DESIGN ANALYSIS AND CONSTRUCTION OF A CHINCHIN-MAKING MACHINE

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Abstract

Numerous solutions to the problems of Africans are usually technologies developed by the western world. Some operations are still being performed manually such as the production of ChinChin which is labour intensive, time-consuming and unhygienic. There are existing technologies that offer some degree of solution, producing strands of the ChinChin pasta that further requires manual cutting into the desired shapes and length. The introduced solution is a technology that can cut rolled flour into strands and simultaneously slice them into smaller and desired rectangular shapes and sizes. This was done by carefully selecting the required part and determining the required output demands. These parts were fabricated together and tested for optimal production. It was observed that all parts of the machine functioned effectively with an efficiency of 70%. This solution will be of great help to snack production if fully developed.

Keywords: Cutting machine, ChinChin, flour milling

INTRODUCTION

The African continent is overdependent on western technology for solutions to its numerous problems. The market is flooded with imported technologies and devices which are adapted for use usually not for the intended purpose. Partly because there is no alternative solution and such technologies produce a close solution to the desired. Yet, only locals who understand their fundamental needs can provide the exact solutions to their problems. Historically, the continent had their technology and ways of doing things evident in its ancient tools, arts, sculptures, etc. This dilemma is the case of making the Nigerian popular snack called ChinChin. This is a fried snack in West Africa, a singed nibble and is these days exceptionally famous in many spots throughout the planet. It is a crunchy singed batter of wheat flour and some other baking ingredients. In West Africa, ChinChin is usually made from flour and other ingredients that are widely taken as a household staple, snacks centres, restaurants and a menu of several outdoor catering services. Despite its wide acceptance and high-volume consumption, the production process is usually done manually. It is energy-demanding, tedious, and time-consuming exposing workers to back-straining risk.

Advancement in technology is rendering continuous reduction in human effort and saving a lot of time to get more things done. An observation of the ChinChin commercial production line shows that business owners are faced with the slow pace it takes their employees to mix the ingredient, level it up and then cut it to shape before frying. The observed ChinChin processing machines all have a common major setback as they are only capable of producing ChinChin pasta cut into strands (Olutomilola, 2020). Operators then spend more time and energy cutting these strands into the required shape and size usually in smaller rectangular shapes or cubes using a knife and cutting board. This process of cutting with the use of a knife is backbreaking, unhygienic and time-consuming. Automating this process by introducing a cutting mechanism will eliminate all labour experienced in the processing of the snack. For a long time, the domestic mincing method had remained an outstanding household and commercial means of preparing the dough before frying it into "ChinChin". The use of wooden boards with rollers has been the common means of caterers in Nigeria for preparing the dough and the use of knives for dicing the dough. This method is also prevalent in many parts of the world where foods are prepared by mixing flour. The mixed dough is first flattened using a roller on a board before cutting into the required shapes using a knife. Moreover, this method of processing exposes the dough to contamination from contact with the working surface (Ranjit & Subha, 2014). In the absence of a wooden roller, some caterers make use of bottles or other objects as rollers.

In other techniques, cold extrusion has been an important method employed in the production of certain confectionery products like pastry dough, pasta and hot dogs (Harper, 1979). This technique involves the extrusion of the product without heating or distorting forming long strands (Berry, 2000). Despite the extensive work done in food extrusion,

such technology is lacking in dough-based confectioneries which are still manually done with less appropriate processing methods (Vincent, 1984). Despite the energy demands, women are the ones involved in this laborious task making it less attractive to them as most men in this part of the world shy away from kitchen activities (Bencomo & Dominguez, 2000). In effect, this has created limitations on commercializing the product restricting the volume of its production. This is because the only economical means of its product is the old method of production using a roller and board to flatten the dough and the use of knives to finish the cutting of the dough into required sizes (Slater, 1984).

