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Article · December 2016

DOI: 10.14445/22315381/IJETT-V42P214

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Abstract:

Cassava (Manihot esculenta crantz) is one of the alternative sources for low cost carbohydrates and is considered as one of the major crops in the Philippines, Nigeria and Brazil. It is a perishable root crop and easily deteriorates. Hence, the processing of the cassava after harvest is necessary to extend the shelf life of root tubers. This study is therefore on the design and construction of an effective labour less motorized machine of 970mm × 770mm × 1380mm in dimension for the frame, the barrel is 600mm in diameter and 920mm long with a total volume of 0.260m^3 for the peeling operation of cassava tubers in rural areas. Locally available materials such as hard wood (mansonia) is used for the barrel, mild steel for the frame were used in constructing the machine. The machine was tested for soaked and un-soaked cassava, 20kg feed per loading per trial. During testing, the maximum length of tubers to feed is 150mm for peeling and the largest diameter of tuber peeled is 70mm. The average peeling efficiency was 80.1%.

Keywords: *Barrel, Deteriorate, Peeling, Shelf life, Soaked,*

INTRODUCTION

Cassava, (Manihot esculanta crantz) is a dicotyledonous perennial plant that belong to the botanical family Euphorbiaaceae. Cassava is important in many developing tropical countries such as the tropical parts of Africa, Indonesia, Brazil, Philippines, and west India. It is said that Africa accounts for more than half about 88 million tons of cassava i.e. 55% of the world production [1]Cassava is the third largest source of low cost carbohydrates among crop plants and known to be one of the major crops in the Indonesia, Philippines has evolved from stone and wooden implement into simple household knives. This makes the peeling of large quantity of cassava difficult. According to peeling of the outer layer, periderm is essential. In case of the manual process, it is time consuming and most of the time, the cortex and fleshy part of cassava is wasted. There is therefore a need for a machine with such a mechanical advantage to peel with precision, minimum waste and satisfactory volume with a short economic time. This will allow further process to be neat, time and economic effective. According to [2] some of the world farmers process their cassava for food business by producing products like Cassava chips which are sold locally in the municipality of Salcedo with the aid of the community based participatory Action Research.

There are various ways in which cassava can be peeled, namely; manual peeling, chemical peeling, steaming method of peeling and mechanical method. The manual method of peeling Cassava is primitive and cumbersome. It is carried out by hand because of its economic and industrial potential. Cassava is the most perishable of all root tubers, and can experience physiological deterioration within two or three days after harvesting. It must therefore be processed quickly after harvesting. The unit operations involved in the appropriate processing of cassava includes peeling, grating, pressing, drying, milling, sieving, extrusion and frying to obtain products such as dried chips, flour, garri, cassava grate etc. Cassava peeling has been practiced as far back as when cassava came in existence, but the instrument for peeling

peeling of cassava using edged object like the knife [3]. The chemical peeling method or processing is developed for peeling sweet potatoes in processing industries, which is not suitable for cassava root. Immersion time will be required for cassava roots because they have peels that are tougher than those of potatoes.

The steaming method subjects the tubers to high stem pressure over a short period of time to avoid partial cooking (or eventual cooking). The disadvantage of steaming method is that the tubers could be subjected beyond the time required which may lead to cooking.[3] A good example of a cassava peeling machine was built in FUTA having mechanical features i.e. single and double gang models A and B cassava peeling machine which resulted in the production of commercial modes designed and developed. It was effective but not suitable for peeling cassava with small size and also Self-Fed model C FUTA cassava peeling machine which is a modification with capacity of 10 tons per day [4]

Akintunde [5] developed a peeling machine made up of two perforated drums rotating in opposite direction .the tuber was soaked in water to soften the cortex .it was reported that efficiency of 83.05 and tuber loss of 54% with an output capacity of 40kg/hr. According to[6],[7],[8] , sizing of cassava tubers improve peeling efficiency. Agbetoye, [9] reported that 8% of useful flesh was lost with efficiency of less than 80%and low capacity of 40kg/hr. In 2006 [10] in his design to achieve a capacity of 410kg/hr by using abrasive brushes .The brush rotate at a range of 500-1500 revolution per minute.

