Fabrication of modern motorized Coconut (*Cocos nucifera*) De-husker to reduce the fatigue of the humans

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Abstract : Coconuts are normally de-husked manually using either a machete or a spike. Attempts made so far in the development of de-husking tools have been partially successful and ineffective in replacing manual methods. The reasons for the failure of these tools include unsatisfactory and incomplete de-husking, breakage of the coconut shell while de-husking, spoilage of coir, greater fatigue in manual methods, etc. A power operated coconut de-husker was developed to increase the de-husking efficiency and reducing the fatigue of the operator. This paper describes the design modification and performance evaluation of de-husker as well as the implication of the results obtained. The de-husker principally consists of electric motor of 1 hp 3 phase, two rollers each of diameter 520 mm length and 150 mm diameter with the thickness of 3mm, gear reducer of 5:1 ratio and V-belt pulley. The machine includes a base positioned on a supporting surface with two rollers. The rollers are forced to rotate in the opposite direction towards the center at different speeds (driving gear- 11.5 rpm and driven gear- 5.7 rpm). Penetrating spikes are formed on each roller which are arranged in a patterned array that facilitates the penetrating, gripping and shearing of the coconut husk. The time taken for de-husking a coconut was found to be 14 sec. The machine worked efficiently with dry coconut of the moisture content 25-35 %. The average capacity of the machine was 220 nuts per hour, whereas in manual method it was 150 nuts per hour.

***Index Terms*— coconut, power operated, de-husking, motor, rollers**

I. INTRODUCTION

Coconut, the fruit of the coconut palm tree which has the scientific name as Cocos nucifera, belongs to the family arecaceae [1]. Philippines and Srilanka are the world largest producer of coconut. It is found in the tropic and sub-tropic areas (Chan and Elevitch, 2006). Coconuts are large, dry drupes, ovoid in shape, up to 15" long and 12" wide. The coconut is smooth on the outside, yellowish or greenish in color. Within the outer shell is a fibrous husk one to two inches (2.5 to 5 cm) thick.

In Philippines, the coconut is commonly called the “tree of life” (Margolis, 2006). The inner shell is brown and hard, surrounding the white coconut meat. Coconut husks are the rough exterior shells of the coconut. This outer shell or husk has to be removed for the usage of coconut. Coconuts are different from any other fruits because they contain large quantity of water and when immature they are known as tender-nuts may be harvested for drinking. When they mature they still contain some water and can be used as seed nuts or processed to give oil from the kernel, charcoal from hard shell and coir from fibrous husk [2].

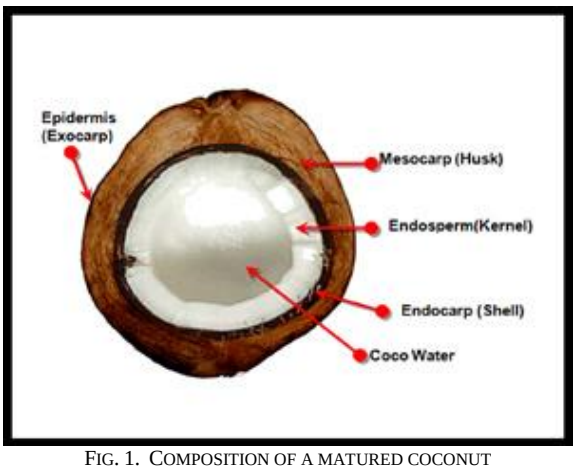

FIG. 1. COMPOSITION OF A MATURED COCONUT

TABLE I
ESTIMATION OF PRODUCTION OF COCONUT

States / Union Territory	Area '000 Hectares	Production	Productivity
Kerala	797.21	5968.01	7486
Karnataka	517.29	5041.15	9745
Tamil Nadu	465.11	6917.25	14872
Andhra Pradesh	121.92	1828.46	14997
Odisha	50.78	324.93	6399
Gujarat	31.63	295.03	9328
West Bengal	29.30	370.83	12656
Maharashtra	28.08	187.47	6676
Goa	25.75	128.13	4976
Andaman & Nicobar Islands	21.90	129.97	5935
Assam	20.23	136.61	6753
Bihar	15.25	141.42	9273
Tripura	6.91	28.30	4096
Lakshadweep	2.57	70.91	27591
Puducherry	1.96	34.09	17393
Telengana	1.61	24.09	14963
Chhattisgarh	1.52	22.10	14539
Nagaland	1.45	16.32	11255
Mizoram	0.03	0.12	4000
All India	2140.50	21665.19	10122

