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Determination of Nut Exit Configuration on Rotor for Effective Whole Kernel Production in Centrifugal Cracker

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Abstract: The effect of nut exit configurations on rotor on the production of whole kernels in centrifugal palm nut cracker was investigated. In this study four configurations namely: single flat arm, double flat arm, rectangular arm and sleeve-less arm were run each at six speeds to discharge nuts onto impact surface of cracking drum. The percentages of whole kernels produced per configuration per speed were evaluated. The rectangular arm configuration recorded the highest release of whole kernels. The rotor speed range of 31 to 33 m/s was favourable for whole kernels production irrespective of the exit configurations.

Keyword- Configuration, Kernel, Nut, Rotor, Speed,

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I. INTRODUCTION

Oil palm tree varieties grown abundantly in Nigeria are the Dura, Tenera and Pisifera. Its ripe fruits are harvested and processed to obtain palm oil, nuts and fibres. Each of these products can further be processed to other products of economic importance. The nuts are very useful only if they are processed to obtain kernels and shell fragments. These products find application as raw materials in various industries [1], [2]. The nut processing involves drying, cracking and separation. The drying is to enhance loosening of kernels from shells. The cracking is to facilitate the release of kernels from the nuts. For effective recovery and utilization of kernels, the nuts need to be cracked in a manner that would produce high percentage of whole kernels. This is necessary since increase in production of split kernels encourages liberation of free fatty acid vis-à-vis rancidity of oil due to exposure of oily portion to environmental influence such as humidity and temperature [3], [4]. The separation process is basically to obtain kernels of high purity (kernels free of shell fragments) from cracked nut mixtures. The two main methods of separation are the dry and wet methods. The wet method can achieve 90-100% kernel separation. This method is expensive, the effluent discharged is not environmentally friendly and the kernels are liable to quick infection by fungus. The infection could lead to rancidity of oil. The dry method is preferred but is associated with low purity kernels due to difficulty in separating shell fragments from kernels in the cracked nut mixtures. Low purity kernels causes increase in processing cost as well as reduction in oil recovery. This is due to increase in wear and tear of the oil milling shaft caused by high presence of shell fragments, increase in sludge formation and quick blockage of oil filter caused by fine crushed shell particles obtained during oil milling. Hence, intermittent shut down for filling or replacement of the worn kernel oil milling shaft, cleaning of the blocked oil filter and crushed oil pump. Consequently, effective man-hours operation and quantity of oil produced per day are reduced [5], [6], [7].

High purity kernels obtained from dry method are in high demand and are sold at higher prices. To obtain high purity kernels by dry method, it is necessary that high production of whole kernels and small shell fragments relative to kernel sizes are required. These parameters are influenced by the cracking unit features, operating conditions and technique of separation.

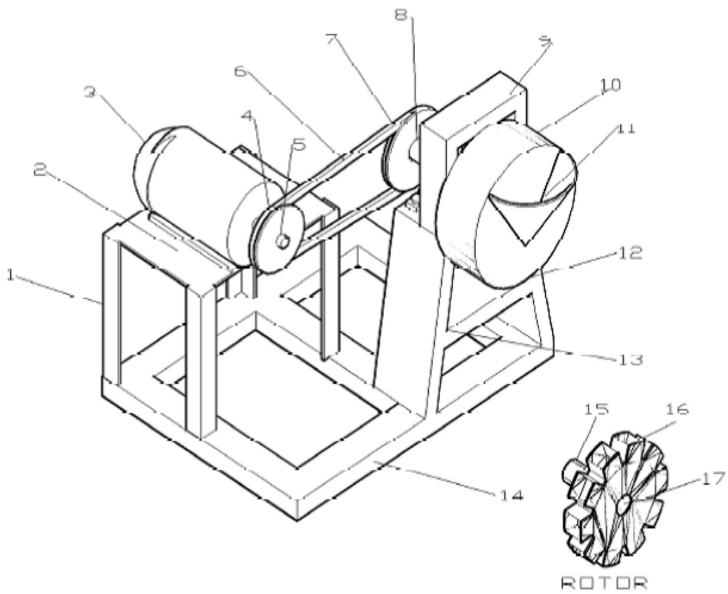
One of the most modern mechanical devices used for nut cracking is the centrifugal nut cracker. Its cracking unit features are the rotor, nuts exit channel(s), nuts inlet channel and impact surface. Usually, nuts from hopper enter the nuts inlet of the rotor for onward discharge from the nuts outlet(s) of rotor to impact surface of the cracking drum [3], [8]. The nuts are sometimes guided to the cracking drum to facilitate nut cracking. There are various designs of nut guides. The shape, size and length of the nut guide(s), in addition to other parameters such as the rotor speed, ratio of rotor diameter to cracking drum diameter, the nature of nut impact surface and the number of nut distribution channel on rotor can affect centrifugal nuts cracker efficiency of whole kernels production. The most commonly used nut exit guide(s) on rotor are in form of single blade(s) and double blades. However, some rotor may be designed to have barren (no guide) nut exit. More so, in some cases the nut guide(s) may be designed to also assist in increasing the speed of the nuts on to the nut cracking drum. The speed of nuts is a function of the rotor speed and nut impact energy required to release whole kernel following nut cracking [9], [10], [11]. When the nuts travel out from the nut exit of the rotor, there exist collisions between the nuts themselves in the cracking chamber. Random collisions are reduced if nuts are made to pass through channel(s) onto the impact surface of the cracking drum. Thus, effectiveness of nut delivery at required impact energy on impact surface would increase to enhance the release of whole kernels following nut cracking. This implies that the input energy has overcome the friction between nuts and the channel walls to guarantee effective release of high yield of whole kernels following nuts impact on the surface of the cracking drum [3], [8], [12]. This study therefore investigates nut exit channel configuration that would facilitate increase in the production of whole kernels.