MATERIALS AND METHOD

In fabricating the cassava peeling machine, the design based on the feasibility study was carried out with the following considerations. The materials for construction of the machine were chosen based on their availability, properties, machinability and economic considerations. The following were put into consideration while designing the machine.

i. Volume of production, kg/min.
ii. Design analysis.
iii. Material selection.
iv. Fabrication/component analysis.
v. Operation analysis.
vi. Maintenance.
vii. Cost Effectiveness

VOLUME OF PRODUCTION.

Feasibility studies on the availability, population density of the people in the chosen area, demand for cassava ,its derived product and the need to improve on the existing method of operation that necessitate the design of cassava peeling machine were considered. He machine is designed to peel 20kg of cassava with the average length of 150mm and the numbers of batches per day were determined.

Peeled Parts	1.73Kg
The Peeled Cassava	18.27Kg
The Volume of Barrel	$0.260m^3$

Table1: Volume of production.

The configuration of the machine is (970×770×1380) mm in size. The volume of the drum is $0.260m^3$ while the power to generate the operation is approximately 9.7kw.

The machine configuration was based on the design analysis below

Table 2

Part Name or parameter	Input	Analysis	Decision/ Remark
Total mass, m Of the drum	m_1 = mass of the wooden material 30kg m_2 = mass of cassava = 20kg m_3 = mass of cleaner =1.3kg m_4 = mass of the brush = 2.02kg m_5 =mass of the shaft = 4.12kg	M = m1 + m2 + m3 +m4 M = 30kg + 20kg + 1.3kg + 2.02kg + 4.12kg M = 57.44kg	M = 57.44kg
Circumferential Force, F on the drum	M = 57.44kg $g = 9.81m/s^2$	F = 57.44 × 9.81 F = 563.49N	F = 563.49N
Speed of the driven pulley, N2	d1 = 0.075m N1 = 3600rpm d2 = 0.485m	$N_2d_2 = N_1d_1$ $N_2 = \frac{N_1 x d_1}{d_2}$	

		$= \frac{3600\ x\ 0.075}{0.485}$ = 556.70rpm $\omega_2 = \frac{2x\pi x N_2}{60} =$ 367.99 rad/s	N_2 = 556.70rpm
Speed ratio, r	N1 = 3600rpm N2 = 556.70rpm	$r_s = \frac{N1}{N2} = \frac{d1}{d2} = \frac{485}{75}$ = 6.5	$N_1 : N_2$ = 6.5:1 OR $d_2:d_1$ = 6.5:1
Velocity, V	ω_2= 367.99rad/s r_2 = 0.2425m	V = $r_2\omega_2 = r_1\omega_1$ V = $r_2\omega_2$ = 0.2425 x 367.99 = 91.42 m/s	V = 91.42m/s
Power output, P_o	F = 563.49N V = 91.42m/s	P_o = F x V = 563.49 x 91.42 = 51514.26 W = 51.51 KW	P_o=51514.26W = 51.51KW
Input power, P_i	P_o = 51.51KW Engine eff. η = 0.8 %	$\eta = \frac{P_o}{P_i}$ $P_i = \frac{P_o}{\eta}$ $= \frac{51.51}{0.8}$ = 64.39 KW	P_i = 64.39 KW
Efficiency, η	$\eta = \frac{P_o}{P_i}$ = 0.8 %	$\eta = \frac{51.51}{64.39}$ = 79%	η = 79 %
Centre distance between pulley, C	d_1 = 0.075 m d_2 = 0.485m L = 1.055m	C = L $\frac{1.5(d_2+d_1)}{2}$ = 1.055× $\frac{1.5(0.485+0.075)}{2}$ = 0.4431m	C = 0.4431m
Torque, T	P = Txω T = $\frac{p}{\omega}$	T = $\frac{51.51\ x\ 10^3}{367.99}$ = 136.63Nm	T = 136.63Nm
Power required to drive the machine (W) = 13.0hp	1hp = 0.746	13hp = 13 × 0.746 = 9.698 × 10^3 = 9.698kw	= 9.698kw

In view of the peeling operation the following power generation were considered while testing the machine.