By products

Major coconut products like husk and shell can be converted to value added products like activated carbon, shell charcoal, shell flour and shell based handicrafts.

Some of the by- products of coconut are:

1. The nut
2. The shell
3. The coir

The Nut: It is used in food processing industry and commonly used in homemade foods, sweets etc. Coconut oil is extracted from the nut (dried) which is also used as hair oil and even used for cooking.

The Shell: In ancient period, people used the shell as weapon. Even now, the shell is used as a fuel in many small- scaled industries due to high carbon content. It is normally used in rural areas as cooking fuel. Now days the shell is used in modern paintings and carvings.

The Coir: Though the coir industry predominantly works on traditional finished yarns for ropes, matting and carpets, new avenues have emerged for the use of coir in the manufacture of panel boards as replacement to timber, sidewalls, floors and train seats. The coconut pith is used a soil former and agricultural nutrient. In Tamil Nadu, Karnataka and Andhra Pradesh, coconut husk was extensively used as fuel by the brick industry and sugar mills. Even though there will some problems to perform de-husking. In the harvesting and commercial growing of coconuts, a problem exists in the ease of removal of the relatively hard and difficult to remove husk portion. Coconut fruit of the type grown commercially is valuable for both the nut as well as the husk itself. The manual dehusking involves risk due to injury, time consuming and labour fatigue. This leads to less productivity and more labour cost. Based on the above facts a power operated coconut dehusker, which serves to separate the husk from the nut in a manner which will facilitate clean separation and gathering of the husk and recovery of the nut is essentially required. Hence, the project on development of a coconut dehusker was taken up for medium scale dehusking. The operational cost of the machine was estimated and the operation cost of the machine was compared with the conventional method.

II. TRADITIONAL METHODS OF DEHUSKING THE COCONUT

De-husking Coconut using Machete

The coir, which is the coconut husk has become a very useful substance in today's environmental and economic concerns. It was used for repelling mosquitoes when burnt and if it is shredded, can used as pillows, mattresses and to provide the fiber for making clothing, to make filters for aquariums, the fiber can now be used in place of synthetic fiber for making automobile parts and as fuel. Fig 3 shows one of the traditional methods of dehusking coconut using a machete [3]. This consumes human energy. This method is skilful, risky and tedious. The use of the machete poses danger to the worker.

Two blade dehusking machine

In this two-blade model, one blade is inserted inside the husk of the coconut and nother blade helps in the process of peeling. A 1.5 hp motor is coupled through a belt to a long cylindrical metal rod. Two sharp blades are fixed at the tip of the rod. The blades are three - quarter of an inch long and placed one inch apart. The rotation of the blades would dehusk the coconuts. A switch is used to operate the machine. The principle of this machine is conversion of electrical energy from electrical motor into mechanical energy in terms of rotation of the centrally mounted iron shaft. The power is being transmitted to the rotating shaft from the electric motor through the belt-drive. This rotation facilitates the dehusking process. A better grip on the coconut is provided by the iron plate, which acts as the stopper that prevents the nut to slip away vertically. Hands of the worker may get damaged because he/she has to hold the coconut during dehusking [3].

Hydraulic Dehusking machine

There are many hydraulically operated dehusking machine available in the market which are used to remove the outer coconut husk from the coconut fruit. They are capable of dehusking 350 pieces of coconut fruit per hour with single operator. These type of machines require more care and maintenance. They are reliable to certain extent because of breakage during operation. This involves skilled labour who has to know the complete theory of operation of hydraulic systems and properly trained to operate and maintain it. The machine is very expensive and the technology involved in the machine is complex and inaccessible.

