# Determination Of Optimal Angle Of Projection And Separation Of Palm Nut Shell And Kernel Using A Designed Cracker/Separator Machine

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**Abstract:** Efficient separation of cracked palm nut shell from kernel has been an age long industrial problem. To a large extent this has hindered the production of palm kernel in large quantities to satisfy the yearnings of agro allied processing and manufacturing industries. Experiments were performed on cracking and separation of palm kernel from the shell by angular projection method and effect of projection angle on efficiency of separation investigated. This was carried out using a designed cracker-separator machine with a casing where cracking and projection are achieved with the aid of several blades. Varied angles of projection between 0-55$^0$ were tested and corresponding values recorded. Analysis of data generated showed 11$^o$to be the best angle of projection to which 87% separation efficiency was achieved. This result is expected to aid small scale processors meet the demand of palm kernel processing in developing economies.

**Keywords:** Palm kernel, Cracking, Separation, Projection angle, Efficiency

## 1.0 INTRODUCTION:

The oil palm (Elaeis guineensis) originated from the tropical rain forest region of Africa, but due to its economic important as the world highest yielding source of edible and technical oils, it is now grown as a plantation crop in most countries with high rainfall in tropical climates within 23o N to 23o S of the equator and longitude 17o W to 102o E [1]. The pulp is made up of the exocarp and mesocarp which contains the palm oil in its cell debris, while the central nut is made up of the shell (endocarp) and edible kernel which contains the palm kernel oil. These two distinct non-toxic edible oils from the oil palm fruits are both very important in the world trade. The three main varieties of the oil palm distinguished by their fruits characteristics are dura, pisifera and tenera [2].

**Dura:** this has a very thin pericarp, 40 -70% of fruit weight with very little and a very big shell of about 2-5mm thickness. The kernel size is generally bigger than other varieties**.**

- **Tenera:** this has a thick pericarp of about 60% fruit weight containing very high oil and thick shell (1-2.5mm) which promotes easy cracking.
- **Pisifera**: this has a thicker pericarp with higher oil yield with little or no kernel.


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According to Anaekwe, 2011, it is generally believed that no part of the oil palm tree is useless. After the processing of the fresh fruit bunch to yield palm oil, the product that is left is the shelled palm nut which can be cracked to yield the palm kernel nut and the shell. While the shells can be used as fuels and road construction, though the market is not well developed in the country, the palm kernel nut can be crushed and processed to yield palm kernel oil and cake. Palm kernel processing industry is very popular in the third world countries because of the dependency of many companies on palm kernel and palm oil as raw material [4,5]. The processing of the palm kernel entails cracking the shell to produce the nut for industrial use. Cracked kernel produced must be separated from its shell to make it convenient for further processing in the industries. Separation of cracked mixture which results from the nut cracking stage and consists of kernels, broken shells, unbroken nuts and dusts requires the recovery of each of these constituents of the mixture. It is a very important activity in the kernel recovery process of palm mills. In the developing countries, small scale palm mills make use of manual labour for the separation of the kernels. The kernels are handpicked from the mixture and at the same time the unbroken nuts are recovered and taking back to the mill for cracking. This method is slow, laborious and unsuitable for large scale mills. But modern methods of cracked mixture separation have been devised which are classified into two namely: systems based on density and systems based on shape. The principle involved in the system based on density employs the difference in density between the kernels and the shells to chart paths for their independent recovery. Clay-bath and hydro-cyclones are two methods devised for cracked mixture separations based on density. These methods of separation are usually known as wet processes since water is always involved and the kernels have to be dried at the end of the separation [6]. Various researchers have worked on the palm nut given its importance and multi-purpose use. Nyanjou [7] worked on the modernization and innovation of palm oil extraction process while Adzimah and Seckley, [8] modified the design of an already existing palm nut fibre separator. Parveen et al, [9] reviewed the palm oil mill effluent treatment methods.

