PERFORMANCE IMPROVEMENT IN PALM-NUT CRACKING MACHINES

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ABSTRACT:

The data for energy required to crack palm nuts has been used to design a modified palm nut-cracking machine, with a view to improve the performance of the machines. Tests performed on a prototype of the machine resulted in an extraction efficiency of 78.4%. This compares with the cracking efficiency of 65% recorded by existing palm nut cracking machines.

KEY WORDS: Performance, Improvement, Palm-nut, Cracking, Machines.

1.0 INTRODUCTION:

The sustainable industrialization of a nation like Nigeria requires the production of new machines and the modernization of existing machines in order to improve their efficiency. The **palm produce industry** is one of the key industries that have produced reasonable proportion of the country's GDP especially before the advent of crude oil production. In the quest for Nigeria to diversify her industrial base, it has become necessary to modernize the palm produce machines.

The palm kernel a product of the palm produce industry is known to have multiple uses in industry including food, cosmetics and medicine. The palm kernel is obtained by cracking the palm nuts. Thus the palm nut-cracking machine is a very important machine in the industry that requires modernization.

1.1 SURVEY OF EXISTING MACHINES:

An initial observation of local palm nut cracking machines shows that: [1]

(i) Cracking and extraction efficiencies are low

(ii) Large quantity of nuts come out not cracked and

(iii) Sizeable quantities of kernels are smashed.

It therefore became necessary to further investigate the cause of these undesirable characteristics in order to redesign the machines for improved efficiency.

The machines in three (3) palm produce organizations were investigated. These organizations are [1]

(i) A palm kernel company owned by a private entrepreneur,

(ii) Risonpalm Ltd in Rivers State and

(iii) The Nigeria Institute for Oil Palm Research (NIFOR).

In case (i) the sole proprietor used a horizontal machine produced by roadside technicians. A test performed with the machine showed a cracking efficiency of 65% with large quantity of the kernels smashed while 35% of the nuts not cracked. Cracking efficiency is defined as [2]

$$\eta_c = \frac{\text{Quantity of cracked nuts}}{\text{Total qty of nuts fed into m/c}} \times 100\% \quad ...(1)$$

While extraction efficiency is defined as

$$\eta_e = \frac{\text{Qty of kernels (satisfactory cracked)}}{\text{Total qty of nuts fed into m/c}} \times 100\% \quad ...(2)$$

In Risonpalm (case ii) two vertical machines were in use. The machines were industrial type machines manufactured in Luxemburg. One machine was used for small size range of nuts while the other was used to crack large size range of nuts. Both machines were powered by 5 HP electric motors at a speed of 1,500rpm. The machines produced a high rate of nuts that were not cracked and smashed kernels as they record only 48% extraction efficiency [1]

NIFOR (case iii) had one horizontal and on vertical machines. The efficiencies of these machines could not be determined, as the Institute was not producing at the time of visit.

A summary of the efficiencies of the machines is shown below in table 1.

The causes of the problems of uncracked nuts and smashed kernels were found to be

(i) If the nut does not have adequate kinetic energy at the time it impacts on the cracking drum (or ring), the nut will not crack.

(ii) If the kinetic energy of the nut is two high, the nut will crack and the kernel gets smashed.

Thus there is an optimum energy for each nut to be cracked without any of the above problems [1].

2.0 MODIFIED DESIGN OF CRACKING MACHINE:

2.1 Cracking Energy Requirement:

In the palm nut-cracking machine (a centrifugal machine) the nuts to be cracked are directed into a rotor, which throws the nuts onto a stationary metal drum (or ring). The metal drum absorbs most of the kernel's kinetic energy during the impact and the resulting impact stresses cause the shells to crack and release the kernel [2]. For a nut to get cracked, the rotor must give it the appropriate velocity with which it strikes the metal drum, thus the nut must have the appropriate kinetic energy at impact.

Thus in the design of the palm nut cracking machine, the rotor must be made to transmit the necessary energy to the nuts. Consequently, the power of the energy source (prime mover) must be determined for the machine to crack a given quantity of nuts in a given time. This energy data has been generated as shown in reference [2]. Observation of graphs in ref. [2] shows that 95% extraction efficiency occurs twice on each graph corresponding to the three size ranges of nuts tested. The first occurred at an energy slightly less than that expected to correspond to 100% efficiency while the second occurred at energy slightly greater than that expected for 100% efficiency. The graphs did not show the energy corresponding to 100% efficiency. Therefore the energy levels corresponding to the first 95% efficiency was used for the design of the modified palm nut cracking machine.

