Available online www.unicrossjournals.com

JOURNAL OF CONTEMPORARY RESEARCH (JOCRES)

RESEARCH ARTICLE VOL. 2 (2) ISSN:2814-2241

Date Accepted: 30th September, 2023

Pages 45 - 60

# DEVELOPMENT AND TESTING OF A COCONUT CRACKING AND SCRAPPING MACHINE

NWAMBA, CHARLES OBINNA[1], ANYANDI, JOSEPHAT ADIE[2], OVAT, FRIDAY AJE[3], KUBIAT EFFIONG AKPAN[4]

[1]Northwest Petroleum Retail Services Outlet, Asaba, Delta State-Nigeria

[2,3]Department of Mechanical Engineering, University of Cross River State, Calabar-Nigeria

[4]Department of Mechanical Engineering, University of Uyo, Akwa Ibom State-Nigeria.

*Correspondence Author: fridayovat@unicross.edu.ng, +23408038599332

## Abstract

Extraction of the coconut meat manually poses significant risk of injury to the Operator's hands and also a tedious process. This work is aimed at solving the imminent hazard during cracking and extraction of coconut meat from the endocarp. It was also done to reduce human effort in cracking and scraping. Although there are machines that have been developed to handle the problems of cracking and scraping of coconut for domestic and industrial use. However, integrating cracking and scraping functions in one machine to perform these tasks is not common. Besides, the scraping machines that are available in the market still require human handling of the coconut. To scrape properly, pressure is required. An integrated coconut cracking and scrapping machine was developed as presented in this work to effectively handle the task of cracking and extracting coconut flesh with less operational risk. The cracking unit of the machine uses a spring-loaded hammer that is operated by a rotating crank. The crank is powered with an electric motor. Cracking efficiency of up to 89.91% was obtained on the basis of the crack formed on the shell in relation to its size along the cracking axis during test.

The scrapping unit of the machine was tested using different blades and coconut sizes. Three sets of scrappers were designed and produced with Two, three and four blades, the scrappers were tested on the coconut samples and their individual efficiencies were obtained as 80.44%, 86.34% and 87.16% respectively at a motor speed of 2300rpm. The efficiencies were computed on the basis of the grain volume determined theoretically, in relation to the actual volume of coconut particles collected after scrapping.

**Keywords:** Coconut, Cracking, Scrapping, Development, Performance, Machine, Analysis.

## 1. Introduction

Coconut *(Cocos nucifera* L.*)* is a monocotyledonous plant of the family *Arecaceae* and the monospecific genus Cocos. Recent theory indicates that it originated in Polynesia (Justin). Almost every part of the coconut tree can be used in either making commercial products or meeting the food requirements of rural communities This palm can be found growing over most of the islands and coasts of the subtropics and tropics[1] under varying climatic and soil conditions.

Coconut is cultivated using several soil types like coastal sandy, laterite, loamy, clayey, alluvial and reclaimed soils of low marshy lands. The best suitable soil conditions for the best performance and growth of the palm are proper drainage, water table availability of within 3m, good water retaining capacity and lack of rock or any hard substratum within 2m of the surface. While it grows well on fertile free-draining soils, it also does well on sandy, saline soils and prefers areas with abundant sunlight and regular rainfall. A yearly rainfall of about 2000 mm per year, which is well distributed thoroughly, is very ideal for maximum production and proper growth[2].

Agricultural mechanization plays a significant role by increasing the production, reducing cost of cultivation and processing. Post-harvest mechanization implies the use of agricultural machinery in performing the operations fast and efficient. Mechanization helps in increasing and processing of agricultural commodities. It reduces the drudgery in performing various post-harvest operations and minimizes post-harvest losses.

Coconut provides many necessities of life including food and shelter. Cultivation is done mostly for its nuts; its yield includes fiber, oil cake and oil. Tender coconut contain water which act as refreshing drink and are excellently used as isotonic in many tropical countries. The liquid in coconut is not only thirst-quenching but also mineral drink with enormous benefits to human health [3]. Coconut is made up of traces of fats, protein and minerals like sodium (Na), potassium (K), calcium (Ca), iron (Fe), copper (Cu), phosphorus(P), sulfur (S), chlorine (Cl), Vitamin C, vitamin of the B group like pantothenic acid, biotin, nicotinic acid and riboflavin [4].

Coconut liquid comprises of some organic compounds having healthy growth enhancing properties. It also carries cells oxygen and nutrient, boost human immune system, increase the human metabolism, diabetes control, detoxify and fight against viruses and also, it’s important in the human body in fighting against those viruses in human that causes herpes, flu and AIDS, [3].

It was [5] that described the presence of vitamins, sugar, organic acids, fatty acids, amino acids, fibers and minerals in coconut water. Besides, minor constituents such as free ammonia gas also contributes to the over flavor and mouth feel [3]. Despite the numerous uses associated with coconut, a common problem been encounter by developing country like Nigeria is cutting and scrapping the tender coconut. Present tools and trends used are messy, unsafe and need skill and training.

Present tools used for cutting the coconut shell and scrapping the edible part of the coconut are unsafe and messy. Some of the existing machines are manually operated and come as a single unit i.e. there is machine for cutting also equipment for scrapping. therefore, the present study is aimed at developing a motor driven machine that will perform both the cutting and scrapping processes.

Coconut plays a significant role in the economic, cultural and social life of over 80 tropical countries [6]. Over the years, the coconut palm has been referred to as “the tree of the Heavens” and “tree of a hundred uses” [7]which indicates its remarkable usefulness and qualities. It is a major source of income for rural families and plays an important role in wealth generation and improving the quality of life in many tropical countries.

Coconut is one of the important nut crops in Nigeria. Its production is 9,072,55 Metric tons from 12,825 acres of land in 2004-2005[8]. It is mostly grown in the southern part of the country. The liquid endosperm which is contained inside a young coconut is called coconut water. It is fat free and low in calories. Sodium, potassium, phosphorus, chloride and magnesium are the main minerals found in coconut water, besides vitamin C and sugars, [9]; [10]; [11].

