Computer Aided Design and Fabrication of Garri Rotary Fryer with Brush Scrapping Device

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Abstract
A simple gari frying machine with brush scrapping device was done using Computer Aided Design (CAD), and then fabricated. The gari frying machine consists of a rotary shaft with paddles having brush scrappers at the tip. This system is inserted into a drum to fry sieved cassava mash with the aid of charcoal as the source of heat in the chamber is controlled by introducing heat exchangers.
The paddle shaft is driven by a synchronous electric motor of 3.75kw with 1460rpm. As the shaft rotates, the paddle having a to and fro conveyor effect, turns the dewatered sieved cassava mash being fried. The total cost of production is ₦176, 095.

Keywords: *Cassava, gari, frying machine, CAD*

I. INTRODUCTION

Gari is a creamy-white, granular flour with a slightly fermented flavor and a slightly sour taste made from fermented, gelatinized fresh cassava tubers. Gari is widely known in Nigeria and other West African countries. [1]

Cassava (Manihotescilenta) is a tropical herbaceous perennial plant growing up to 3 – 5m in height. The leaves are deeply indented, palmate 3 – 7 lobed, attached to a slender stem by long petioles. The flowers are small, greenish yellow occurring in panicles. The seeds form in capsules, which explode upon ripening to distribute their load. The roots form large starchy tubers, somewhat similar to sweet potato, with a dark brown fibrous covering and white flesh.

Cassava appears to have originated in Brazil and Paraguay, but has spread throughout tropical areas of south and Central America long before the arrival of Columbus. It arrived on the west coast of Africa at the end of sixteenth century which is now one of the most important food crops in tropical countries throughout the world. It ranks as the 6th most important food crop worldwide, even though in western countries it is little known or used. [1][2][3]

The Stages involved in gari processing are harvesting, washing, peeling, grating, pressing/dewatered, sieving, drying, frying and packaging. Gari is the most popular form in which processed cassava consumed by millions of people in Africa continent, especially in the west sub-region [4].

The dewatered cassava mash is fermented under high pressure for two to four days in order to minimize the cyame acid [2], the dehydraated cassava mash comes in form of cake that can be big as the size of the sacks in which they are packed and compressed. The cake that can be formed from cassava mash is a serious constrain to the granulation of gari, a paramount factor for efficient frying. This is due to the fact that the cake cassava mash needs to be pulverized and sieved into granules form with residual dods and fibres separated.

II. LITERATURE REVIEW

Gari is traditionally made in Africa and is made from cassava tubers [5]. Processing cassava to gari is a gradual process in which gari frying is the last stage. It is becoming common to produce it in commercial quantities using mechanized means. The tubers are harvested, peeled by removing the outer covering, and the white pulp is grated in a grating machine. Before the advent of the machine, the cassava is manually grated, the grated cassava is then put into a jute sack and the sack tied.

Traditionally, this is left to ferment for three to seven days depending on the type of cassava mash been made. This step is very important as the fermentation process help to reduce and de-toxify the high cyanide content of the cassava. The sacks filled of cassava mash are stacked up on each other, and a wooden board placed below and above the sacks [6]

The wooden board placed below and above the sack is then tensioned by tightening it with rope so as to allow the water to run out of the grated cassava being processed.

Usually by day three, the grated cassava would have lost quite some water and it would have become reasonably solidify a bit to form cassava flakes. Recently, cassava pressing machine of different operation mechanism has been introduced to compress and Squeeze water out of the grated cassava. The water running out of the cassava is very rich in starch. After the pressing then the dewatered cassava mash has to be broken up and sieved to remove the large lumps and fibres and to obtain fine product of cassava which after fried becomes gari.

Considering the traditional method of frying gari, we see that the time and stress that will be expended on it will be much. So this method is overcome by making use of mechanized machine. Moreover, such expected improvements are likely to come over considerable factors like maximum drying time, rate of feed, temperature control, cheap source of energy, scope of maintenance and safety precautions, [7].

III. DESIGN OF PARTS

A garri rotary fryer with brush scrapping device involves a lot of parts that require design. CAD has been employed to carry out the calculations, as well as the detailed drawings of the various parts making up the machine.

