Conceptual Design of Coconut Dehusking Machine

Stephen Kwasi Adzimah Samuel Oppong Turkson
Department of Mechanical Engineering,University of Mines and Technology, Tarkwa, Ghana

Abstract
Generally, coconuts are dehusked manually using a machete. These methods require skilled labour and are laborious to use. Attempts made so far in the development of dehusking tools have only been partially successful and not effective in replacing manual methods. The reasons stated for the failure of these tools include unsatisfactory and incomplete dehusking and breakage of the coconut shell while dehusking. Based on this a hand - operated coconut dehusking machine is being designed to solve this problem. This machine takes into consideration the dangers, hazards and risks involved in dehusking the coconut which will be efficient, productive, environmentally friendly, less laborious, easy to use and ergonomic, easy to assemble and disassemble, and most importantly, cost effective in production, maintenance and repairs .The machine will use hydraulic system, including a ram, fed from a pump, which does the dehusking at a rate of 70-80 coconuts per hour.
Keywords: Coconut; Dehusking; Machine; Skilled labour; Manual

1 Introduction

1.1 Information about Coconut

Coconut, the fruit of the coconut palm tree which has the scientific name as *Cocos nucifera*, belongs to the family *arecaceae*. Philippines 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 5cm) thick. 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. The coconut is known for its great versatility as seen in many domestic, commercial, and industrial uses of its different part. They are part of the daily diet for many people. Coconuts are different from any other fruits because they contain large quantity of water and when immature they are known as tender-nuts or jelly-nuts and 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 (Anon., 2011).

Fig. 1 Coconut Fruit (Anon., 2011)

Coconut palm is grown throughout the tropics for decoration as well for it many other uses. Virtually every part of the coconut palm can be used by humans in some manner and has significant economic value. Coconut versatility is sometimes noted for its naming. In Sanskrit, it is kalpa vriksha (the tree which provides all the necessities of life); in the Philippines, the coconut is commonly called the “tree of life” (Margolis, 2006).

The various parts of the coconut have a number of culinary uses. The seed provides oil for frying, cooking, and making margarine. The coconut water is consumed as a refreshing drink throughout the humid tropics and is gaining popularity as a sports’ drink. Coconut water can be fermented to produce coconut vinegar.

Coconut husks are rough exterior shells of the coconut. While the husks are not used for food like the meat and liquid found within the exterior shell, the coconut husk can be utilized in several ways. The coconut husk has become a very useful substance in light of today's environmental and economic concerns (Anon., 2003a).

Fig.2 Husk of a Coconut (Anon., 2003b)

Fig. 3 Dehusked Coconut (Anon., 2003b)

2 Traditional Methods of Dehusking the Coconut

2.1 Dehusking Coconut Using a Machete

The coconut husk, also known as the coir, has become a very useful substance in light of today's environmental and economic concerns. It can be used for repelling mosquitoes when burnt, if shredded, can used as pillows, mattresses and to provide the fibre for making clothing, to make filters for aquariums, the fibre can now be used in place of synthetic fibre for making automobile parts and as fuel. However the current traditional methods employed for dehusking the coconut leaves much to be desired. Fig. 4 shows one of the traditional methods of dehusking coconut using a machete. This is done by using human energy. This method is risky and tedious and yet requires skills. The use of the machete poses a great danger to the worker.

Fig. 4 Dehusking Coconut Using a Machete (Anon., 2007)

2.2 Method of Dehusking Coconut using a Two - blade Dehusking Machine

Fig.5 shows another method of dehusking coconut using a two - blade dehusking machine. In this two-blade model, one blade would be inserted inside the husk of the coconut 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 are fixed at the tip of the rod. The blades are three - quarter of an inch long and placed one inch apart. The rotating motion of the blades would dehusk the coconuts easily. A switch is used to operate the machine. Initially, the switch could be turned with only by hand. This coconut-dehusking 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 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. 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 dehusking.

Fig. 5 Two-Blade Dehusking Machine (Anon., 2007)

2.3Traditional Method of Dehusking a Poker

Fig. 6 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 working for about two to three hours.

Fig. 6 Traditional Method of Dehusking (Anon., 2007)

2.4 Application of Hydraulic Systems for Dehusking Coconuts

The hydraulic systems are easily usable, economical and we can get a large force at the output by applying small input force. Hence we conclude some of the design criteria to fabricate an economical and perfect working coconut dehusking machine.

