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Design and Fabrication of a Manual Hydraulic Palm Oil Press Machine using Locally Sourced Materials

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Abstract
Palm oil production in Nigeria is not fully exploited due to non-mechanization in the production process. The know means of processing palm oil in Nigeria is through the traditional method. The traditional method of extracting palm oil focuses more on the digesting and pressing of the palm fruit done by hand and leg which is inadequate to meet domestic demands. High demand in palm oil for both local and international consumption cannot be met by traditional method of extraction which does not only have low production rate, but is equally unhygienic, laborious and time consuming. For this reason, a manually operated hydraulic palm oil press machine was designed, fabricated, and tested using locally available material. This machine was aimed at reducing time and energy consumption, low production rate, intensive labour, and eliminate unhygienic state encountered in the traditional method of pressing oil. The basic features of the palm oil press are the frame, cage, pressing plate, hydraulic jack, pressure hose, collector, jack cylinder and piston, hydraulic tank, aider, and spout. The hydraulic tank of 53 tons was operated manually and the hydraulic oil was transferred to a hydraulic jack of 5 tons through a hose, which then enabled pressing operation on the pressing plate to the digested palm fruit. The machine was designed to accommodate 36 kg of palm fruit per press. The outcome of the results showed that an average pressing time of 5.3 minutes and average efficiency of 76% was achieved.
Key words: Hydraulic press machine, design, palm oil, efficiency, pressing time

1. Introduction
Palm piece oil is a fundamental item in Nigerian economy because of its job as a wellspring of homestead pay and nourishment prerequisite. Also, it gives immediate and aberrant work to around four (4) million Nigerian. Additionally, palm bit oil contributes an expected 70% of the nation's national utilization prerequisite of vegetable oils (Poku, 2002; Nzeka, 2014). The decrease in palm piece oil item in Nigeria advertise which has come about to significant expense of the item required the requirement for a task improvement of a

manual pressure driven palm oil press machine. Huge level of palm part oil in Nigeria showcase is prepared from the customary strategy which isn't just unhygienic however difficult and tedious (Adebayo, 2004; Oyejide, and Omeche, 2018; Oseni and Michael, 2002). Despite, Nigeria is the third biggest maker of palm oil on the planet however she despite everything imports palm oil to satisfy local need. The objective of Nigeria hence ought to be to fulfil residential need. Additionally, there has been consistent ascent in the interest of palatable palm oil for both local and modern employments. The know methods for preparing palm part oil in Nigeria is through the conventional technique. The conventional technique for extricating palm oil concentrates more on the processing and squeezing of the palm natural product done by hand and leg which is deficient to satisfy residential needs.

Absorption and oil extraction (squeezing) are the most troublesome and significant activities in conventional strategy for handling palm organic product, in this way, early endeavours focused on these errands. In little scope preparing, absorption and squeezing activity are normally work serious exercises. The customary technique, which is naturally work escalated, includes two procedures. The first is known as "hard oil" procedure, and it requires a long length of maturation to isolate natural products from bundles and to mellowing the monocarp. The matured organic products are beat in a wooden mortar with wooden pestles followed by expansion of water to separate the oil. The aged organic products are bubbled before beat so as to extricate the oil. The blend is depleted and bubbled, and the wipe oil skimmed off. The 'delicate oil' process is an enhancement for the 'hard oil'. A lot of vitality and assets have been put to building up the strategy equipped for expanding both the extraction rate and amount of palm oil, consequently the main option is automated the procedure (Azodo, et al., 2013; Isaac and Morakinyo, 2012; Nwakwojike, et al., 2012). The motorized technique normally included the utilization of machine in removing of palm oil. For example, a press machine is utilized to remove palm bit oil by the utilization of exceptional strain to palm organic products. The extricated oil is depleted into holders and filled the clarifier. This isolates the oil from its debasements to recuperate the most extreme conceivable yield of unadulterated oil. It is done because the liquid coming out of the press is a blend of palm oil, water, flotsam and jetsam, stringy material, and non-sleek solids (Oseni, 2015; Gunn, 2014). Since water is mostly dissolvable in oil, drying must be finished. For this to be done, the oil is first warmed to a temperature simply above 100^{o}C before it is then sent to a characteristic drier, where it is extended in a far layer and presented to air ventilation. At long last, the dried oil is moved to a tank for capacity.

2. Methods

2.1 Research Design

The exploration configuration involves the thought of a populace of press machines that are accessible. Existing plans were survey and another structure that will achieve the examination targets was picked.

