American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-6, Issue-12, pp-83-88
www.ajer.org
Research Paper Open Access

Rotor to Drum Diameter Ratio Required for Effective Cracking of Palm Nut in Centrifugal Cracker

[1*]Antia, O.O,[2]Aluyor, E
[1]Department of Agricultural and Food Engineering, University of Uyo, Akwa Ibom State, Nigeria
[2]Department of Chemical Engineering, University of Benin, Edo State, Nigeria
*Corresponding author: *Antia

ABSTRACT: *The estimation of a favourable ratio of rotor diameter to cracking drum diameter that would enhance effective delivery and cracking of nuts to yield high percentage of whole kernels was carried out. In this study, dried palm nuts 4.88 % wb of mixed variety (Dura and Tenera) were classified into five size ranges based on nut geometric mean diameter. Seven diameter ratios were chosen. Each rotor diameter to drum diameter ratio was run at seven speeds. For each speed each nut size range was subjected to impact on the cracking drum surface of a Test Rig (centrifugal nut cracker). The nuts were assessed after impact. Result showed that rotor diameter to cracking drum diameter ratios of 0.22, 0.33 and 0.67 enhanced effectively the cracking of palm nuts to yield high release of whole kernels. Economical production of high percentage of whole kernel using centrifugal nut cracker tends to favour rotor diameter to cracking drum diameter of 0.67 and speed of 31 m/s.*

KEYWORD: *Rotor, Cracking Drum, Palm Nuts, Whole Kernels, Speed.*

Date of Submission: 27 -11-2017 Date of Acceptance: 11-12-2017

I. INTRODUCTION

The oil palm fruit is a sessile drupe that varies in shape and have an outer exocarp or skin; a middle mesocarp or pulp rich in palm oil; an inner endocarp or shell enclosing the kernel. There are three common and major varieties of oil palm in Nigeria, namely: Dura, Tenera and Pisifera. The Dura type has thin mesocarp, thick shell with large kernels; the Tenera type has thick mesocarp with thin shells and average size kernels; Pisifera has thick mesocarp and thin shells with small kernels. These fruits are usually harvested and processed to obtain oil, fibre and nuts (FAO, 2009).

The nuts are processed through various unit operations: drying, cracking, separation and kernel oil extraction. The palm oil and kernel oil obtained are used for making soap, margarine, refined edible vegetable oil, etc. The fibres and the nut shell fragments are used as fuel while charred nut shells are useful as packing material in distillation column. The palm kernel cake is used as animal feed (FIRRO, 1993; Illechie et al., 2005).

Nut cracking could be done using traditional and modern methods. The nut cracking using mechanical operated device is the modern method while cracking of nuts manually is the traditional method. The traditional method of nut cracking is cumbersome but yield whole kernels of high purity. The most widely used modern type of nut crackers is the vertical or horizontal centrifugal nut cracker. Some parameters that enhance efficient nut cracking to yield high percentage of whole kernel have been studied. These parameters include: operating conditions for nut drying (ASAE, 1982; Okoli, 2003; Antia et al.,2014), nut cracking for kernel release (Asoegwu, 1995; Okokon et al., 2007; Antia et al., 2013); kernel separation (Akubuo et al., 2002; Illechie et al., 2005; Sangwichien et al., 2010), and nut cracker machine design (Obiakor et al., 1999; Koya, 2006). The kernels following mechanical nut cracking require good separation technique to achieve high recovery of purity kernels (kernels free of shell fragments) from the cracked nut mixtures. Increase in the quantity of shell fragments in separated kernels increases the chances of having increase in the rate of wear and tear of the kernel oil milling shaft. Thus, low recovery of oil is achieved since more oil is trapped in the sludge formed by fine crushed particles of the shell fragments. Therefore, high purity kernels are in high demand. In addition to good separation technique, the mechanical cracking of nuts to yield whole kernels with minimal split kernels is essential for easy separation of cracked nut mixtures to obtain high purity kernels. More so, for split kernels the oily surface of the kernel is exposed to the environmental influence; and depending on the duration of exposure fatty acid liberation could occur to cause rancidity of the oil milled (Koya, 2006; FAO, 2009).