Thus the following design criteria's have to be fulfilled to reach the farmers goal: The quality of peeled coconut is the main criteria; the dehusking capacity of machine per hour; contamination of coconut with lubricating system of the machine; collection of properly peeled coconut; collection of separated husk; the requirement of manpower. flexibility of machine with respect to handling.

2.5 Advantages and Disadvantages of the Coconut Dehusking Machine

2.5.1 Advantages

Change of attention towards hydraulic system; hydraulic machines are more efficient and easy to use; we can get more force at the output by applying a small amount of force at the input.

There are six basic components required in a hydraulic system: a tank in a reservoir to hold the liquid, which is usually hydraulic oil; a pump to force the liquid through the system; an electric motor or other power or manual sources to drive the pump but in this case it will be a hand-operated pump; valves to control liquid direction pressure and flow rate; an actuator to convert the energy of the liquid into mechanical force or torque to do useful work; tubes which carry the hydraulic oil from one location to another (Kundu and Cohen, 2002).

2.5.2 Design Criteria for the Coconut Dehusking Machine

The main expectation of coconut customers is to have high quality products. Along with the quality, the farmer also needs high capacity and most efficient equipment for more productivity. Therefore, the design of the machine should involve the use of hydraulic mechanism and application of force with leverage; it should be user - friendly, rapid and can be operated safely; it should be small enough to be either carried by at most two workers or rolled into place; should be conveniently assembled or disassembled; it should be able to removes husks of various shapes and sizes; the coconut shell of any thickness and hardness can be removed easily. it should be operated by anyone regardless of age; it should be simple and easy maintained; it should not require lengthy training for the operation and the machine can be understood easily; it should be portable; it should be able de-husks about 70 to 80 coconuts per hour.

2.5.3 Disadvantages

The cost of the machine should affordable for the common man. Also, the hydraulic pump and cylinder should be taken care of at a considerable cost so as to avoid oil leakage at the joints.

3. Design of the Hand-operated Coconut Dehusking Machine

The conceptual design, description of its parts and the mode of operation or the working principle of the hand-operated coconut dehusking machine are outlined as follows: 1) Hydraulic pump; 2 Control valve; 3 Cylinder; 4) Hydraulic tubes; 5)Seals, fittings and connections; 6) Coconut holder; 7) Ram; 8)Plunger; 9) Reservoir tube.

This coconut dehusking machine peels off the coconut husk from coconut fruit to obtain dehusked coconut fruit via mechanically controlled dehusking devices. It consists of a hand-operated hydraulic pump, which pumps the oil to the cylinder for the downward movement of the ram. The ram is connected to the poker directly. The coconut is placed on the holder in vertical position. The coconut holders are made of mild steel material. The ram is moved down by the hand pedal operating the hydraulic pump by the hand 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 hand lever provided to operate. But the force produced from the hydraulic cylinder will be around ten times the force we apply to the hand lever i.e. around 300 N force can be obtained from the cylinder.

At the upward movement of the hand lever plunger, it 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 hand lever plunger will push the oil out through another non-return valve which passes through the hydraulic tubes into the cylinder. These tubes 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 downward slide of the ram. Since we have used the hydraulic systems we can get about 300 N of force at the ram end from the force of 30kg that applied to the hand lever plunger.

The ram is connected to the poker directly. So during the downward stroke of the hand lever the pump pushes the oil to the hydraulic cylinder which forces the ram to move out of the cylinder. The coconut will be placed in the coconut holder which will be at a fixed point. As the ram moves downwards the poker also moves downwards. The poker smashes on the coconut in the holder to dehusk the coconut. The coconut is dehusked, because of the pressure between the poker and the holder. The release of the pumping is effected by another hand lever which through the cranking lever will push the ram inside. This makes the non-return valve to open to return the oil back into the oil reservoir. The process is repeated for the next coconut which will be dehusked

