RESEARCH ARTICLE

DESIGN AND CONSTRUCTION OF A LOW COST COCONUT HUSK REMOVING MACHINE

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ABSTRACT

De-husking 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. These affect the production rate of de-husking the coconut also more hazardous and harmful to user. To overcome the limitations and problems in the present methods, a manual or automated machine should be designed and fabricated. This research is to design and fabricate a low-cost coconut husk removing machine. The main purpose of this machine is to eliminate problems and limitations involved in de-husking process and to promote some small-scale industries and self-employment, especially for women. The machine with manual loading and unloading of coconuts will yield productivity higher than the existing process with less manpower. Also, the machine can accommodate different sizes of the coconut that are cultivated anywhere in Sri Lanka. Also, various experiments have been conducted on both dry and mature coconuts in order to determine the force required to de-husk the coconut. Test result and assessment of the present manual machine in both laboratory and field conditions are also reported. Safety aspects are incorporated. The unit can de-husk about 70 coconuts per hour compared with about 40 nuts per hour from a skilled worker using the spike method. Cost benefit analysis indicates that it should be commercially viable.

Keywords: *Coconut husk remover, De-husking, Manual machine, Self-employment*

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1. INTRODUCTION

Sri Lanka is one of the leading producers of coconut. It is usually grown in coastal areas. Coconuts are large, dry drupes, up to 38 cm long and 30 cm wide. The coconut is smooth on the outside, yellowish or greenish in color. Within the outer shell is a fibrous husk 2.5 to 5 cm thick. The inner shell is brown and hard, surrounding the white coconut meat.

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Coconut husks are the rough exterior shells of the coconut. This outer shell or husk has to be removed for the usage of coconut.

1.1 Present study

There are many methods to de-husk the coconut. It is by manually, mechanically and also by the use of machines. Manual de-husking with knife is a common practice. Need for the improvement in present method is the lack of sufficient manpower. This necessitates the use of appropriate machinery to aid in various tasks in coconut plantation. Traditional devices currently in use, such as the blade and spear are dangerous and minimum productive. Based on this realization we are planning to make the device that simplifies an important process as well as increases the productivity of the coconut industry. This new mechanism will indirectly boost any economy that relies on coconut plantations.

1.2 Machine description

This coconut de-husking machine peels off the coconut husk from coconut fruit to obtain de-husked coconut fruit via mechanical controlled de-husking devices. The coconut is placed on the holder in vertical position. The holder is moved up by the foot operation mechanism. The top assembly which comprises the gripper pokers held vertically with link mechanism and is pivoted to the coconut body. The top assembly movement effects the pokers to move in the downward slide to poke into the coconut and at certain depth will make the pokers to move apart at 45 degrees by the pusher link mechanism to tear apart the husk with force. The foot operated holder can be adjusted to the required height by the height adjuster. The foot lever is operated to continue the pumping till the mechanism is pulled down to its lowest position till the coconut is de-husked from the fruit. The foot operation is returned to the original position and also the top assembly is lifted back to its original position by the release valve operation of the pump and cylinder facilitating the removal of the coconut. The main parts involved in the research project are hydraulic pump, cylinder, coconut holder mechanism, height adjusting knob, and poker arms.

1.3 Field of use and benefits

This machine is useful to the coconut estates and co-operatives, coconut growers and coconut processing factory. The machine can provide faster work rate and less human interaction. This machine is expected to increase the coconut production, hence an

additional income to coconut growers. It is useful to the coconut growers by many ways. It does not require direct human force as in normal methods because in this hydraulic pump and cylinder is used to enhance the force at the head of the coconut to put pressure on poker assembly. Also the coconut of any size and shape can be de-husked easily. It is easy to operate, does not need skilled labor, rapid, safe operation and simple maintenance. It can be easily assembled and disassembled and it can be carried from one place to another.

