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Design of an Improve Cassava Peeling Machine

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Abstract:* All the unit operations involved in the post-harvest processing of cassava such as grating, drying, milling, pressing, sieving, molding, extrusion and frying have been mechanized successfully. However, cassava peeling remains the only unsuccessfully mechanized process which has constituted a bottleneck to the commercial processing and industrialization of cassava tuber utilization. This project work is aimed at developing an improved cassava peeling machine with a minimal loss of useful flesh. The principal parts of this design work includes a hopper, electric motor, shafts, bearings, wire brushes, and a V-belt attached to the pulley that rotates the shafts embedded with wire brushes. A ten consecutive tests were carried with a total number of ninety-three (93) cassava tubers used. However, out of the ninety-three cassava tubers used for the test, six broken cassava tubers were recorded. The percentage mass of peel (%) by manual and machine, peeling efficiency (%), percentage of broken and unbroken cassava tubers were calculated for. The results showed that the machine is 85% efficient and a minimum percentage peels recorded. Also, the percentage of broken cassava tubers recorded was 5% and this simply means 95% of cassava tubers used for the test were successfully peel without any breakage. To know the actual percentage peel removed by machine and manual, the mass of cassava tubers and mass of peel removed both manually and by machine were used. The results analysis showed that 13.13% was obtained for manual peeling and 15% for machine peeling. Therefore, the machine is expected to cause minimum useful flesh loss.
***Keywords*— Cassava tubers, cassava peeling machine, efficiency, cassava peels, broken and unbroken cassava tubers.**

I. INTRODUCTION

Cassava, *Manihot esculenta, is* a tuberous starchy root crop of the family *Euphorbiaceae*. It is a food crop just like yam tubers, potatoes tubers, etc. However, cassava is different from other food crops tubers because of it drought tolerance and it ability to do well on marginal soils [1]. Cassava is believed to grow well in areas with annual rainfall of 500 – 5000mm and in presence of full or limited sunshine, but susceptible to cold weather and frost [2]. It is a cheap source of calorie intake in human diet and a source of carbohydrate in animal feed. It origin can be trace to South America but is now grown in most of the tropical countries of the world like Brazil, Indonesia, Nigeria, DR. Congo, Congo, Uganda, Ghana and many other countries of the world [3]. Recent statistic showed that Nigeria is currently the largest producer of cassava in the world with an estimated annual output of over 34 million tonnes of tuberous roots. In comparison to other tubers crop, it is high yielding, more resistant to pest and diseases, with cyanide contents as low as 3.1mg/100g [4].

Cassava has several advantages compared to other carbohydrate root crops, with much variation in nutrient quality. The calorific value of cassava is high, compared to starchiest crops. The protein content is extremely low; however, it ranges between 1-3% [5]. A cassava root contains a number of mineral elements in appreciable amount, which are useful in the human diet. The root contains significant amounts of iron, phosphorus and calcium, and is relatively rich in vitamin C [6].

However, before cassava tuber is processed into any of its food and some of its non-food products, it must be peeled. In food industries, the peel must be completely removed without removing the useful tuber flesh. Major cassava peeling problem arises from the fact that cassava roots exhibit appreciable differences in weight, size and shape [7]. There are also differences in the properties of the cassava peel which varies in thickness, texture, and strength of adhesion to the root flesh. Cassava processing deserves attention in order to meet local and international demand. The unit operation in cassava processing include peeling, grating, boiling/parboiling, drying, milling, sieving, extrusion and frying [3]. All the unit operations have been mechanized successfully except peeling. Cassava peeling remains a global challenge to design engineers [8] thus this research work.

II. MATERIALS AND METHODS

This phase involves how the materials and components used in the design of the cassava peeling machine is selected, practically fabricated and eventually put together. The machine consists mainly of hopper, electric motor, shaft, bearing, wire brush and v-belt attach to the pulley that rotate the shaft embedded with wire brush.