A. Design Shaft

Using Autodesk Inventor to design the main shaft of the machine, some input loads on the shaft have to be calculated. The loads on the shaft include the weight of cassava mash coming on the shaft from the hopper, belt tensions and reactions at the bearings

1. Calculation of the weight of the cassava mash

Mass of cassava mash = density of cassava mash x volume of the hopper

Volume of the hopper $V = \frac{1}{2}(a+b)h \times l$

$$a = 350mm = 0.35m$$

$$b = 350mm = 0.35$$

$$h = 320mm = 0.32m$$

$$i = 330mm = 0.33m$$

$$V = \frac{1}{2}(0.35 + 0.35)0.32 \times 0.33$$

$$= \frac{1}{2}(0.7)0.1056 = 0.03696m^3 = 36.96mm^3$$

$$The\ volume\ of\ the\ Hopper = 36.96mm^3$$

$$Density\ of\ the\ cassava\ mash = 1509\ kg/m^3$$

M =*density* ×*volume*

M =1509×0.03696

M = 55.77*kg*

Weight of cassava mash =$M \times$ g

Weight of cassava mash = 55.77×9.81= 547.1N

This is the maximum weight of cassava mash that can occupy the total volume of the hopper time.

2. Determination of the tension on the belt

$$T_s = (T_1 - T_2)\frac{D_2}{2}[8].$$

Where:

T_1 = Tension in the tight side of the belt
T_2 = Tension in the slack side of the belt
D_2 = Diameter of the smaller pulley = 0.094m

$$24.524 = (T_1 - T_2)\frac{0.12}{2}$$

$$T_1 - T_2 = 408.733N$$

NOTE THAT:

$$\frac{T_1}{T_2} = 3 \quad Assumed\ belt\ tension = 3$$

$$T_1 = 3T_2$$

Substitute T_1 into $3T_2$

$$3T_2 - T_2 = 408.733N$$

$$2T_2 = 408.733N$$

$$T_2 = 204.367N$$

$$T_1 = 3T_2$$

$$T_1 = 3 \times 204.367 = 613.101N$$

3. Calculation of reactions at the bearing supports Given the parameter of the weight

The mass of the pulley on the machine M_p= $3kg$
The weight of pulley w_p= $3 \times 9.81 = 29.43N$

Weight of pulley on the machine w_p= $T_1 + T_2 + w_p =$

$$w_p = 613.101 + 204.367 + 29.43 = 846.898N$$

The weight of paddle and the mash on the mass on the shaft $= \frac{\text{weight of cassava mash}}{\text{No of paddles}} \times weight\ of\ paddle$

Paddle 1 =0.5kg $\times 9.81 = 4.91N$

Paddle 2 = o.52 $\times 9.81 = 5.10N$

Paddle 3 = 0.55 $\times 9.81 = 5.40N$

Paddle 4 = 0.51 $\times 9.81 = 5.00N$

Paddle 5 = 0.55 $\times 9.81 = 5.40N$

Paddle 6 = 0.54 $\times 9.81 = 5.30N$

Paddle 7 = $0.53 \times 9.81 = 5.20N$

Paddle 8 = $0.52 \times 9.81 = 5.10N$

Paddle 9 = $0.5 \times 9.81 = 4.91N$

Paddle 10 = $0.54 \times 9.81 = 5.30N$

$$w_1 = \frac{549.1}{10} + 4.91 = 59.62N, w_2 = 59.81N, w_3 = 60.11N, w_4 = 59.7N, w_5 = 60.11N, w_6 = 60.01N, w_7 = 59.91N, w_8 = 59.81N. w_9 = 59.62N, w_{10} = 60.0$$

$$Taking\ moment\ from\ reaction$$

$$R_{1=}\ 846.898 \times 0.810 - R_2 \times 0.710 + 59.62 \times 0.14 + 59.81 \times 0.232 + 60.11 \times 0.372 + 59.71 \times 0.483 + 60.11 + 0.6 - 60.01 \times 0.144 - 59.91 \times 0.232 - 59.81 \times 0.372 - 59.62 \times 0.483 - 60.01 \times 0.6 = 0$$

$$665.45 - 0.71R_2 = 0$$

$$665.45 - 0.71R_2$$

$R_2 = \frac{665.45}{0.71}$= 937.25N

$$R_2 = 937.25N$$

$R_1 + R_2 =$ (Sum of the weight acting on the shaft)

$$R_1 + R_2 = 1445.618N$$

$$R_2 = 1445.618 - R_2$$

$$R_2 = 1445.618 - 937.25 = 508.37N$$

$$R_2 = 508.37N$$

IV. FABRICATION PROCEDURE

The fabrication of the garri rotary fryer with brush scrapping devicewas carried out with detailed design drawing and the machine was constructed with the locally available material such as stainless steel sheet, mild steel sheet, angle bars, flat bar, bearings, wire brush, stainless steel shaft, bolts and nuts, stainless and mild steel electrode, etc. The fabrication procedure is therefore analyzed below;.