The cost of this machine is lesser as compared to the present available machines. Also these available machines require external electrical power supply and the worker should be skilled with the machine. Also these machines are not safe because they work with a very high speed and a large tools and equipment.

1.4 Traditional coconut de-husking machines

The traditional methods of husking machines and their efficiency, durability, ease of operation etc. There are many different methods followed by the farmers of our region. In that some are more effective and some are costlier. Some of those machines are described below. In the Figure 1 (a) is one of the traditional models of coconut husking machine which consists of a solid vertical shaft and a poker which has two parts one of which is fixed two solid shafts and another one is movable. The movable poker is fitted to the arm which can be lifted to husk the coconut. It is cost effective but it requires large force to operate which makes it not to use in some places. In the Figure 1(b) shows one of the traditional methods of coconut husking machine which consists of one vertical sharp column like structure in which poker is fixed at the top. This is worked by using human energy. This is cost effective and efficient also but danger to the worker involved is more because if his hand slips from the coconut the sharper edge will directly move into his hands and it may create injury to the hands. And hands may be pained if the worker is continuously worked for about three to four hours. Now a day the availability of labours is a very big problem, if available daily wages will be very high.

(a) (b)

Figure 1: (a) Traditional tool, and (b) Traditional method of de-husking

1.5 Two blade de-husking machine

In this two-blade model one blade would be inserted inside the husk of the nut and the other blade would help in the process of peeling. A 1.5 hp motor is coupled through a belt to a long, cylindrical metal rod. Two sharp blades were fixed at the tip of the rod. The blades were three quarter of an inch long and placed one inch apart. The rotating motion of the blades would de-husk the coconuts easily. A switch was used to operate the machine. Initially, the switch could be turned only by hand. Figure 2 shows a two blade de-husking machine.

Figure 2: Two blade de-husking machine

This coconut de-husking machine, works on the principle of 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 of the machine blades facilitates the de-husking 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. But the problem in this machine

is that the hands may get damaged because the worker has to hold the coconut in his hand during de-husking.

1.6 Change of attention towards hydraulic systems

Now a day the hydraulic machines are more efficient and easy to use. And also can get more force at the output by applying a small amount of force at the input. Hence the hydraulic system has been studied to make a hydraulic machine. Some of the details about the hydraulic systems are discussed here. In the recent there has been a significant increase in the use of hydraulics in our industries. The use of hydraulic systems as a means of power transmission in modern machines evolved a few decades earlier in the western world [1, 2]. Hydraulic systems are now extensively used in machine tools, material handling devices, transport and other mobile equipment, in aviation systems, etc [1, 2, 3]. There are six basic components required in a hydraulic system:

1. A tank is a reservoir to hold the liquid, which is usually hydraulic oil.
2. A pump to force the liquid through the system.
3. An electric motor or other power or manual sources to drive the pump.
4. Valves to control liquid direction pressure and flow rate.
5. An actuator to convert the energy of the liquid into mechanical force or torque to do useful work.
6. Piping which carries the liquid from one location to another, in this case the piping is not there, the tank, pump, and actuator are inbuilt [4].

1.7 Basic Component Descriptions

To introduce this mechanism to coconut de-husking operation the main components that we have made use are 1. Hydraulic pump, 2. Springs, 3. Coconut holders, 4. Ram, 5. Cylinder or hone tube, 6. Reservoir tube, 7. Plunger and 8. Poker arm.

1.7.1 Hydraulic pump

Hydraulic pump supplies fluid to the components in the system is shown in Figure 3 [5]. Pressure in the system develops in reaction to the load. Hence a pump rated for 1000psi is capable of maintaining flow against a load of 1000psi. This hydraulic pump has a power density about ten times greater than an electric motor. It has a foot operated pedal

for pumping of the oil to the cylinder. Also it has a foot operated pressure relief valve. It has two non-return valves to control the flow of oil.