2.2 Samples and Sampling Design

The machines were chosen purposively dependent on the wide assortment that exists. The test units are the machines/gear structured and delivered in this exploration work.

2.3 Population

By populace, it is implied the presence of various sorts of the machine. Most likely, past analysts had done a ton of research work to create various kinds of squeezing machines. Be that as it may, the productivity got in their structure is generally low. So, this current plan is planned to realize improvement in existing structures.

2.4 Source and Size of Data

For this examination work, enquiries were produced using these sources:

i. Experimental investigation of the machine segments/parts, parameters to assess productivity and yield;

ii. Outline sources demonstrating past scientific investigation, standard/variable qualities and expatiation of certain parts;

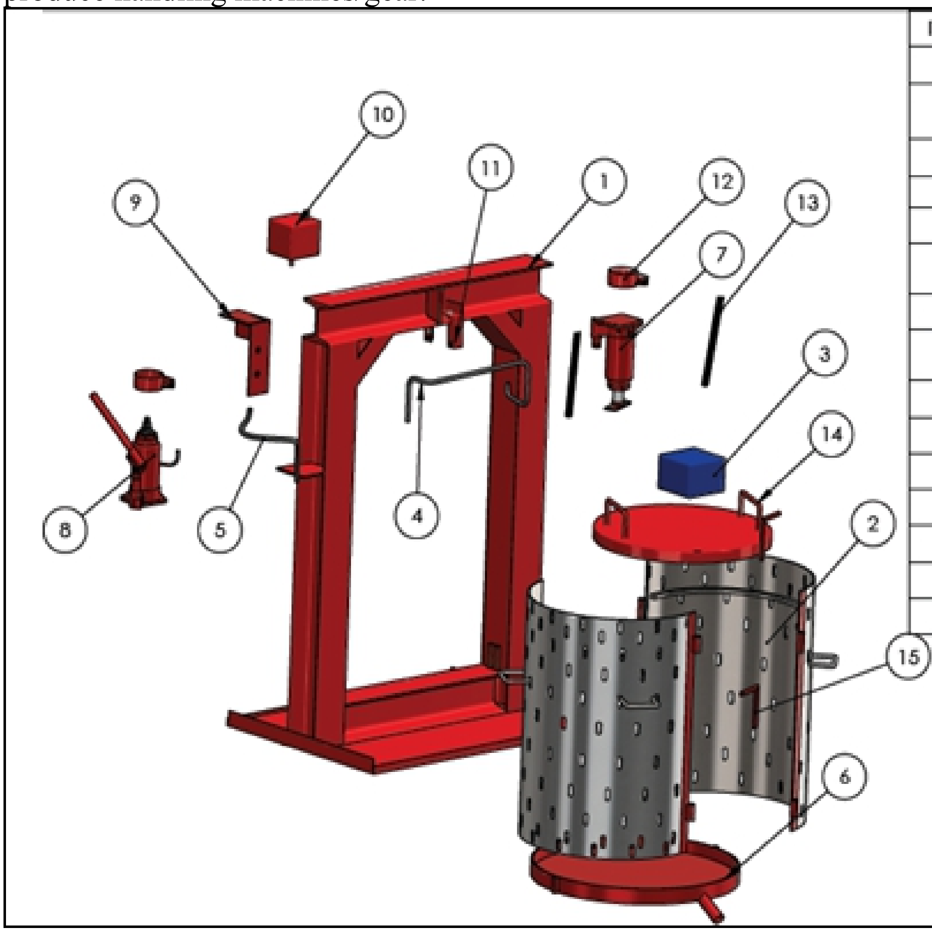
iii. Evaluate diaries/materials on palm produce handling machines/gear.

2.5 Data Collection

The information utilized in this exploration work is essentially acquired by test runs perceptions. Past parts, hardware, values utilized were examined to see what might be helpful in this examination work. This was accomplished either by test running in the research facility or by receiving effectively demonstrated outcomes truly expressed. Qualities applicable to this exploration work were noted and applied to the plan and creation of the machine.

2.6 Machine Configuration

The detonated perspective on the machine is appeared in Figure 1.



ITEM NO.	PART NUMBER	QTY.
1	Frame	1
2	Compressing Unit	2
3	Aider	1
4	Hydrualic Line	1
5	Hydrualic Hose	1
6	Palm oil collecting Pan	1
7	Hydraulic Jack	1
8	Manual Hydraulic pump	1
9	Tank Post	1
10	Hydraulic oil tank	1
11	Jack post	1
12	Jack clip	2
13	Springs	2
14	Pressing Plate	1
15	Lock rod	4

Figure 1. Exploded View of Hydraulic Palm Press

Figure 2 shows the orthographic view of the machine.

