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Development of Kokoro Snacks Extrusion Machine for Cottage Industry in Yewa Land, South-West, Nigeria

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Abstract

In the absence of good meal, light food is taken as an alternative quickly and conveniently and it could be substituted for food when taken in large quantity. There are different snacks such as meat pie, eggroll, doughnuts, Kokoro (local snacks) etc., they are mostly used as souvenirs and sometimes as a substitute for food during travelling when carrying food flasks or packages is not appropriate. Kokoro (local snack) is a snack that is produced from corn. The process of production is grinding, mixing, extrusion, frying and packaging. According to past scholars, grinding is accomplished by use of grinding stone carved out of rocks into desired shapes and sizes while the mixing is done manually with hand and the billets are rolled into the required shape by hand on a wooden table. This research work and its invention can eliminate the tedious and unhygienic process of mixing and rolling by designing and fabricating a machine for mixing and extruding the billet into desired shapes.

Keywords: Kokoro, Meal, Extrusion, Mixing, Billet

Introduction

Snacks are form of foods usually consumed to achieve light sustenance in a quick and convenient way and it can also be substituted for meal when taken in large volume. There are varieties of snacks in Nigeria, they are meat pie, egg roll, doughnut, kokoro etc. Kokoro is a processed and fried product from maize that is been produced locally mostly by the Southwest of Nigeria, it is produced mostly in large quantity in Imasayi and Iboro, a part of Ogun state. Kokoro is majorly consumed in every part of Nigeria and some other African country as snacks (Akinsola, Alamu, Otegbayo, Menkir & Maziya-Dixon, 2020). It is a snack that is produced from processed corn. The production process of Kokoro encompasses several critical processes such as grinding, mixing, rolling/extrusion and frying (Aluwi *et al.,* 2016; Aktas-Akyildiz,, Masatcioglu & Köksel, 2020). All these processes require a machine which comprises essentially a gasoline engine, transmission shaft, hopper, mills, spiral conveyor and stands. This machine is designed to reduce or eliminate the rigours involved in producing Kokoro manually.

Another important stage in Kokoro production is frying which also increases its shelf life and makes it suitable for storage over a short period. Deep fat frying is incorporated in this process, which involves simultaneous heat and mass transfer of the product. It involved the extraction of moisture from wet Kokoro in the form of vapor bubbles and oil is absorbed simultaneously. However, the consumption of snacks is inevitable because of high cost of food materials or during travelling when it is not easy to bring out cooler from the bag and be eating publicly in a commercial vehicle, so this may necessitate the consumption of at that time. As a result of high demand for Kokoro daily, high production is necessary and this machine will be more helpful to aid the production process of a quality snacks. There are enormous techniques of producing Kokoro, but the focus in this paper is to adopt and improve on the method used by the Imasayi and Iboro people of Ogun State, Nigeria. From the past design, there has been no machine in a single compartment for producing Kokoro in existence except by arranging these machines in a production line.

Kokoro (Local Snacks) Production

It is believed that snacks can be used to increase the nutritional status of consumer by incorporating nutrient such as carbohydrates, fiber and protein from plant sources which have health benefits (Antun *et al.,* 2017). Kokoro is a fried snack, it is a sweet, cookie-like product made from maize, salt, groundnut oil and onion. The processes involved in the production of Kokoro are discussed and diagrammatized as thus. First, grinding and mixing are very important in the process because there must be a high level of homogeneity of the mixture. It is estimated that more than 80% of the raw materials used for the production of animals, requires grinding according to (Bruneel, Pareyt, Brijs, & Delcour, 2010). Summarily, grinding is done for all kinds of cereals, and by-products from agriculture and feed industry such as meal, cake and mineral nutrients according to (Bisharat *et al.,* 2013).

Plate 1: Exploded drawing of grinding machine

The second process involves mixing. Mixing processes are very vital operations in industrial process engineering which are aided by the use of either impeller mixer or by gear control mixing techniques. The main objective of these processes is to make a heterogeneous physical system homogeneous by using manipulating operations. The diagram of Horizontal mixer is shown below.