A. The Frame

The frame was made of 72 x72 x4mm mild steel angle bar, 36x 36x2mm mild steel angle bar, 45x45x3mm mild steel angle bar and 18xmm mild steel flat bar which were welded together to form the complete frame of the machine as shown in figure 1, below.

Four pieces of mild steel angle bar iron was cut to a length of 763mm and another 4 pieces of angle bar iron; two of it was cut to a length of 861mm and other two to a length of 550mm. The 763mm length were placed at a vertical of slight taper towards the top end and welded at the top to the 861mm and 550mm length such that they form a rectangle at the top.

The mild steel angle were cut into four lengths of 450mm each, two of which were welded to the standing leg at both lesser length side at a distance of 230mm and 356mm from the top respectively. These are used to hold the two removable heat exchanger trays.

It was cut into four pieces of which two were 550mm and the other two were 725mm. The 725mm each was welded to the 550mm at a distance of 95mm from the ends. This was welded to the standing frame at a distance of 510mm from the top of the frame. Its function is to hold the charcoal pot such that there will be free entrance exits for the pot.

This was cut into four pieces of 710mm each. They were welded to the heat exchanger hangers, two to each at a distance of 95mm from the ends. They are used to support the heat exchanger tray and prevent it from sagging. The frame was covered at each side with a mild steel cover of thickness 18mm lagged with kaolin.

The frame was covered at the four sides with mild steel sheet lagged with kaolin having a door face through which the charcoal pot and heat exchanger is inserted. The frame is the standing structures caring the drum and its organs, charcoal pot and heat exchangers.

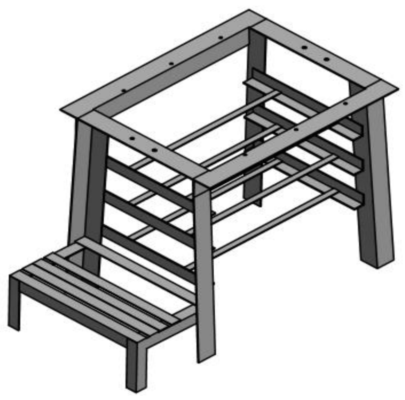


Fig. 1: Frame.

B. The Drum

The drum is made of stainless steel materials of 2mm thickness. The stainless sheet was taken to rolling machine and was rolled to the required diameter of 45mm, cut to 690mm height and welded at the joint with stainless electrode.

Inside the drum is paddled shaft which is been turned by the electric motor. As the cassava mash is charge into the drum, rotating paddle turns it. Heat is supplied to the drum by the burning charcoal inside the charcoal pot to cook and dry the gari. A discharge opening was provided at lower end of the drum face opposite to pulley side of discharging the fried gari. An opening cover with iron net was created beside the hopper base on the drum. This allows the steam generated inside the drum to escape to the atmosphere and this action prevents condensation to occur in the drum. An angle bar was welded to two sides of the drum at the center and three bolt and nuts holes were created on each of them. This is to prevent the moving and to be held firmly to the frame. The drum is then lagged with kaolin at the top so as to prevent burning of the operator. The drums also have a cover which makes the shaft removable.

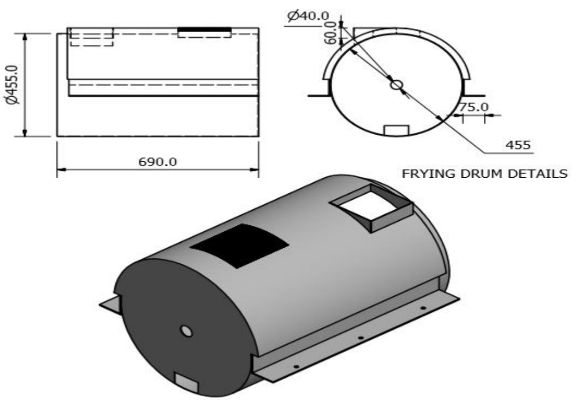


Fig.2: Isometric View of the drum

C. The Hopper

The hopper is also made of the same stainless materials. The stainless sheet was cut into four each has dimensions of 360x330x140 with the height of 320mm shown in the above diagram. They were welded together using stainless electrode. It was not positioned directly but slightly tends to a side. An opening was created at the side facing operator' standing position through which the hopper is covered.