III. RECENT METHOD OF DE-HUSKING COCONUT

Ganesan (1984) worked on a dehusking machine for coconut. The unit consists of three pairs of mild steel blades mounted at 120 degrees apart at one end of the sliding mechanism. The sliding effect is achieved by rolling over a cam. Jacob and Bastian (1998) developed a domestic dehusking tool commercially known as KAU Coconut Dehusking Tool (KAU CHT) [4]. It consisted of a stationary wedge, movable wedge, hinge pin, wedge seat, lever and pedestal with base. The lever fixes to the one end of the hinge pin helped in the swivel of the movable wedge and provide the necessary mechanical advantage needed in the dehusking.

IV. MATERIALS AND METHODS

The design details and the constructional features of the de-husker are given as follows:

Calculation of power requirement

Design Stress of the peg material: Mild steel, with a safety factor (S.F) of 2.2, was selected for normal conditions.

Yield Stress of Mild Steel = 295 MPa (Budynas and Nisbett, 2011)
Design stress = Yield stress/ S.F---------- (1)

Substituting in equation 1

= 295* 106/ 2.2
= 134.09 Mpa

Therefore, 35 kg of force is required at the spikes for de-husking a coconut (Mahadevan, K. and Reddy, B. K. (1987)
Force required = 35 kg
= 343.35 N

Distance between centres of roller, C = 0.115m
= F* C
= 343.35* 0.115
= 39.485 N-m

Assuming roller speed N_1 as 11.5 rpm and N_2 as 5.7 rpm and efficiency of the machine as 85%:

Power required, hp = $2\pi N_1 T/ 4500$ (Khurmi and Gupta, 2005)---------- (2)
where,

T = Torque (kg-m)
N_1 = Roller speed (rpm)

Substituting the value of N_1 and T= 51.22 in the equation 2, we get the power required as 0.83 hp.

Actual power requirement = Calculated hp/ Mechanical efficiency ---------- (3)

Assuming 85 % of mechanical efficiency, actual power requirement by equation 3 = 0.83/ 0.85 = 0.922 hp

Hence, 1 hp motor was selected.

Selection of spur gears:

No. of teeth (driving gear) = 65
No. of teeth (driven gear) = 120

V. MACHINE DESIGN

The machine includes a base positioned on a supporting surface, such as floor of the processing plant. Two rollers each having an elongated configuration is disposed in spaced apart, parallel relation to another on the base. Interconnection of the rollers are forced to rotate in an opposite direction relative to one another end and at relatively different speeds (driving gear = 11.5 rpm, driven gear = 5.7 rpm). The rollers rotate in a direction towards the centre such that a coconut will be forced into the spacing between the rollers.

An important feature is the existence of a penetrating means formed on each roller. Each spike was arranged in the distance of 7.5 cm in parallel. The spikes are in the patterned array, which facilitates the penetrating and gripping and shearing of the coconut husk.

The electric motor (1hp) with 5:1 speed reduction unit is used to drive the rollers. The power is transmitted from motor to reduction unit using V- belt and further power from reduction unit to rotating rollers is transmitted with shaft. During operation, the spikes penetrate the coconut and because of shear force, dehusking of coconut takes place.

Development of Coconut De-husker details

The power operated coconut dehusker consists of the following components:

1. Roller
2. Spike
3. Motor
4. Power transmission

Rollers: There are two rollers with the dimension of 520 mm length and 150 mm in diameter. The rollers were made of a mild steel sheet with the thickness of 3 mm. The rollers define two outer exposed surfaces, which are considered the upper portions of the roller. In such an orientation, the rollers rotate in a direction towards the centre such that a coconut, place thereon, was forced into the spacing between the rollers. A set of rollers was used to produce shearing force.