In mechanical nut cracking, high yield of whole kernels and low kernel breakage could be obtained if nuts are subjected to repeated impact at low speed. The low speed of impact would encourage reduction in the intensity of secondary impact such that kernel release at first impact of nut may not split. The cumulative impact energy is approximately equal to the work required to cause the nut to crack (koya, 2006; Oke, 2007). So far the yield of high percentage of whole kernel using mechanical device still require improvement to enhance easy separation of kernels from cracked nut mixtures to achieve kernel of high purity. In this study, the rotor diameter to cracking drum diameter ratio required for effective mechanical nut cracking using vertical centrifugal crackers is to be investigated in respect to whole kernel production.

II. MATERIALS AND METHODS

A centrifugal nut cracker was used as a Test Rig to carry out this study. The cracking drum of the Test Rig has a stationary hard impact surface of internal diameter of 450mm (Illechie et al., 2005). A shaft to key a rotor of any chosen diameter is located centrally in the cracking chamber. The shaft is run by a v-belt-pulley transmission system powered by an electric motor. The pulley diameter used depends on the rotor speed desired. The cracking chamber has a cover attached with funnel having 50mm diameter hole located in such a way that nuts can pass from the funnel into a 50mm diameter rotor nut inlet for onward discharge to the cracking drum. The nuts are guided from the rotor to the impact surface of the cracking drum by rotor arm. Each rotor arm is 50×50mm rectangular tunnel of 4mm thick. The tunnel length depends on the diameter of the rotor since the gap between the end of the arm and the cracking drum surface is maintained constant at 25mm (Oke, 2007). The Test Rig is shown in Figure 1.

Procedure:

Ready to crack nuts of mixed variety (Dura and Tenera) were classified into five size ranges based on nut geometric mean diameter as follows: GMD < 12 mm, 12 mm ≤ GMD < 15 mm, 15 mm ≤ GMD < 18 mm, 18 mm ≤ GMD < 21 mm and GMD ≥ 21 mm. Seven rotor diameter to cracking drum diameter ratios of 0.17, 0.22, 0.33, 0.44, 0.56, 0.67 and 0.78 were chosen to fit into the cracking drum diameter of 450 mm. Each rotor has two arms to guide nuts onto impact surface of the cracking drum. Each rotor diameter was run at seven speeds (24, 26, 28, 30, 32, 34 and 36 m/s). Bulk sample of one hundred (100) nuts per speed were then subjected to impact on the cracking drum. The cracked nut mixture per speed was collected and categorized into three (3) groups namely:

(i) Percentage of fully cracked nuts that release whole kernels (% FC)
(ii) Percentage of un-cracked nuts and partially cracked nuts with no release of kernel (% FU)
(iii) Percentage of smashed nuts (% FWS)

For each set of data three replicates were carried out. The data obtained were analyzed statistically using the average percentage method of time series analysis to select rotor diameter to cracking drum diameter ratio in the order of its cracking efficiency (Spiengel et al., 1999). The speed required for effective nut cracking was also estimated. The cracking efficiency was based on whole kernels released following nuts cracking.

III. RESULTS AND DISCUSSION

The average percentage trend for fully cracked nuts that release whole kernels (FC), smashed nuts (FWS) and uncracked nuts (FU) were computed for each of the diameter ratios and is presented in Figure 2.

From Figure 2 the rotor diameter to cracking drum diameter ratios 0.22, 0.33 and 0.67 were effective to release whole kernel. To choose the most suitable diameter ratio, evaluation of the three selected diameter ratios were carried out based on the speeds run and products (smashed nuts, uncracked nuts and whole kernels) percentage trend following nut cracking. The results are presented in Figures 3, 4 and 5, respectively.