Coconut water presents anti-cardiogenic properties and can be used as dehydrating solution administrated in oral and intravenous form, the later in case of severe dehydration. It has a great demand especially during the hot season. It is very effective especially for diarrhea attacked people and excellent tonic for old and sick. The processed water from the green coconut increase the coconut water availability making the producer to sell at a good price[12];[13 and [14].

It was [15] that developed a tender coconut splitter and punch at Kellappaji College of Agricultural Engineering and Technology, Tavanur. It is made up of a seat and punch assembly. The punch was pivotally attached to a hand-lever, which was hinged along a horizontal pin mounted on a stand. The swinging up and down of the hand-lever causes reciprocating of the punch up and down in a sleeve. Though it could punch a hole on the tender coconut, punch movement through the sleeve was not easy.

Also [16] developed a tender coconut punch, activated by a slider crank mechanism. In this equipment, a tender coconut was placed on a ring stand and as the main hand-lever was lowered, the punch moved downward and punched the husk and shell. Difficulty was experienced in punching more matured tender coconuts due to increased hardness of the shell.

Again [17] developed a tender coconut cutter in KAU. It comprised mainly a base, a stand, a swiveling head, a blade and a hand – lever. The base was a wooden plank. The stand was mounted on the base. The swiveling head was loosely mounted concentric to the stand and retained at a height of 20cm. The blade was 30 cm long and 5cm wide. Its cutting edge was serrated and tips of serration were at a distance of 4 cm. One end of the blade was attached to swiveling head through a horizontal hinge to enable the blade to be operated in a vertical plane, and the other end was pivotally attached to hand-lever 70cm in length.

They [18] developed a household coconut punch-cum-splitter. This small tool can drill through a tender coconut within a minute. It was made from a stainless-steel tube which was molded with an ergonomically designed plastic handle. The end of the stainless steel is having a cutting profile like a reversed saw tooth with sharp cutting edge along the periphery. In clockwise rotation, it will have smooth cutting edge which will cut the soft tender coconut fibers and not pull the fibers. In anticlockwise rotation, it will cut the hard shell like a sharp saw tooth. The tender coconut opener is having a plastic molded stem in the middle of the tube for push out the material inside the tube, after opening the Tender Coconut.

He [19] developed a tender coconut cutter-cum-punching machine at KVK, Thelliyoor, near Kozhencherry. The machine's design allows easy and swift cutting and punching of tender coconuts. It takes hardly a minute to make a nut ready to serve. Operators find the machine safer and user-friendly than the conventional machine. The cutter, weighing 15 kg, consists of a 30-cm blade, 50-cm lever, and an iron stand.

Most of the machines described above were commercialized. But power consumption and cost of the machines were the barriers to adopt. It is possible only by the skilled person and it was not economical for the common people. Based on the above it was considered that there exists a necessity to develop a manually operated tender coconut cutter.

There are basically two type of coconut scrapping machine in terms of operation. There are the manually operated scrapping machine and automatic scrapping machine.

Today there are various method used for scrapping the coconut. These techniques have many limitations in process. These methods are widely used for scrapping. These techniques are,

1. Manually scrapping method
2. Automatic scrapping method

## 2. Manually scrapping technique

Any of the coconut scrapping, greater, shredder makes the job easier and much more efficient, so if you are planning on making fresh coconut a regular part of your diet, you may want to consider picking up one, there are rather inexpensive and do not take up much space unless you get the full bench model. Throughout Nigeria, Malaysia, the South Pacific Islands, India, Thailand and other growing coconut regions employ a traditional tool used to scrape the meat from inside of a split coconut shell is a low wooden bench with an iron grating tool or scrapping hook attached to one end. Sometimes called 'rabbit', many of these small, low benches were carved to resemble animals and rabbit was the most common design[20].

### 2.1 Automatic Scrapping Technique

The method of Hand-Arm Vibration (HAV) is vibrated and transmitted to the hand using hand-held power tools and hand-guided equipment, or holding material during machine operation. HAV mostly practiced by workers that use tools such as Jackhammer, Chainsaw, Grinders, Riveters, and Impact Wrenches

It has been predicted and initially proven that the biodynamic scenes such as stresses, vibration forces, and strains, power absorbed and dissolute in the system are connected closely with injuries vibration-encouraged and abnormality of the tissues or biological structures of the system[20]. Many Researchers have work extensively on coconut dehusking machines, coconut cracking/cutting and scrapping machines among others with unique features. Some of these machines are listed below; [21], Design and Development of Coconut Dehusking Machine; [22], Development of and performance evaluation of coconut dehusking machine; [23], Design and fabrication of multi-blades coconut scrapping machine with single drive; [24], Design and Fabrication of Coconut Dehusker; [25], Design and fabrication of cocoutdehusking machine; [26], Design and Fabrication of Pneumatic Operated Coconut Dehusking Machine; [27], Design and Development of Hydraulic Coconut Dehusking Machine; [28], Coconut shell breaker machine; [29], Performance Evaluation of Power Operated Coconut deshelling Machine for Different varieties of Coconut; [30], Design and Development of a Coconut dehusking Machine (Machine Component Design); [31] Design and Fabrication of tender coconut cutting machine etc.

There are lots of dangers associated with cutting and scrapping of coconut using the traditional and mechanical means, its stressful, time-consuming and most times, hazardous when considering number of coconuts that are to be cut for domestic and commercial purposes.

Research has shown that different cracking and scrapping machines have been developed. While some work independently as cracking/cutting machines, others work as scrapping machines/tools as stand-alone. The literature for a machine that carries out cracking and scrapping of coconut simultaneously is scanty. This work therefore aims to address this challenge including that of Operators safety when cracking and scrapping are done manually.