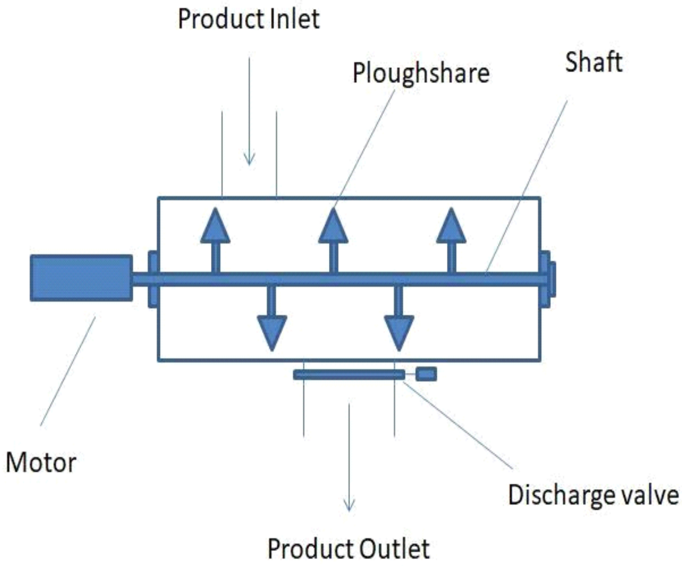


Figure 1: Horizontal Mixer

The third process is extrusion stage. Extruding process involve pushing material throughout a shaped orifice or die or mould (Alam, Kaur, Khaira, & Gupta, 2016; Bordoloi, & Ganguly, 2014; Brennan, Monro & Brennan, 2008). The extruded product is called the extrudate. The extrusion machine works due to the gravitational pull of the maize pellet is fed into the extruder from the mixer, and then it forms drops into the extruder chamber, which allows the connecting rod to move the piston to and fro, forcing the pellet through the die. Then the maize pellet is allowed to pass through the die to give it the required shape. Figure 2 below shows the type of extrusion machine used for Kokoro production.

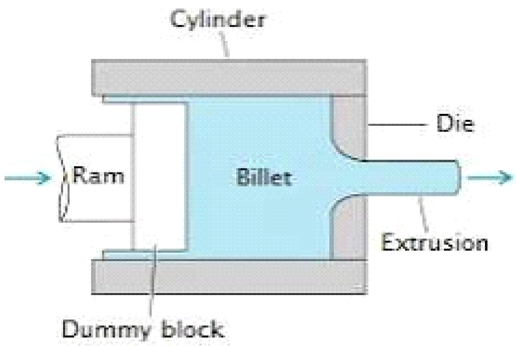


Figure 2: Direct Extruder

The last process involves frying stage. Frying is the oldest and most primitive methods of cooking. Frying is a process that involves simultaneous heat and mass transfer, oil is the medium of heat transfer into the food, while moisture migrates out and oil is absorbed into the food (Altan, McCarthy, & Maskan 2008a; 2008b; Bibi, Kowalski, Ganjyal, & Zhu, 2017).

Materials and Methods

A machine for mixing maize and other ingredient and extrusion of maize pellet for Kokoro production was designed and fabricated. The parts comprise of Mild steel, angle iron, gear box, belt, stainless steel plate, stirrer blade, sheet metal, shaft, bearing, pulley, Petrol engine, dies, bolt and nut, generator were purchased materials used for Fabrication of the Kokoro processing machine, when the machine is put at work, the material is mixed with the help of an impeller or a stirrer and then pushed through a die orifice of 10mm cross-section, its shape changes to reflect the die's shape.

Selection of Materials

Materials Composition for the Design and Fabrication

The list of materials used for the design and fabrication of a Kokoro processing machine are: Sheet metal (Stainless steel plate and mild steel plate), Stainless steel blades, Shaft, Gasoline engine (generator), Bearing, Round pipe, Angle iron, Gear box, Stainless pipe, Paints, Non-polar solvent, U-channel, Bolt and nut, and they are well discussed below:

Sheet Metal

Sheet metal is a metal formed by an industrial process into thin, flat pieces. This sheet metal gauges are based on thickness 2mm, the sheet metal is cut, bent and stretched into desired shape, which is done by cutting the sheet metal. The stainless-steel plate and mild steel are to be used having thickness of 1.5 mm with the area of 800 mm by 400 mm.