Nwankwojike et al [10] worked on the modification of the sequence of unit operations in mechanized palm fruit processing. He reported that induced free space among nuts in the press cake as the palm oil is expelled during pressing was identified as the basic cause of excessive nut breakage/crushing when screw press is used for palm oil extraction. Ezeoha et al, [11] worked on finding out available reports on engineering properties of palm kernels and they proposed average values to be adopted in the design of process machinery while Jimoh and Olakunle, [12] determined the effect of heat treatment during mechanical cracking of various varieties of palm nut. However, technology improvement for processing palm fruit, nut, and kernel requires accurate information on both the physical and mechanical properties. For instance, stripping and pressing are important unit operations in palm oil processing. The efficiency of these unit operations rely on the mechanical behaviour of palm fruits under compression loading since they involve the application of pressure [13]. The physical properties of fruit, nut and kernel were studied by Akinoso and Raji [14]. They found out that the moisture content and temperature effects on mass and force at break point of palm fruit, nut and kernel of the two varieties (tenera and dura) were significant at $p \leq 0.05$. Sphericity was not significantly ($p \leq 0.05$) dependent on treatment. From the foregoing it is evident that the problem of cracking and separation of palm nut still poses a challenge to small scale farmers in developing countries like Nigeria. This work shows the possibility of cracking and separating simultaneously using a designed cracker-separator which employs the principle of projectile motion.

## 2.0 Brief description of machine:

The designed machine imparts force on the kernel nut against the hard wall of the metal (anvil) thereby breaking the shell to pieces and releasing the kernel seed. The separation is achieved by angular projection. The cracking impeller, air blades and the sweeping blades are coupled to a rotating shaft housed in a metal casing. The cracking and sweeping chamber are integral and only separated by a small demarcation. Cracking is achieved with the impeller and air generated by the air blades pushes both the cracked shell and the kernels to the sweeping chamber. The high speed rotating sweeping blades forces the mixture out through an involutes hole inclined at a predetermined separation angle. Both the cracked shells and the kernels move like a projectile in air outside the exit involute. The differential in density (weight) and the aerodynamic properties of the shells and kernels aid the desired separation. The heavier and smoother of two mixtures which are the kernels drop at a longer distance from the point of projection. Thus the shells, kernels and fibres drop at different points on the line and angle of projection as shown in Fig 1. In this manner separation is achieved. The two points at which the aggregates drop become collection points for both kernels and shells. The percentage separation achieved with this method lies between 80-87%. The aerodynamic properties the aggregates play an important role in the distance travelled. In this work, the optimum angle of projection, the percentage separation and distance travelled by shells and the kernels are determined respectively. The forces acting on a particle when projected from the exit channel are the propelling force, inertia force and drag force.

### 2.1 Scope and limitations:

This work was carried out with a designed cracker/ separator with dimensions: height = 1.1m, width = 0.16m, casing diameter = 0.64m, length of chute = 1.15m, diameter of exit chute= 0.2m, length of stand = 0.64m and impeller diameter of 350mm. All experiments were carried out under normal conditions of room temperature and relative humidity.

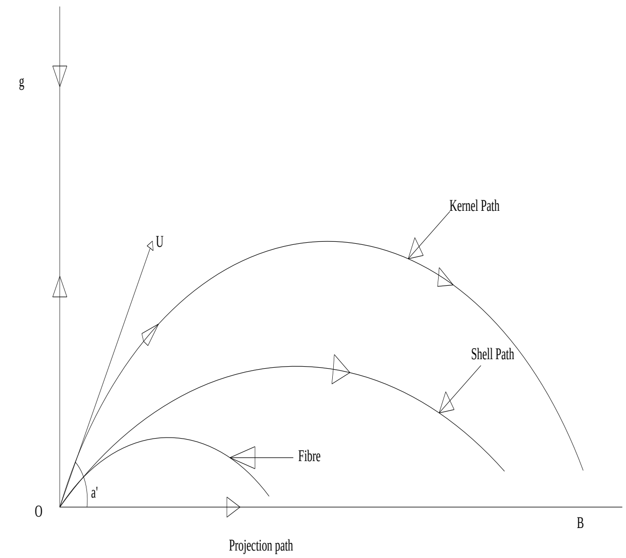


**Fig.1:** Angular projection path

## 3.0 Materials and methods:

The samples used were obtained from Emene market in Enugu East L.G.A of Enugu State Nigeria. A heap of already digested (locally) palm nut with moisture content of between 15 – 18% db was bought and carefully cleaned to remove debris and dirt. 5kg was carefully weighed out and stored in containers. A mild steel platform was fabricated that allows angular adjustments on which the fabricated machine was placed so as to obtain projectile angles of $0^o$ ($180^o$), $6^o$, $11^o$, $22^o$, $33^o$, $44^o$, $55^o$ using an industrial protractor. The samples were fed into the machine and each experiment was run for an average time of 15mins. The aggregates as dispersed were then collected and weighed individually and their corresponding weights recorded. The percentage separation achieved was then calculated using the following equation:

$$S = \frac{\text{weight of aggragate collected}}{\text{initial weight of nut}} \times 100\%$$