Figure 3: Model of a hydraulic pump

1.7.2 Springs

To design the machine, we have used 5 numbers of springs. In that 3 are tensile and remaining 2 are compressive springs. All the 5 springs are made up of spring steel material. The 2 tensile springs used in the front are of same type and same dimensions and 2 compressive springs used at the top are also of equal dimensions.

1.7.3 Coconut holders

These are used to hold the coconut during de-husking. Three coconut holders are used in setup is shown in Figure 4. These holders are made up of mild steel. The holder end is made circular to hold the coconut tightly and the outer shape is in "Y" shape for external lock. The diameters of these circular holders are 40 mm each. These holders are connected directly to the cylinder ram through the links.

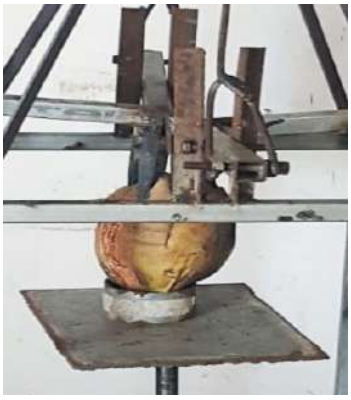

Figure 4: Model of a coconut holder

1.7.4 Ram

Ram comes out of the cylinder and it supplies the power produced from the hydraulic pump to the parts of the machine. During the idle position of the machine ram will be inside the cylinder or hone tube. This is made out of EN8 steel (an unalloyed medium carbon steel with good tensile strength) round bar of diameter 52 mm cut for the length of 290 mm and being rough turned on lathe machine to maintain the diameter as 50.2, 49.5, 42 groove for the width of 12, 46.8 mm step diameter for the length of 35 mm. It is then drilled from one side to tap M12 for the depth of 25 mm to lock the bolt with the moving jaw. The undercut is done for the diameter of 49.5 mm to be convenient for external grinding. This ram is then loaded for external grinding to make the diameter as 49.95 collar, 49.00, 46.4, and 44.00 mm.

1.7.5 Cylinder or hone tube

Hydraulic cylinders are actuation devices that utilize pressurized hydraulic fluid to produce linear motion and force. Important operating specifications for hydraulic cylinders include the cylinder type, stroke, maximum operating pressure, bore diameter, and rod diameter. This is made out of round bar of Mild steel of diameter 65 mm cut for the length of 280 mm and turned on lathe machine to make the diameter as 60 mm for the length of 275 mm and internal bore as 50 mm for the entire length. End chamfer is done on internal bore for 3 mm × 30 degree at both the ends and from outside at both the ends threading is done of size M60 × 2 mm for the length of 26 mm from both the ends. Then internal grinding is done to suit it to the diameter of 50 mm. It is then honed on honing machine for 50 mm diameter.

1.7.6 Reservoir tube

Reservoir tube is used for the storage of the hydraulic oil inside the pump. This is made out of mild steel tube of diameter 76 mm with internal diameter of 68mm cut for the length of 110 mm and being faced on lathe machine to maintain the length as 150 mm and end chamfer is machined for outside diameter as 0.5mm × 45 degree. It is counter bored for the diameter 70.15 mm for the depth of 14 mm at both the sides and then counter bored for the size of 3 mm × 30 degree.

1.7.7 Plunger

This is made out of EN8 round bar of diameter 25 mm being cut for the length of 100 mm and turned on lathe machine to make the diameter as 24.6 mm and step diameter of 20.8 mm for the length of 60 mm and undercut is made of diameter 17 mm and the end radius is made with radius 13mm to end at the diameter as 13.5 mm at 20.8 mm diameter side. This is then ground on cylindrical grinding machine to make the diameter as 20.00 mm.