## 3. MATERIALS AND METHODS

### 3.1 Materials

Materials selected for the machine were mild steel and stainless steel. Mild steel was used in production of the frame and support components of the machine. For parts that were expected to have contact with the coconut shreds, such as the cutting blades, stainless steel was used. The machine was fabricated using standard engineering manufacturing processes; namely marking out, cutting and welding. After assembly and testing, finishing was done on the machine using automobile paint spray.
Stainless steel was selected as the blade material. This was done to ensure that food contamination due to the use of a material that can corrode was prevented.

### 3.2 Design of the cracking unit

The free body diagram of the cracking mechanism is shown in Figure 2.0. The movement of the cracking hammer is facilitated by the rotation of a crank relative to the impact portion of the hammer. $F_{TCR}$ is the total cracking force that is imposed on coconut in the cracking unit. This value is the sum of the weight of cracking mass, $W_{CM}$, spring force, $F_s$ and the force due to motion of the hammer. The relation is expressed in Equation 1.

$$F_{TCR} = W_{CM} + F_s + F_m \quad 3.1$$

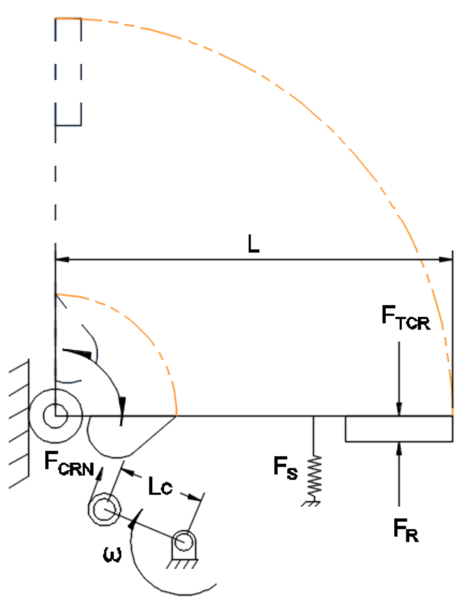


Figure 2.0: Mechanics of the Cracking Operation

The hammer is designed to return to a horizontal position after being deflected by the crank using an extension spring. The force on extension spring was calculated using Equation 2.

$$F_s = I_T + (D \times k) \quad 3.2$$

Where:

D is the distance the spring is deflected

$I_T$ is the initial tensile force on the spring

k is the stiffness of the spring

Furthermore, the force due to motion of the hammer, $F_m$ is computed because potential energy is stored in the hammer when it moves from the horizontal to vertical position. While the spring force returns the hammer, the stored energy, E is converted to kinetic energy on striking the coconut shell. This is best described mathematically as shown in Equation 3[32].

$$E = mgh = \frac{1}{2}mv^2 \quad 3.3$$

Where;

m = mass of the hammer

g = acceleration due to gravity

h = height of displacement of the hammer

v = the velocity of the hammer

But, according to [33], the energy absorbed on impact is average work; thus,

$$E = \frac{F_m}{2} \times d \quad 3.4$$

Where d is deformation of the coconut

$$\text{Therefore, Force, } F_m = \frac{mv^2}{d} \quad 3.5$$

$$F_{TCR} = W_{CM} + F_s + F_m \quad 3.6$$

Force required to lift the hammer with the crank, $F_{CRN}$ was computed using the principle of moments. Referring to Figure 3.2, the free body diagram was used in the analysis.

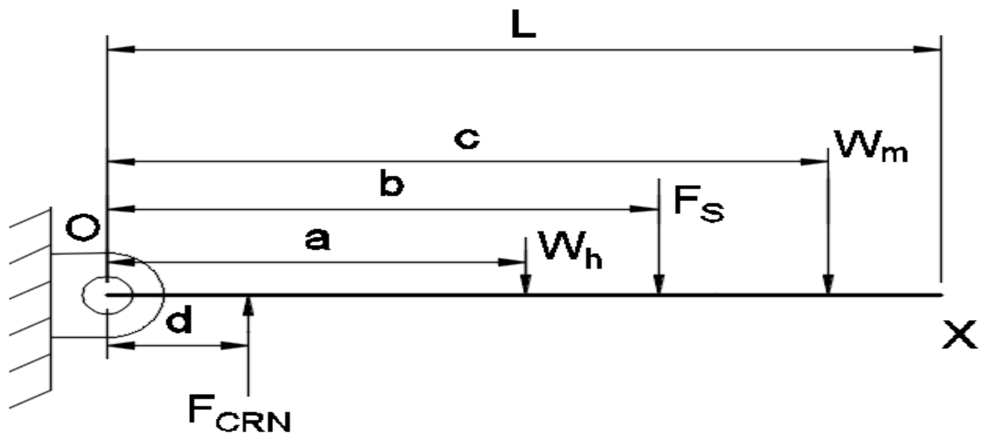


Figure 2.1: Free-body diagram of the hammer lifting mechanism

Taking moments about O,

$$(F_{CRN} \times d) = (W_h \times a) + (F_s \times b) + (W_m \times c) \quad 3.7$$

$$F_{CRN} = \frac{(W_h \times a)+(F_s \times b)+(W_m \times c)}{d} \quad 3.8$$

The force thus computed was generated by the rotation of a crank with length, $L_c$. With the minimum required force to operate the hammer, $F_{CRN}$ and crank length, $L_c$, the torque developed by the motor was calculated using Equation 9.

$$T = F_{CRN} \times L_c \quad 3.9$$

An electric motor was selected to provide the required torque. Chain drive was used to facilitate power transmission from the electric motor to the drive shaft (Mahadevan and Balaveera, 2018[34].Velocity ratio, r of the chain drives was computed using Equation 10.

$$r = \frac{number\ of\ teeth\ on\ the\ smaller\ sprocket}{number\ of\ teeth\ on\ the\ larger\ sprocket} \quad 3.10$$

Also, power transmitted by the drive shaft was computed using Equation 11.

$$P = \frac{2\pi NT}{60} \quad 3.11$$

Where;

T = torque transmitted (in N-m)

N = shaft speed (rpm)

The main drive shaft provides the torque required to operate the cracking hammer as well as the coconut holder. Although the two chambers are not operated simultaneously, the shaft is subjected to torsional stresses.