2.2 MODIFIED DESIGN OF MACHINE:

In the modified design of the cracking machine, the energy data was used to size the rotor components and it was used to determine the power of the prime mover (1.5HP) [1]. The impinging velocity data was also used to determine the diameters of the stepped pulley to be attached to the rotor shaft. The horizontal machine was designed for a capacity of 2.75 tonnes of nuts per hour. This machine was designed for use by rural farmers [1]. The front view assembly drawing showing the components of the machine is shown on Fig. 1

2.3 PRODUCTION OF THE MACHINE:

The machine was produced for a rural farmer/trader who requested for a single diameter pulley, as he was not prepared to grade nuts before cracking. The machine was also powered with an existing HONDA G 200,5HP S.I. engine with an operating speed of 1500rpm [3].

The important dimensions of the machine (as built) include

(a) **CRACKING DRUM**

(i) Diameter D_c = 355mm

(ii) Length L_D = 175mm

(iii) Metal thickness t = 10mm

(b) **ROTOR**

(i) Diameter D_R = 210mm

(ii) Length L_R = 75mm

(c) **PULLEY DIMETERS**

(i) Engine pulley diameter D_e = 110mm

(ii) Rotor pulley diameter D_p = 75mm.

2.4 ROTOR SPEED AND IMPINGING VELOCITY CALCULATION

From the information given above, noting that tangential velocity of any particle of belt in contact with any of the pulleys must be equal for smooth operations means that [4]:

$N_eD_e = N_r\, D_r$ ....(3)

Where

N_r = the angular speed of the engine,

D_e = the diameter of the pulley on the engine shaft,

N_r = the angular speed of the rotor, and

D_r = the diameter of the pulley on the rotor shaft.

$$\Rightarrow N_r = \frac{D_e}{D_r} N_e = \frac{110}{75}(1{,}500) = 2{,}200\text{rpm}$$

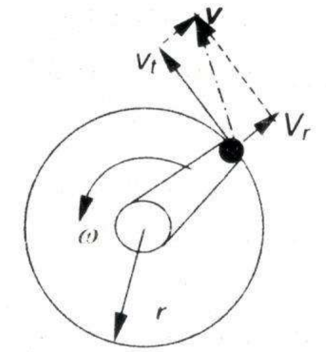

Fig. 2: Palm nut at Rotor outlet

The nut as it leaves the rotor outlet must have the same tangential velocity as the corresponding point on the rotor. Consequently, [5].

V_t = vvr .... (4)

where V_t = tangential velocity of the rotor.

$$vv = \frac{2\pi N_2}{60} = \text{angular speed of the rotor}$$

r = radius of the rotor.

Substituting numerical values into Eq. 4 yields

$$Vt = \frac{2\pi rN}{60}$$

or $Vt = 24.2ms^{-2}$

The impinging velocity is the vector sum of the tangential and radial velocities. However, from previous tests and calculations [1] the radial velocity was found to be 1.625% of the tangential velocity and can therefore be neglected. Thus the impinging velocity imparted on the nuts as they leave the rotor was taken as 24.2ms^{-2}. This is the constant impinging velocity that was used to crack all the nuts during the test.

3.0 TESTS, RESULTS AND DISCUSSION

3.1 METHODOLOGY

In order to ensure optimum crackability of the nuts, a quantity of fresh palm nuts were dried for about six (6) days [2]. The nuts were then graded with the use of a vernier caliper and grouped into the recommended size ranges [3].

1. $d < 12$ mm
2. $12mm \leq d \leq 15mm$
3. $15mm < d \leq 20$ mm
4. $d > 20mm$

A total of five hundred (500) nuts from each grade of nuts were cracked at different times in the machine. In order to ensure that the nuts were not scattered or lost, a small bag was tied over the machine outlet. The machine was started and then the five hundred (500) nuts for each size range of nuts were poured into the machine through the hopper.

When all the nuts had passed through the machine, the machine was stopped and the bag was removed making sure that no nut or kernel was lost. The clean cracked nuts were then counted and the extraction efficiency was calculated using Eq. 2.

3.2 TEST RESULTS:

For each size range of nuts, the extraction efficiency and percentage of un-cracked nuts were calculated and tabulated as shown in table 2.

3.3 DISCUSSION OF RESULTS:

As seen from the results, entries in the last column of table 2 show percentages of nuts that were partly cracked. This means that visual inspection of the nuts showed visible cracks on the nuts but the nuts were not fully cracked to release the kernels. Thus they could neither be classified as fully cracked nor as un-cracked.

It is also seen from the results that an average extraction efficiency of 78.4% was achieved. This compares favorably with the cracking efficiency of the machines surveyed before the modified design was made. Table 3 shows the comparison between the modified design and the older machines.

The machine efficiencies shown in rows 1 of table 3 only indicate the percentage of nuts cracked. This percentage included undetermined amount of kernels that were smashed. Thus the actual extraction efficiency must be lower.

