

Development of a new Coconut Dehusking and Cutting Machine

Sooraj SJ, Vaisakh VS, Sibin Raj PS, Jyothish JS, Jinto Cheriyan, Vishnu V Chandran

Abstract— This paper presents a new innovative machine for Dehusking and Cutting a coconut. It consist of two units- a dehusking and a cutting unit coupled to each other by an elliptical path. Two rollers with spikes does the dehusking and after that the dehusked coconut moves with the assistance of gravity towards the cutter. The cutter is controlled using a cam. A detailed literature survey on the existing technologies is done and calculations supporting the construction are made.

Index Terms— Dehusking, Spiked Rollers, Cam, Cutter, Elliptical Path, Solid Works, Autodesk Inventor

1 INTRODUCTION

One of the major challenges in the coconut oil making industry is coconut de-husking and cutting. These mostly done manually. This causes wastage of time that never comes back. We are trying to overcome this problem by making a coconut de-husking and cutting machine which is more efficient than existing machines.

Coconut is one of the world's most useful and important perennial plants. A coconut can be divided into three parts:

1. Exocarp – outer covering
2. Thick fibrous fruit coat- husk
3. Endocarp-inner shell

The diameter and length of a coconut varies from 145mm-200mm and 245mm-295mm respectively. There are three sunken holes of softer tissue called 'eyes' at one end of the nut. Inside the endocarp there is a thin white, fleshy layer about 12.25mm thick at maturity known as 'coconut meat' and is filled with coconut water. As a south Indian especially a keralian we know the importance of the coconut flesh which is a major part of our curries and coconut water which is a natural drink. Coconut water is rich in cytokines which helps in the growth of coconut tree. It is a clear liquid which contains sugars, vitamins, minerals, electrolytes, enzymes, amino acids, bioactive enzymes such as acid phosphatase, catalase, dehydrogenase, diastase, peroxidase, RNA-polymerases. These help in the digestion and other metabolism in humans. Coconut water has a better composition of minerals like calcium, iron, manganese, magnesium and zinc than some of the fruit juices like oranges. Also it is rich in B complex vitamins such as riboflavin, niacin, thiamine, pyridoxine and folates.

Coconut husk is used for many applications such as coir industry, mat industry, for cultivation of certain plants etc. Coconut shell earlier used as spoons now finds application in hand-craft items, use as reinforcement along with cement instead of gravel for high strength and durability. Thus all parts of the coconut is a gift from nature.

We began to think the idea of coconut de-husking and cutting machine when we realised the effort in de-husking and cutting of coconuts in coconut oil making industry. Our machine consists of two main units a de-husking and cutting unit and a channel connecting them. Several machines were developed earlier and they have some disadvantages such as an operator is necessary for removing de-husked coconuts, non-safe, uneconomical etc.

2 LITERATURE REVIEW

Coconut De-husking Machine for rural small scale farm Holders comprise of two rollers with spikes, screw conveyor, barrier plates, conveyor belt, two spur gears and a handle was developed for small scale production in the rural areas [1].

Hydraulically operated coconut de-husking machine mainly consists of hydraulic cylinders, de-husking mechanism, hydraulic power pack, fruit gripping mechanism, and frame [2].

Coconut water is rich in minerals, nutrients and other enzymes [3]. Various de-husking machines like coconut husk removing tool, coconut husking machine, coconut spanner, keramithra coconut de-husking machine etc, their working and properties are studied [4].

Cam design and gear design for the machine are studied as both of these are integral parts for our two units. Cams are mechanical devices simple in operation but give more complex movements like lifting of valves and other parts [5]. Worm and pinion gear design is studied and this is used in first unit for speed reduction [6].

Coconut and its properties and physical characteristics are studied as our processing product is coconut [7].

Some of the commonly available manually operated and external power assisted dehusking machines are mentioned below.

2.1 Manually Operated Dehusking Machines

Mini Coconut Dehusker shown in Fig 1 consist of a tong- like tool mounted on a pillar. The coconut was kept on a platform and was impaled from the top with sharp jaws of the tool swinging downwards about the pillar. After penetration, the handles of the tool were pulled outwardly to separate the jaws. This ripped of the husk into one sector. The operations were repeated till complete de-husking. Since it is completely operated by the man, it didn't become popular.

