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Empirical Determination Of Number Of Distribution Channel On Rotor For Effective Discharge Of Nuts In Centrifugal Nut Cracker

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***Abstract*—The relationship between the rotor disc diameter and the number of distribution channel on rotor disc for effective discharge of nut in a centrifugal nut cracker was carried out. This would help in the design and operations of an effective nut cracking unit of a centrifugal nut cracker. In this study, dried nuts of mixed variety (Dura and Tenera) were classified into five size ranges based on their geometric mean diameter (GMD). Twenty nuts from each of these size ranges were selected randomly and mixed to form a fair representative sample of bulk nuts used per experimental run. Four rotors disc each with different number of nut exit channel were used for discharging the nuts on to the impact surface of the cracking drum. Each rotor was run at six different speeds. Data generated indicates that the rotor speed is independent of the number of distribution channel(s) for effective discharge of the nuts. Also, the more the number of distribution channel, the faster the rate of nut discharged on to the impact surface; and this increased the rate of achieving fully cracked nuts with release of whole kernels. The optimal speed range for increase in whole kernel release was 29 to 33m/s. Empirical equations developed could be used for estimating the minimum, average and maximum number of distribution channel required for effective discharge of nuts from the rotor disc of a centrifugal nut cracker.**

Keywords—Channel; Nut; Speed; Kernel; Rotor; Cracker

I. INTRODUCTION

When palm fruit is harvested and processed, one of the important products is the palm nut. The nut is usually dried and then cracked to obtain kernel and shell fragments. Bulk kernels are further processed to obtain palm kernel oil and palm kernel cake. These products find application as raw material in various industries.

The primary pre-requisite for effective release of whole kernel is drying of the nut. The nut could be dried by either indirect heat transfer methods such as hot air convection oven or direct heat transfer methods such as sun drying[1, 2]. In modern technology, the nuts are cracked in a nut cracker machine in order to obtain kernels. Two of the major types of mechanical nut cracker used in oil palm mills are: the roller nut cracker and (b) the centrifugal nut cracker. In the roller nut cracker, the nuts are cracked in between two fluted rollers revolving in opposite directions. The clearance between the rollers is variable but the nuts are of different sizes. This makes the machine to operate at reduced efficiency. However, the efficiency could be improved depending on the effectiveness of the design [10, 12, 13].

In a centrifugal nut cracker, the operating principle is the centrifugal force. The design is such that nut falls by gravity through the hopper channel into the nut inlet of the cracking chamber. The cracking chamber is installed with impeller blades or rotor disc. The number of blade and/or the number of nut outlet in a given rotor diameter used varies from one researcher to another. This seems to cause its efficiency to also vary. For most nut cracker, the cracking efficiency is above 90% [10, 6, 14, 15]. In assessing cracking efficiency the release of high percentage of whole kernel was not considered; yet very important as high percentage of split kernels would enhance losses of kernels during separation from shells fragments. This is because of reduction in size and shape when compared with shell fragments. Also, the split kernels would have their oily surface exposed to environmental influence. This could cause low quality attribute resulting from the liberation of fatty acid; hence possible rancidity of the oil.

In an effort to crack nut mechanically to obtain whole kernel and separate the kernel from shell fragments effectively, various studies have been carried out. It is worthy to note that, due to morphological variation of nuts the force required in breaking nuts would vary even when they are of the same size. The interactions between adjacent nuts in a cracking chamber especially in centrifugal nut cracker may tend to obstruct the direct impingement of the individual nut unto the impact surface, hence causing some nuts to be discharged unbroken [3, 4, 5, 6, 7, 8, 9, 10, 11].

This study therefore seeks to develop a relationship, if any between the rotor disc diameter and the number of distribution channel on the rotor disc. This would help in predicting the number of distribution channel per rotor diameter required for

effective discharge of nuts to cause the release of high percentage of whole kernels.