Thisstudyis tomodifytheinitialdesignofthe commercialChinChincuttingmachineso it can cut the rolled dough into strands and then slice them into smaller desiredrectangularshapesorsizeseliminating the laborious cutting involved in domestic ChinChin production as well as improving its production output. This will make outdoor catering and confectionaries easier and aid mass production of the snack while retaining the quality of the products. Time and energy will be conserved for other useful purposes or in extreme cases eliminate redundant manhours. The proposed solution is in two sections, the first section flattens the raw dough to the required thickness and the second section cuts it horizontally and vertically to obtain the required shape depending on the adjustment given to the cutting blade. This solution targets commercial ChinChinproducers who are involved in the mass production of theproductin Nigeria.

The initial designs of domestic ChinChin cutting machinesthatareavailableinNigerianmarketstoday can only cut rolled flour into strands. After the machine might have cuttherolledflourintostrands,themanualmeansof cuttingwithaknifeisusuallyemployedbyoperators to achieve the desired shapes and sizes. This **Nigerian ChinChin cutter machine** is an imitation of handcraft production and the design is simple. First, shape the dough, then put it on the roll and then rolled into the mould knife while the mould knife cuts the dough into certain shapes. Dough produced this way is the same in length, width, and thickness.

The existing design of the industrial ChinChin cutting machine cuts the dough into small pieces after it is pressed into a sheet using two sets of pressing rolls and then passed into a cutting mould which automatically slices it into strips. This has been employed in China as part of a production line for products similar to ChinChin and may be suitable for a ChinChin production line incorporated with other machines such as the fryer and mixer. Because of the increasing popularity of ChinChin in our world today, our goal is to design an affordable flour milling and slicing machine for the production of ChinChin to help small-scale production. The problems associated with the existing ChinChin machine that prompt the design are listed as follows:

- Extremely time consumption
- Excessive Human labour due to its numerous parts and function
- It is expensive and suitable for large production line

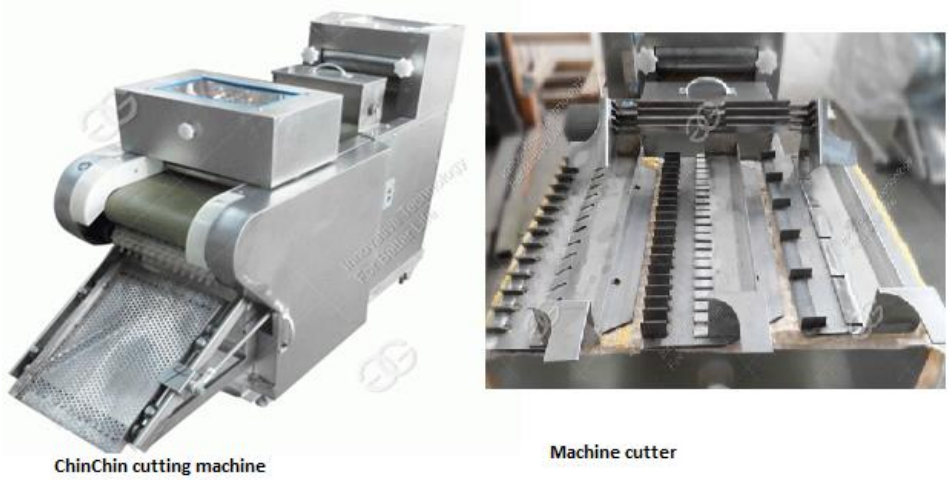


Fig. 1: The ChinChin cutting machine (www.gelgoogm.com)

METHODOLOGY

Design requirements for the flour milling and cutting machine

The following factors are considered during the design modification of the industrial ChinChincuttingmachineto achieve optimal production. These form the bases on which the material and design processes are selected (Olutomilola, 2020).

1 **The weight and stability:** The materials selected for the partsare light to reduce the overall weight of the machine. They must also be durable and prevent unwanted haphazard movement of the machine while in operation. It is mounted on a solid base

2 **Procedure and Flexibility:** These materials selected can be locally sourced and easily processed. The parts tolerances in their measurement aremadeaslargeaspossible within acceptable limits toavoidassemblyerrors.Themachinedesign considers flexibility in designing the cutting shaft to ease the procedures of changing to the desiredcuttinglength.