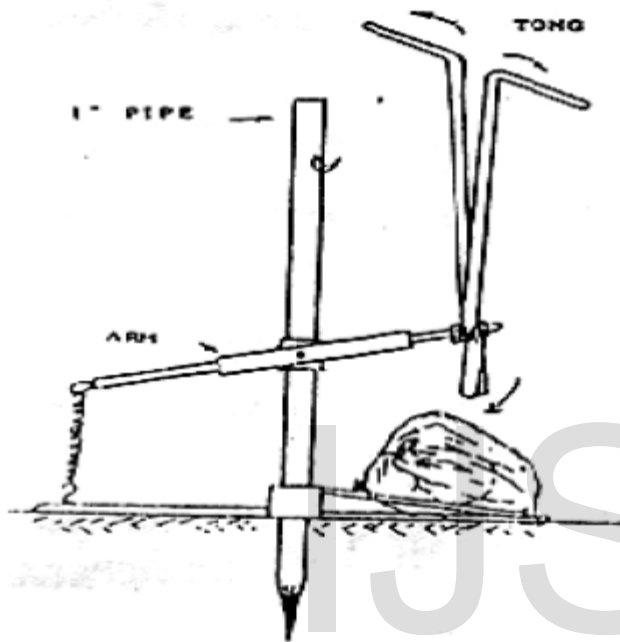


Fig 1 Schematic Diagram of Mini- Coconut Dehusker

KAU Coconut Dehusking Machine shown in Fig 2 is a foot operated husking tool from Kerala Agricultural University, India. Upon depressing the foot pedal downwards by one foot, the movable blade gets separated from the stationary blade, thus, ripping apart a sector of the husk of a coconut remaining impaled on the juxtaposed blades. Operations had to be repeated completely for removing the husk in three or four sectors. In this case, the blades were manually operated. So it was not accepted by the people.

Keramithra Coconut Dehusking Machine [4] shown in Fig 3 consist of mainly a stationary wedge, a movable wedge, a hinged pin, a wedge seat, a lever and a pedestal with a base. The coconut was impaled with both the hands on the two juxtaposed wedge-like blades oriented upwards. On pulling the lever upwards by one hand, the movable blade or wedge placed on the load arm of the lever swings away from the stationary blade loosening a sector of the husk from the nut. By repeating twice or thrice the husk can be completely separated from the coconut. But it is not so good for large scale husking.

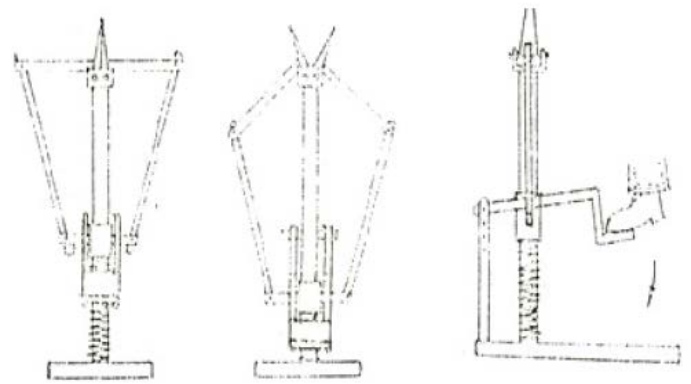


Fig 2 Schematic Diagram of KAU Coconut Dehusking Machine



Fig 4 Schematic Diagram Hydraulic Coconut Dehusking Machine
 Hydraulic Coconut Dehusking Machine [2] shown in Fig 4 consist of electric motor, hydraulic system, arm-like structure, holding

mechanism. The de-husking machine was powered by an electric motor which was powered by an electric motor which was attached to hydraulic system. Hydraulic power was used to operate the arm like structure which was used for opening the coconut husks. Holding mechanism was used to hold the coconut in a standing position in which the eye was on the top position. It also included some lifting mechanism for lifting the holding mechanism. The major disadvantage was that it is bulky and had high power consumption.

In Twin Blade Dehusking machine shown in Fig 5, a twin-blade was been developed in such a way that the husking of the coconut was done by inserting coconut onto one of its twin-blade and the other flat blade would help in the process of peeling. A 1.5 hp motor coupled through a belt to a long, cylindrical metal rod with two sharp blades fixed at the tip of the rod of the machine. The blades were 19cm long and placed two inches apart. The rotating motion of the blade aided to husk the coconut easily. A switch was used to operate the machine by the operator with his leg in each husking. This rotation of the blade facilitated the husking process. The disadvantage in using it was concerned with safety and this can be done only by a skilled person.