II. METHOD

In this study dried nuts (6.83 %wb) of mixed variety (Dura and Tenera) were classified into five size ranges based on their geometric mean diameters (GMD) as follows: GMD<12 mm, 12 mm≤ GMD<15 mm, 15 mm≤GMD<18 mm, 18 mm≤GMD<21 mm and GMD≥21 mm. Twenty nuts from each of these size ranges were selected randomly and mixed to form a group of fair representative sample of 100 bulk nuts to be used per experimental run. A centrifugal nut cracker (Test Rig) cracking unit having a cracking drum diameter of 450 mm and four replaceable rotor designs was employed. Each of these rotors had different number of rectangular shaped nut exit channels ranging from one to four. All rotor used had same diameter of 200 mm and nut inlet diameter of 50 mm. The and models obtained for predicting effective number of nut exit in rotor of any specified diameter. The speed range that can achieve effective discharge of nut and high percentage of fully cracked nuts that release whole kernels was obtained.

$$\%\,\mathrm{NFC} = \left[\frac{\mathrm{NFC}}{\mathrm{NDR}}\right] \times 100 \qquad (1)$$

$$y_{\min} = \left[\frac{a}{b}\right] D_R \qquad (2)$$

$$y_{\max} = \left[\frac{c}{b}\right] D_R \qquad (3)$$

Where $y_{\min}$ is the minimum number of channel distribution, $y_{\max}$ is the maximum number of channels on the rotor had same dimensions of (i) length (35mm) (ii) Width (50 mm) and (iii) breadth (50 mm).

The rotor with one exit point for nut was fixed onto a driving shaft located centrally in the cracking drum. This rotor was run at six different speeds of 23, 27, 29, 31, 33 and 35 m/s). A group of one hundred nuts per speed were subjected to impact from the rotor to the nut impact surface of the cracking drum. At the end of each experiment, the following assessments were carried out.

(i) Number of nuts discharged from the rotor (NDR)
(ii) Number of the discharged nuts that are fully cracked with release of whole kernels (NFC)

Hence, 500 nuts per speed were used totaling 3000 nuts for the six speeds. This experiment was repeated for rotor with two, three and four exit points for nuts. The generated data were analyzed

channel distribution, D_R is the diameter of rotor to be used for nut discharge/ cracking, a is the minimum number of distribution channel used in achieving 100% nut discharge from rotor diameter used for the experiment, b is the diameter of the rotor used for the experiment and c is the calculated maximum number of distribution channel on rotor when considering rotor circumference, exit dimension (50mm) for nut discharge and gap that would exist between each distribution channel.

III. RESULTS AND DISCUSSION

The percentage of nuts escaping per speed per number of distribution channel is presented in Table 1.

Table 1: Percentage of nuts escaping per speed per number of distribution channel(s)

	Speed (m/s)							Number of channels
	23	27	29	31	33	35	37	
% Nut escaped	84	84	85	85	84	82	82	1
	86	87	87	87	88	86	86	2
	100	100	100	100	100	100	100	3
	100	100	100	100	100	100	100	4

The percentage of fully cracked nuts per number of distribution channel(s) per rotor speed is presented graphically in Fig. 1