Spikes: The spikes were arranged in a plurality of rows wherein each row has an elongated, curvilinear configuration extending at least along a major portion of the length of each roller. The spikes were sharpened and shaped with the help of lathe machine and set from one another in a substantially equal distance in a patterned array in which the plurality of spikes of each roller were positioned to facilitate the penetrating, gripping and tearing of the coconut husk once placed on the exposed outer portion of the roller. The relative rotation, in the fore mentioned opposite direction, serves to provide the tearing action on the husk once penetrated by the spikes. The total numbers of pikes were 108 and the length and diameter of the spikes were 10 mm and 25 mm.

Motor: The prime mover selected was 1 hp 3 phase motor. The maximum rotational speed of the motor was 1440 rpm.

Frame: It includes a support base mounted or supported on a surface, the floor of dehusking machine with the length of 62.5 cm followed by the width 60.0 cm and Height 77.0cm.

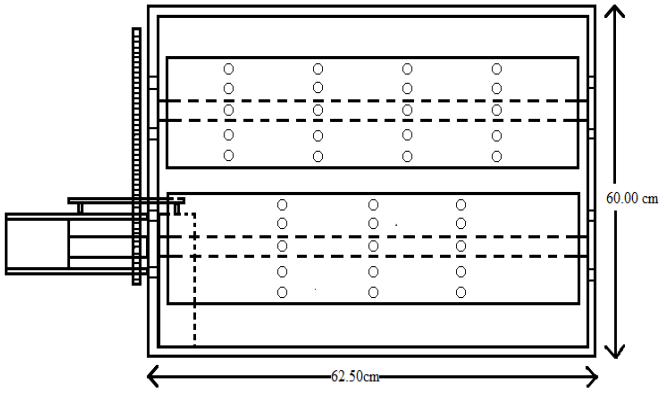

Fig. 2. Top view of the Machine (AutoCAD Diagram)

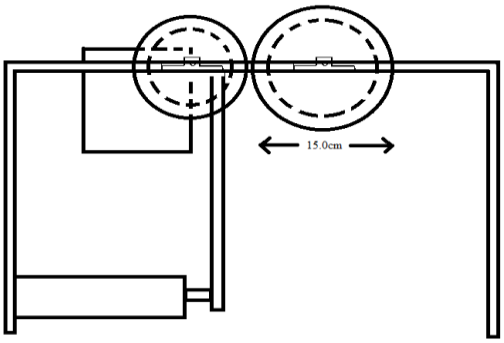

Fig. 2. Side view of the Machine (AutoCAD Diagram)

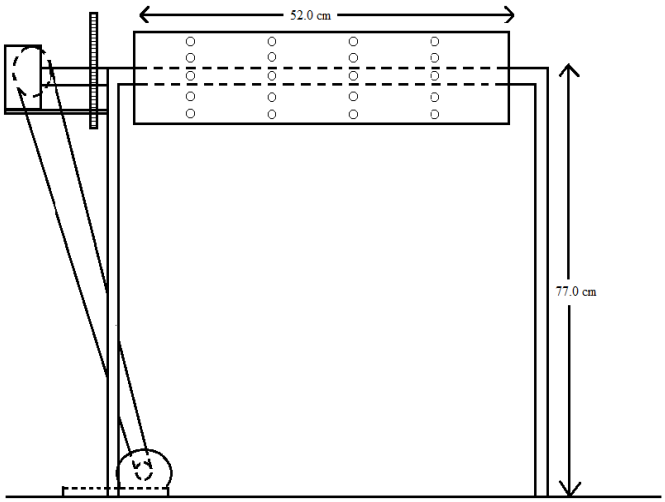

Fig. 3. Front view of the Machine (AutoCAD Diagram)

VI. RESULTS AND DISCUSSION

In the first trial, it was observed that the breakage of coconut and the dehusking was improper. The reason is that the distance between the rollers was 2.5 cm causing the slippage during the operation. The distance between the rollers were adjusted to 5 cm. It was also found that the dehusking was improper due to the peg length and the roller speed. When the peg length was 5 cm. The penetration depth was higher in the coconut and the shell portion was damaged. Hence, the length was reduced to 2.5 cm and the trials were conducted. At this dimension, the dehusking was better and there were no damage to the shell.