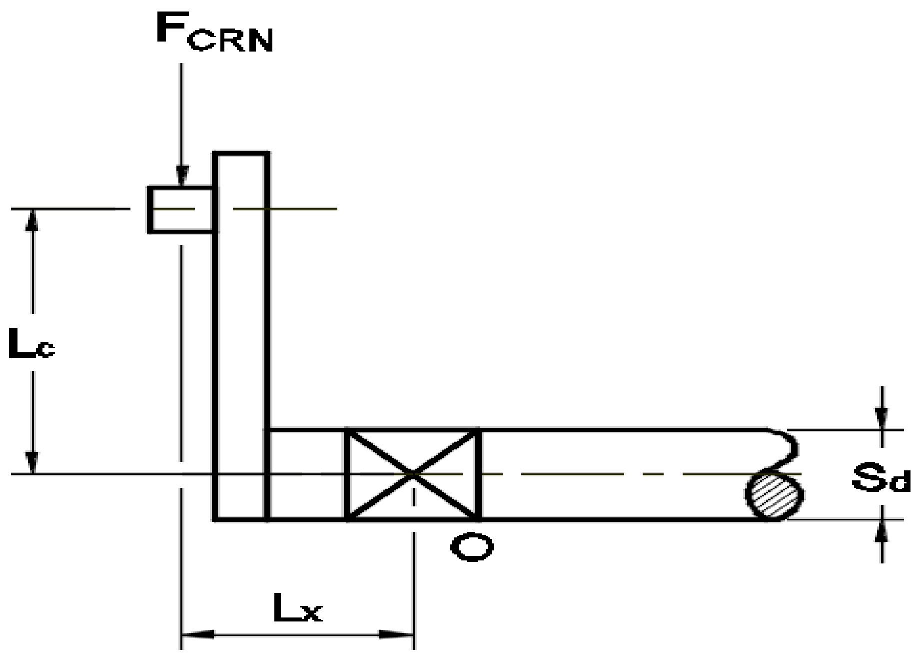


Figure 2.2: Stresses due to loading of the crank

Bending moment at the centre of the bearings of the main drive shaft.

Taking moments about the bearing at O,

$$M = (F_{CRN} \times l_x) \quad 3.12$$

But, bending stress, $\sigma_b$ due to the bending moment is given by:

$$\sigma_b = \frac{M}{Z} \quad 3.13$$

Where Z = section modulus of the shaft

$$Z = \frac{\pi}{32} \times {S_d}^3 \quad 3.14$$

$$\therefore \sigma_b = \frac{32M}{\pi {S_d}^3} \quad 3.15$$

Furthermore, shear stress due to the torque transmitted was computed using Equation 16.

$$\tau = \frac{16T}{\pi {S_d}^3} \quad 3.16$$

The efficiency of the cracking unit was determined based on the length of crack that develops on the coconut along the cracking axis (the shorter dimension of the coconut) using the Equation 17.

$$Cracking\ Efficiency, \eta_{cr} = \frac{length\ of\ observable\ crack}{diameter\ of\ coconut\ along\ the\ crack\ axis} \times 100\% \quad 3.17$$

**3.3 Design of the Scrapper Assembly**

The scrapper unit is the part of the machine that facilitates shredding of the coconut endosperm. For reasons of evaluation, three scrapper rotors were produced; each having blades with serrated edges. Each rotor had different number of blades: two, three and four. Before using the scrapper part of the machine, the cracking hammer is locked in position. A half-split coconut is installed firmly in the holder, then the scrapper blade is moved into position for the scrapping process. The main drive motor is turned on as well as the scrapper motor. While the coconut is rotated in its locked-in position, the user moves the scrapper towards the walls of the endosperm for scrapping. The speed of operation of the scrapper was variable. This was done to observe the performance of the machine at various speed settings.

The scrapping speed, $V_c$ was computed mathematically using Equation 18.

$$V_c = \frac{\pi d n}{12} \quad 3.18$$

Where

d = diameter of the scrapper

n = revolutions per minute of the scrapper spindle

Cutting power, $P_s$ at the spindle is related to the tangential cutting force, $F_t$ and the scrapping speed as shown in Equation 19.

$$P_s = \frac{F_t \times V_c}{60000}\ (kW) \qquad 3.19$$

$$F_t = \frac{T_s}{R} = \frac{2T_s}{d} \qquad 3.20$$

Where;

$T_s$ = torque of the cutting spindle

R = radius of the spindle

But, $T_s = \frac{60P_s}{2\pi n}$ 3.21

Thus, substituting Equation 21 in Equation 20,

$$F_t = \frac{60P_s}{\pi d n} \qquad 3.22$$

The scraping efficiency, $\eta_{scr}$ was determined based on how long it took to completely remove the edible portion of the coconut (endosperm). This was assessed using the three different blades configuration and coconuts of roughly the same size. Mathematically,

$$\eta_{scr} = \frac{Volume\ of\ coconut\ grits\ produced,\ V_{GT}}{Grain\ volume, V_G} \times 100\% \qquad 3.23$$

According to Bello, et at (2018), grain volume is given by:

$$V_G = \frac{\pi b^2 a^2}{6(2a-b)} \qquad 3.24$$

Where;

a = length of the coconut along the major axis (mm)
b = width of the coconut along the minor axis (mm)
$V_{GT}$ Was obtained by physical measurement.