From Figure 3, the highest % FC was achieved at nut hurling speed of about 30 m/s. At this point the lowest values of % FWS and % FU were recorded. In Figure 4, the lowest % FWS and % FU values correspond to rotor speed of about 30 m/s. At this speed of 30 m/s, a high yield of FC was obtained. From Figure 5 a high % FC was achieved at speed of about 32 m/s where lowest value of % FU and % FWS were recorded. Based on Figures 3, 4, and 5 the speed range of 30-32 m/s averaging 31 m/s could be used to achieve effective cracking. Koya (2006) noted that during nut cracking little or no % FWS is required in order to ease recovery of kernel during separation from the cracked nut mixture. However, % FU could be reduced in favour of % FC if the nuts are subjected to repeated impact using suitable impact energy that would cause little or no damage to the kernel wholeness. Based on this premise, a close observation of Figures 3, 4 and 5 showed that at point where lowest values of % FWS and % FU with high % FC were achieved, less than 30% FWS was obtained for 0.67 while more than 30% FWS was recorded for 0.22 and 0.33 diameter ratios. Hence, the rotor diameter to cracking drum diameter that would be recommended is 0.67.

The 0.67 rotor diameter to cracking drum diameter ratio chosen as the ratio that could yield increase in the percentage of production of fully cracked nuts was tested using speeds chosen in the procedure section. The result of the test is presented in Figures 6.

The point of intersect of % FWS and % FU lines from Figure 6 is the point for which the lowest value of FWS, FU with the highest value of FC was achieved. This intersection corresponds to a speed of 30.6 m/s. It is suggested that higher % FC could be achieved if other cracking unit features and operating conditions are suitably maintained. Therefore, in designing rotor for centrifugal nut cracker a model equation to be used is of the equation form:

$$\text{The Rotor diameter } (D_R) = [R_d] \times [D_a] \qquad (1)$$

$$D_a = \text{drum diameter } (mm)$$

$$R_d = \text{rotor to drum ratio} = \text{constant} = 0.67$$

IV. CONCLUSION

The rotor diameter to cracking drum diameter ratio of 0.67 was found to be effective for nut cracking. The average hurling speed to enhance nut cracking to yield whole kernel is approximated as 31 m/s.

REFERENCE

[1]. Akubuo, C.O. and Eje, B.E. (2002). Palm Kernel and Shell Separator. BiosystemsEngineering.81 (2): 193 – 199

[2]. Antia, O.O., Obahigbon, K., Aluyor, E. and Ebunilo, P. (2013).Modeling of some related parameters for Cracking Palm Nut in a Centrifugal Nut Cracker. Advanced Material Research.824:255-261

[3]. Antia, O.O., Obahigbon, K., Aluyor, E. and Ebunilo, P. (2014). Study of Moisture Content Dynamics of Fresh Palm Nuts during Drying, International Journal of Engineering Science Invention,3(21): 19-23

[4]. ASAE (1982).American Society of Agricultural Engineers Year book.ASAE :345

[5]. Asoegwu,S.N.(1995).Some Physical Properties and Cracking Energy of Conophor Nuts at different Moisture Content. Int. Agrophysics. 9:131-142

[6]. FAO (2009).Small Scale Palm Oil Processing in Africa. FAO Agricultural Service Bulletin, 148: 1-56

[7]. FIRRO (1973).Distillation Apparatus for Crude Alcohol. Technical Information Bulletin for Industry, 2 (2): 2

[8]. Illechie, C.O, Aibangbee, G.F, Amiolemhen, P.E. and Ogblechi, S.R. (2005).Development of an Automatic Cracker – Separator. Proceeding of the Nigerian Institution of Agricultural Engineers.27: 295 - 297

[9]. Koya, O.A. (2006). Palm Nut Cracking under Repeated Impact Load.Journal of Applied Science, 6 (11): 2471 – 2475

[10]. Oke, P.K. (2007). Development and Performance Evaluation of Indigenous Palm Kernel Dual Processing Machine.Journal of Engineering and Applied Science.2 (4): 701-705