3 **Cost:** Theoverallcostofthemachine is to be kept as low as possible. The parts are sourced locally. Also, thedesignand the labour costs are kept minimal.

4 **Performance and Maintenance Procedure:** There is the consideration for the maximum permissible degree of freedom between parts in contacts such as the gears, the cutting shafts and driveshafts as well as for easy maintenance. Lubrication of these parts is automatically done bythepasta which has been initially mixed with margarine or vegetable oil.

Material selection for parts ofthe machine

To satisfy the operational requirements and design purpose, standard values were used in developing the design considerations, specification analysis and drawing (Khanna, 2014). The design is divided into 4 main components which are:

- **Electric motor:** This is carefully rated to produce sufficient torque and wattage. It produces 1HP which is equivalent to 746watts at 1500RPM.
- **Chassis:** This is the main supporting structure of the machine to which all other components are attached, it is made of mild steel. The chassis was designed to the level at which the static and dynamic loads were dealt with, without undue deflection or distortion. It produces mechanical characteristics such as high load-bearing capacity, creep resistance, high fatigue strength, and excellent machinability. It is cheap to procure and readily available.
- **Milling Roller and the cutting gate:** This part is made of Stainless material that provides qualities such as easy to clean, durability and chemical resistance (Figure 2).
- **Gear Box:** This controls the speed or power of the harvester. It is made from a metal plate of 6mm and it is 320mm x 320mm.

Calculation analysis

The required Power necessary to drive the roller shaft and the Conveyor system is calculated below:

$$Density = \frac{mass}{volume} \quad (1)$$

$$Stainless\ steel\ density = \frac{7850kg}{m^3}$$

$$volume\ of\ the\ stainless\ steel\ pipe = \pi r^2 l \quad (2)$$

$$Outer\ radius(r1) = 40.5mm, Inner\ radius(r2) = 40.5mm, the\ thickness = 4mm\ , l = 0.381m$$

$$= \pi({r_1}^2 - {r_2}^2) \times l \quad (3)$$

$$= \pi(0.0445^2 - 0.0405^2) \times 0.381$$

$$volume\ of\ the\ stainless\ steel\ pipe = \ 4.070 \times 10^{-4} m^3$$

And from equation (1) $mass = volume \times density$

$$= \ (4.070 \times 10^{-4} \times 7850) = 3.025kg$$

$$Weight = mass * gravity \quad (4)$$

$$= 3.025k \times 9.81 = 30N$$

$$Torque\ (\tau) = Force \times perpendicular\ distance \quad (5)$$

$$= 30 \times 0.004 = 12Nm$$

$$Power = torque * \ angular\ speed\ (\omega) \quad (6)$$

$$\omega = \frac{2\pi n}{60} = 2\pi \times \frac{1200}{60} = 157rpm$$

And from equation (6) $Power = \ 0.12 \times 157$

Power (A) $= \mathbf{18.84W}$

Next, the power required to drive the Rod inside the Stainless-steel Pipe is derived below using equations (1) to (6):

$$Mild\ steel\ density = \frac{7850kg}{m^3}, radius(r) = 15mm, \ l = 0.762m$$

$$volume\ of\ the\ Mild\ steel\ shaft = \pi r^2 l$$

$$= 3.142\ (0.015^2) \times 0.762 = \mathbf{0.00054m^3}$$

$$mass = volume \times density = \ (0.00054 \times 7850) = \mathbf{4.22kg}$$

$$Weight = mass * gravity = 4.22kg \times 9.81 = \mathbf{41.38N}$$

$$Torque\ (\tau) = Force * perpendicular\ distance \ = 41.38 \times 0.004 = 0.62Nm$$

$$Power = torque * \ \omega$$

$$\omega = \frac{2\pi n}{60} = 2\pi \times \frac{1200}{60} = 157rpm$$

$$Power(B) = \ 0.62 \times 157 = \mathbf{97.34W}$$

Therefore, the total power required to drive the Stainless Steel pipe with a Mild steel rod is

$$Power\ (A) \ + \ Power\ (B) \ = \ \mathbf{18.84W} \ + \ \mathbf{97.34W} \ = \ \mathbf{116.18W}$$