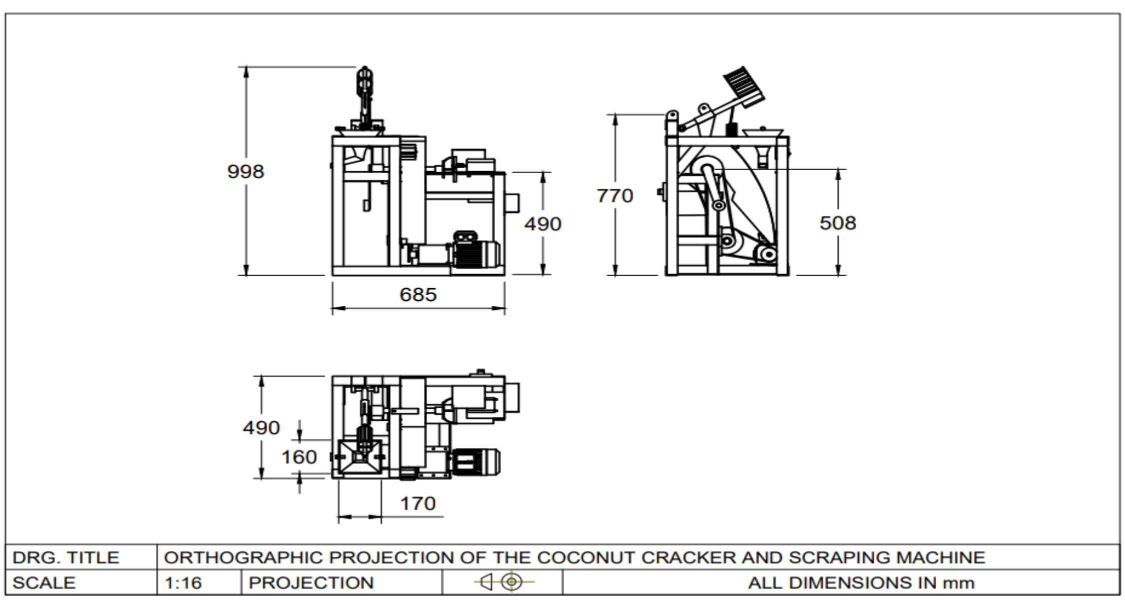


Figure 2.3: Orthographic Projection Of The Coconut Cracker And Scrapping Machine.

## 4. Principles of operation of the developed machine.

The machine developed has compartments for cracking as well as scrapping the coconut. For cracking process, the coconut is placed in the cracking chamber, then held firmly by adjusting bolts on either side of the cracking chamber. It is required that the coconut be held firmly so as to ensure that it does not move out of the cracking chamber; thereby reducing the effect of the hammer impact. The cracker makes use of a cracking hammer that has a knife edge. Masses are placed above the knife to increase the impact force thereby resulting in cracking the coconut with lesser external power from the prime mover.

The scrapping unit of the coconut processing machine comprises a holding jaw and a user-controlled scrapping motor. The scrapper blades were designed to facilitate effective removal of the edible part of the coconut. It comprises a number of saw-edged blades, arranged tangentially to the direction of rotation of the scrapping motor spindle. To facilitate performance evaluation of the machine, the scrapping tool was made removable. Thus, two, three and four-bladed tools were produced and used in the evaluation.

## 5. Testing of the Cracking Unit

The cracking unit was tested using various sizes of coconut. The cracking compartment was designed with a screwed holder; this is adjusted to firmly secure the coconut in place, so that it would not rotate while cracking. Data collected for the testing of different sizes of coconut in the cracking unit is presented in Table 4.1.

Figure 2.4: Cracking machine undergoing testing

### 5.1 Testing of the Scrapping Unit

The scrapper unit of the machine which includes scrapper blades ranging from 2 to 4 blade were tested with coconut fruits of different sizes. Each coconut of different diameter was inserted into the scrapping chamber and made to run with scrappers of blades 2, 3 and 4 but retaining the same scrapper spindle diameter. The results are discussed in chapter four.

### 5.2 Scraper with two Blades

Diameter of the scrapper spindle = 18mm

Figure 2.5:A two-bladed scraper

### 3.3.4 Scraper with three Blades

Diameter of the scrapper spindle = 18mm

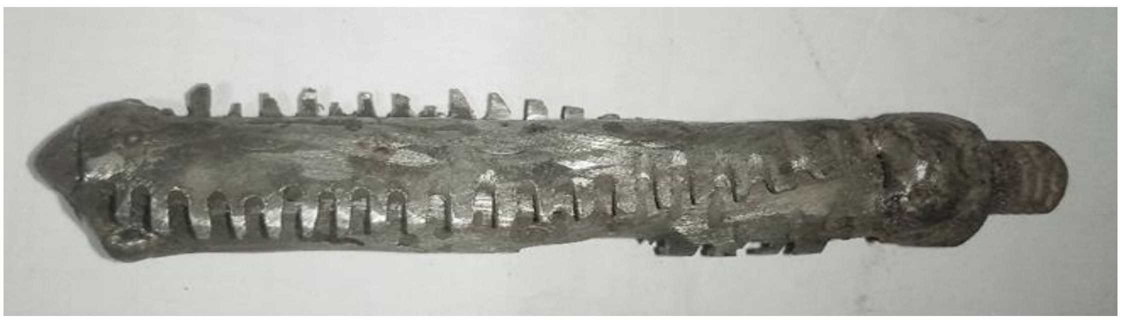

Figure 2.6: A four-bladed scraper

### Scraper with four blades

Diameter of the scrapper spindle = 18mm

Figure 2.7: A four-bladed scraper

## 6. Results and Discussion

In this chapter, the results of testing the coconut cracker and scrapper machine are presented in tabula and graphical forms. Data collected based on these tests include the operating speed of the scrapper motor and number of blades on the scrapper, and also, the test parameters for different diameters of coconuts. Based on the quality of the processed product, the efficiency of the coconut scrapper and cracker is discussed.

**Table 1.0: Data Obtained for Cracking Unit Testing**

| No. of samples | Coconut size (mm) | Length of observable crack (mm) | Length of crack on the coconut (%) |
|---|---|---|---|
| 1 | 88.00 | 72.00 | 81.82 |
| 2 | 95.00 | 81.00 | 85.26 |
| 3 | 99.00 | 83.00 | 83.84 |
| 4 | 101.00 | 86.00 | 85.15 |
| 5 | 102.00 | 87.00 | 79.41 |
| 6 | 105.00 | 90.00 | 84.76 |
| 7 | 106.00 | 91.00 | 85.85 |
| 8 | 109.00 | 98.00 | 89.91 |
| 9 | 111.00 | 95.00 | 85.59 |
| 10 | 113.00 | 100.00 | 88.50 |

The efficiency of the cracking unit was determined based on the length of crack observed on the coconut in relation to the coconut size. Figure 1.0 shows a graph indicating the length of crack produced in relation to the different sizes tested.

