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Design and Construction of a Dual Powered Groundnut Decorticating Machine

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ABSTRACT: The groundnut decorticating machine was fabricated to break open groundnut pods with little or no damages done to the kernels. The machine was constructed in such a way that it can be powered either by a petrol engine (internal combustion engine) or human. The machine comprises of feeding unit; threshing chamber, the discharge chutes and cleaning unit. A handle was fastened on the machine to enable it usage in areas where there is high fuel pump price or engine failure during operation. Three samples of groundnut; A, B and C at different moisture content (24%. 28% and 32%) were used for the performance evaluation of the machine. From the test and result obtained; the mean capacity of the machine was 92kg/hr, the mean decorticating efficiency was 92%, mean cleaning efficiency was 29%, mean percentage losses was 7%, the mean percentage of broken kernels was 85%, and the mean percentage of unbroken kernels was 13%. On the other hand. decorticating with human indicate the following result; the machine capacity obtain was 48kg/hr, the machine efficiency and percentage of kernels losses are 76% and l7%. The machine was constructed using locally sourced materials.

Keywords: Design, Construction, Dual powered, Groundnut, Decorticating Machine

I. INTRODUCTION

1.1Background of Study

Groundnut (arachis hypogea L.), also known as peanut or earthnut, is a member of the papilionaceae, Groundnut was cultivated in Peru as far back as about 300BC where it is believed to have originated. It was brought to West African from Brazil in the 16th century (Miller, 1983; Anyanwu et al. 1973). Groundnut comprises of two main types, the first being the bunch or erect type in which the main stem and branches grow upright so that there is little spreading; the nuts are found closed together at the base of the plant. This type is suited for mechanical harvesting. The second is the creeping type with branches trailing along the ground and the plant therefore has spreading habit. Most of the ones grown in West Africa and Nigeria are of the creeping type (Levetin and McMathon, 1999). Groundnut is grown as an annual crop on about 19 million hectares in tropical and sub tropical regions and the warmer areas of temperate region of the world principally for its edible oil and protein rich kernels or seed, bore in pods which develop and mature below the soil surface (Asiedu, 1989). Major world producers of groundnut include the United States of America, China, Brazil, Senegal and Nigeria, with the United States been the largest exporter, producing kernels. cake meal and oil equivalent to about 360,000 tonnes in shell (Miller, 1983). Groundnut production in Nigeria is mostly in the Sudan zone and Northern

Guinea savanna zone, Kano, Bauchi, Borno, Kaduna and Sokoto are large producing States with Benue, Plateau, Nasarawa, Adamawa, Taraba and Niger States and Federal Capital Territory (FCT, Abuja) as the minor producing area (RMRDC, 1989). Groundnut is one of the most important food legumes in the world (Norde et al., 1982). It has been identified as one of the leguminous species with the greatest potential for both food and industrial purposes in the tropical region of Africa (Miller, 1983). It is an important economic crop in many states of Northem Nigeria to the extent that some states in the producing areas depend mostly on the revenue from its sales to finance rural development. Preliminary studies reported by (Kutte, 2001), shows that groundnut seed contains 42 to 52% oil, which is obtained by mainly crushing the seed. The oil is a desirable cooking and salad oil, because of its high quality, containing about 80% unsaturated fatty acids such as Oleic and linonoic acids. Groundnut is an excellent source of protein to balance diets high in cereals and starchy foods, and to supplement animal proteins. Groundnut cake contains concentrated proteins, minerals and vitamins (Hamman and Caldwell, 1974); Levetin andMcMathon,1999).

Both digging and shelling of groundnuts present a great problems in making the product ready for market. Usually after harvesting the crop, they are shelled, decorticated, cleaned before usage either as cake or extraction of the oil for cooking purposes. Decorticating is the removal of the shell or peanuts with least damage to the seed or kernel. In Nigeria the most common method of groimdnut shelling/decortications is by the traditional method which involved hand shelling; This process involves moisturizing the groundnut pods with Water, spreading over a threshing floor in thick layers and then beating with sticks and stirring frequently until all pods are broken (Asiedu, 1989). Another method is by applying finger pressure in form of a compressive impact force which yields low out- put per man in an hour (1-2.5kg) but with a unique advantage of excellent result with respect to breakage of kernels and at range of 96-98 of kernel count. Another old method that is still in existence among some local farmers in rural areas is gathering the pods in a mortar and then beating them (Asiedu, 1989). All these methods of decorticating groundnut are uneconomical, laborious, time wasting (especially when handling large volume of groundnut) very harmful to human thumb, etc. at the end of a day work. But now the commercial hand and power operated groundnut decorticators are being used in the country, both of these machines Work on the same principle, the main difference lies in their capacities.