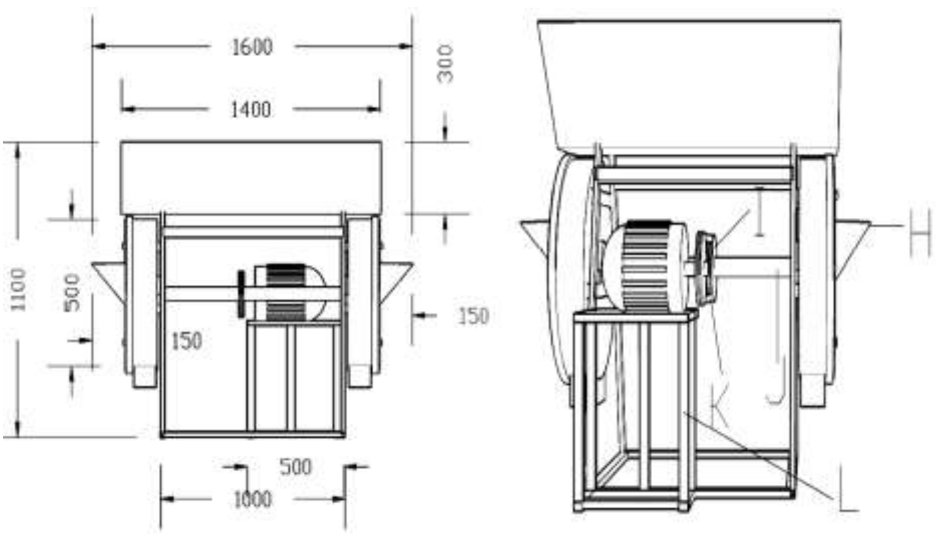
[11]. Obiakor, S.I. and Babatunde, O.O. (1999).Development and Testing of the NCAM Centrifugal Palm Nut Cracker. AGRIMECH Research and Introduction Bulletin of the National centre for Agricultural Mechanization (NCAM), January, 1999

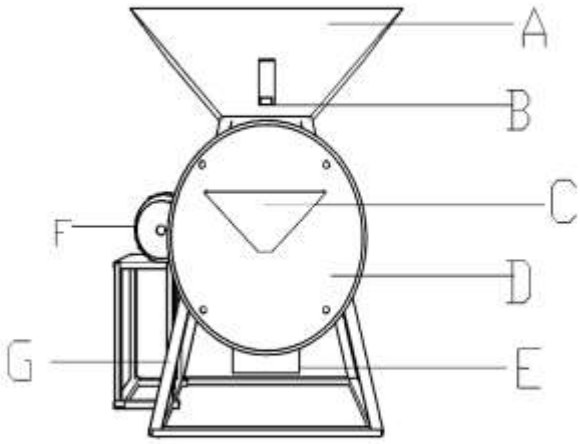
[12]. Okoli, J.U. (2003). Optimum Drying Time for Palm Nut for Efficient Nut Cracking in Small Scale Oil Palm Producing Mills.Global Journal of Engineering Research. 2 (1and 2): 7- 10

[13]. Okokon F. B., Udoh, M., Antia, O. and Erete, I. (2007). Investigation into the Grading of Large Scale Palm Nuts for Cracking.World Journal of Biotechnology. 8 (2): 1376 – 1384

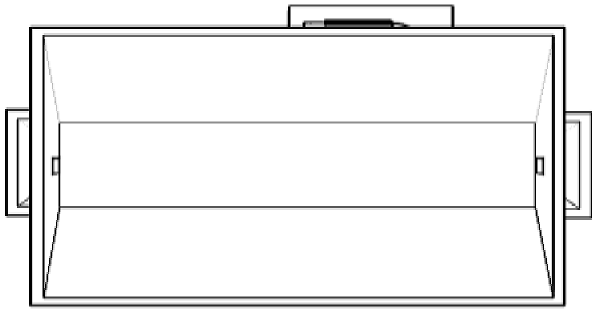
[14]. Sangwichien, C., Ruangmee, A. and Sumanatrakul, P. (2010).Separation Efficiency of Palm Shell and Kernel Mixture by using Different Types of Media. Proceeding of 2010 International Conference on Chemical Engineering and Applications.Singapore,26-28 February 2010

[15]. Spiengel, M.R. and Stephens, L.J. (1999).STATISTICS.Schaum's Outline Series. 3rd ed. McGraw-Hill Companies.