**Table 2.0: Data Obtained for Scraping Unit with two blades**

| S/N | Major axis diameter, a (m) | Minor axis diameter, b (m) | n (rpm) | $V_c$ (m/s) | $P_s$ (kW) $\times 10^{-3}$ | $V_G$ (m³)$\times 10^{-4}$ | $V_{GT}$ (m³)$\times 10^{-4}$ | $\eta_{scr}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.105 | 0.09 | 2300 | 10.84 | 3.6 | 3.7 | 2.5 | 68.23 |
| 2 | 0.114 | 0.10 | 2300 | 10.84 | 3.6 | 4.6 | 3.1 | 67.14 |
| 3 | 0.118 | 0.10 | 2300 | 10.84 | 3.6 | 5.2 | 4.2 | 80.53 |
| 4 | 0.121 | 0.10 | 2300 | 10.84 | 3.6 | 5.5 | 4.4 | 79.33 |
| 5 | 0.119 | 0.10 | 2300 | 10.84 | 3.6 | 5.7 | 4.8 | 84.62 |
| 6 | 0.121 | 0.11 | 2300 | 10.84 | 3.6 | 6.2 | 5.1 | 82.67 |
| 7 | 0.124 | 0.11 | 2300 | 10.84 | 3.6 | 6.4 | 5.2 | 81.63 |
| 8 | 0.124 | 0.11 | 2300 | 10.84 | 3.6 | 6.9 | 6.1 | 88.64 |
| 9 | 0.128 | 0.11 | 2300 | 10.84 | 3.6 | 7.3 | 6.2 | 85.05 |
| 10 | 0.125 | 0.11 | 2300 | 10.84 | 3.6 | 7.6 | 6.6 | 86.55 |

The average efficiency of the scrapping unit of the machine based on the data obtained is 80.44%. Table 2.0 shows the grain volume to the volume of grits collected for the scraper with two blades.

$P_s$ = Scrapper power on kilowatts

$V_c$ = Scrapper speed

$V_G$ = Grain volume

$\eta_{scr}$ = Scrapper efficiency

**Table 3.0: Data Obtained for Scraping Unit with three blades**

| S/N | Major axis diameter, a (m) | Minor axis diameter, b (m) | n (rpm) | VS (m/s) | PS (kW) × $10^{-3}$ | VG ($m^3$) × $10^{-3}$ | VGT ($m^3$) × $10^{-3}$ | $\eta scr_{scr}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.105 | 0.09 | 2300 | 10.84 | 3.6 | 3.7 | 2.6 | 69.6 |
| 2 | 0.114 | 0.10 | 2300 | 10.84 | 3.6 | 4.6 | 3.2 | 68.5 |
| 3 | 0.118 | 0.10 | 2300 | 10.84 | 3.6 | 5.2 | 4.3 | 82.1 |
| 4 | 0.121 | 0.10 | 2300 | 10.84 | 3.6 | 5.5 | 4.5 | 80.9 |
| 5 | 0.119 | 0.10 | 2300 | 10.84 | 3.6 | 5.7 | 4.9 | 86.3 |
| 6 | 0.121 | 0.11 | 2300 | 10.84 | 3.6 | 6.2 | 5.2 | 84.3 |
| 7 | 0.124 | 0.11 | 2300 | 10.84 | 3.6 | 6.4 | 5.3 | 83.3 |
| 8 | 0.124 | 0.11 | 2300 | 10.84 | 3.6 | 6.9 | 6.2 | 90.4 |
| 9 | 0.128 | 0.11 | 2300 | 10.84 | 3.6 | 7.3 | 6.3 | 86.8 |
| 10 | 0.125 | 0.11 | 2300 | 10.84 | 3.6 | 7.6 | 6.7 | 88.3 |

The average efficiency of the cracking unit of the machine based on the data obtained is 86.34%. Table 3.0 shows the grain volume to the volume of grits collected for the scraper with three blades.

**Table 4.0: Data Obtained for Scraping Unit with four blades**

| S/N | Major axis diameter, a (m) | Minor axis diameter, b (m) | n (rpm) | VS (m/s) | PS (kW) × $10^{-3}$ | VG ($m^3$) × $10^{-4}$ | VGT ($m^3$) × $10^{-4}$ | $\eta scr_{scr}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.105 | 0.09 | 2300 | 10.84 | 3.6 | 3.7 | 2.6 | 70.96 |
| 2 | 0.114 | 0.10 | 2300 | 10.84 | 3.6 | 4.6 | 3.2 | 69.82 |
| 3 | 0.118 | 0.10 | 2300 | 10.84 | 3.6 | 5.2 | 4.4 | 83.75 |
| 4 | 0.121 | 0.10 | 2300 | 10.84 | 3.6 | 5.5 | 4.6 | 82.51 |
| 5 | 0.119 | 0.10 | 2300 | 10.84 | 3.6 | 5.7 | 5.0 | 88.01 |
| 6 | 0.121 | 0.11 | 2300 | 10.84 | 3.6 | 6.2 | 5.3 | 85.98 |
| 7 | 0.124 | 0.11 | 2300 | 10.84 | 3.6 | 6.4 | 5.4 | 84.89 |
| 8 | 0.124 | 0.11 | 2300 | 10.84 | 3.6 | 6.9 | 6.3 | 92.19 |
| 9 | 0.128 | 0.11 | 2300 | 10.84 | 3.6 | 7.3 | 6.4 | 88.46 |
| 10 | 0.125 | 0.11 | 2300 | 10.84 | 3.6 | 7.6 | 6.9 | 90.02 |

The average efficiency of the cracking unit of the machine based on the data obtained is 87.16%. Table 4.0 shows the grain volume to the volume of grits collected for the scraper with four blades.