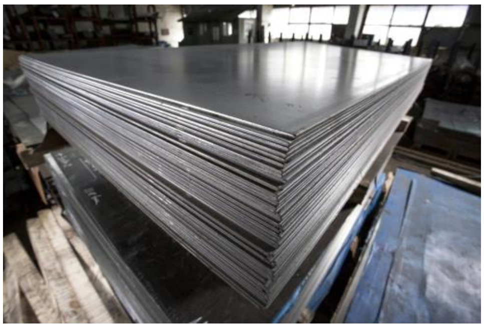


Plate 2: Sheet Metal

Angle Iron

The angle iron is a fixture used to ensure the rigidity of the sheet metal and the gasoline engine in other to obtain a rigid frame, the square pipe are based on the accuracy, all external surfaces are finished by grinding off the chips to ascertain a smooth surface, and the angle iron are in standard length.

Plate 3: Angle iron

Stainless Steel Blade

The mixing unit consists of several blades of the same dimension, they are made up of stainless steel due to their ability to prevent contamination of the food product and resistance to corrosion. These blades are cut into appropriate dimension and joined to the shaft for thorough mixing of the pellet with other ingredients.

Plate 4: Stainless blade

Gasoline Engine

This is an engine with a power rating of 1.6Hp. It is used to generate the torque needed for shaft rotation.

Plate 5: Petrol engine (Generator)

Bolt and nut

This is used for coupling the cut-out parts together, selecting bolts and nuts having a threading diameter of 10mm, 14mm and 17mm.

Plate 6: Bolt and nut

U-Channel

U channels are used as trim for extrusion base of the machine, they are also used industrially for hand and stair railings, for escalators, in commercial spaces. Metal railings are easier to maintain and longer-lasting than their plastic or wood counterparts.

Plate 7: U Channel

Gearbox

A gearbox contained sets of contained gear train, or component consisting of a series of integrated gears within a housing. In the most basic sense, a gearbox, is used to alters torque and speed between a driving device like a motor and a load.

Plate: 8 The Gearbox

Design Calculations

Volume and Capacity

Since the mixing chamber is rectangular, the volume is given by equation 1

$v = l \times w \times h$ ... (1)

Where v is the volume of the chamber, l is the length which is 0.31m, w is the width which is 0.31m and h is the height which is 0.26m.

Therefore, v = 0.31*0.31*0.26; **V= 0.02499m³**

Output speed of gearbox

Assumed Input Speed from generator =3600rpm

Gear ratio = 17.861:1

Output Speed = $\frac{3600}{17.861}$; **Output Speed =201.56rpm**

3.2.3 Toque transmitted by Gearbox

Torque transmitted by gearbox is given as:

$$T = 9.55 * \frac{P}{N} \quad ... (2)$$

Where T is the torque transmitted (Nm), P is the power of the gearbox (watt), N is the number of revolutions per minute of the output shaft of the gearbox (rpm). The gearbox is of 2.01Hp which equals 1498.86W.

Using equation 3, the developed torque is calculated as

$$T = 9.55 * \frac{1498.86}{201.56}; \; T = 71.02\text{Nm}$$

Diameter of the Shaft

The shaft is a solid shaft having little or no axial loading. The diameter of the shaft is given by the equation (3).

$$D^3 = \frac{16}{\pi Ss}\sqrt{(KbMb)2 + (KtMt)2} \quad ... (3)$$

Where Mt is the torsional moment (Nm), Mb is the bending moment (Nm), Kb is the combined shock and fatigue factor applied to the torsional moment, Ss is the allowance shear stress (N/m2).

