
Moderately dry	250–280	35–45
Dry (brown colour)	280–300	35–45
Completely dry (greyish colour)	300–320	40–45

The average dimensions of coconut are found as follows

1. Shape : Ovoid
2. Dimensions : 300 mm long X 200 mm wide
3. Thickness of fiber : 20 to 40 mm
4. Weight : 1 Kg
5. While dehusking the coconut husk removes as 3 parts, each of width : 40 to 80 mm

Design of Various Element of Coconut Dehusker shall be carried out as follows

A) Design of Cutting Tynes:

The adhesion between fibers in the husk is greater than that between the shell and the husk; hence separation occurs at the husk-shell interface. The thickness of fiber is in the range of 20 to 40mm. The dimension of tynes should be so selected that to get effective penetration with coconut.

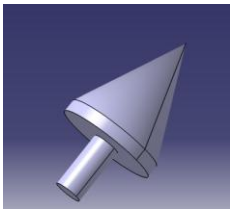

Fig. Cad Model of Tyne or Cutting Pins

The tynes can be attached to cylindrical rollers either by welding or by using fasteners. The advantage of using fasteners is that the damaged tynes can be easily replaced.

B) Design of Cylindrical Rollers:

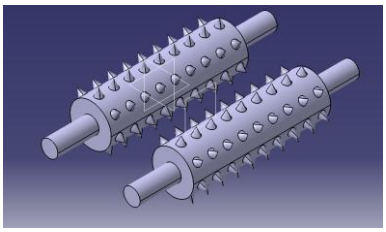

Fig. Cad Model of Cylindrical Rollers

The dimensions of cylinders are designed in a manner to obtain effective mesh with coconut husk. Assumptions used,

1. Coconut contacts with cylinder at an average angle of 30 degree contact sector
2. The 1/6th of width of coconut should be inserted into the intermediate space between cylinders. (Approximately 30mm).

C) Horizontal and Circular Pitch of tynes:

Both horizontal and circular pitch has to be designed. Horizontal pitch is the distance between tynes along the axis or length of cylinder. Circular pitch is the distance between tynes about the periphery of cylindrical roller. For selecting the horizontal pitch the average length of coconut is to be considered. It is found to be 300mm. The tynes are mounted on cylinder in such a way that optimum number of tynes should be in contact with the coconut. This will help in reducing the load on each tynes and increase efficiency of dehusking operation. For selecting circular pitch average width of coconut is found to be 200mm. Suitable number of tynes should be selected to have good mesh and effective dehusking.

D) Provision for Adjustment of Intermediate distance between rolling Cylinders:

As coconuts varies considerably in size and shape there is a need of adjustment in distance between pair of rollers for desired depth of insertion. For making such adjustment two radial slots are made into the vertical plates.

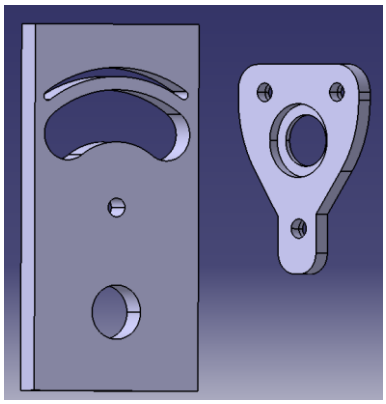

Fig. CAD Model of Vertical Plate and Swiveling Plate

The two gears are mounted on the shafts of cylindrical rollers, meshing with other gears fitted on a shaft in the vertical plate. So the roller gear and fixed gear are meshing with each other. The bearing on roller shaft is press fitted into the slot on swiveling plates. This bearing can move into the

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radial slot of vertical plates. Pair of swiveling plate is fitted with vertical plates by using 3 set of nut and bolts. One bolt at the bottom is inserted in a hole on vertical plate. Other two bolts are placed in radial slot of vertical plate into which these can be moved along the radial groove. Whenever we are interested to change the intermediate distance between the cylindrical rollers, the swiveling plates are loosened and shafts are shifted according to the size of coconuts and then as desired intermediate distance is achieved the 3 set of nut and bolts is tightened.

The cylinders with cutting tynes are mounted on shafts and are fitted into the radial slots by using bearings and swiveling plates. The bearings are press fitted into the swiveling plates. Each pair of these swiveling plates can be firmly attached to the vertical plates with nut and bolts.

For effective dehusking of coconut it should get good mesh with rollers. As coconut varies considerably in size and shape depending upon variety and maturity if the distance between rollers is constant for such a variation in size and shape effective dehusking would not be achieved. It is stated that $1/6^{th}$ of width of coconut should be inserted into the intermediate space of cylinders i.e. approximately 30mm for effective dehusking. For that the shafts has to be moved into the radial slots to make that desired change in distance between cylinders.

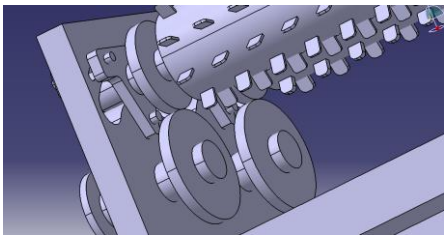

Fig. Adjustment in intermediate distance between shafts

As the shaft is moved radially into the slot the gear on shaft will roll over the fixed meshing gear and when the desired intermediate distance between cylinders is obtained that position can be fixed with nut and bolts of swiveling plates.

E) Power Transmission and Speed Reduction Unit

The power from electric motor is transmitted to the rotating cylinders through pulleys and gears. Power should have less speed and high torque at the rotating cylinders and this is obtained by using a speed reduction gearbox. The gears and pulleys will be arranged in such a way that desired output is obtained by making use of readily available sizes of gears and pulleys, so as to keep the manufacturing cost low.

IV. CONCLUSION

Coconut is grown on a large scale in India, this horticultural crop have become source of income and employment in many parts of southern states. All the parts of coconut earn revenue and some are even exported like coir products. Post harvesting operation of coconut is tedious job to perform, and involves much human drudgery. Skilled workers for coconut dehusking are diminishing these days. Many attempts have been made to mechanize this operation by developing various tools and even power operated machinery.

The present work aims to develop a semi-automatic power operated coconut dehusking machine with eliminating the drawbacks of previously developed tools and machinery. The proposed machine makes use of rotating cylinders with cutting tynes attached over their surface, which rolls in opposite direction to remove the husk from the shell of coconut. A provision to adjust the distance between rotating cylinders is made to accommodate various sizes of coconuts due to change in variety and maturity. The cutting tynes are attached to the cylinders with fasteners so that easy replacement of damaged tynes is possible. Accordingly the proposed machine will be designed thoroughly, manufactured and tested.

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