1.2 Development of Decorticating Technology in Nigeria

Having found that the traditional hand operated and semi-rotary type decorticators are unsatisfactory, attention has since been concentrated over developing the prototype of the imparted decorticators to reduce cost and the manual power requirement. Some of the development include the use of local raw materials, design and construction e.g 'Nagari' discovered among some development project in 1975, but shelling trials with different pipe and iron rods sizes did not produce any better decorticating performance over the previous type, this was later abandoned in 1976 (Kutte, 2010).

The next modification was the construction of groundnut decorticators (I.A.R, 1975). All these recommended power decorticators for both large and small scale decortication. Aseidu (1989) constructed a manually-operated groundnut decorticator using locally sourced materials. The machine components were mainly the frame, hopper, perforated screen, handle, crushing plate and the oscillating quadrant.

The study therefore seeks to design and build a dual powered groundnut decorticating machine that will be capable of breaking open the groundnut seed out of the shell with minimum damage to the seed so that the farmers can maintain the nutritive value of the produce for consumption and equally avoid wastage during the decorticating process. The following steps were therefore taken in the construction of the decorticating machine:

i. Evaluate the performance of the groundnut decorticating machine.
ii. Using petrol/diesel engine
iii. Using human/manual effort.
iv. Construction of a dual powered groundnut decorticating machine

II. MATERIALS AND METHODS

2.1Design Consideration

The materials needed for the fabrication of the Dual Powered groundnut decorticating machine were selected based on certain consideration as follows ; cost, availability, durability, workability, acceptability, toughness, strength, resilience and stiffness etc.

2.2 Factor Affecting Decorticating

The factors affecting the performance of a sheller have been classified by Asota (1996) into three categories, namely machine based factors(e.g. Cylinder speed, cylinder-concave clearance, type of cylinder and fan speed, crop-based factors(e. g crop moisture content and orientation) and operator — based factors (e. g feed rate, skill and experience). Other factors are:

i. Cylinder concave clearance
ii. Cylinder characteristics
m. Concave configuration
iv. Feed rate
V. Sources of power
vi. Method of shelling
vii. The tensile strength of the seed
vm. The variety of the crop
ix. The drying method employed after harvest
X. Moisture content of the pods
xi. The physical characteristic of the pods
xii. The damage done to the pod.

Physical and mechanical factors govern the quality of kernel produced and the efficiency of decorticating (Sesay, 1994; Musa, 1997).

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Moisture content is one among the parameters that determines the effectiveness of decorticating. Effects of relative humidity, temperature and variety on equilibrium moisture content variability were investigated. The decision to use a 3mm thick plate for the concave Was due to the fact that after metal sheets are perforated, they become sufficiently plastic and thinner material Would easily tear apart under unbearable loads but the 3mm thick plate was still sufficiently strong even after perforation. Galvanized sheet was also used for the sieve and outlet because these parts are directly involved in grain handling because of its anti-corrosive property.

2.3 Description of the Groundnut Decorticator

2.3.1 Feed device

This can also be refered to as the hopper, it holds and introduces the groundnut kernel into the thrashing chamber for decortications. The device was constructed in form of frustrtun of a pyramid to enable it hold a specific quantity of groundnut and deliver it at a time. The construction was be made from 1.5mm (upper end 300 x 500mm, base end 500 X 100mm) metal sheet.

2.3.2 Decorticating cylinder

The cylinder was constructed with 1.5mm black plate (285 X 175mm) and a (26Omm X 60mm) was fastened to the cylinder in three places with l0mm bolts and nuts, a shaft of length (600mm) and diameter (22mm) was passed through the threshing cylinder supported by two pillow bearings (P 205) at both end. The threshing cylinder was constructed with 2mm thick metal of length (600mm) and diameter of (3 00mm)

2.3.3 The handle

The handle was constructed in such a way that the operator can apply rotational motion in order to decorticate the pods. It was constructed with a 20mm X 100mm fastened to a thick plate 150mm X 40mm pipe of diameter 300mm X40Omm (external) respectively so that they fit into each other perfectly. The handle was fastened with bolt and nut to allow for easy removal.