II. METHOD

A rotor having 200 mm diameter with a constant number of three (3) distribution channels for nuts was fixed into the cracking chamber of a Test Rig (centrifugal nut cracker). The rotor diameter, width, nuts outlet and inlet dimensions were not varied. Four different configurations of channel of distribution for nuts were used. These configurations are replaceable at the nut outlets of the rotor. One configuration was fitted properly to all the nut outlet of the rotor at a time. The configurations used were as follows: (1) Single flat arm –S (2) Double flat arm-D (3) Rectangular arm – R (4) sleeve – less arm - C.

Dried and ready to crack palm nuts of the Dura and the Tenera varieties were each classified into three size ranges based on nut geometric mean diameters as follows: small size GMD < 13 mm, medium size 13 mm ≤ GMD < 19 mm, large size GMD > 19 mm. Twenty nuts from each classified size range of each nut variety were picked and mixed together to form a group of 120 nuts; as a fair representative of bulk nut of mixed variety (Dura and Pisifera).The investigation was then carried out using the Test Rig shown in Fig.1 and having the exploded view of the cracking chambers unit features in Fig. 2.

Each channel configuration was run at six different speeds (23, 27, 29, 31, 33 and 35 m/s). For each speed, each group of nuts (one hundred and twenty dried palm nuts) was introduced from a hopper into the nut inlet of the rotor for onward discharge from the nut exit(s) of the rotor onto the hard stationary impact surface of the cracking drum. Three replicates were carried out. A total of 2160 nuts were used. The efficiency of each channel configuration was assessed based on the percentage of whole kernels released. The data generated were analyzed in order to select the best channel configuration and speed range required for maximizing whole kernels production in centrifugal nuts cracker.



PARTS LIST	
S/N	DESCRIPTION
1	ELECTRIC MOTOR STAND
2	ELECTRIC MOTOR BASE
3	ELECTOR MOTOR
4	ELECTRIC MOTOR PULLEY
5	ELECTRIC MOTOR SHAFT
6	V-BELT
7	ROTOR SHAFT
8	ROTOR SHAFT PULLEY
9	FRAME
10	CRACKING DRUM
11	NUT INLET
12	CRACKMIX OUTLET
13	FRAME
14	BASE
15	ROTOR COUPLE TO SHAFT
16	ROTOR ARM
17	NUT INLET TO ROTOR

FIGURE1. Isometric view of centrifugal nut cracker (Test Rig)