Since there are 2 milling rollers, the total power required to drive the milling chamber is given as $(powerA + PowerB) \times 2$

Total power required to drive the milling chamber = 116.18×2 = **232.36W**

Power required by the Conveyor System

The conveyor is made up of 2 Channel Iron, 4 Roller Pipe, 2 Roller shaft

The power required to drive the Conveyor is derived below using equations (1) to (6):

$$Mild\ steel\ density = \frac{7850kg}{m^3}$$

$$volume\ of\ the\ stainless\ steel\ pipe = \pi r^2 l$$

$$Outer\ radius(r1) = 38mm, Inner\ radius(r2) = 34mm, \quad the\ thickness = 4mm\ , l = 0.381m$$

$$=\pi(r_1{}^2 - r_2{}^2) \times l = \pi(0.038^2 - 0.034^2) \times 0.381 = 9 \times 10^{-4} \times 0.384$$

$$volume\ of\ the\ mild\ steel\ pipe = \ 3.45 \times 10^{-4} m^3$$

$$mass = volume * density = \ (3.45 \times 10^{-4} \times 7850) = 2.7kg$$

$$Weight = mass * gravity \ = 2.7kg \times 9.81 = 26.48N$$

$$Torque\ (\tau) = Force * perpendicular\ distance = 26.487 \times 0.004 = 0.106Nm$$

□□□□□ = □□□□□□ * □

$$□ = \frac{2□□}{60} = 2□ \times \frac{1200}{60} = 157□□□$$

$$□□□□□ = \ 0.106 \times 157 = 16.6□$$

Power (C)= $16.60□$ + Power B = $16.60□ + 97.34□ = 113.94$

The conveyor system is made up of 2 shafts, the combined power of the shafts is determined as

Total power = $113.94□ \times 2$ □□□□□□ □h□□□ = $227.88□$

The total power required for the design = 232.36w + 227.88w = 460.24 □

Since 1 horsepower (HP) = 746 W. The calculated combined power for the motor is 0.62 hp. Therefore, a 1 hp electric motor power is selected to drive the conveyor system.

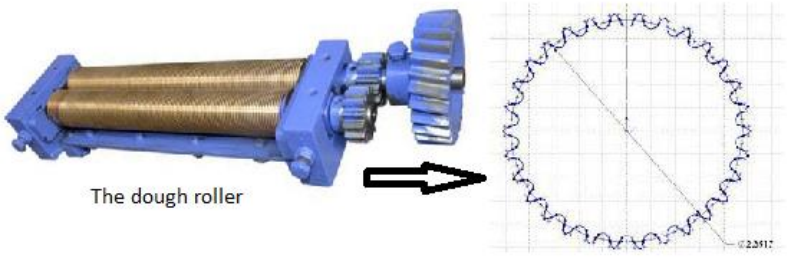
Bill of materials

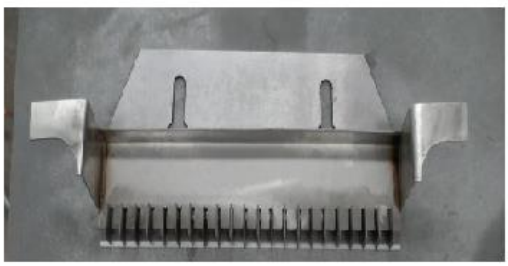
Table 1: Bill of engineering materials and evaluation

S/N	Material description	Quantity	Unit price (₦)	Total amount (₦)
1	Electric motor	1	57,000	57,000
2	Body plate 1.5mm	1	21,500	21,500
3	Angle iron	4	5,500	22,000
4	Electrode	1 pack	1750	1750
5	Stainless electrode	16	300	4,800
6	Cutting disc	2	800	1600
7	Roller	4	1500	6000
8	Channel iron	2	3500	7000
9	Stainless pipe	2	5000	10000