Table 3

Trial 1	10 hp = 7.46kw	Too low speed
Trail 2	13 hp = 9.698kw	Moderate speed
Trial 3	15 hp = 11.19kw	High speed

RESULTS

THE PEELING EFFICIENCY.

The machine having completed, in terms of design and fabrication, was tested to verify if the efficiency of peeling is satisfactory. In fact, all the design concepts and calculated results were religiously followed and arrived at with little or no variations. Finally, the peeling machine was tested with approximately linear cassava. With continuous rotation of the handle, the tuber portion that comes in contact with peeling drum was rapidly bruised off.

Sample calculation.

Sample 1

Diameter of the tuber before peeling = 52.00mm

Diameter of the tuber after peeling = 50.50mm

Thickness of tuber peeled by the machine ($t_{a)}$ = 1.50mm

Ideal thickness to be peeled (t_i) = 2.00mm

Efficiency of peeler = $\frac{ta}{ti} \times 100$

$= \frac{1.50}{2.00} \times 100 = 75\%$

Sample 2

Diameter of the tuber before peeling = 55.00mm

Diameter of the tuber after peeling = 53.545mm

Thickness of tuber peeled by the machine ($t_{a)}$ = 1.75mm

Efficiency of peeler = $\frac{ta}{ti} \times 100$

$= \frac{1.75}{2.00} \times 100 = 87.5\%$

Sample 3

Diameter of the tuber before peeling = 75.15mm

Diameter of the tuber after peeling = 73.55mm

Thickness of tuber peeled by the machine ($t_{a)}$ = 1.60mm

Efficiency of peeler = $\frac{ta}{ti} \times 100$

$= \frac{160}{2.00} \times 100 = 80\%$

Sample 4

Diameter of the tuber before peeling = 60.35mm

Diameter of the tuber after peeling = 58.78mm

Thickness of tuber peeled by the machine ($t_{a)}$ = 1.57mm

Efficiency of peeler = $\frac{ta}{ti} \times 100$

$= \frac{1.57}{2.00} \times 100 = 78.5\%$

Sample 5

Diameter of the tuber before peeling = 70.50mm

Diameter of the tuber after peeling = 68.91mm

Thickness of tuber peeled by the machine ($t_{a)}$ = 1.59mm

Efficiency of peeler = $\frac{ta}{ti} \times 100$

$= \frac{1.59}{2.00} \times 100 = 79.5\%$

Thus, Average Efficiency = $\frac{75+87.5+80+78.5+79.5}{5}$ = $\frac{400.5}{5}$ = 80.1%