1.7.8 Poker arm

The poker is a part used to peel the coconut husk. This is made up of the mild steel material. The tip of the poker is made sharper to pierce into the coconut husk. The other end of the poker is fitted to upper assembly by using bolt and nut, which gives provision for oscillation of the poker. The middle portions of these pokers are connected to the movable ring by the links. There are 6 numbers of pokers which are fitted in a radius of 65 mm to upper assembly and the poker is about 200 mm long. Another link connects the poker to the holding ring which is of 80 mm and it is connected to the poker at a distance of 110 mm from the tip of the poker. The thickness of the poker is 10 mm. The holes are drilled in the poker to fit to the assembly by using the nuts and bolts.

2. MATERIAL AND METHODS

2.1 Working Principle

This coconut de-husking machine peels off the coconut husk from coconut fruit to obtain de-husked coconut fruit via mechanically controlled de-husking devices is shown in Figure 6. It consists of a foot operated hydraulic pump, which pumps the oil to the cylinder for the upward movement of the ram. The ram is connected to the coconut holder directly. The coconut is placed on the holder in vertical position. The three coconut holders made of mild steel material are connected to the ram. The coconut holder is moved up by the foot pedal operating the hydraulic pump by the foot lever. The actual force on the plunger will be around 30 kg but we feel only about 5 kg of force. This is due to the length of the foot lever provided to operate. But the force produced from the hydraulic cylinder will be around ten times the force we apply to the foot lever i.e. around 300 kg force can be obtained from the cylinder. The upward ram movement will move the coconut holder closer to each other to hold the coconut tightly. At this position

the hydraulic force will overcome the force exerted by the two tensile springs provided at the front side.

At the upward movement of the foot lever plunger will suck the oil from the tank into the pump chamber through the non-return valve provided, which makes the oil to be sucked into the pump cylinder. At this time the release valve is in closed position. The downward stroke of the foot lever plunger will push the oil out through another non return valve which passes through the metal pipe into the cylinder. These pipes are properly sealed and fitted so that no oil will be leaked through the joints. The oil entering and filling the cylinder chamber makes the ram to move out of the cylinder effecting the upward slide of the ram. Since we have used the hydraulic systems we can get about 292 kg of force at the ram end from the force of 30 kg that applied to the foot lever plunger.

The coconut holder connecting links are hinged to the coconut base holder and the ram. This coconut base holder is also hinged to the ram which while moving out or upward will make to close down on the bottom of the coconut. The holder ends are sharp which tends to pierce into the base part of the coconut. The arrangement is such that the coconut will be firmly held at the base holder. There is one more arrangement for adjusting the initial height difference between poker and the base holder. This can be adjusted only while the base holder starts moving in upward direction. At the end of this piercing, the ram touches the coconut base holder which is connected through the body holders and guided in the pillars and bushes. After the holder firmly connects to the coconut for the further foot pedal operation the base coconut holder will move upwards bringing the coconut closer to the poker that will pierce into top portion of the coconut and will stop at a height that adjusted by the adjusting knob.

Further pedal operation will lift the poker arm holding ring effecting the downward slide of the vertical pokers (since the distance between the top assembly and the base reduces) onto the coconut head. The top end of poker arm is rigidly fixed to the top ‘H’ shaped mild steel holder which is connected to the long shaft coming from the base. The connecting links are provided and are connected at the middle of the poker arm to the ring at the top and this ring is connected to the ram and also this ring mounted to the base long shaft for the guideline for the movement. Due to the upward movement of this ring

the connecting links will pull the vertical pokers to the sideways. The top assembly will be stationery effecting the pulling of poker links out at 45 degree removing the husk out of the coconut and leaving only the coconut fruit. Due to the 45 degrees' movement of the poker arm the coconut fruit will not be harmed.

The release of the pumping is affected by another foot lever which through the cranking lever will push the release pin inside. This makes the non-return valve to open to return back the oil into the oil reservoir. The return stroke is affected by the two springs provided at the front face and one at the back side connecting the moving base (base gripper) along with the link holder ring. During releasing the top ring will come downward effecting the poker to move upward and poker will come closer to each other. After the ring comes down and seats at a point the coconut base holder will start moving downwards and the coconut holder will leave the coconut shell and settles at the original position. At this time the full length of the ram will be inside the cylinder and oil will be stored inside the reservoir. The process is repeated for the next coconut which is to be de-husked.