A. Functional design requirement

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1) Estimation of power required by the machine (watts)
2) Determination of approximate length of the belt (m)
3) Determination of load on shaft pulley and belt tensions (N)
4) Selection of bearing for shaft
5) Determination of minimum shaft diameter (m)
6) Determination of load on the peeling brush (N)

B. Power required to Peel Cassava

$$P = FV \tag{1}$$

Where,
P = power to turn the shaft
V = speed
F= Force= mass x acceleration due to gravity

$$V = \frac{\pi DN}{60} \tag{2}$$

Where,
V= Speed
D= Diameter
N= Speed in revolution per minute
Force = mass x acceleration due to gravity
That is,

$$F = ma \tag{3}$$

Where,
m = mass
a = acceleration due to gravity
Substituting equation 2 and equation 3 into equation 1

$$P = \frac{ma\pi DN}{60} \tag{4}$$

C. Belt design

$$2.3 \log \left({}^{T_1}/_{T_2} \right) = \mu\theta \tag{5}$$

Where,
θ= angle of wrap of an open belt
μ= coefficient of friction
T_1= Tension in the tight side of the belt
T_2= tension in the slack side of the belt
x = distance between the pulleys
For cross belt,
Angle of contact is given by

$$\sin\alpha = \frac{R+r}{x} \tag{6}$$

For open belt,
Angle of contact is given by

$$\sin\alpha = \frac{R-r}{x} \tag{7}$$

Angle of wrap;

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$$\theta = 180 \pm 2\sin^{-1}\left(\frac{R-r}{x}\right) \tag{8}$$

Where,
r = radius of small pulley
R = radius of big pulley
X = distance between the two pulleys
For peeling machine with inner (rotation) the angle of contact is,
For open belt from equation (5) angle of contact is given by

$$Sin\ \alpha = \frac{R-r}{x} \tag{9}$$

Angle of wrap,

$$\theta = 180 \pm 2\sin^{-1}\left(\frac{R-r}{x}\right) \tag{10}$$

$$P = (T_1 - T_2)v \tag{11}$$

Where,
P = Belt power (watts)
V = Belt speed (m/sec)
T_1 and T_2 are tension on the tight and slack sides respectively (N)

$$T_1 - T_2 = \frac{p}{v} \tag{12}$$

From, equation 5

$$2.3\log\left({T_1}/{T_2}\right) = \mu\theta$$

Where μ= coefficient of friction between belt at pulley for mild steel pulley and rubber belt,
But for open belt, angle of contact is given by,

$$\text{Sin}\ \alpha = \frac{R-r}{x}$$

D. Design for velocity ratio for belt drive

Velocity ratio for belt drive is the ratio between the velocity of the driver and the follower (driven). It may be expressed mathematically as:

$$\frac{N_2}{N_1} = \frac{d_1}{d_2} \tag{13}$$

Where,
d_1 = diameter of the driver
d_2 = diameter of the follower
N_1 = speed of the driver
N_2 = speed of the follower
Length of the belt that passes over the driver in one minute is given by;

$$\pi d_1 N_1 \tag{14}$$

Similarly, length of belt that passes over the follower in one minute is given by,

$$\pi d_2 N_2 \tag{15}$$

Since the belt passes over the driver in one minute is equal to the length of the belt that passes over the follower in one minute Therefore;

$$\pi d_1 N_1 = \pi d_2 N_2 \tag{16}$$

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Therefore,

$$\frac{N_2}{N_1} = {d_1}/{d_2} \tag{17}$$

Figure 1 shows the physical model of improved cassava peeling machine and figure 2 shows the skeletal view of improve cassava peeling machine