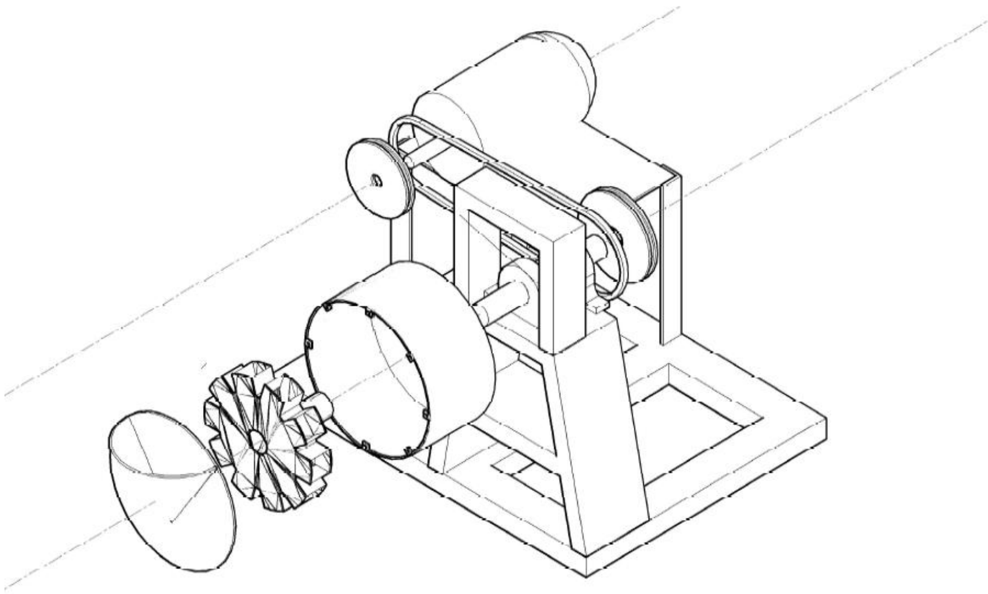


FIGURE. 2. Exploded view of cracking drum unit features of Test Rig.

III. RESULTS AND DISCUSSION

The percentage of fully cracked nuts with release of whole kernels was computed per channel configuration per rotor speed. For each channel configuration, the percentage of fully cracked nuts increased with increase in speed up to 33 m/s; beyond this speed, the percentage of fully cracked nuts started to reduce as shown in Fig. 3.

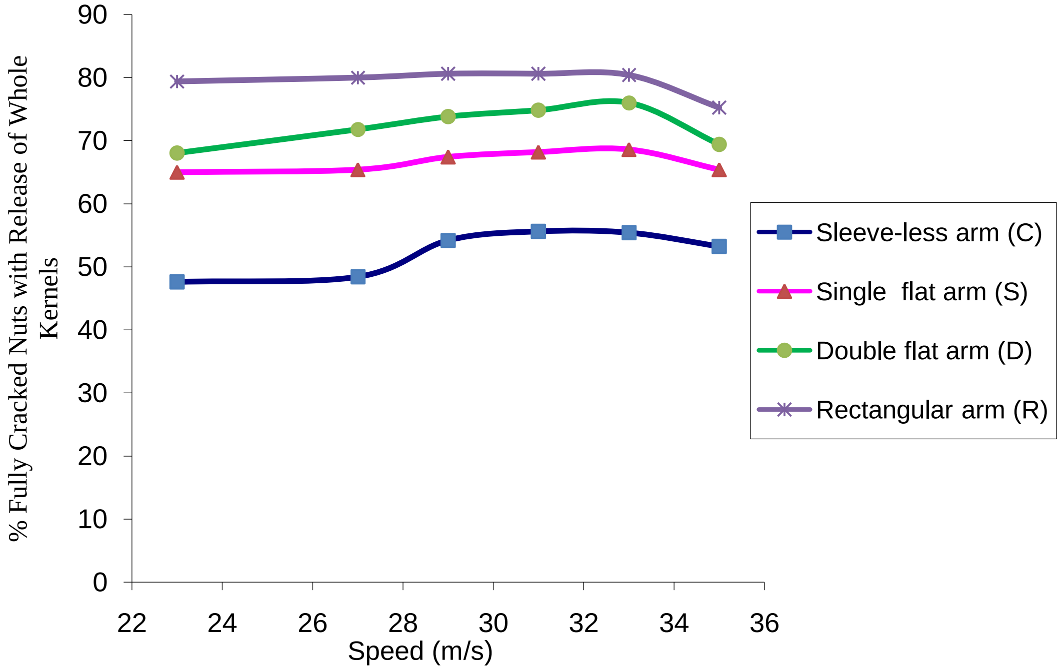


FIGURE 3. Percentage of fully cracked nuts with release of whole kernel against rotor speed for different configuration of channel

This is because an increase in nut speed from 33 m/s caused bruises to the kernels. In some cases, nuts were smashed. This implies that above this speed the impact energy acquired by the nuts is more than enough to crack nuts and release whole kernels. The aggregate % of fully cracked nuts with release of whole kernels per channel configuration is presented graphically in Fig. 3.

From Fig. 3, the peak range of speed for high % fully cracked nuts with release of whole kernels irrespective of channel configuration is 31 to 33 m/s. The channel configuration observed to record the highest level of fully cracked nuts is the rectangular arm (R). This configuration recorded 82 % fully cracked nuts with release of whole kernels when compared with other channel configurations used for this study.

IV. CONCLUSION

The rectangular arm configuration of nut exit channel on rotor enhanced whole kernel production at rotor speed range of 31 to 33 m/s.

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