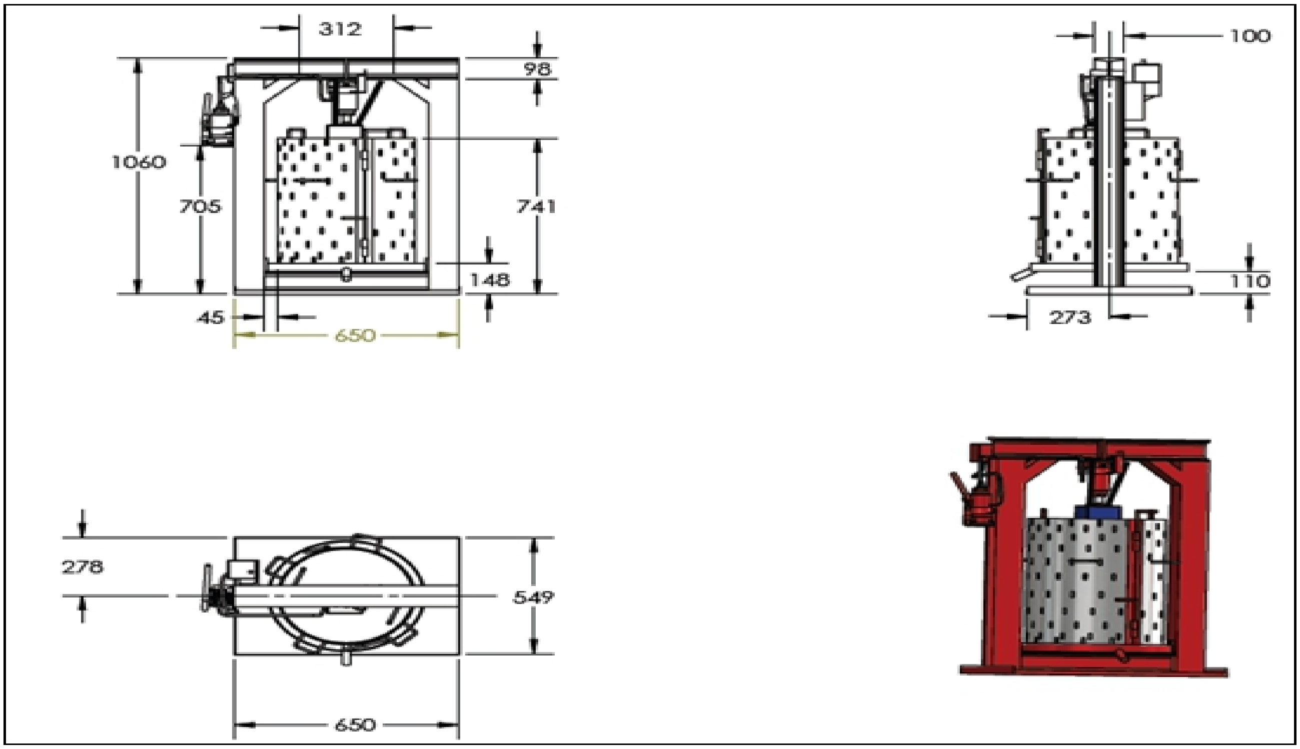


Figure 2. Orthographic Drawing of the Manual Hydraulic Palm Fruit Press Machine

Figure 3 shows the compressing unit design

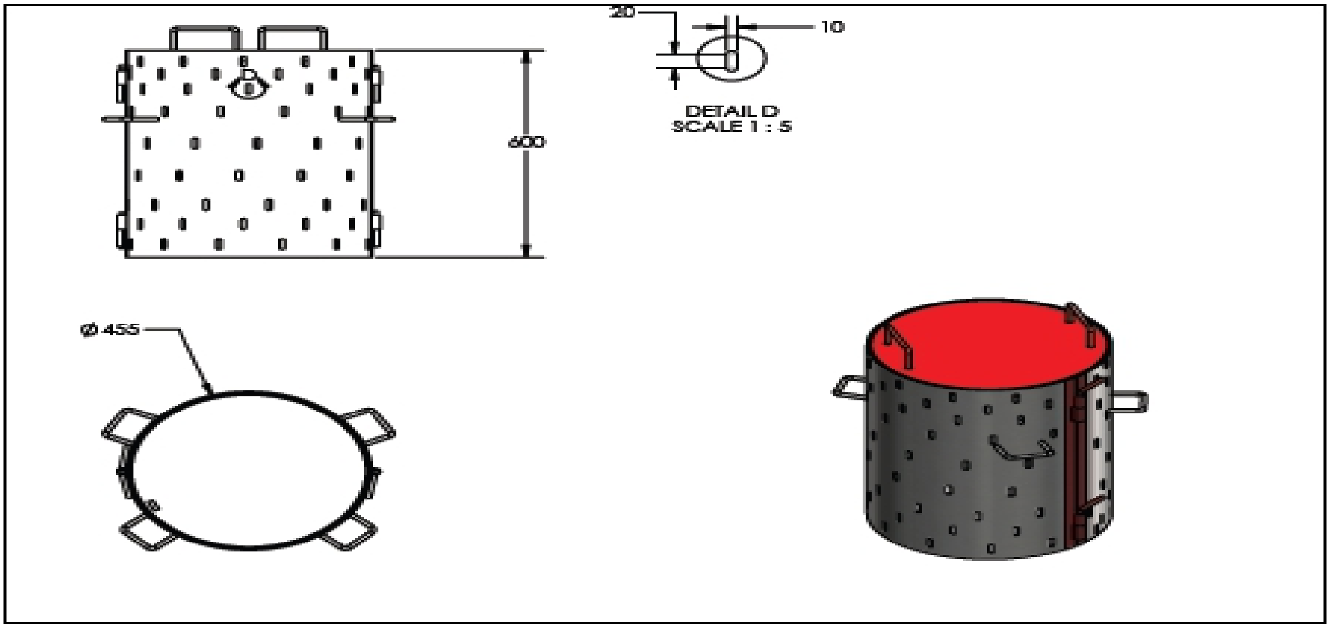