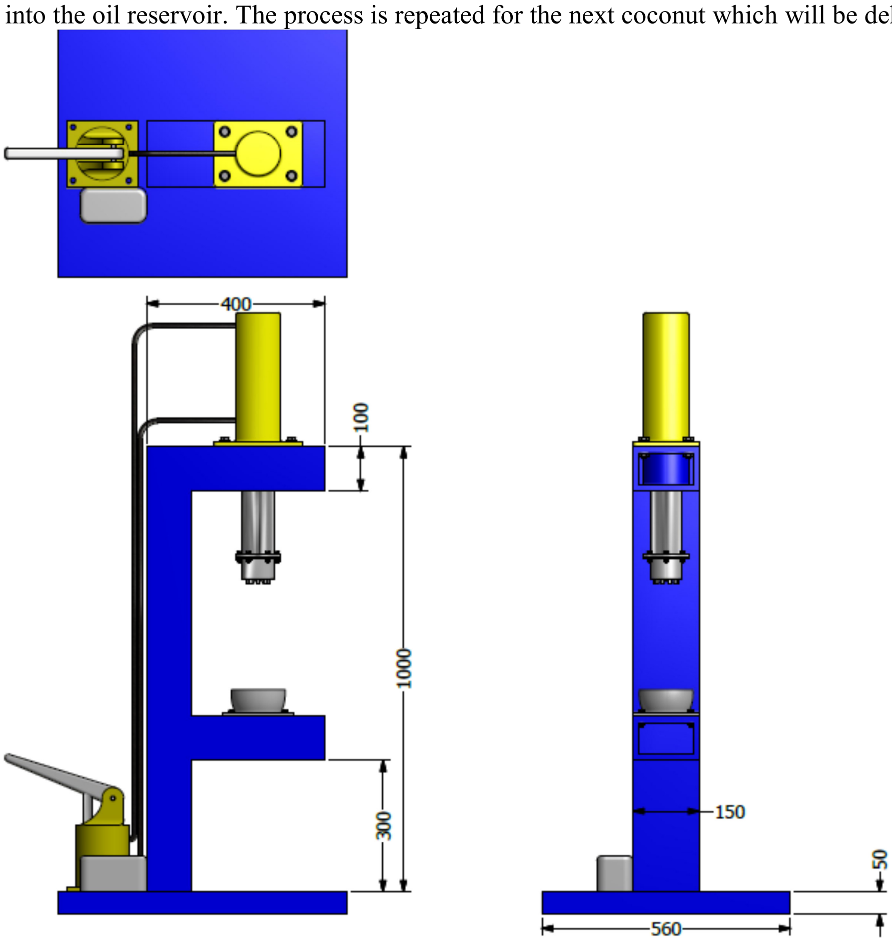
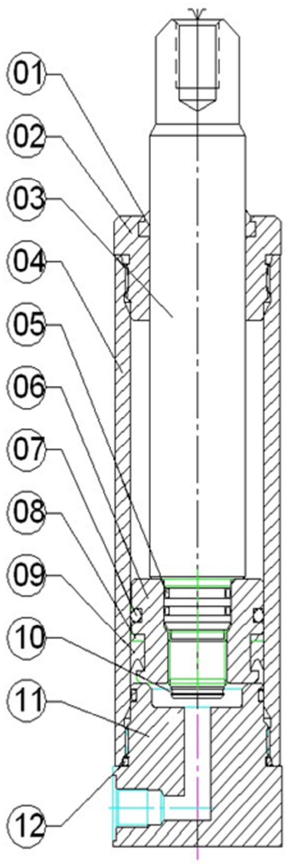


Fig. 3 Orthographic Projection of the Proposed Design



SR.NO.	DESCRIPTION	SIZE/DRG.NO.	MAKE	QTY.
01	WIPER RING	36 X 44 X 7/5	DADSON	01
02	FRONT FLANGE		DADSON	01
03	RAM		DPDH	01
04	CYLINDER		DPDH	01
05	'O' RING	20 X 2.65 C.S.D.	DADSON	02
06	PISTON HEAD		DPDH	01
07	'O' RING	42 X 4 C.S.D.	DADSON	01
08	BACKUP RING	50 X 40 X 2.5	PRERNA	01
09	P.U. PISTON SEAL	50 X 40 X 10	B.S.IND.	01
10	CIRCLIP			01
11	END FLANGE	4 RIHC 06310	DPDH	01
12	'O' RING	50 X 3 C.S.D.	DADSON	02

Fig. 3.4 Parts Details of a Single Acting Hydraulic Cylinder (Anon., 201

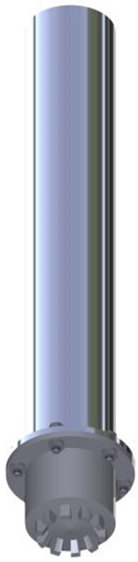


Fig. 3.5Model of a Ram

4 Design Calculations

4.1 Calculations of Parameters of the Components of the Design

4.1.1 Design Stress of the Chosen Material

Mild steel, with a safety factor (S.F) of 2.2, was selected for normal conditions.