2.3.4 Concave

The concave was constructed with 3mm mild steel. The metal plate was perforated with an oblique shape (lOmm) diameter through which the shelled groundnut fall to allow both the kernel and chaff pass through. The concave has support at both side to allow for easy removal. The concave was constructed with length 520mm, diameter 375mm. The concave and threshing cylinder is made in such a way that there is room for adjustment or repair.

2.3.5 Frame (Support)

The frame was constructed with 3mm angle iron to provide a good support. It was constructed to a height of (700mm), length (610mm) and a width of (38Omm). All the components of the machine are mounted on the frame. A mini frame of height (23 8mm), width (330mm) and length (330mm) was attached to the main frame which serves as the motor carrier.

2.3.6 Blower (Fan)

The fan was constructed with 1.5mm metal sheet of length (260 X 70mm) enclosed in a housing of (325mm X 180mm) with an outlet to allow for the flow of air to separating the grains from the chaff. The fan delivers air stream against a product with the aim of pneumatic conveyance, aeration or winnowing. It delivers the volume of air required to perform the operation above and has some basic characteristics like the air flow rate, air pressure, air speed and power requirement.

2.3.7 Power transmitting unit

The power required to drive the threshing cylinder and blower is either the use of petrol engine internal combustion engine, or human through the handle for mechanical power transmission, the speed required is assumed to be 200rpm. The petrol engine is generated powered, transmitted directly to the cylinder shaft which operates the drum and at the same
time drives the shaft.

2.4 Performance Evaluation

Some performance parameters, such as evaluation capacity (kg/h), shelling efficiency (%),
material efficiency (%) and mechanical damage (%), as earlier used by Kutte (2001) was
applied in testing a sheller as follows:

Throughput capacity (kg/h) = $\frac{Qt}{t}$ -------------------------- (1)

Where:
Qt = weight of whole grain collected per unit time, kg
t = Shelling time, h

Shelling efficiency (%) = $\frac{b}{a}$ x 100 ------------------ -- (2)

Where = Weight of shelled kernel collected at all outlets per time, kg
a = Total kernel input per unit time by weight, kg

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Cleaning efficiency = $\frac{c}{d}$ X 100 --------------------------- -- (3)

Where :

c = weight of shelled kernel collected at main kernel outlet per unit time, kg

d = weight of main kernel mixture collected per unit time, kg

Decorticating efficiency = Mass of decorticated pods ------- (4)

Total weight of decorticated and undecorticated pods

Kernel loss = Mass of kernel loss with pods ------------------(5)

Mass of decorticated kernels

Kernel damage = Mass of damaged kernels -------------------------(6)

Mass of decorticated kernels

III. RESULTS AND DISCUSSIONS

3.1 Testing with Petrol Engine

After the construction work, three samples of groundnut 4kg each (A,B, and C) with size 11 mm x 30mm were collected from the entire mass meant for the test.The three samples collected was initially set at a moisture content of 24%. The initial moisture content (24%) of the groundnut was used to determine the quantity of water needed to vary the moisture content at 24% moisture content, 28% moisture content and 32% moisture content to know which of the sample will give the best result during decortication.

To vary the moisture content of the three sample (A. B and C) , The formula Qw = A (b-a)/(100-b) according to Aremu, and Fadele (2011) was used.

Qw = quantity of water to be added (kg)

A = initial mass (kg)

b = desired moisture content (%)

a = initial moisture content (%)

24% moisture content now form the initial moisture content of the entire mass of groundnut for the testing. This moisture content is now varied from 24% to 28% to 32% using the Formula ; Qw = A(b-a)/(l0O—b).

100 is a constant

To determine the water requirement of sample A at 24 % Mc

Solution

given data

Quantity of water (Qw) =‘?