Method of metal joining

The selected and fabricated parts were joined together by welding and fastener joining processes. The use of a fastener was incorporated for joining parts of the machine that are subjected to wear and tear as a result of excessive usage. In selecting the joining processes, several factors were considered. The applied load on the parts and the required fastener; the threading and required stiffness, and the number of fasteners needed. The parts of the body of the machine were welded. Some other factors were considered during the assembling of the components to produce the final product (Figure 3) such as accessibility; environmental conditions like temperature and water exposure; the required installation process; and weight restrictions of the materials to be joined. All electrical components were also connected accordingly.







The cutter gate

Fig. 2: The Selected and fabricated parts

Testing of the machine

In evaluating the performance of the fabricated machine, all rotating parts were properly lubricated for smooth operation, and electrical connections were properly connected. The following ingredients were required in the appropriate quantity: Cups of all-purpose flour; baking powder (optional, for a softer inside texture); salt; nutmeg (optional); margarine or butter; sugar; evaporated milk; egg; and oil for frying. All these ingredients were mixed and processed as required for the dough for making ChinChin. They were combined and rolled together until the dough was formed into a ball. The dough was rolled until it was about ⅜-inch thick. The dough was fed into the machine and cut into strands of about ½-inch long which is cut in the other direction into small squares of dough about ½-inch by ½-inch. The squares were sprinkled with flour, separated and collected into a bowl. In a medium saucepan, oil was heated and the dough squares were poured into the heated oil and stirred continuously with a slotted spoon. It was allowed to fry for about 1-2 minutes until they are golden brown. The ChinChin were received out of the oil and allowed to cool.

sizes of ½-inch by ½-inch with some variations. The power requirement was determined and found to be with the machine tolerance.The performance efficiency of the fabricated ChinChin cutting machine was determined by the doughbeing fed intoit



Fig 3: The fabricated ChinChin cutter

DISCUSSION

The prototype of this machine was designed and fabricated according to the prescribed design requirements and processes. Even though most of the materials for its construction were locally sourced, the parts functioned properly. The rollers were able to roll the dough to the desired

thickness of ⅜-inch. The dimensions of the cutter accurately were observed to produce the required dough

. The efficiency of the machine was determined by testing the milling output of the wheat flour in a refined and pasty form. The following are the observed and calculated characteristics:

- Since the mass of the milling component from the designed calculation is 3.025 kg
- The minimum weight of flour that can be refined by the milling component is at least 1kg and at most 4kg due to the capacity of the motor.
- Load is given by the weight of milling output of the wheat flour which is equal to (3.025+4) kg.
- The velocity ratio of a rotating body is given as 5.
- Effort = power supply by the electric motor through chain transmission = 2

□□□□□□□□□□ = □□/□□ (7)

□□ = □□□□/□□□□□□ (8)

$$\square\square = \frac{7.025}{2} = 3.5125$$

$$\square\square\square\square\square\square\square\square\square\square = \frac{3.5125}{5} \times 100 = \mathbf{70\%}$$

From the efficiency of the machine determined, it was observed that all parts of the machine functioned effectively. This work has been able to provide solutions to issues that necessitate the invention and re-modification of a flour milling and cutting machine to limit time spent, energy consumed and the stressundergone by producers during the process of ChinChin production.

CONCLUSION

The fabricated ChinChin rolling andcuttingmachine is needed to reduce the laborious work faced during the preparation of the snack. Itsdesign analysisand the test results prove that this machine will eliminate the setback involved in the mass production of the snack. The technical requirement to operate it is minimal owing to its design simplicity and can fully integrate into any production process. The machine is relatively light in weight and durablewith lessvibration.Itisalsonoteworthytosay that the machine will be highly cost-effective and will

requirecheapmaintenancesinceallthematerialsused for the fabrication of the machines were sourcedlocally. It is recommended that further evaluation be made to ensure its full development for commercial uses.

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