## 7. Discussion

The coconut cracking and scrapping machine was designed, fabricated and tested according to the established standards. The machine was found to be effective in producing coconut guts from an uncracked coconut fruit. The coconut cracker machine was tested using ten (10) different samples of coconut with sizes ranging from 88mm – 113mm diameter. It was observed that the cracks on the coconut samples increases with the sizes of the coconut. For instance, 88mm size coconut recorded a 72mm length of crack when loaded which translates to an efficiency of 81.82%. This is with exception of sample number 9 which has a size of 111mm with a 6-crack length of 95mm. What is the responsible? This can be attributed to operators' error in feed P sample.

Again, the 113mm size coconut recorded an observable crack length of 100mm which indicates an efficiency of 88.50%. The result obtained from the cracking test is presented in Table 1.0 and represented graphically in figure 4.1. From the data and graph shown, it suggests that, the cracking machine produced higher cracking margin and higher efficiency when cracking coconut of higher diameter as can be seen in samples 101 9, 8, 7 and 6.

From the result shown in Table 4.2 to 4.4 and figures 4.2 to 4.5 respectively, the result represents the test obtained from scrapping of the coconut samples in different scrapping units with two, three and four blades.

The blades have major and minor axes represented as (a) and (b) respectively. The revolution per minute (rpm) of the electric motor is constant for all the blade types and is given as 2300 rpm, $V_c$ is Scrapper speed, $P_s$ = Scrapper power on kilowatts, $V_G$Grain volume and $\eta_{scr}$ = scrapping efficiency.

With the scrapping test carried out, ten (10) different samples of coconut of different diameters were used. The corresponding sizes were tested against the different number of scrapper blades ranging from 2 to 4 blades. The result was recorded as shown in the corresponding tables and figures. For Table 4.1, samples 14 increased proportionately on the major axis diameter and dropped at sample 5 and increased again between 6 and 9 and dropped at 10 whereas for the minor axis there was marginal increase from 1-2 and remain constant between 2-5 and increased marginally, between 6-7 and remain constantly to the tenth sample. Why – what happened.

The rmp, $V_c$, and $P_s$ remained constant while $V_g$ and $V_{GT}$ increased steady with the number of samples and the major and minor axes of the scrapper.

The efficiency of the scrapper blades increased as the major axis of the coconut increased with size. This expression can also be seen in the graph represented in figure 4.2. The average efficiency of the scrapper unit with 2 blades is 86.78%. the result of three blade scrapper is shown in Table 4.3 and figure 4.3. The same number of samples were used for the test and from the table the values obtained from the two-blade scrapper for the major axis, minor axis and $V_G$ are exactly the same. However, the $V_{GT}$ and the efficiency of the scrapper are slightly different. The values of the efficiency with respect to the two-blade and three-blade scrapper follow the same pattern. The average efficiency of the three-blade scrapper 82.05%. Table 4.4 and figure 4.4 shows the result obtained for using scrapper with four blades. Again, compared to two-blades, and three-blades, the data generated using four-blades scrapper are the same for major axis, minor axis and $V_G$ except for $V_{GT}$.

The average efficiency for the four-scrapper blades is 66.89%.

From the efficiency of the different number of scrappers blades, it shows that the higher the number of blades the lower the scrapping efficiency of the scrapping unit. The average efficiency of the two-blades, three-blades and four-blades scrappers is (86.78+82.05+66.89) = 78.57%

## 8. Conclusion

In this work a machine was developed to carry out cracking and scrapping of coconut for both domestic and industrial uses. The machine was fully developed and tested for the cracking and scrapping units. The combined efficiency of the machine shows an average value of 86% at a speed motor of 2300rpm.

With this machine the challenges of injuries on the Operator while using the local method of cracking and scrapping has been eliminated completely.

## References

[1]. Dowe, J. V. F. (2023). UNSPECIFIED, and UNSPECIFIED (2023) *Saribuspendulinus, a New Fan-Palm from New Guinea.* Palms, 67 (1). pp. 13-25.

[2]. Sankaran M, Damodaran V, Singh DR, Sankar IJ, Jerard BA(2012). Characterization and diversity assessment in coconut collections of Pacific Ocean Islands and Nicobar Islands, African Journal of Biotechnology. 2012; 11(97):16320- 16329.

[3]. Poduval, M., H. Abu and P. K. Chattopadhyay 1998. Evaluation of coconut cultivars for tender nut waters for West Bengal. Indian Coconut Journal, 29(1), 3-4

[4]. Muralidharan K, Jayashree A. (2011). Value added products from coconut: Coconut for health & wealth, Indian Coconut Journal. 2011; 54(8):24-28.

[5]. Santoso, U., Kazuhiro, K., Toru, Ota., Tadahiro, T. and Akio, M. (1996). Nutrient composition of Kopyor coconut (cocos nucifera L). Food Chemistry. Vol. 57(2):299-304.

[6]. Oyoo, M. E., Muhammed, N., Kimani, C.N. and Githiri, S.M. (2016). Assessment of the genetic diversity of Kenyan coconut germplasm using simple sequence repeat(SSR)markers. African Journal of Biotechnology. Vol.15(40):2215-2223.

[7]. Lukose R.M.(2013). The chemical composition of tender coconut (Cocos nucifera L.) water and coconut meat and their biological effect in human body, International Journal of Green and Herbal Chemistry. 2013; 2(3):723-729.

[8]. Alonge, A. F. and Adetunji, W. B. 2011. Properties of Coconut (Cocos Nucifera L.) relevant to its Dehusking. Journal of Agricultural Science and Technology A1. Published by David Publishing, USA, 1(11):1089 – 1084. DOI:10.17265/2161-6256/2011.11A.020.