Fig 5 Schematic Diagram Twin Blade Coconut Dehusking Machine

Rotary Coconut Dehusker consist of a stationary concave, enveloping a rotating drum. The clearance space between the drum and the concave formed a converging volute to accept the whole coconut at the inlet and accommodate the husked smaller nut at the outlet. Numerous small blades were fixed on the outer surface of the drum and the inner surface of the concave. The coconut was fed at the inlet and into the clearance between the inlet and the drum which gets compressed slightly by the system and forces to roll or revolve. In the process, the blade penetrated the husk and punctures it along different planes. The shear force exerted upon the coconut by the blades of the rotating drum and the concave cause to rip open the husk along different planes. In some cases, the coconuts were completely husked and the nut emerged out at the outlet. In some cases, full coconuts with punctured and softened husk emerged out. Such coconuts required secondary operations to completely remove the husk.



Fig 6 Picture of rotary coconut dehusker

The mechanical coconut husker consisted of three main components- an inlet throat, a husking mechanism and an outlet. The husking mechanism of the machine consisted of two rollers powered by a 1.5 hp, 1440 rpm, and single phase AC electrical motor with integral reduction mounted almost vertically at the top of the machine and a gear box. Power was transmitted to the roller through helical gears. The powered rollers mounted in the right row rotate at a speed of 50 rpm, the outermost one carrying a series of slightly curved sharp hook-like knives that engage with the husk when coconuts are fed from the mouth of the throat. The whole nut was fed through the feed chute holding it vertically by hand, towards the converging throat where it was caught between the two rollers. In the process, the sharp right roll consisting of slightly curved hook-like knives engage with the husk and left spring loaded rollers press the coconut towards the right spiked rollers. As the rollers rotated, the husk gets detached from the shell, effecting a complete de-husking of coconut. The de-husked coconuts falls outlet below the roller where the gap between the spiked rollers and spring loaded rollers and were collected.



Fig 7 Schematic Diagram of mechanical coconut dehusker

3. EXPERIMENTAL SET UP

Our machine consists of two units one dehusking and other cutting unit. These are connected by using an elliptical path. Coconut comes to the second unit by gravity.

3.1 Dehusking Unit

This consists of two spiked rollers which are rotating in opposite direction and coconut is placed in between these rollers. The coconut is initially gently pressed so that the spikes impinges to the husk and the rotating effect causes a shear stress to act on the husk causing the husk to shear away when shear force exceeds the binding force of husk.

Main problems faced are transfer of husked coconut, speed reduction of prime mover as we need about 30rpm for the rollers. The first problem was overcome by giving an inclination to the frame which hold the rollers so that there is an inclination between rollers. The speed reduction is achieved by using a worm and pinion assembly. Power is supplied by using a 1hp AC motor.

De-husking unit consists of two rollers of maximum diameter 130mm and minor diameter 40mm. The material used for making the rollers in MS and spikes are also made from the same material with conical shaped head and cylindrical tail. The total length of spikes is 50mm and these are drilled and welded in rollers. The rollers are powered by 1hp motor through speed reduction worm and pinion. Worm and pinion is used as the reduction ratio is high that is 50:1. Two rollers are rotated in opposite direction by two spur gears in which input is only given to one gear. All this is supported by a frame made of MS angles of (50x50)mm in size.