Figure 3. The Compressing Unit

Figure 4 shows the pressing plate.

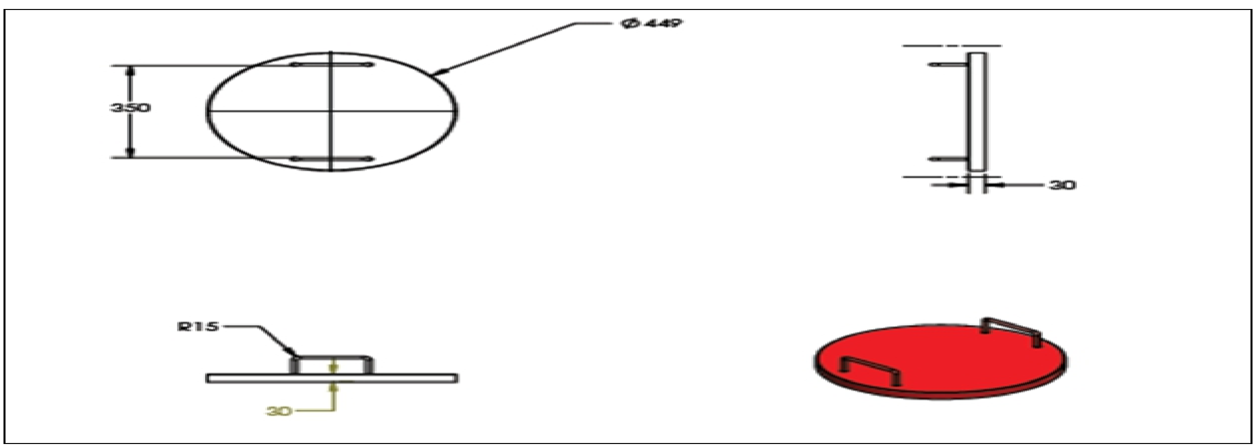


Figure 4. Pressing Plate

Figure 5 shows the machine frame.