[9]. Magda, R. R. (1999). Cocosoft drink: Health beverage from coconut water. Food Market Technology. Vol. 6:22-23.

[10]. Campos, C. F., Souza, F. E. A., and Gloria, M. B. A. (1996). Chemical Composition, enzyme inactivation on flavour quality of green coconut water. Journal of Food processing and Preservation. Vol. 20:487-500

[11]. Nathan, J. and Collins Vox, 1999. The Chemical Composition of Tender Coconut (Cocos Nucifera L.) Water and Coconut Meat and Their Biological Effect in Human Body. International Journal of Green and Herbal Chemistry, Vol.2, No.3; 723-729.

[12]. Priya, S.R., and Ramaswamy, L. (2014). Tender coconut water-natures elixir to mankind. International Journal of Recent Scientific Research. 5(8): 1485-1490.

[14]. Sylianco, C.Y.L., Guevara, A.P., Wu, L.S., Serrane, E and Mallorca, R. (1992). Antigenotoxic effect of coconut meat, coconut milk and coconut water. Philippine journal of science.21: 231-253.

[15]. Shamsudeen, K.P and Anitha, J. (1997). Development and testing of a tender coconut Punch and splitter. Unpublished B.TechProject Report. Kerala Agricultural University, Kerala, India.

[16]. Pranathi, N. D., Telaprolli, N and Velag, P. (2021). Designing the tender coconut punching tools. Journal of Scientific Research. Vol.65(04):126-130. DOI:10.37398/JSR.2021.650421.

[17]. Shamsudeen, K. P., J. Anitha and J. Jippu 1999. KAU tender coconut cutter. Indian Coconut Journal, 30(6), 9

[18]. Roshni T., Jippu J., Ratheesh C.S., Sachin J., Sreevisakh K.L. (2009). Development of a Household Coconut Punch-cum-Splitter". Agricultural Engineering International: the CIGR Ejournal. Manuscript 1188. Vol. XI. May, 2009.

[19] Sreekanth S. N. (1999). Physio-chemical constituents of tender coconut. The Indian Journal of Agricultural Science. Vol 69(10): 50-61.

[20]. Jippu, J. V, (2014). A Review of coconut husking machine", International Journal of Advanced Research in engineering & Technology (IJARET), ISSN 0975-6995(Print) ISSN 0976 – 7002 (Online) Volume 5, Issue 3, September - December (2014), pp. 68-78.

[21]. Wadile, P. A. and Kolhe, K. P. (2017). Design and Development of Coconut DehuskingMachine".International Journal of Advance Engineering and Research Development. Volume 4, Issue 5, May -2017.

[22]. Ovat, F. A. and Odey S. O. (2019). Development of and performance evaluation of coconut dehusking machine. The International Journal of Engineering and Science (IJES). Vol.8(10). PP15-22

[23]. Senthil, K. G, Kamaraj, K. Kaviraju, s. and Mano, B. T. (2018). Design and fabrication of multi-blades coconut scrapping machine with single drive. International Journal of Recent Engineering Research and Development (IJRERD). Vol, 03(02). PP19-23.

[24]. Sujaykumar, G.,Shashidhar, B. Asantapur, V. C., Prashanth, K., Dhanush, D. (2017). "Design and Fabrication of Coconut Dehusker". Journal of Mechanical Engineering and Automation p-ISSN: 2163-2405 e-ISSN: 2163-2413.

[25]. Amal P. V, Sibin, S., Abhiram, B. E., Albin, J. S., Sony, K. (2020). Design and fabrication of cocoutdehusking machine. International Journal of Engineering Applied Sciences and Technology, 2020 Vol. 4, Issue 10, ISSN No. 2455-2143, Pages 348-351.

[26]. Vijay, K., Tile, G.,Praveen K, Prema D, Srikanth, Yashvanth B G. (2017). Design and Fabrication of Pneumatic Operated Coconut Dehusking Machine" International Journal of Innovative Research in Science, Engineering and Technology, Vol. 6, Special Issue 15, 122-130.

[27]. Sharanbasappa, N., Murthy C, Santosh, S. K (2017). Design and Development of Hydraulic Coconut Dehusking Machine" International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321- 9653; IC Value: 45.98; SJ Impact Factor: 6.887 Volume 5 Issue VII.

[28]. Yuliat, H. S. and Ignatius, J. M. (2019). Coconut shell breaker machine. AIP Conference Proceedings 2114. 080004. Htts://doi.org/10.1063/1.5112475.

[29]. Man, M. D., Matthew, Manikantan, A. C., Ramarathinam, M. and Hebbar, K. B. (2020). Performance Evaluation of Power Operated Coconut deshelling Machine for Different varieties of Coconut. Journal of Agrisearch. Vol. 7(30: 154-157.

[30]. Azmi, H., Sanuddin, A. B. Zakimi, M. Z., Jamali, M. S., Radhwan, H.,A., Khalil, N. M., Akmal, A. N. A. and Annuar, A. F. (2015). Design and Development of a Coconut dehusking Machine (Machine Component Design)". Journal of Advanced Research Design ISSN (online): 2289-7984 | Vol. 4, No.1. Pages 9-19.

[31]. Balachandar, K., Chaithanya, K., Balamurugan, S and Vijay, Ch.K. 2018. Design and Fabrication of tender coconut cutting machine. International Journal of Research Cultural Society.2(3):188-190.

[32]. Budynas, R. G. and Nisbett, J. K. (2011), Shigley's Mechanical Engineering Design, McGraw-Hill Publishers, New York, 9th edition, 1088 pp.

[33]. Khurmi, R. S Gupta, J. K. (2005). A Textbook of Machine Design. 14th Edition S. Chand and Company Limited. Ram Nagar, New Delhi -1105s, 2005. S 2494-1974.

[34]. Mahadevan, K. and Balaveera, K, R. (2018). Design Data Hand Book for Mechanical Engineers in S.I. and Metric Units, CBS Publishers and Distributors, New Delhi, 3rd edition, 544 pp.

.