For this type of horizontal shaft bending moment is zero i.e**.** **Mb= 0**

Therefore equation (3) reduces to equation (4)

$$D^3 = \frac{16}{\pi Ss}\sqrt{(KtMt)2} \quad ... (4)$$

The shear stress Ss of the chrome shaft is $55MN/m^2$ and for rotating shaft with minor shock load Kt = 1.0

Also, torsional moment Mt is given by equation (5)

$$Mt = \frac{P}{2\pi N} \quad ... (5)$$

Using a 1.499KW, 201.56rpm, the torsional moment in the shaft is calculated as

$$\mathbf{Mt = 1.499*10^3* \frac{60}{2\pi*201.56}; \ Mt = 71.02}$$

$D^3 = 16/55*10^6*3.142\sqrt{(1.0*71.02)^2}$; $D3 = 9.26*10^{-8}*71.02$; $D^3 = 6.5765*10^{-6}$

D = 0.0187m

D = 18.7mm

From the calculated result, it is assumed that 20mm diameter is selected to the nearest standard size of the shaft.

Design Drawings

Various designed drawing for each section for the fabricated machine were shown in the drawings below. The drawings shown in Plate 10, 11 and 12 below illustrate all the detailed parts, both assembled and exploded views of the machine.

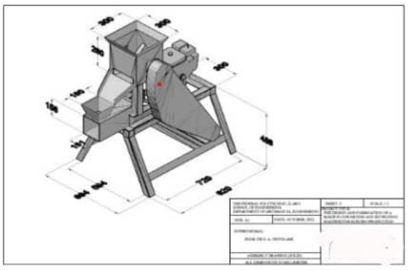


Plate 10: Assembly Drawing

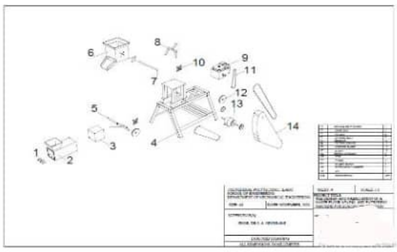
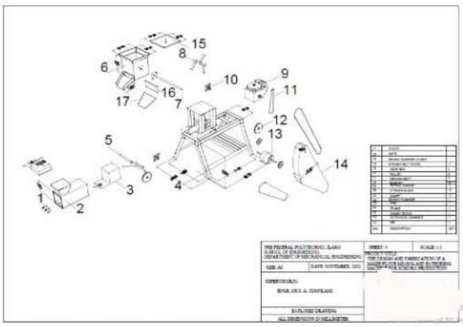


Plate 11: Exploded view of the Hopper and Base section



Results and Discussion

The fabricated maize mixing and extruding machine for Kokoro production was tested perfectly well when compared to the indigenous method of mixing and kneading/rolling. To achieve the desired safety factor, hardness test was carried out. Unlike the other methods of mixing and kneading/rolling, this newly designed machine makes the work easier, efficient and much faster than the indigenous way of producing Kokoro with 85% efficiency. It was however observed that the rate of mixing and extruding maize in this machine was faster. This manuscript presents a detailed, functional and highly efficient low-cost maize mixing and extruding machine by minimizing traditional technique of mixing and the health condition of individual, this machine is design for local Kokoro producers, in other to improve the healthy and hygienic condition of an individual. It is expected that an average local producer in Nigeria can afford the machine.

Conclusion and Recommendation

A maize mixing and extrusion machine for Kokoro processing powered by a generator (1.6hp) was designed and fabricated from locally available materials to improve Kokoro production. The tests have shown that the machine satisfied most of the general and functional requirements of a machine in this category. This machine developed as a local mechanized method of mixing and kneading/extrusion of maize will be embraced by Nigeria Kokoro producers especially the Imashayi and Iboro people of Ogun state for its simplicity of use, low-cost production or procurement, ease of fabrication and maintenance, low cost of maintenance combined with increase in the quantity of Kokoro production. The machine has an efficiency of about 80 %. It is also recommended that future modifications should be incorporated into the development of the machine. By adding both milling and coiling die into the design of the future production machine.

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