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Overview of Operational Factors in Performance of Palm Nut Cracker-Separator

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ABSTRACT

This paper presents an overview of effects of operational parameters on performance of palm nut cracker-separator. It explained how impact energy, moisture content, temperature and rotor speed influence performance of palm nut cracker and separator systems. Recent research articles covering the application of these operational factors were reviewed. Careful application of these parameters will make the cracker/separator perform effectively, and thus more worthwhile to use. Furthermore, this work have assisted in identifying the challenges faced in implementing these factors from a practical point of view. However, each of the operational factor considered has its own unique input toward the overall performance of the cracking and separation operations in palm kernel oil processing. Thus, if properly harnessed, it is expected the cracking and separation machinery with very effective performance can be designed and processed.

Keywords : Palm Nut, Operational Factors, Performance Parameters, Cracker, Separator

I. INTRODUCTION

Palm kernel is a major viable agricultural produce in Nigeria [1],[2]. Palm kernel are obtained from cracking palm nuts of the palm tree and then removing the shells. The challenges of cracking palm nut more effectively, while protecting the embedded kernel from being crushed has attracted some research attention [3]-[6]. The nut shell possesses high resistance to fracture, while the embedded kernel is itself fragile. At failure, the nut fractures in a catastrophic brittle manner with the shell breaking into pieces. Because the physical properties of the kernels and shells are close [7],[6],[8] the resulting mixture presents a difficult problem of separation, In addition, kernel breakage during nut cracking makes the separation more difficult and, the market value of the kernels reduced. It is worthwhile therefore, to control the nut cracking process to enhance mixture separation. To this end, some school of thought have suggested that the nuts are sufficiently dried to enable the kernel shrink away from the shell, to reduce the possibility of crushing the kernel during nut cracking process.

Existing methods employed in nut cracking are manual and the use of powered mechanical nut crackers [9]. In the manual method, the processor breaks the nuts, one at a time between two stones, and by experience, judging the magnitude of force applied once or repeatedly. The impact is controlled to prevent kernel breakage. However, manual methods are cumbersome and time consuming, but have the advantage that the separation of kernel from shell is done simultaneously. On the other hand, there are two types of modern palm kernel cracker mechanisms; the hammer impact and the centrifugal impact types [10]. Hammer impact type breaks or cracks the nut on impact when the hammer falls on it; while centrifugal impact nut cracker uses centrifugal action to crack the nut [11],[12]. These modern crackers are not free of limitations. In the centrifugal type, the nuts are fed into a slot turning at a very high speed and are hurled against a cracking ring; or with other types, fed against impact beaters turning at high speed. Therefore, large quantities of nuts are processed at a time, but efficient separation techniques are required to retrieve the kernels. The nut experiences multiple impacts, bouncing on the cracking wall, and secondary collisions with the walls of the rotating channels, or with the beaters. In spite of the repetitive impacts, however, some of the nuts are discharged uncracked; while, some kernels from cracked nuts are crushed. It may be assumed that broken kernels result because the kernels were further impacted excessively after the nutshell had been broken.

Furthermore, because the palm nut is non-homogeneous and non-isotropic, variations exist in the nuts of same grade; the force required to crack a nut also depends on its diameter and its orientation against the cracking wall [4],[6]. The most challenging process in kernel recovery, once the nuts are broken, is the separation of the kernel and shell mixture. Currently, two techniques are employed in the separation of the kernel and shell mixtures: wet and dry methods. The wet method is used whenever the separation is done in a liquid medium, as a result of the differences in specific gravities of the constituents; while in the dry method, no liquid medium is used.

Whilst, most separators are liquid based, requiring enormous energy in re-drying the product; attempts to separate the kernels from its shell without admission of liquid have not yielded satisfactory results [13],[14],[7],[6]. Sophisticated equipment consisting of hydro-cyclone, conveyors and bin dryers are also too expensive for most farmers who operate as clusters of small scale processors, but providing about 77% of total yearly production [15]. Evidently, most difficulties in the dry systems were experienced with kernels and shell particles of comparable size grade; but better efficiencies were anticipated with shell particles of uniform but distinct sizes from the kernels [16].

The search to obtain the best method of extracting high quality palm oil and kernel products from palm fruit with minimum waste has been a global concern since the origin of the palm [2]. The separation of these palm kernel nuts from its shell is an important process needed to complete the operations needed for palm kernel oil production [6]. Hence, cracking and separating processes are two major operations that require serious development for drastic improvements in quality and quantity of palm kernel oil produced [3].