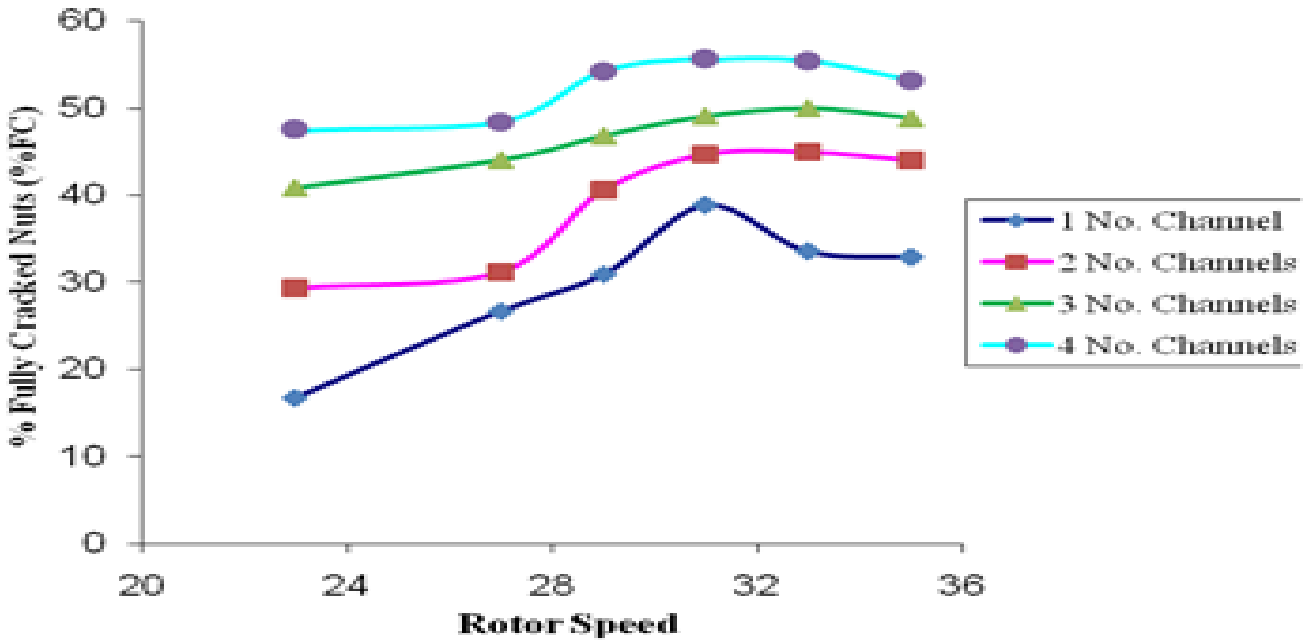

Fig. 1: Percentage of Fully Cracked Nuts against Rotor Speed per Number of Distribution Channels on Rotor

From Fig. 1, the speed range of 29 to 33 m/s having optimum at 31 m/s result in increase in the production of fully cracked nuts following whole kernel release. Effective discharge of nuts from the rotor of the centrifugal nut cracker to achieve increase in fully cracked nuts was also observed. The implication of Fig. 1 patterns is that the percentage of nuts cracked could be improved if appropriate rotor speed, number of distribution channels on rotor, rotor to drum ratio, impact energy and impact surface are employed. From experimental data, empirical equations were developed to estimate the minimum, average and maximum number of distribution channel that may be required; depending on the rotor diameter.

$$y_{Min} = \left(1.5\times10^{-2}\right)D_R \quad (4)$$

$$y_{Max} = \left(5.5\times10^{-2}\right)D_R \quad (5)$$

An average number of distribution channels (y_{ave}) for rotor based on (4) and (3) were developed as (6)

$$y_{ave} = \left(3.5\times10^{-2}\right)D_R \quad (6)$$

These equations were used to predict the number of distribution channels on different rotor diameters and are presented in Table 2

Table 2: Predicted values of minimum, averaged and maximum channel(s) on rotor using (2), (3) and (4)

Rotor diameter (mm)	Maximum number of distribution channel(s) on rotor $y_{max} = (5.5\times10^{-2})D_R$	Minimum number of distribution channel(s) on rotor $y_{min} = (1.50\times10^{-2})D_R$	Average number of distribution channel(s) $y_{ave} = (3.5\times10^{-2})D_R$
75	4	1	3
100	6	2	4
150	8	2	5
200	11	3	7
250	14	4	9
300	17	5	11
350	19	5	12

These rotors were tested for effective discharge of nuts and the result presented in Table 3.

Table 3: Rotor number of distribution channel and % nuts discharged using rotor speed (31 and 33m/s) obtained from fig. 1

Rotor Speed (m/s)	Diameter of Rotor (mm)	Rotor Maximum Number of Channel	% of Nuts Discharge from Maximum Number of Channel	Rotor Minimum Number of Channel	% of Nuts Discharged from Minimum Number of Channel	Rotor Average Number of Channel	% of Nuts Discharge
31	75	4	100	1	100	3	100
	100	6	100	2	100	4	100
	150	8	100	2	100	5	100
	200	11	100	3	100	7	100
	250	14	100	4	100	9	100
	300	17	100	5	100	11	100
	350	19	100	5	100	12	100
33	75	4	100	1	100	3	100
	100	6	100	2	100	4	100
	150	8	100	2	100	5	100
	200	11	100	3	100	7	100
	250	14	100	4	100	9	100
	300	17	100	5	100	11	100
	350	19	100	5	100	12	100

This indicates that the empirical equations developed can be used with reasonable validity.

IV. CONCLUSION

From this study, the number of distribution channel obtained from the developed equation(s) guaranteed 100 % discharge of nuts from the rotor disc. The percentage of fully cracked nuts that released whole kernels is optimal at speed range of 29 to 31 m/s.

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