This helps to prevent the splashing out of the gari from the inside of the drum and also to prevent dirt from going into the drum.

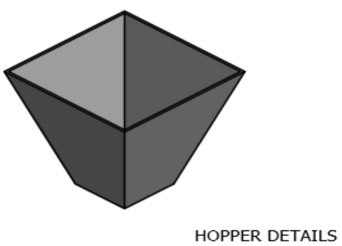


Fig. 4: Hopper details.

D. The Charcoal Pot

The charcoal pot is made of mild steel sheet. The mild steel sheet was first cut into 508mm by 711.2mm. the edges were folded at right angle towards the same direction by 101.6mm on bending machine. The sides then become 305mm by 508mm. It also consists of a handle which is used to carry it as shown in figure 4.

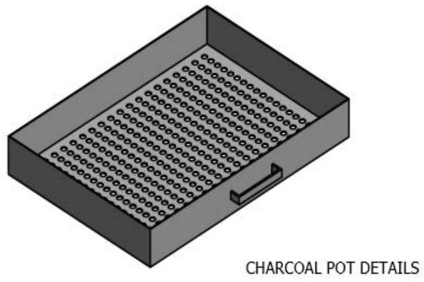


Fig. 4: Charcoal pot details.

E. The Heat Exchanger

Two heat exchangers, each of 455mm of 2mm thickness were made of mild steel sheet. They are placed at the top of charcoal pot to control the heat transfer to the drum.

F. Shaft And Paddle

The shaft is made of stainless steel iron rod of 40mm diameter with total length of 1072mm. Paddles were welded to the shaft as shown in figure 3.3 at an angle 45^0. This angle allows the cassava mash being carried by the paddles to drop and have contact with the surface of the heated drum again and again. This action allows all the granules of the cassava mash to have contact with the drum.

The paddle is made of stainless steel sheet of 2mm thickness welded to the shaft as explained above were arranged such a way that it has an alternate conveyor effect. The stainless sheet was first cut into a trapezoidal shape of 170mm side length having the other two sides to be 200mm by 120mm respectively as shown in figure a. it was later folded at 20mm at the ends as shown in figure (c) above. Then the wire brush was joined to it as shown above in figure (c) by folding and welding. The cup holding the wire brush was allowed to go a little into the folded opening, the total length was ensured to be 205mm. the fold was later pressed tightly to hold the wire brush firmly. The brush has a direct contact with the drum to remove any gari that sticks to the wall of the drum. The total numbers of paddle used were ten and were arranged in alternate form having the welding angle opposite to each other.

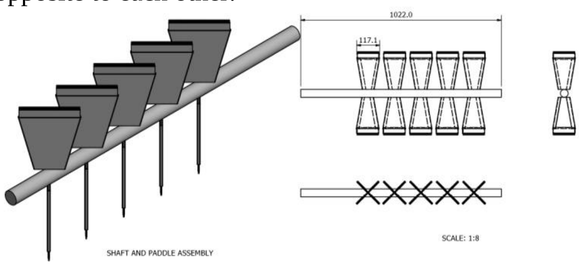


Fig. 5: Shaft and paddle assembly.

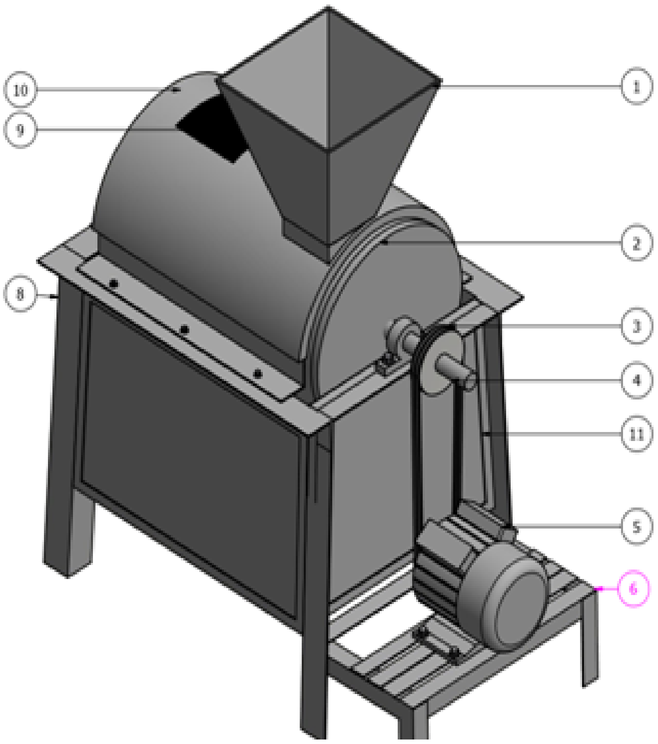
G. *The Ash Tray*

The ash tray is made of mild steel. It was first cut into 508mm by 685.8mm but later bent at right angle at the edges towards the same direction by 50.8mma. The ash tray is placed on the floor directly under the charcoal pot to receive the droplets of ashes from the burning charcoal in the pot as shown in figure 7.