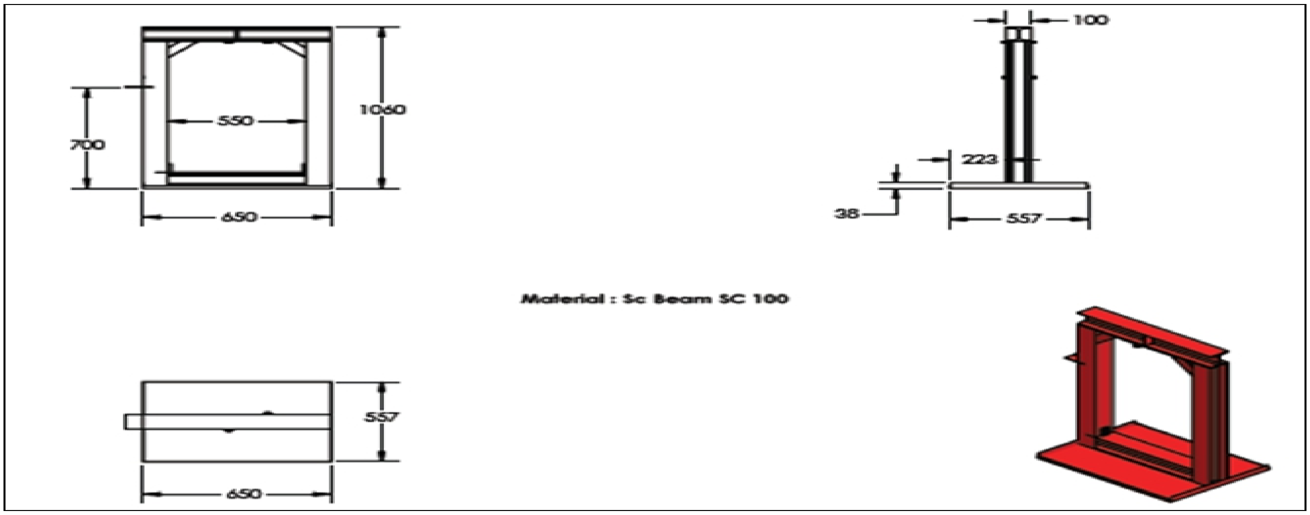


Figure 5. Machine Frame

Figure 6 shows the palm collector

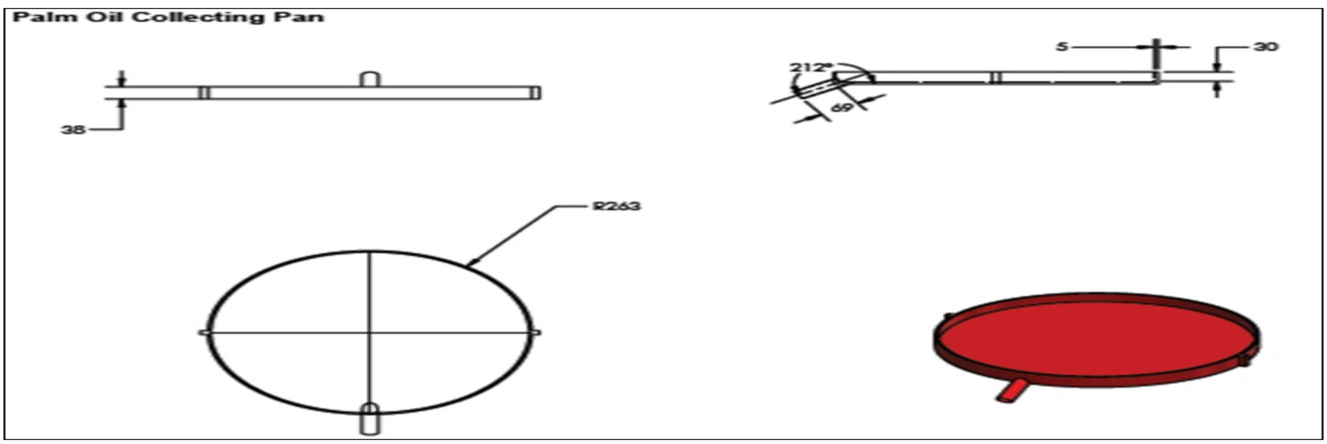


Figure 6. Palm Oil collecting Pan Dimensions

2.7 Components and Materials Used

Table 1 shows the materials used and components

Table 1. Components and Materials Used

S/N	Components	Materials Used
1.	Compressing unit	Mild Steel
2.	Aider	Mild Steel
3.	Frame	Mild Steel
4.	Hydraulic line	N/A
5.	Hydraulic hose	Polyethylene
6.	Palm oil collecting pan	Mild Steel
7.	Hydraulic jack	N/A
8.	Manual hydraulic pump	N/A

9.	Tank post	Mild Steel
10.	Hydraulic oil tank	Mild Steel
11.	Jack post	Mild Steel
12.	Jack clip	Mild Steel
13.	Springs	Mild Steel
14.	Pressing plate	Mild Steel
15.	Lock rod	Mild Steel

Packing Unit

Processed palm organic product is taken care of into this unit which holds the processed palm natural product for compacting and extraction of the oil. It was produced using 3mm thick sheet metal, used to withstand the developed interior weight because of squeezing pressure**.**

The Shell Cover or Pressing Plate

The shell spread/squeezing plate is sliced to round state of measurement 449mm and is comprised of gentle steel of 30mm thickness.