Hence, the efficiency of peeling the machine is estimated at 80.1%

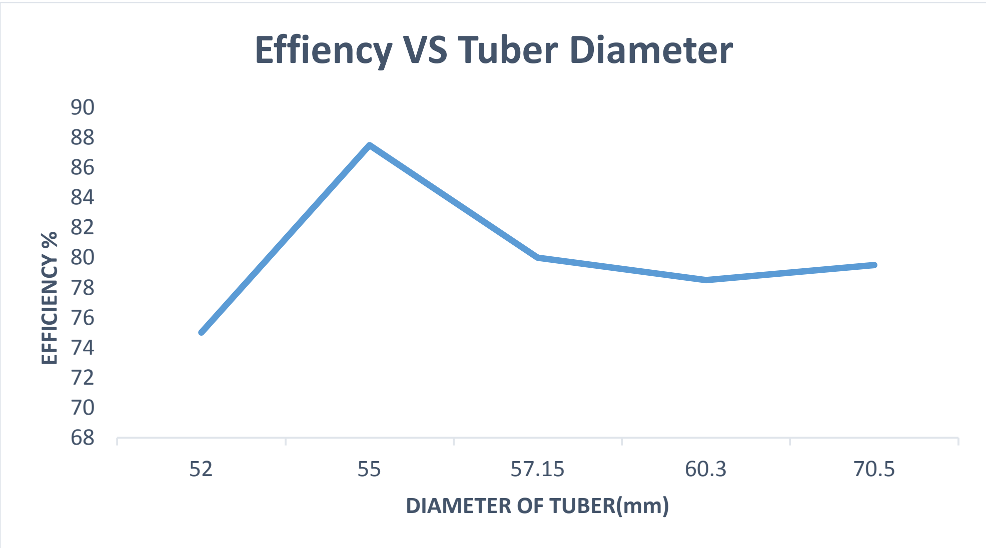

Figure 1: **Graph of efficiency against the diameter of cassava tuber.**

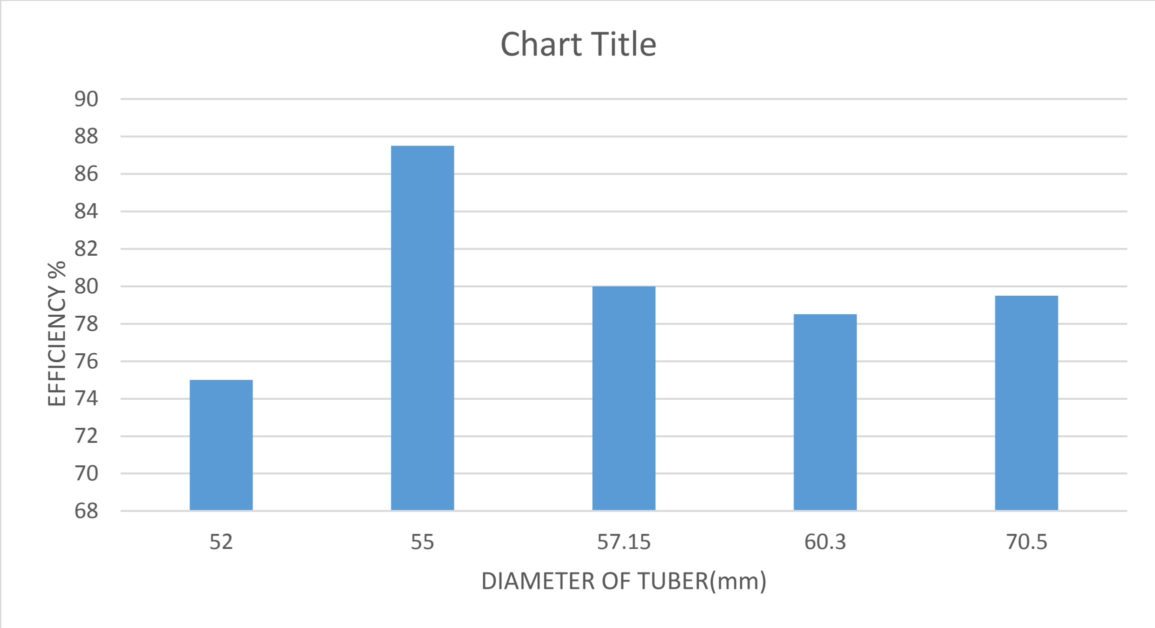

Figure 2: Bar chart of efficiency against the diameter of cassava tube

Performance

The machine having completed, in terms of design and fabrication, was tested to verify if the efficiency of peeling is satisfactory. In fact, all the design concepts and calculated results were religiously followed and arrived at with little or no variations. Finally, the peeling machine was tested with approximately 100-150 mm length of cassava. With continuous rotation of the handle, the tuber portion that comes in contact with peeling drum was rapidly bruised off.

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