In contrast, the 78.4% extraction efficiency recorded for the modified design shows the percentage of fully and clean cracked nuts. It is also necessary to note that the impinging velocity for the modified machine that was tested is lower than the required velocity for 100% extraction efficiency for the various size ranges of nuts (table 4) [2].

Since extraction efficiency is sensitive to impinging velocity, it can be deduced that the actual cracking efficiency of the modified machine may be higher than is shown by the test results. If the pulley was made to impart the required impinging velocity to the nuts the extraction efficiency would have approached the design efficiency of 95%.

4.0 CONCLUSION:

From the above discussion of the results the following conclusions were made.

i. The performance of palm nut cracking machines have been greatly improved as the test on the modified cracking machine resulted in 78.4% extraction efficiency.

ii. The 78.4% extraction efficiency compares favourably with 65% cracking efficiency with a large amount of smashed kernels.

iii. The efficiency of the modified cracking machine should be higher than the 78.4% obtained form the test as the impinging velocity obtained with the test set up is less than the required impinging velocity.

5.0 REFERENCES

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Table 1: Efficiencies of the Machines Surveyed

S/N	ORGANIZATION	TYPE OF M/C	EFFICIENCY (%)
1.	Sole prospector	Horizontal	65% cracking efficiency
2.	Risonpalm	Vertical	48% extraction efficiency
3.	NIFOR	Vertical /Horizontal	Not determined

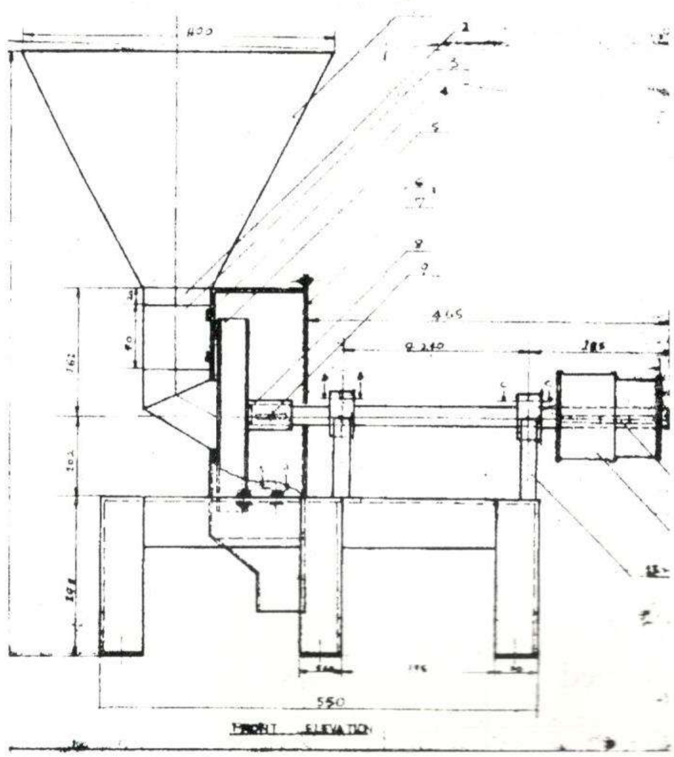

Fig. 1: Front View Assembly of Cracking Machine

TABLE 2: TEST EFFICIENCIES OF THE DIFFERENT NUT SIZES

		EFFICIENCY %		
Rotor speed	**Nut size range**	**Fully cracked (Extraction)**	**Uncracked**	**Partly cracked**
2200rpm	d<12mm	77.4	21.4	1.2
	$12 \leq d \leq 15$mm	78.0	20.2	1.8
	$15 < d \leq 20$mm	78.2	20.0	1.8
	d> 20mm	80.0	18	2.0
	Average % tage	78.4	19.9	1.7

TABLE 3: COMPARISON OF MACHINE EFFICIENCIES

S/N	TYPES OF MACHINE	CRACKING EFFICIENCY	EXTRACTION EEFFICIENCY
1	Private entrepreneur	65%	Not determined
2	Risonpalm	Not determined	48
3	NIFOR	50	Not determined
4	Modified Design	78.4	78.4

TABLE 4: COMPARISON OF IMPINGING VELOCITIES

S/N	NUT SIZE RAGE	IMPINGING VELOCITY		EFFICIENCIES	
		Required	Modified M/C	Required	Modified M/c
1	$d > 12$ mm	29.279	24.2	100	77.4
2	$12 \leq d \leq 15$mm	30.382	24.2	100	78.0
3	$15 < d \leq 20$mm	26.476	24.2	100	78.2
4	$D > 20$mm	-	24.2	100	80.0