Researchers over the years employed several separation methods and media like water, clay, carpets, fans, blowers and sieves to separate palm kernels from the shell but none of them was able to report substantive success rate for the separation of palm nut and shell operations. Achieving efficient and better cracking and separation of palm nut shell from kernel in the processing of palm kernel oil has been a teething problem over the years. Largely, this affects the production of palm kernel in large quantities needed to satisfy the yearnings of agro-allied processing and manufacturing industries [17]. Therefore, it is paramount to note that cracking and separating processes are two major operations that require serious development for drastic improvements in quality and quantity of palm kernel oil production. Finally, there is need to investigate properties that affect cracking and separation of palm nuts. This is aimed at ascertaining the effects of the functional properties on the performance of machineries used in the cracking and separation operations of palm nut. This appraisal of the various contributing factors to effective cracking and separation of palm nut is expected to ease the identification of appropriate operating factor values prediction.

II. FACTORS INFLUENCING CRACKING AND SEPARATION PERFORMANCE OF PALM NUTS

Cracking of palm nut and separation of palm kernel-nuts mix forms an integral part of the palm kernel oil processing. The effectiveness of cracking and separation as regards kernel recovering with little or no loss of kernel through breaking becomes paramount [18]. There are significant parameters for every nut cracker machines on which the cracking of nuts and separation of palm kernel from the shell should never be neglected. The parametric factors that affect cracking and separation of the kernel shell though hard but brittle from the kernel include; angular speed of the rotor shaft, the diameter the shelling drum, thickness of the shelling drum wall, palm kernel nut sphericity, moisture content, feed rate, instantaneous position during impact and shell thickness. These variables have effects on the overall productivity in this stage of palm kernel oil processing. Performance of such machine(s) can be evaluated with responses such as throughput capacity, cracking/separation efficiency, energy utilization efficiency and Kernel recovery. The performance indices used for every palm kernel nut cracker are defined as follow: The throughput capacity was defined as the rate in kg/h at machine process the palm nut. Kernel recovery was set to assess the percentage of the kernels which were recovered from the sample introduced into the machine. Consequently, kernel loss a compliment of kernel recovery is defined as the percentage of the kernels, which were discharged with the shell. Cracking/Separation efficiency is the ratio of the total kernel cracked/separated by the machine to the total mass fed into the machine. Thereafter, energy utilization efficiency is the power consumption rate of the machine expressed in percentage.

The effects of moisture content, speed of cracking shaft and feed rate on cracking and separation efficiency

[19] undertook a study to determine the optimum moisture content of nuts for high yield of whole kernels during cracking. Thirteen identical groups of fresh palm nuts with 240 nuts per group were subjected to oven drying at a temperature of 105°C. Before conducting the experiment, they recorded the initial mass of each nut and at 2 h-intervals, a group was randomly selected and each of the 240 nuts cracked by impact after weighing for the determination of the nut moisture content. From their experiment they concluded that the percentage of cracked nuts after impact cracking was used to determine the optimum moisture content. The average moisture content was 2.5% wet basis or 2.57% dry basis. Also, at the optimum moisture content condition, they stated that 84.2% of the cracked nuts yielded whole kernels while drying is needed to facilitate the total release of the full kernel when the nut is cracked

[3] submitted also on the influence of the moisture content and cracking shaft speed on the percentage of the broken palm nut during cracking and separation operations. The operating speed of the shaft of the cracker cum separator played tremendous role during cracking and separation of nuts from palm shell. At a speed of 1200 rpm the maximum broken nut at all moisture content was investigated. The percentage broken nut was observed to be the highest at 16.1% moisture content and the lowest at 9.3% moisture content. This shows that percentage of broken nuts reduces with decrease in kernel moisture content up to an optimal level of 9.3% as far as the percentage of cracked nut increases. [15],[20] concluded that as the moisture content reduces, kernel loosed from shell and this creates sufficient clearance between kernel and shell to absorb impact during cracking. In addition, the cracking efficiency of the machine increases with the feed rate. [8] reported 87%

cracking efficiency for a variable size nut cracker. [21] obtained 71.3% cracking efficiency for a vertical centrifugal cracker and 50.38% for a centrifugal impact approach. Also, [22] investigated the effect the speeds of centrifugal palm nut cracker rotor has in determining the characteristics of the constituents of the crack mixture. Their results showed that rotor speed affects the entire production of the whole kernel, broken kernel and the size of shell particles. [23] studied the impinging velocity that will give the maximum cracking efficiency of a vertical shaft centrifugal palm nut cracking machine. From their analysis, they concluded that the total impinging velocity of 36m/s was obtained and results of testing the cracker showed that it has cracking efficiency of 98.75% and kernel extraction efficiency of 63.4%. [24] also reported a cracking efficiency of 98.75% from a vertical shaft centrifugal nut cracking machine. This results show that the moisture content, shaft speed and feed rate influenced the cracking efficiency of the machines considered.