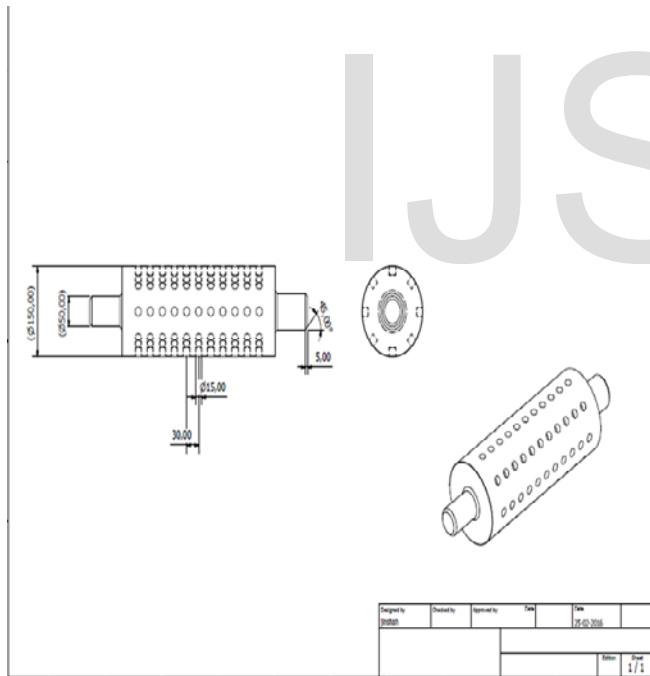


Fig 8 Schematic diagram of roller

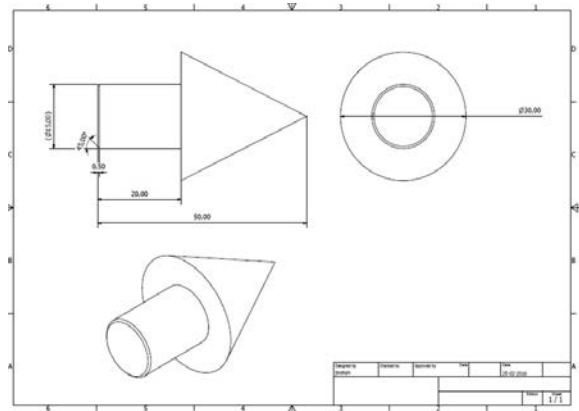


Fig 9 Schematic diagram of spike

3.2 Cutting unit

Cutting unit consists of a knife which is pivoted to a stand. Power is given on to the knife through two cams. Coconut which is de-husked comes to this unit through an elliptical path. On landing to this unit coconut falls on a groove and at this time the knife falls down and cuts the coconut into two parts

The knife is made up of MS bar with length of 70cm and varying breadth of 7cm and 15cm. This is attached to a cross bar which is at a distance 25cm from shorter end. This cross bar has a direct connection with the cam, which is connected to a 1hp AC motor through some reduction gears.



Fig10 Assembly of cutting unit

4. MATHEMATICAL CALCULATIONS

We have to find out number of spikes, angular velocity, torque generated.

4.1 Dehusking unit

Number of spikes in each circle = 8

Total number of circles = 6

Above numbers are obtained by dividing the circle equally and from the dimension of spikes (dia 30mm and 20mm end to end distance).

Number of spikes in one roller = $6 \times 8 = 48$

Total number of spikes = $48 \times 2 = 96$

Speed of rotation, $N = 30\text{rpm}$

$$\begin{aligned}\text{Angular velocity, } w &= 2\pi \times 30 / 60 = 3.14 \text{ rad/s} \\ V = rw &= 6.5 \times 3.14 / 100 = 0.204 \text{ m/s} \\ \text{Torque generated } T &= 60P / 2\pi \times 30 = 60 \times 746 / 2\pi \times 30 \\ &= 237.46 \text{ Nm}\end{aligned}$$

4.2 Cutting Unit

Mass of the knife = volume x mass density

$$\begin{aligned}&= 40 \times 7 \times 0.5 \times 7.85 + (15 \times 30 \times 0.5 - 0.5 \times 0.5 \times 5 \times 8) \\ &\quad \times 7.85 \\ &= 2786.75 \text{g} = 2.786 \text{ Kg}\end{aligned}$$

$$\begin{aligned}\text{Weight of the knife} &= mg \\ &= 2.786 \times 10 \\ &= 27.86 \text{ N}\end{aligned}$$

5. FUTURE EXPANSIONS:

The secondary unit can be automated with the help of electronics and this involves the use of sensors and chips. Then the coconut water can be collected from the groove filtered and can be chilled and used as cool drinks. At the end the two coconut pieces can be transferred to another unit which consists of blades to peel of the coconut meat and this can be dried in drier and then transferred to chuck for oil extraction.

6. CONCLUSION:

Our aim is to increase coconut cultivation. This can be achieved by increasing the price of coconut and one way to achieve this is through faster transformation of it into useful products like coconut milk, coconut oil, coconut water etc. By doing this oil price can also be regulated to an extent. This is because the cost of production is decreased. Our machine helps indirectly to reduce wastage of coconut on seasons. It also overcomes major difficulties that we are facing with its competing machines.

7. REFERENCES

1. B. N. Nwankwiji, O. Onuba, U. Ogbonna "Development of coconut de husking machine for rural small scale farm holders", International Journal of Innovative Technology & creative engineering (IISN-2045-8711), VOL. 2, NO. 3, March 2012.
2. Mr. Vinod P. Sakhare, Mr. Ketan K. Tonpe, Dr. C. N. Sakhale "Performance Analysis of Hydraulically Operated Coconut De-husking Machine", JETIR (IISN-2349-5165), Volume 1, Issue 2.
3. www.nutrition-and-you.com
4. Abi Varghese R, Jippu Jacob " A Review Of Coconut Husking Machines" Volume 5 Issue 3, September- December(2014)pp.68-78.
5. www.camcoindex.com
6. www.rmct.com
7. Wikipedia