Initial mass (A) = 4kg

Desired moisture content (b) = 24%

Initial moisture content (a) = 24%

From the formula: QW = A (b—a)/(100-b)

Substituting the values into the formula we have

Qw = 4(24-24)/(l O0-24)

Qw = 4(0)/(76)

Qw = 0kg

To determine the water requirement for sample B at 28% Mc

Solution

Given data

Quantity of water (Qw)?

Initial mass of groundnut (A) = 4kg

Desired moisture content (b) = 28%

Initial moisture content (a) = 24%

From the formula: Qw = A(b-a)/(100-b)

Substituting the values into the formula we have

Qw = I 4(28-24)/(100-28)

Qw = 4(4)/(72)

Qw = O.277kg or 277g

To determine the Water requirement of samplc C at 32% Mc

Solution

Quantity of water (Qw) = ?kg

Initial mass of groundnut (A) = 4kg

Desired moisture content (b) = 32%Mc

Initial moisture content (a) = 24%Mc

From the formula: Qw = A (b-a)/(100-b)

Substituting the values into the formula we have:

Qw = 4 (32-24)/(100-32)

Qw = 4(8)/68

Qw = O.588kg

Qw = 0.588kg

The results obtained from testing the constructed decorticating machine using the three samples of groundnut at different level of moisture content is presented in table 3.1

Table 1: Results obtained during testing.

S/No	Initial mass of G/nut(unshelled) (kg)	Mass of G/nut(shelled) (kg)	Mass of unsplit kernels (kg)	Mass of split kernels (kg)	Mass of chaff collected through the chaff outlet(kg)	Kernel losses (kg)	Mass of chaff collected through kernel outlet (kg)
A	4kg at 24% Mc	3.00	0.15	1.50	0.30	0.15	0.80

B	4kg at 28 %Mc	4.00	0.25	1.70	0.55	0.35	1.20
C	4kg at 32% Mc	4.00	0.35	1.65	0.51	0.35	1.20

Mean capacity of the Machine = Weight of decorticated pods/Time taken (hrs)

= 12+40+40/3 =92kg/hr

Calculating the efficiency of the decorticating machine using the result from samples A,B and C.

For sample A:

$$\text{Efficiency} = \frac{\text{Mass of shelled groundnut}}{\text{Initial mass of unshelled groundnut}} \times 100$$

$$= \frac{3}{4} \times 100 = 75\%$$

For sample B

$$\text{Efficiency} = \frac{\text{Mass of shelled groundnut}}{\text{Initial mass of unshelled groundnut}} \times 100$$

$$= \frac{4}{4} \times 100 = 100\%$$

For sample C

$$\text{Efficiency} = \frac{\text{Mass of shelled groundnut}}{\text{Initial mass of unshelled groundnut}} \times 100$$

$$\text{Efficiency} = \frac{4}{4} \times 100 = 100\%$$

$$\text{Mean efficiency of the machine} = \frac{\text{Sample (A + B + C)}}{3} = \frac{75 + 100 + 100}{3} = 92\%$$

Calculating the percentage (%) losses of the decorticating machine using the results from Samples A, B, and C

$$\text{Percentage losses } \frac{\text{Mass of kernel loss}}{\text{Mass of unshelled kernel}} \times 100$$

For sample (A)

$$\text{Percentage losses} = \frac{\text{Mass of kernel loss}}{\text{Mass of unshelled ground}} \times \text{l00} = \frac{0.35}{4} \times 100 = 3.8\%$$

For sample (B)

$$\text{Percentage losses} = \frac{\text{Mass of kernel loss}}{\text{Mass of unshelled groundnut}} \times \text{IOO} = \frac{0.35}{4} \times 100 = 8.8\%$$

For sample (C)

$$\text{Percentage losses} = \frac{\text{Mass of kernel loss}}{\text{Mass of unshelled groundnut}} \times 100 = \frac{0.35}{4} \times 100 = 8.8\%$$

Calculating the percentage of split kernel of the decorticating machine using the result from A,B and C

$$\text{Split kernel} = \frac{\text{Mass of split kernel}}{\text{Mass of shelled groundnut}} \times 100$$

For sample (A)

$$\%\text{ of Split kernel} = \frac{\text{Mass of split kernel}}{\text{Mass of shelled kernel}} \times 100 = \frac{1.5}{1.75} \times 100 = 85.7\%$$