## 4.0 Results and Discussion

**Table 1:** Experimental data

| Angel of projection ($^0$) | Avg Distance travelled (m) | | | % separation |
|---|---|---|---|---|
| | Fibre | Shell | Kernel | |
| 0 (180) | 2 | 13 | 17 | 80 |
| 6 | 2.4 | 10 | 14 | 83 |
| 11 | 2.8 | 12 | 16 | 87 |
| 22 | 3.0 | 15 | 20 | 78 |
| 33 | 3.2 | 17 | 23 | 75 |
| 44 | 3.5 | 25 | 30 | 72 |
| 55 | 1.9 | 12 | 14 | 65 |

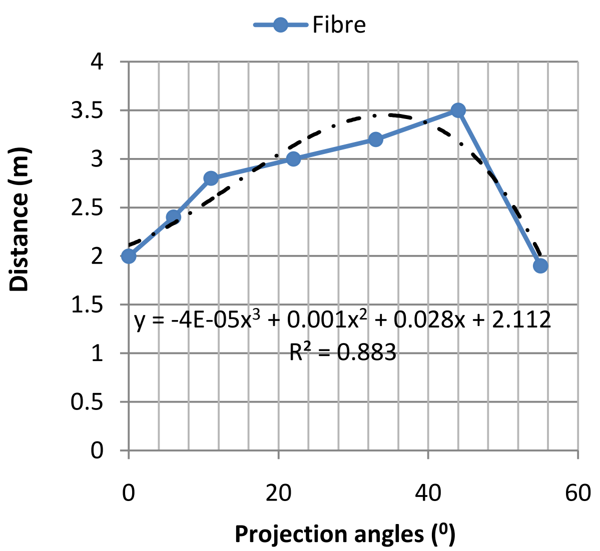


**Fig 2: Distance versus projection angle (fibre)**

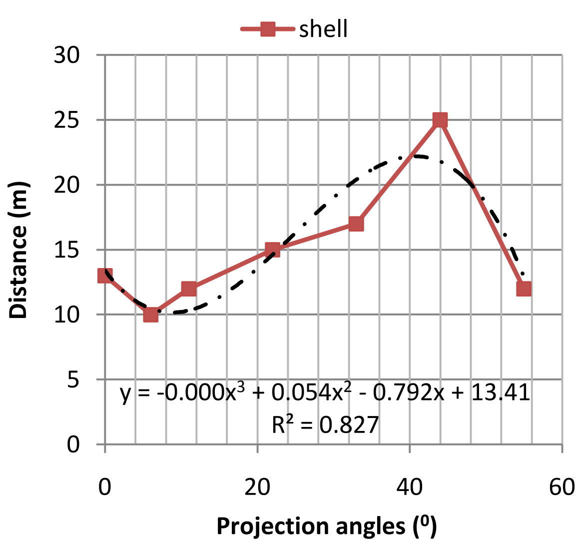


**Fig 3: Distance versus projection angle (shell)**

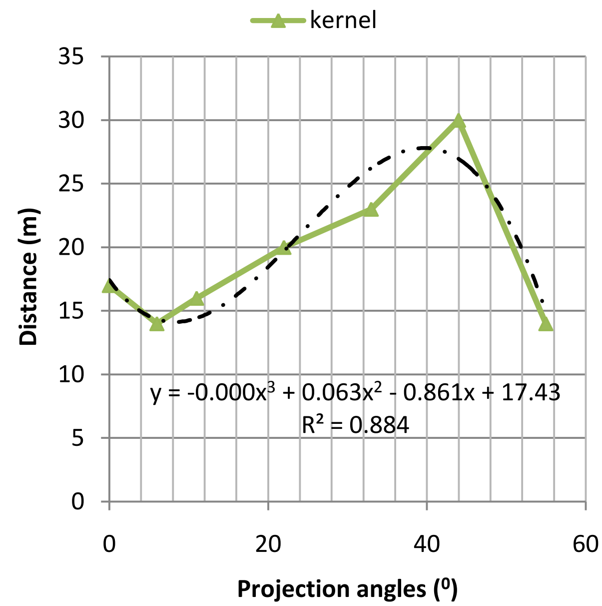


**Fig 4: Distance versus projection angle (kernel)**

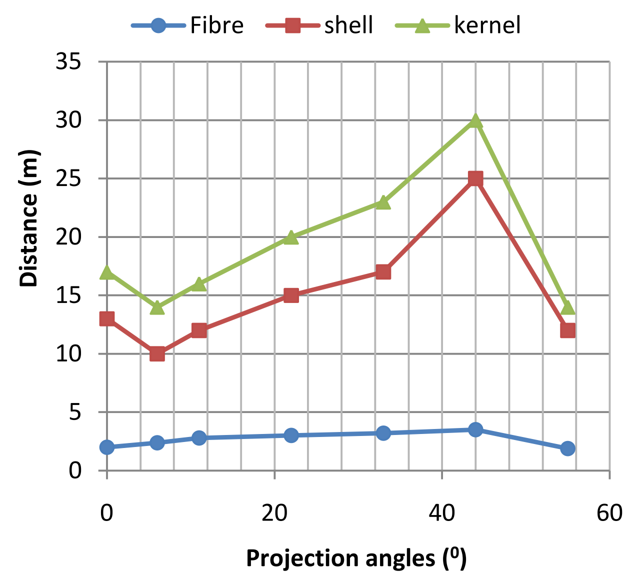


**Fig 5: Combined plot of distance travelled versus projection angle (All Aggregates)**

Figs 2- 4 show plots of distance covered by each individual aggregate with respect to the projection angles observed. It can be seen that all three aggregate samples followed similar trend and were best described by third order polynomial equations. The $R^2$ values for all three plots were also found to be very similar (0.883, 0.884 and 0.827 respectively for fibre, shell and kernel). Fig 5 presents a combination of all plots and shows