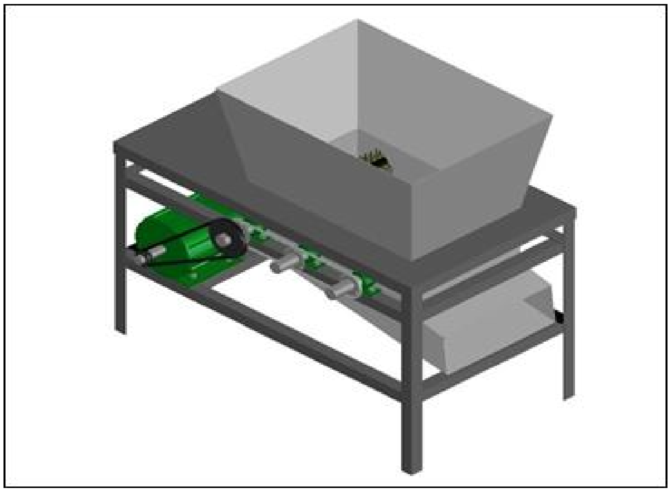

Fig. 2 Physical model of improved cassava peeling machine

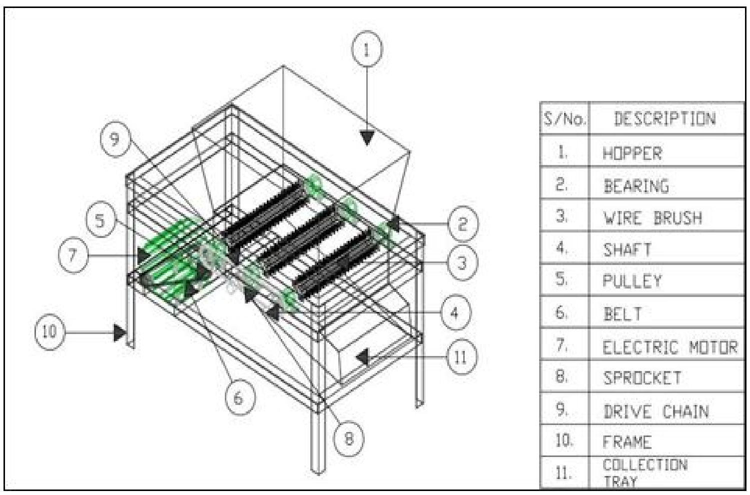

Fig. 2 Skeletal view of improve cassava peeling machine

III.RESULTS AND DISCUSSION

Table 1 and Table 2 showed the results obtained with the designed machine.

TABLE I

RESULT OBTAIN WITH CASSAVA PEELING MACHINE

S/N	Cassava tuber	Mass (kg)
1.	Mass of unpeel cassava tubers M	6.00
2.	Mass of peel removed manually M_1	0.80
3.	Mass of cassava tuber peeled manually M_2	5.20
4.	Mass of peel removed by machine M_3	0.90
5.	Mass of peeled cassava tuber by machine M_4	5.10

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TABLE III
Broken and Unbroken cassava

S/No.	Unbroken cassava tubers	Broken cassava tubers
1.	9	-
2.	10	-
3.	8	-
4.	13	2
5.	7	-
6.	8	1
7.	12	2
8.	9	-
9.	10	1
10.	7	-
	93	6

A. Percentage mass of peel (%)

$$\frac{Mass\ \ of\ \ peels}{Mass\ \ of\ \ unpeeled\ \ \ tubers} \times \frac{100}{1} \tag{18}$$

Percentage (%) mass of peels removed manually $= \frac{M_1}{M} \times \frac{100}{1}$

$$\frac{0.80}{6} \times \frac{100}{1} = 13.33\%$$

Percentage (%) mass of peels removed by machine $= \frac{M_3}{M} \times \frac{100}{1} = \frac{0.90}{6} \times \frac{100}{1} = 15\ \%$

B. Peeling efficiency (%)

$$P.E = \frac{Mass\ \ of\ \ peel\ \ removed\ \ \ manually}{Total\ \ mass\ \ of\ \ peels\ \ remvoed\ \ \ by\ machine} \times \frac{100}{1} \tag{19}$$

$$P.E = \frac{M\ 4}{M} \times 100\ \%$$

$$\frac{5.10}{6.0} \times \frac{100}{1} = 85\%$$

C. Percentage of broken cassava tubers

Percentage of broken cassava $= \frac{Number\ \ of\ \ broken\ \ cassava}{Total\ \ number\ \ of\ \ cassava} \times \frac{100}{1}$ (20)

$$= \frac{6}{120} \times \frac{100}{1} = 5\%$$

D. Percentage of unbroken cassava tubers

Percentage of unbroken cassava tubers = 100 - Percentage of broken cassava (21)

= 100 - 5 = 95%

The cassava peeling machine was successfully designed and evaluated for performance. The mass of unpeel cassava tubers (M) used was 6kg and the mass of peel removed manually (M_1) was 0.8kg. This implies that the mass of cassava tuber peeled manually (M_2) was 5.20kg. This results obtained were used to drawn comparison with the peeling machine. The outcome showed that the mass of peel removed by machine (M_3) was 0.90kg and the mass of peeled cassava tuber by machine (M_4) was 5.10kg. A ten consecutive tests were carried with a total number of ninety-three (93) cassava tubers used. However, out of the ninety-three cassava

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tubers used for the test, six broken cassava tubers were recorded. The percentage mass of peel (%) by manual and machine, peeling efficiency (%), percentage of broken and unbroken cassava tubers were calculated for. The results showed that the machine is 85% efficient and a minimum peel were recorded. Also, the percentage of broken cassava tubers recorded was 5% and this simply means 95% of cassava tubers used for the test were successfully peel without any breakage. To know the actual percentage peel removed by machine and manual, the mass of cassava tubers and mass of peel removed both manually and by machine were used. The results analysis, showed that 13.13% was obtained for manual peeling and 15% for machine peeling. Therefore, the machine is expected to cause minimum useful flesh loss.