For sample (B)

$$\%\text{ 0f Split kernel} = \frac{\text{Mass of split kernel}}{\text{Mass of shelled kernel}} \times 100 = \frac{1.7}{2.00} \times 100 = 85\%$$

For sample (C)

$$\%\text{ of split kernel} = \frac{\text{Mass of split kernel}}{\text{Mass of shelled kernel}} \times 100 = \frac{1.65}{2} \times \text{l00} = 82.5\%$$

Calculating the percentage of unsplit kernel of the decorticating machine using the result from Sample A , B and C

$$\% \text{ of unSplit kernel} = \frac{\text{Mass of unsplit kernels}}{\text{Mass of shelled kernels}} \times l00$$

For sample (A)

$$\% \text{ of unsplit kernel} = \frac{\text{Mass of split kernels}}{\text{Mass of shelled kernels}} \times l00 = \frac{0.15}{1.75} \times l00 = 8.6\%$$

For sample (B)

$$\% \text{ Of unsplit kernel} = \frac{\text{Mass of split kernel}}{\text{Mass of shelled kernel}} \times l00 = \frac{0.25}{2} \times l00 = l2.5\%$$

For sample (C)

$$\% \text{ ofUnsplit kernel} = \frac{\text{Mass of split kernel}}{\text{Mass of shelled kernel}} \times 100 = \frac{0.35}{2} \times l00 = 17.5\%$$

Calculating for cleaning percentage of the decorticating machine using the result from sample A. B and C

$$\text{Cleaning efficiency} = \frac{\text{Mass of chaff collected}}{\text{Total chaff input}} \times l00$$

[Kurt 2001, Jabar 1986]

$$Ec(\%) = \frac{X_d}{X_h + X_d} \times 1O0$$

Where X_b = weight of foreign matter collected at grain outlets
X_d weight of foreign matter collected as foreign matter outlets (Nigeria Industrial standard NlS_ 1997).

For sample (A)

$$E_C(\%) = \frac{X_d}{X_b + X_d} \times l00 = \frac{0.3}{0.8 + 0.3} \times lO0 = 27\%$$

For sample (B)

$$Ec(\%) = \frac{X_d}{X_b + X_d} \times lOO = \frac{0.55}{1.2 + O.55} \times lOO = 3l\%$$

For sample (C)

$$Ec(\%) = \frac{X_d}{X_b + X_d} \times 100 = \frac{0.5}{1.2 + 0.5} \times 100 = 29\%$$

Table 2: Result of testing using human power

Parameters Measured	Value Obtained (Kg)
Weight of groundnut before decortication (kg)	2kg
Weight of unshelled whole kernel	0.1kg
Weight of shelled kernels (unsplit)	0.53kg
Weight of shelled kernel (split)	0.5kg
Weight of chaff kernels	0.5kg
Weight of unshelled and shelled groundnut	1.52kg
Weight of shelled groundnut	0.58kg
Weight of damaged ground nut	0.5kg

$$\text{i. The mean capacity of machine} = \frac{\text{weight of decorticated pods kg}}{\text{Time taken (hrs)}}$$

$$\text{ii. Machine Etificieiicy} = \frac{\text{Weight of shelled groundnut}}{\text{Weight ol' unshelled groundnut}} \times 100 = \frac{l.52}{2} \times 100 = 76\%$$

$$\text{iii. Kernel loss} = \frac{\text{weight of kernels lost with pods}}{\text{weight of kernels lost with pods}} \times 100 = \frac{0.1}{0.58} \times 100 = l7\%$$

IV. CONCLUSION

The construction of a dual powered groundnut decorticating machine was achieved with a deorticating efficiency of 92%. ln evaluating the overall efficiency of the machine, it was discovered that the blower was unable to completely separate the seed from the chaff. The following efficiencies were determined for the machine variables. The mean capacity of the machine was 92kg/hr, the mean decorticating efficiency was 92%, mean cleaning efficiency was 29%, mean percentage losses was 7%, the mean percentage of broken kernels was 85%. and the mean percentage of unbroken kernels was 13%. On the other hand. decorticating with human power indicate the following result; the machine capacity of obtained was 48kg/hr. machine efficiency and the percentage of kernels losses were 76% and l7 % respectively.

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