The roller speed was initially fixed as 30 rpm. Due to the higher speed, the slippage was higher at one end of the coconut and was caught between the rollers. Hence the was reduced to 11.5 rpm. From the dehusking result, it was observed that the clearance of 5cm, peg length of 2.5cmand the roller speed of 11.5rpm was found to be better for dehusking dried coconut.

The maximum voltage and maximum current required for dehusking were found to be 415 volts and 5.2 amperes respectively. The maximum power required was found as 1 hp and the average time taken for dehusking the coconut was 14sec.

TABLE II
DETERMINATION OF COST OF MACHINE

S.No	Particulars	Quantities	Cost (Rs.)
1.	GI Hallow shaft	2	500
2.	1'' MS rod	15kg	350
3.	3/8'' Stud bud	84nos	150
4.	1 HP 3 phase motor	1	5000
5.	1'' bearing	4	800
6.	2'' B- Pulley	1	300
7.	12'' B- Pulley	1	600
8.	V- Belt (B-52)	1	150
9.	Spur gear	2	1100
10.	1 ¼ '' MS Rod	3kg	150
11.	1'' x ¼ '' L Angle	36.5kg	800
12.	2½ '' Bolts and Nuts	6nos	40

13.	1½ Bolts and Nuts	10nos	50
14.	2,3/8 '' Bolts and Nut	2nos	10
15.	Labour Charge	Single	6000

Determination of the Operational Cost

i. Cost of dehusker (P) = Rs. 16000
ii. Useful Life (L) = 20000 hours in 20 years
iii. Annual usage = 1000 hours
iv. Interest rate = 5%
v. Salvage value (S) @ 10% of (P) = Rs. 1600

Depreciation Cost

D = P- (S/L)
= 16000-(1600/20000)
= Rs 0.72 per hour

Interest on investment

I = (P+S)* interest/ 2 *100* working hour in a year
= (16000+1600)* 5/ 2* 100* 1000
= Rs. 0.44 per hour

Repairs and maintenance cost

R = P*12/ (100* 2000)
= 16000*12/ (100* 2000)
= Rs 0.96 per hour

Electricity cost for 1 hr

E = 3*736W
= 2.208 kw* 5
= Rs 11.04 per hour

Wages for the operator

W = Rs 240/ day of 8 hours
= Rs 30 per hour

Operational cost of dehusker

Cost = 0.72+0.44+0.96+30
= Rs 42.1= Rs 42 per hour

Cost Appraisal

Time taken for dehusking s/nut = 14 sec
Average capacity of the unit nuts/hr = 220
Cost of operation of unit (Rs.) = 42
Cost of dehusking (Re./nut) = 42/220
= Rs. 0.19

TABLE III
COMPARISON OF MANUAL AND MACHINE METHODS

S.No	Factors involved	Manual Method	Machine Method
1.	Labours involved	5 persons	1
2.	Wages	Rs. 175/hr	Rs. 42/hr
3.	Efficiency	Fatigue	Constant Output
4.	Production	250/hr	360/hr

VII. CONCLUSION

A low cost automated de-husking machine has been implemented in the field of agriculture to reduce the man power completely and to increase the productivity. The developed unit can de-husk the coconut of size ranging from 10 cm to 15 cm of diameter. The cost of operation of de-husker was calculated by using standard procedure. The cost of de-husking is Rs. 150 for

1000 coconut and it takes an average of 170 nuts per day of 8 hours. The cost of de-husking one coconut in manual method is Rs. 0.25, with the developed unit, the cost of de-husking is reduced to Rs.0.19.

VIII. ACKNOWLEDGMENT

At the outset, we are much obliged to express our deep sense of gratitude to the Lord Almighty who showers blessings on us now and always. I thank my parents who had trusted me and shared their finance. It is immense pleasure to thank my HOD, staff and student friends for their enthusiastic participation and support.

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