IV. CONCLUSIONS

An improve cassava peeling machine was successfully design and this was aimed at solving an age long manual peeling of cassava tubers. Evaluation was carried out on the designed cassava peeling machine. The results obtained show that the machine was efficient and a minimum number of broken and flesh lost were recorded. For all cassava production, the peeler developed from this model will greatly enhance production speed, product integrity, quality and availability at minimum cost. This will also enhance large scale cassava cultivation and reduce unemployment.

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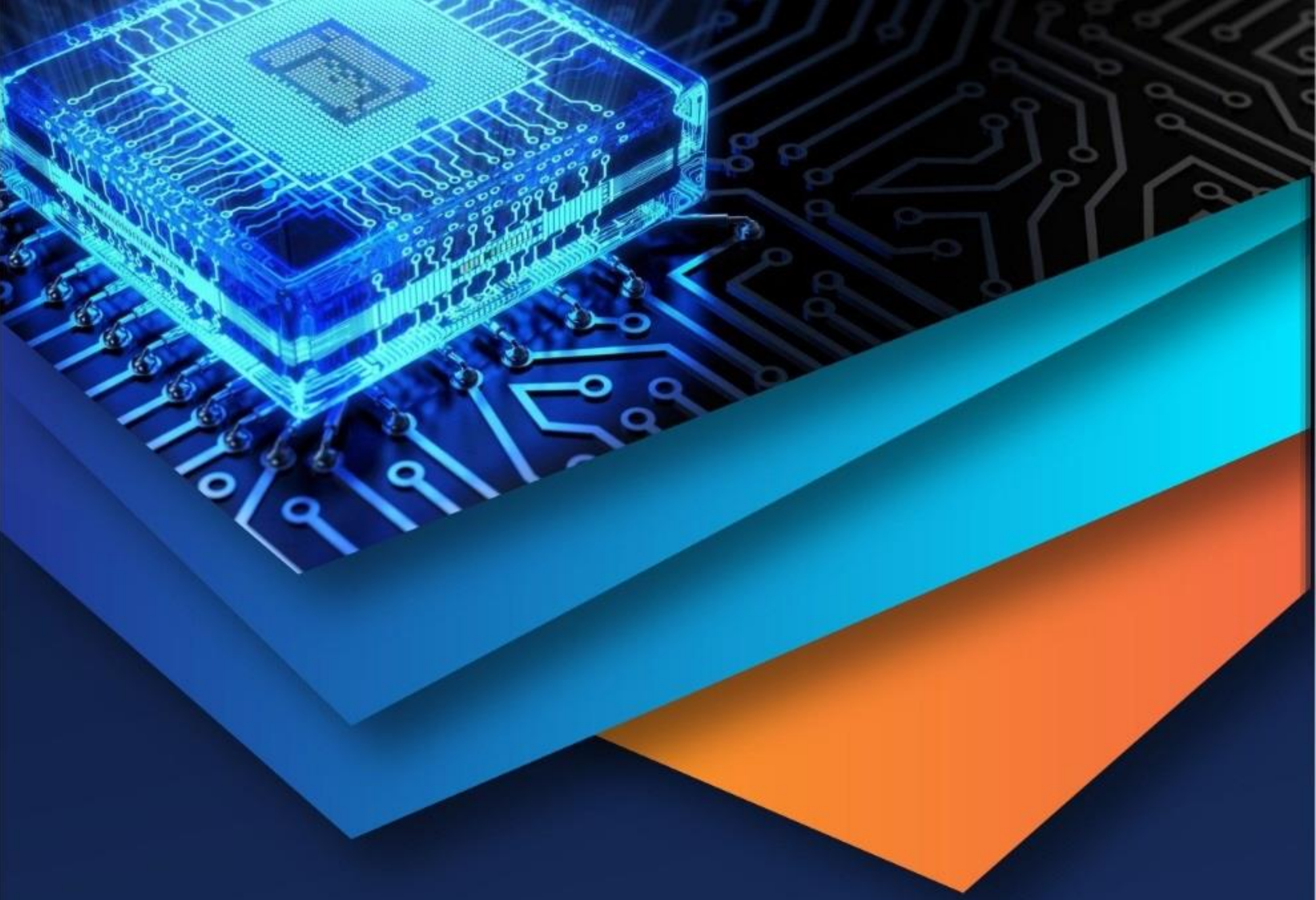

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