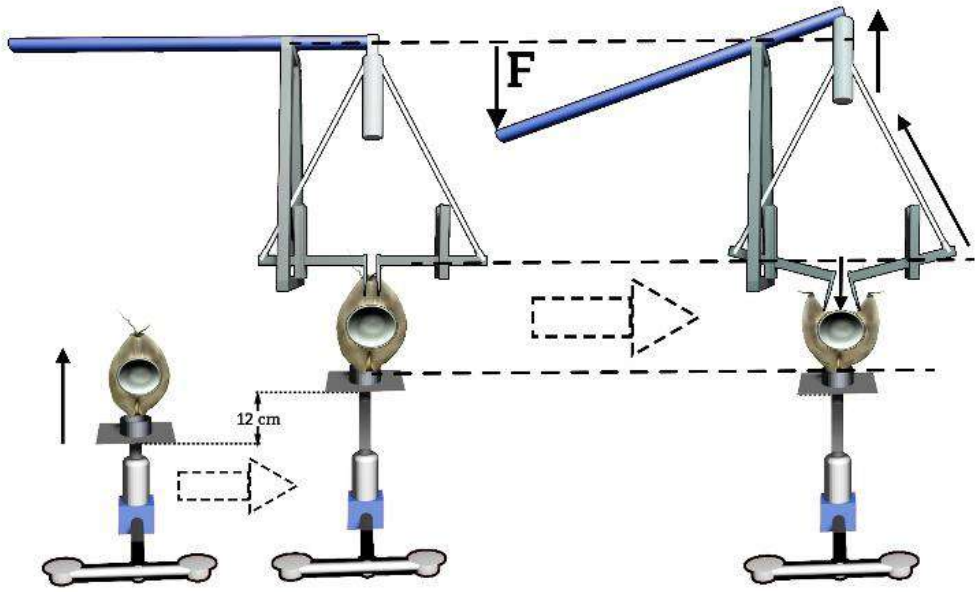

Figure 6: Working Principle of coconut de-husking Machine

2.2 Methodology

Most of the parts in this research project are prepared by the lathe operation (See Figure 7). Various operations like cutting, sanding, knurling, drilling are done by the use of lathe. The shafts are turned on the lathe to get smooth and good surface finish. The height

adjusting knob is also turned to get good surface finish. Along with this drilling, milling and shaping machines are also used for many operations. The coconut base holder assembly is cut and shaped by using milling and shaping machines. Different types of drilling machines are used to drill many holes for the seating of bolts and nuts. The drills are done on the links to connect different links each other. The holes on the height adjuster are made by using drilling machine. Most of the parts are given good and smooth surface finish by using shaping machine and by polishing.

The links and poker arms are made for required shape and length by forging operations. The sharper ends for the poker are cut and fixed to the poker by welding. Casting is done to obtain many parts. The top poker holding ring, coconut base holder, top "H" shaped rigidly fixed poker holder are prepared by casting process.

The main operation done on this machine is the welding. All the parts are joined together by welding process. The welding methods used here are arc welding and gas welding. All the separate parts are assembled together by arc welding process. And some spot welding is also done by spot welding process. The links and some other parts are joined by the bolts and nuts.