Connecting Rods or Lock Pins

These are utilized to bolt the confine before taking care of the processed palm organic products to be utilized for squeezing into confine. They were produced using gentle steel pole by welding having distance across of 30mm.

Casing

The casing of the machine has rectangular shape. Welded to the primary casing for help of the various parts were sub-bolster that incorporates jack arm, slam and jack.

Palm Oil Collecting Pan

The gathering dish is a chamber of distance across 562mm and tallness 30mm with one end opened for gathering the oil from the pen during squeezing.

Aider

This is the place the manual water driven siphon is fixed upon. It is welded to one of the vertical bars of the casing.

The Hydraulic Jack

The water driven jack has a limit of 5tonnes and is fixed to the focal point of the top level bar of the casing.

Water driven Tank

This is utilized as supply to store the water driven oil which helps the pressure driven jack in squeezing activity.

Manual Hydraulic Pump

This has a limit of 3 tons.

2.8 Detailed Design

Assurance of Bending Moment of the Base Plate

The base plate is fixed bar, with the point load at the middle. The heap at the Centre has a power of 5 ton. Figure 7 shows the free body chart of shear power and bowing second.

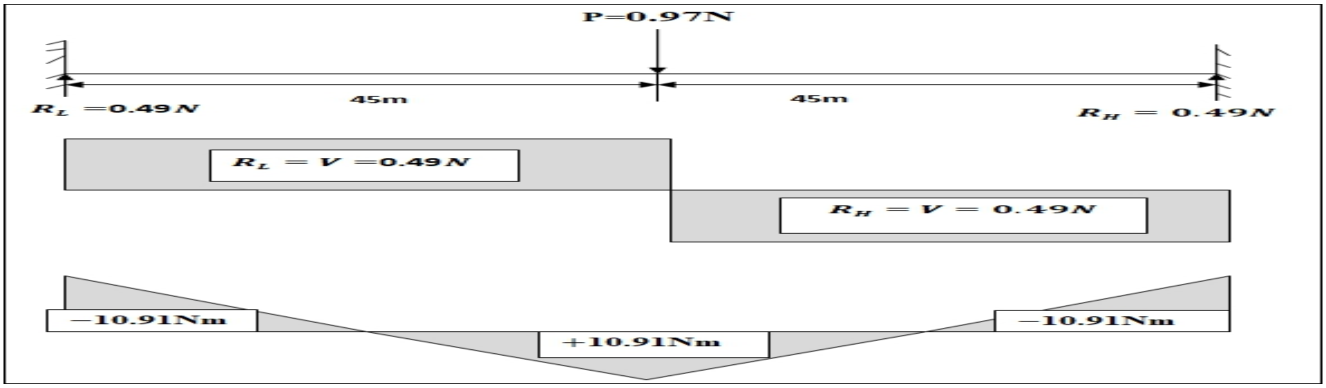


Figure 7. Free Body Diagram of Shear Force, and Bending Moment

R= Reaction load at bearing point (N)
V= Shear force (N)
M= Bending moment (N/m)
R=V

$$Reaction\ of\ left\ hand\ side\ R_L = \frac{P}{2} = \frac{0.97N}{2}$$

$$R_L = 0.49N$$

$$Reaction\ of\ right\ hand\ side\ R_R = \frac{P}{2} = \frac{0.97N}{2}$$

$$= R_R = 0.49N$$

Bending moment at any point x

$$M_{max} = \frac{PL}{8}$$

$$M_R = \frac{P(4(0) - L)}{8} = \frac{-PL}{8}$$

Moment in clockwise direction (M_R) is negative and anticlockwise(M_L) is positive

$$M_R = \frac{-0.97 \times 90}{8} = -10.91Nm$$

$$M_R = M_L$$

$$M_L = 10.91Nm$$

Determination of the Hydraulic Pressure, h_p

Cylindrical stroke = 4cm = 0.04m
Diameter of cage = 620mm = 0.62m
Piston diameter = 2.6cm = 0.026m

$$h_p = \frac{compression\ force}{piston\ diameter} = \frac{f}{c_b} \qquad (1)$$

$$compression\ force, \quad f = \frac{2 \times mass\ of\ displaced\ oil \times cylinder\ stroke}{square\ of\ time\ taken\ to\ achieve\ stroke} = \frac{2ms}{t^2} \qquad (2)$$