Furthermore, [25] studied to accomplish effective separation of kernels from cracked nut mixture. In their study, nuts of bone-dry mass were soaked in water at room temperature and then subjected to cracking. Result revealed that increase in shaft speed correspondingly lead to increase in separation efficiency for all conditions investigated. The highest separation efficiency of 92% was achieved at shaft speed of 1800 rpm with moisture content of 9.3%. The lowest separating efficiency was recorded at 600 rpm speed and moisture content of 16.1%. An effective separation of kernel was made possible as a result of the production of shell fragments sizes that was sieved out to leave behind high % of kernels. For a reduction in separation efficiency indicated that increased moisture content affect aerodynamic behavior and properties of palm kernel separation. [26] reported a separation efficiency of 78.5% for a rotary separator of dry mixture of palm kernel and shell. In comparison, moisture content had more significant effects on separation efficiency than shaft speed.

[22] also presented their study on separation of kernel and shell particles in a cracked mixture. Samples of mixed varieties of ready- to-crack palm nuts at 7.82% mc (w. b) were cracked in with a centrifugal nutcracker of different rotor speeds of 1760, 1891, 2068, 2175, 2250, 2450, 2650, 2800, 2962, 3150, 3300, and 3450 rpm with two replicates. The results however, showed that the unit mass of shell particles decreased from 0.37 to 0.07g with increase in speed compared to kernels (0.65 to 0.80g). The geometric mean diameter (GMD) of the shell particles decreased from 11.09 to 5.72 mm compared to kernels (10.97 to 12.97 mm). Thus making separation more effective.

[20] reported an electrically operated palm nuts cracking machine that was optimized and its performance was evaluated. The machine was modified with the introduction of three pulleys with diameters as 82mm, 75mm and 69mm, and they produced rotor speeds of 2200rpm, 2400rpm and 2600rpm respectively. The rotor speeds used was used to test the designed machine and its efficiency were evaluated. The performance test was carried out and results show that cracking efficiency of the machine increase as the rotor speed increases.

The effects of repeated impacted load on cracking and separation efficiency and kernel recovery

Cracking a whole palm nut under repeated impact load, with the objective of minimizing kernel breakage, was modeled and tested [27]. The models were based on the conversation of energy impacted on the nut by a falling height required to crack a nut, in terms of stiffness, maximum deformation, mass and size of the nut and load cycles. From the experiment conducted, they concluded that their results showed a significant reduction in kernel breakage when palm nuts were subjected to low but repeated impacts

The effect of moisture content and shaft speed on throughput capacity

According to [3], moisture content and shaft speed also influence the throughput capacity of machine of palm kernel nut cracker-separator. The operating speed of the shaft played significant role on the throughput capacity of the machine. At operating speed of 1200 rpm maximum throughput capacity was observed for all moisture content investigated. They stated that at 9.3% moisture content, the throughput capacity was found to be highest while at 16.1% moisture content, it was found to be lowest and they corresponds to 94.5 kg/h and 82.5 kg/h throughput capacity, respectively. This result agrees with [8] and [20].

III. CONCLUSION

This paper presented an overview of the palm kernel cracking and separation techniques with emphasis on the parameters that effect the overall operational effectiveness of the associated processing machineries. This is due to the challenges of cracking the palm nut more effectively, while protecting the embedded kernel from being crushed. Kernel breakage during nut cracking makes the separation more difficult and, the market value of the kernels reduced. It is worthwhile therefore, to control the nut cracking process to enhance the separation of the mixture. Recent applications of these operational parameters were reviewed, this is aimed at identifying the challenges faced in implementing these factors from a practical point of view. In general, it can be concluded that each of the operational factor considered has its own unique input toward the overall performance of the cracking and separation operations in palm kernel oil processing. When properly harnessed, it is expected the cracking and separation machinery with very effective performance can be designed and processed.

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