at a glance that kernel given its greater aerodynamic properties travelled the farthest. The fibres and shell given their irregular shape and the greater impact of drag force on them travelled lesser distances though the shell were not very far from the kernels.

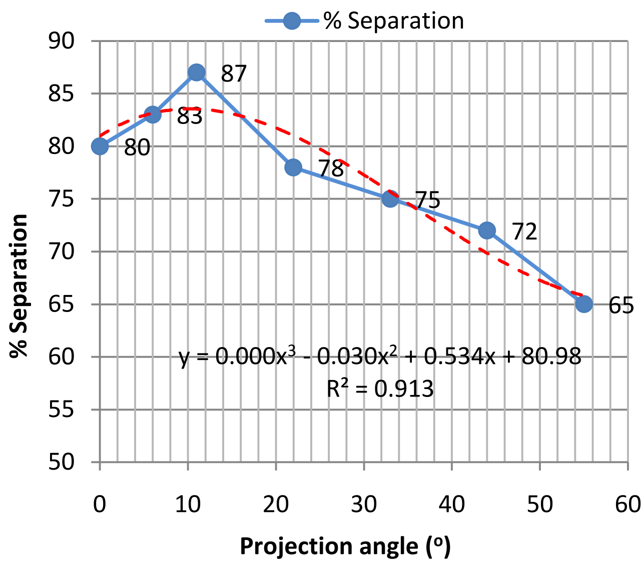


**Fig 6: Percentage Separation versus Projection angle**

From Fig 6, it can be observed that the percentage separation increased with increasing angular adjustments. However, it began to decrease continuously after 11°. This shows that for the machine used the best angle of separation under the stated conditions was 11°.

## 5.0: Conclusion:

From the analysis of the experimental data achieved, the lower angles gave better percentage separation. Among the lower angles, 11° became the optimum projection angle for the designed machine. This automatically implies that the palm nut cracker- separator machine should be built with its projection outlet inclined at an angle of 11°. The exit outlet could also be extended with a bigger pipe of diameter about 150mm and length 1000mm to prevent unnecessary divergence of both shell and seed in the course of travel along the line of projection.

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