$$mass, \quad m = volume\ of\ displaced\ oil \times density$$

$$= cross\ secttional\ area\ of\ cage \times cylindetr\ stroke \times density$$

$$= \pi \frac{D^2}{4} \times s \times \rho_{po} \qquad (3)$$

Thus,

$$m = \pi \frac{0.62^2}{4} \times 0.04 \times 1000 = 12.07kg$$

Putting m in (2),

$$f = \frac{12.07 \times 2 \times 0.04}{1^2} = 0.97N$$

Putting f in Equation (1),

$$h_p = \frac{0.97}{0.026} = 37.16N/m^2$$

Stress Built in the Cage

The cage/compressing unit is subjected to tensile stresses of two types. They include:

i. Circumferential stress
ii. Longitudinal stress

Circumferential Stress

The internal pressure in the cage has the capacity to share the cage into two partss.
Diameter of the cage D = 620mm = 0.62m
Height of the cage H = 600mm = 0.6m
We have that;

$$circumferencial\ stress,\ \sigma_c = \frac{\sigma_h D}{2t} \quad (4)$$

$$Hoop\ Stress = \sigma_h = \frac{pressure}{thickness} \quad (5)$$

$$Thickness = \frac{outer\ diameter\ of\ cage(D) - inner\ diameter\ of\ c}{2} \quad (6)$$

$$Thickness = \frac{0.62 - 0.60}{2}$$

$$Thickness = 0.01$$

$$\sigma_h = \frac{h_p}{t} = \frac{37.16}{0.01}$$

$$Therefore,\ \sigma_h = 3716.30N/m^2$$

$$Therefore,\ \sigma_c = \frac{3716.30 \times 0.62}{2 \times 0.01}$$

$$\sigma_c = 115203.62N/m^2$$

Longitudinal Stress

$$longitudinal\ stress,\ \sigma_l = \frac{1}{2}\sigma_h \quad (7)$$

$$\sigma_l = 1858.15N/m^2$$

Volume of the Compressing Unit/Cage

Volume of the compressing unit is:

$$v = \pi r^2 h \quad (8)$$

$$v = 3.142 \times 0.31^2 \times 0.6 = 0.18\ m^3$$

Area of the Pressing Plates

Area of the pressing plate is:

$$A_p = \pi \times (diameter\ of\ plate)^2 \quad (9)$$

$$A = 3.142 \times (0.6)^2 = 1.13m^2$$

2.9 Fabrication

Figure 8 shows the fabrication processes.

i. Fabrication stages ii. Fabricated Manual hydraulic palm oil press machine

Figure 8. Fabrication Processes

2.10 Model Simulation

Solid Works model was utilized to key out the critical pieces of the manual water powered palm natural product press machine. AS revealed by (Orhorhoro, et al., 2017). SolidWorks is a strong modeller that utilizes parametric (for example imperatives whose qualities can decide the geometry of the model) highlights (for example building squares of the part) base way to deal with make models. Both static and exhaustion disappointment can be breaking down utilizing SolidWorks Simulation model. In this exploration work, the model examination brings about shapes of shading, to key out/recognize significant territories in the manual pressure driven palm natural product press machine. The examination was done on the whole structure of the framework to foresee worry because of the most extreme squeezing limit of the water driven jack (5tons).

3. Results and Discussion

The Solid work reproduction model was used on the whole structure of the framework. The recreation result shows the vital pieces of the machine where most extreme and least estimations of the Von Misses pressure, resultant dislodging, and identical strain were gotten as introduced in Table 2. The Von Mises pressure understanding by the most extreme work state of the framework is not exactly the yield quality of the material and the removal involvement with that condition is insignificant. Along these lines, the framework will withstand the greatest working conditions and will be successful in doing as such. This concurred with the exploration work of (Orhorhoro, et al., 2018), which detailed that for inability to happen, Von Mises pressure must more noteworthy than the yield pressure.

Table 2. Result for the Maximum and Minimum Von Mises Stress, Equivalent Strain and Resultant Displacement

Type	Min	Max
VON: von Mises Stress	1.376e-02 N/m^2 Node: 1183	2.478e+08 N/m^2 Node: 1011
ESTRN: Equivalent Strain	2.745e-14 Element: 5808	3.159e-03 Element: 7726
URES: Resultant Displacement	0.000e+00 m Node: 709	6.770e-05 m Node: 441