V. ASSEMBLYING PROCEDURE

The frame was place on a leveled ground, the drum was positioned horizontally and the shaft with wire brushed paddle was inserted into the drum. The two pillow bearing were put to their position at the ends of the shaft. The bearing screws were tightened to hold the bearing firmly to the shaft.

The drum coupled with shaft was carried by holding the shaft ends and the hopper and placed on the frame by minimum of two people. The drum was adjusted to ensure that the hole of the side angle bar and bearings aligns. 19M bolt and nut were used for the bearings while 17M bolt and nut was used for drum and motor. The motor seat perfectly welded to the frame of the machine, where the motor (synchronous) was fixed and a belt of size 51 was connected to the pulleys.



PART NO	ITEM	DESCRIPTION	MATERIAL	QTY
13	PADDLE	LAGGED SIDE COVER	Stainless Steel	10
12	FRONT & BACK LAGGED COVER	730 X 710 X 460		2
11	LAGGED SIDE COVER	575 X 518 X 460		2
10	FRYING DRUM	Ø 455	Stainless Steel	1
9	VENT			1
8	FRAME	890 X 610 X 765	Mild Steel	1
7	CHARCOAL POT	750 X 320 X 100	Mild Steel	1
6	ELECTRIC MOTOR SEAT	580 X 400 X 200		1
5	ELECTRIC MOTOR	5hp		1
4	DRIVE SHAFT	Ø 40	Stainless Steel	4
3	DRIVEN PULLEY	Ø 300	Mild Steel	1
2	DRUM COVER	Ø 455 X 20	Stainless Steel	1
1	HOPPER	350 X 350 X 330	Stainless Steel	1

BILL OF MATERIALS

Fig. 8: Isometric Viewof the machine

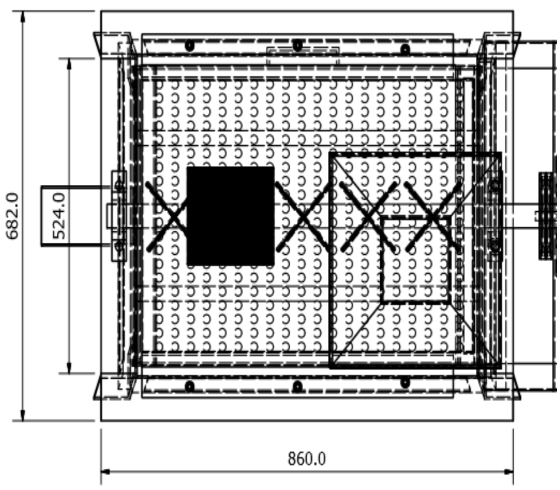


Fig. 9: Plan view of the machine

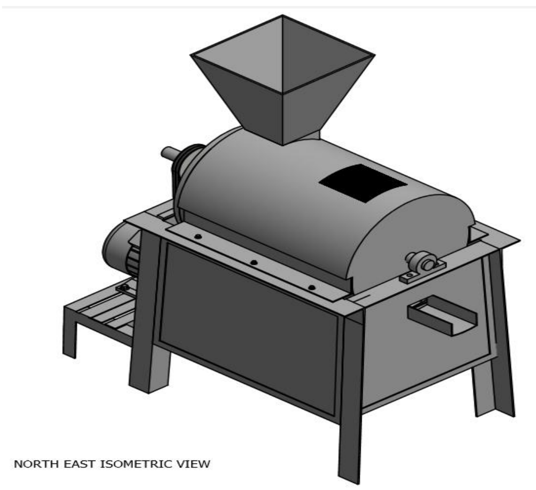


Fig. 10: An Assembled Machine.

VI. CONCLUSION

This machine has successfully turned dewatered sieved cassava mash into fried gari product through cooking and frying action. The operation of this machine has undoubtedly reduced the maximum production of gari at a minimum cost, this type of machine is more efficient since the conditions for withstanding rotation, vibrations and prevention against corrosion were considered during the design and construction of the machine.

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