Yield Stress of Mild Steel, σ_y = 295 MPa (Budynas and Nisbett, 2011)

Design Stress, $\sigma_d = \frac{\text{Yield Stress}}{\text{S.F}}$ (1)

$= \frac{295 \times 10^6}{2.2}$ = 134.09 MPa

4.1.2 Piston

The piston operates within the cylinder. The piston is a short, cylinder-shaped metal component that separates the two sides of the cylinder barrel internally. It is moved by the hydraulic fluid.

Design Stress of Piston, $\sigma = \frac{F}{A} = \frac{4F}{\pi d^2}$ (Khurmi and Gupta, 2005) (2)

where, d = Diameter of piston (20 mm); A = Cross-sectional area of piston and F = Clamping force (300 N

Cross-sectional area of piston, $A = \frac{\pi d^2}{4}$ $A = \frac{\pi \times 0.02^2}{4} = 3.14 \times 10^{-4} m^2$ (3)

Pressure within the cylinder, $P = \frac{F}{A} = \frac{300}{3.14 \times 10^{-4}}$ = 0.9554 Mpa (4)

4.1.3 Ram

The buckling load, $W = \frac{\pi^2 EI}{l}$ (Khurmi and Gupta, 2005) (5)

where, E = Modulus of elasticity of the ram (210 GPa); I = Moment of inertia of the ram's cross-sectional area; l = Length of the ram (15 cm); d = Diameter of the ram

But,

$I=\frac{\pi d^4}{64}$; $W=\frac{\pi^3 d^4 E}{64 l^2}$: $d^4 = \frac{64 W l^2}{E \pi^3}$ (6;7;8) d = $\sqrt[4]{\frac{64 \times 300 \times 0.15^2}{210 \times 10^9 \times \pi^3}}$ = 5.075 × 10^{-3} m = 5.075 mm

4.1.4 Cylinder
This aspect deals with the design consideration for the hydraulic cylinder used. The cylinder efficiency was set to be 95% to take care of minor losses.
4.1.5 Stroke Speed of the Cylinder
Once the cylinder and ram diameters are determined, in relation to the required force and available pressure, the required cylinder stroke speed for most application is 0.5 m/s. Stroke speed is determined using the formula below:

V = $\frac{l}{t}$ (Barry, 2008)

where, V = Stroke speed; l = Cylinder stroke length (0.15 m); t = Time allowed to stroke cylinder (5 s)

V = $\frac{0.15}{5}$ = 0.03 m/s

4.1.6 Required Flow Rate
The required flow rate is calculated using the for

Q = $\frac{A \times V \times 6}{vol}$ (Rajput, 2007) (9)

where, Q = Fluid flow rate; A = Cross-sectional area of the piston; vol = Cylinder volumetric efficiency (0.95)

Q = $\frac{3.14 \times 0.03 \times 6}{0.95}$ = 0.595 litres/minutes

4.1.7 Reservoir Capacity
Recommended reservoir fluid is 3 to 5 times the pump's output flow per minute with a 10% air cushion, expressed by the following formula:
V = 3.3 × Q (10)
where, V = Reservoir volume in litres, Q = Flow rate of pump in litres per minute
V = 3.3 × 0.594 = 1.96 litres
4.1.8 Pump Selection

Input power, $P_i = \frac{g \times W \times h}{1000t}$ (Islam et al., 2007) (11)

where, P_i = Input power in kW, g = Acceleration due to gravity in m/s; W = Weight imposed by the operator in kg; h = Vertical distance through which the hand lever move downward due to hand pressure; t = Time required for the downward movement of the hand lever in seconds

$P_i = \frac{9.81 \times 55 \times 1}{1000 \times 5}$ = 0.108 kW

Output power, $P_o = \frac{P \times Q}{600}$ (Kundu and Cohen, 2002) (12)

where, P_o = Output power in kW; P = Pressure within the cylinder in bars; Q = Fluid flow rate in litres/minute.