After the palm natural products were processed and isolated by hand, the squeezing plate was expelled, the confine was appropriately fixed, and the water driven oil tank was filled to accomplish the necessary level to keep away from the suction of air. The associations were checked to maintain a strategic distance from spillage. This was to maintain a strategic distance from loss of weight that will influence the squeezing weight of cylinder. The processed mash is taken care of into the pen. The squeezing plate was supplanted. The jack is worked physically which empowers water powered oil to be sucked through the hose into the siphon. The oil goes through the weight hose into the smash in this manner developing weight for pushing down the slam which applies pressure on the mash through the squeezing plate. The smash gone down when the switch on the valve was pushed down. This requires little exertion. After the press is finished the switch is pushed up again to come back to its position. The water powered press separates oil from the processed organic product with less work. The squeezing time was additionally recorded. The test was completed for three unique occasions and normal time recorded. The exhibition test result is appeared in Table 3. Figure 8 shows the chart of oil removed against number of tests did. As per Velayuthan and Chan (Velayuthan and Chan, 1983), the oil substance of palm natural products is 35% of the entire weight. Consequently, 4kg of processed palm organic product was taken care of into the pen.

$$Ttal\ amount\ of\ realizable\ oil\ from\ mash = \frac{4}{1} \times \frac{35}{100} = 1.4kg\ of\ oil$$

Test one: 0.97kg of oil was extracted

$$Efficiency\ \eta_1 = \frac{0.97}{1.4} \times 100 = 69.3\%$$

Test two: 1.03kg of oil was extracted

$$Efficiency\ \eta_2 = \frac{1.03}{1.4} \times 100 = 73.6\%$$

Test three: 1.47kg of oil was extracted

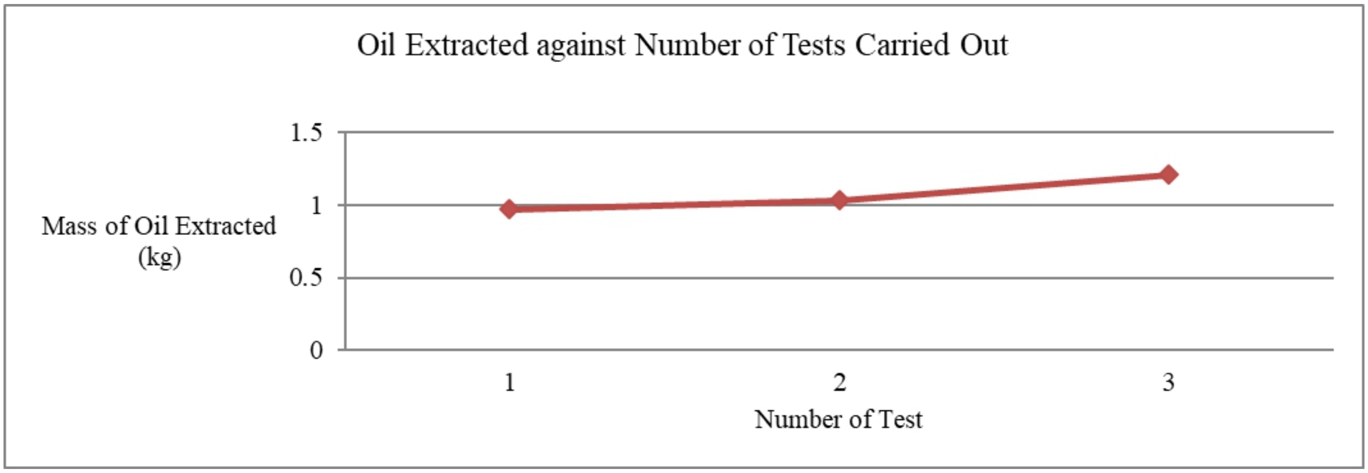
$$Efficiency\ \eta_3 = \frac{1.21}{1.4} \times 100 = 86.4\%$$

$$Average\ efficiency = \frac{69.3 + 73.6 + 86.4}{3} = 76\%$$

The outcome of the results analysis showed that an average time of pressing of 5.3 minutes and average efficiency of the machine was found to be 76 %.

Table 3. Results obtained from Pressing of Palm Fruits

S/N	Mass of palm fruit (M_1) (kg)	Mass of oil extracted (M_2) (kg)	Time taken (Mins)
1	4	0.97	4.3
2	4	1.03	5.7
3	4	1.21	5.9
$\sum$	12	3.21	15.9
Ave.	3	1.07	5.3



Conclusion

As respects to the significance of palm oil in Nigeria, a physically worked water driven palm oil extraction machine was effectively evolved. Test execution was completed on the created machine. The normal time and normal effectiveness required to totally press the mash in the confine was acquired as 5.3mins and 76%. Plus, it was observed that the created machine separated palm oil with less vitality at any rate time. Likewise, the machine was progressively effective when contrasted with customary strategy as of now in utilized in Nigeria.

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