FRONT VIEW BACK VIEW
SIDE VIEW



PLAN

Figure 1: Test Rig I Views

S/N	PART	DESCRIPTION	
1	A	HOPPER	
2	B	EXIT (for nuts from hopper	
3	C and H	FUNNEL (for nut inlet to rotor from hopper	
4	D	CRACKING DRUM	
5	E	CRACKMIXTURE OUTLET	
6	F	ELECTRIC MOTOR	
7	G	FRAME	
8	I	PULLEY (fixed to machine shaft)	
9	J	MACHINE SHAFT (fixed to the rotor)	
10	K	BELT	
11	L	STAND (for electric motor)	

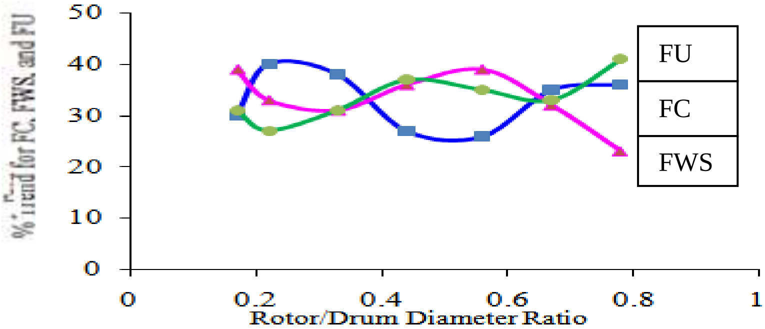


Figure 2: Percentage Trend of FC, FWS, and FU against Rotor/Drum Diameter Ratio

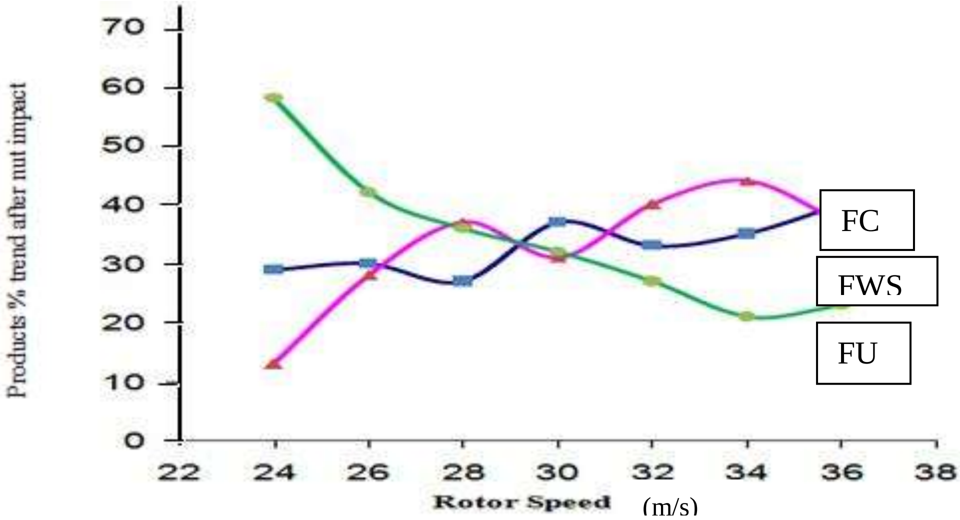


Figure 3: Products Percentage Trend after Nut Impact against Rotor Speed for Rotor/Drum Diameter Ratio 0.22