$P_o = \frac{95.54 \times 0.595}{600}$ = 0.095 kW

Efficiency of the pump,

$E_p = \frac{\text{output power}}{\text{input power}} \times 100 = \frac{0.095}{0.108} \times 100$ = 87.9%

5 Conclusion and Recommendation

5.1 Conclusion

In this research, a hand-operated coconut dehusking machine has been designed. The main features of the machine are: hydraulic cylinders that are actuation devices which utilize pressurized hydraulic fluid to produce linear motion; ram, fed from a pump which does the dehusking; coconut holder, which holds the coconut vertically; reservoir for the storage of hydraulic oil; hand-operated pump, which supplies fluid to the hydraulic cylinder; frame which holds all the components together; hydraulic hose which the oil passes into the hydraulic cylinder; check valves, which regulate the flow of fluid in one direction only.

It is expected that, the machine will be financially beneficial to attract manufacturers who will produce the device for patronage of users or customers and the general public. It will be capable of dehusking 70-80 coconut per hour.

5.2 Recommendations

It is recommended that by introducing a booster to the hydraulic pump, the stroke length can be increased, and the coconut can be dehusked efficiently with using least human effort. Also by introducing motors for the handling operation, the machine can be automated.

6 References

Anon. (2003a), "Coconut Husk", *www.wisegeek.com,* Accessed: February 20, 2013.
Anon. (2003b), "Coconut Husk",*www.vivekamexports.com*, Accessed: February 15, 2013)
Anon. (2004), "Introduction to valves", *www.digitalengineeringlibrary.com,*Accessed: February 24, 2013.
Anon. (2007), "Traditional Method of Dehusking Coconut", *www.wikipedia.com,*Accessed: December 19, 2012.
Anon. (2008), "Mild Steel", *www.wikipedia.com*, Accessed: January 30, 2013.
Anon. (2010a), "A Synopsis of Hydraulic Cylinders", *www.hydraulicmania.com,* Accessed: January 30, 2013.Anon. (2010b), "Hydraulic Oils", *www.castrol.com,*Accessed: February 20, 2013.
Anon. (2011), "Coconut", *www.wikipedia.com,* Accessed: February 26, 2013.
Anon. (2012), "Hydraulic Cylinders", *www.hydraulicsonline.com,*Accessed: February 21, 2013.
Bansal, R. K. (2005), *A Textbook of Fluid Mechanics,* Laxmi Publications Ltd, Bangalore, 1st edition, 610 pp.
Barry, J. O. (2005), "Engineering Power Tools", *www.powertools.com,*Accessed: March 20, 2013.
Budynas, R. G. and Nisbett, J. K. (2011), *Shigley's Mechanical Engineering Design,* McGraw-Hill Publishers, New York, 9th edition, 1088 pp.
Cash, W. (2011), "How to Select the Right Hydraulic Oil", *www.howstuffworks.com*, Accessed: January 30, 2013.
Chan, E. and Elevitch, C. R. (2006), "Species Profile for Pacific Island Agroforestry", *www.traditionaltree.org,*Accessed: January 15, 2013.
Commack, S. (2002), "Hydraulic Pumps", *www.machinedesignbyengineers.com,*Accessed: February 21, 2013.
Hays, D. (2009), "Little Things Mean a Lot in Manufacturing", *Hydraulics and Pneumatics Magazine,* Vol. 2, pp. 38-41.
Islam, M. S., Hossain, M. Z. and Khair, M. A. (2007), "Design and Development of Pedal Pump for Low-lift Irrigation", *Journal of Agricultural and Rural Development,* Vol. 2, pp. 116-126.
Khurmi, R. S. and Gupta, J. K. (2005), *A Textbook of Machine Design,* Eurasia Publishing House (PVT.) Ltd., Ram Nagar, New Delhi-110 055, 14th edition, 1230 pp.
Kundu, P. K. and Cohen, I. M. (2002), *Fluid Mechanics,* Academic Press, 6277 Sea Harbor Drive, Orlando, Florida, 2nd edition, 766 pp.
Mahadevan, K. and Reddy, B. K. (1987), *Design Data Hand Book for Mechanical Engineers,* CBS Publishers & Distributors, New Delhi, 3rd edition, 544 pp.
Margolis, J. (2006), "Coconut Fuel" *www.wikipedia.com,* Accessed: February 20, 2013.
Rajput, P. K. (2007), *A Textbook of Fluid Mechanics and Hydraulics Machines*, S. Chand and Company Ltd., Ram Nagar, New Delhi, 1361 pp.