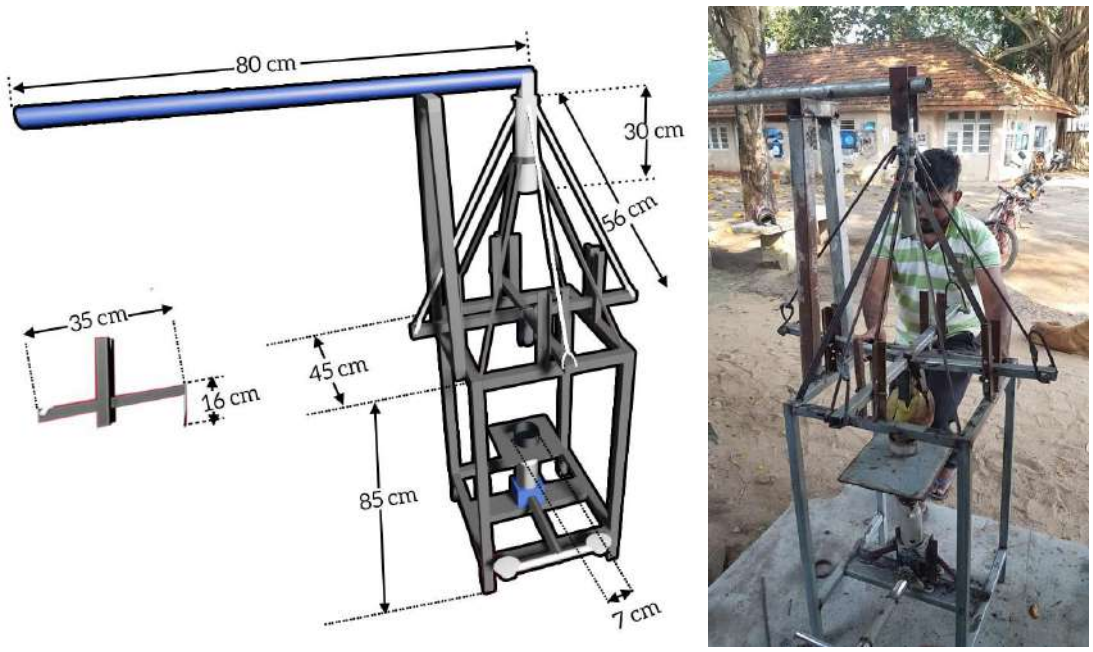

Figure 7: (a) Schematic of coconut de-husking machine and (b) constructed coconut de-husking Machine

3. RESULTS AND DISCUSSION

The coconut de-husking machine prepared by us is operated by hydraulic pump. This hydraulic pump exerts the force ten times more than the force applied on the foot lever. The machine is of 1 feet breadth, 1 feet width and 4 feet height. The whole weight of the machine is about 70 kg. The materials used in this machine are of good quality and durable. And the parts are painted to prevent from rusting. Most of the parts are made from mild steel material and springs are made of spring steel material.

The machine has the capacity to de-husk the coconut of any shape and size. Also the coconut shell of different thickness and hardness can be easily removed by this with a less force. The manually applied force is very less on the foot pedal and the force produced to peel the coconut husk is very high. For a single operation it is taking nearly 1 minute. The machine can de-husk about 70 coconuts per hour. But if the stroke length is increased it can de-husk about 120 coconuts per hour.

CONCLUSION

In this modern world the time and cost have more weightage for each and every operation. So to overcome this concept we have designed and fabricated the machine named “Coconut de-husking machine” to reduce the cost and to save human energy. By viewing many types of machines like manual, traditional, electronic and other, so we conclude that hydraulic machines can be operated using less human effort. This machine has many advantages over other machines. The cost is less compared to other types of machines and the human power used is also very less. The time consumed by this machine is little more. If we increase the stroke length by external mechanisms, we can de-husk quickly about minimum three to four coconuts per minute. Machine can be operated efficiently by unskilled labors.

In this research project we have used very heavy and strong machine parts so as to eliminate the regular maintenance. We conclude that this machine is more useful to the large scale coconut growers and the coconut industry where the large numbers of coconuts are to be de-husked. Furthermore, the stroke length can be increased by inserting a booster to the hydraulic pump. On the other hand, the machine can be

automated by inserting motors for the pedaling operation. These will allow to de-husk more coconuts in a less time with less man power.

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