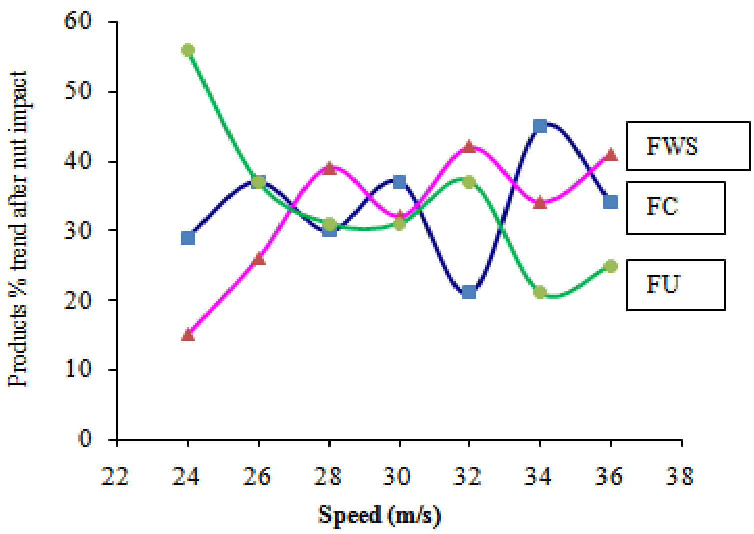


Figure 4: Products Percentage Trend after Nut Impact against Rotor Speed for Rotor/Drum Diameter Ratio 0.33

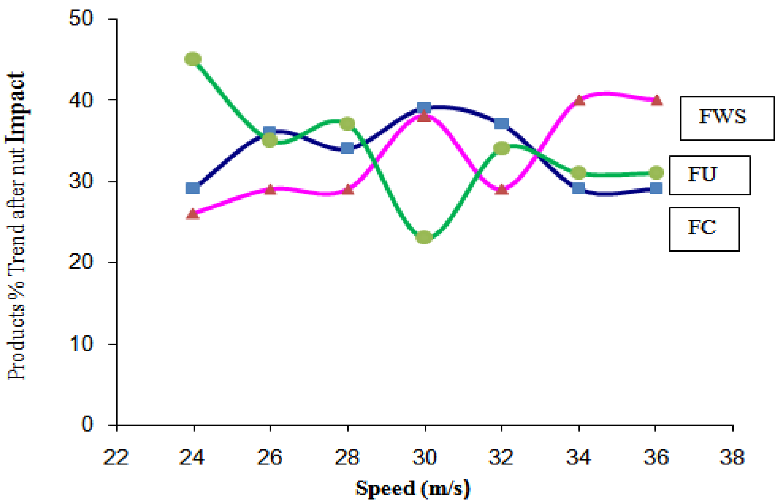


Figure 5: Products Percentage Trend after Nut Impact against Rotor Speed for Rotor/ Drum Diameter Ratio 0.67

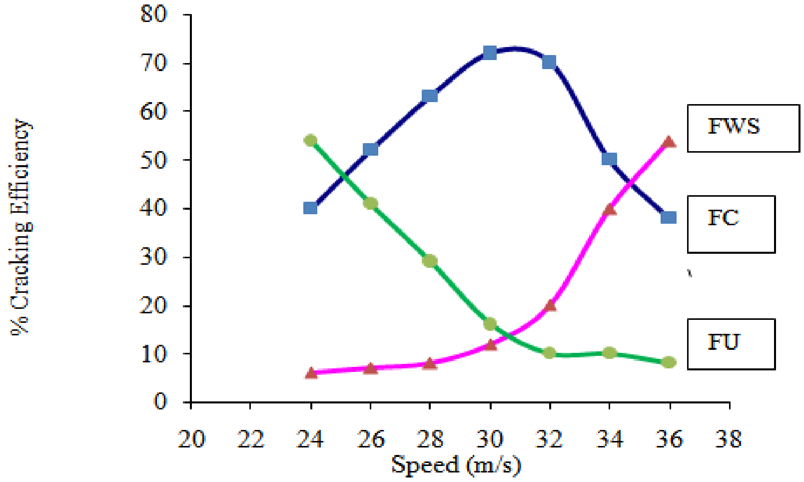


Figure 6: Percentage of cracking efficiency against speed for Rotor/Drum diameter ratio 0.67

Antia. “Rotor to Drum Diameter Ratio Required for Effective Cracking of Palm Nut in Centrifugalcracker.” American Journal of Engineering Research (AJER), vol. 6, no. 12, 2017, pp. 83-88.