DESIGN AND FABRICATION OF AN ELECTRIC YAM POUNDING MACHINE

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CERTIFICATION

This is to certify that this project work was carried out by **OMO-IMAFIDON OSE JAMES** with the Matriculation Number **ENG1604445** of Production Engineering Department of the Faculty of Engineering, University of Benin, Benin city, Edo State, in partial fulfillment of the requirement for the award of Bachelor of Engineering (B. Eng).

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DEDICATION

I dedicate this work to God Almighty for His grace that kept me throughout the course of this project and to my lovely family.

ACKNOWLEDGEMENT

I thank God Almighty who in His infinite mercies gave me this opportunity of a life well preserved to see the successful completion of this project. My sincere gratitude goes to my parents Mr and Mrs Imafidon B.O for their support and encouragement given to me, especially my Mother whose advice and patience facilitated the successful completion of my studies.

Furthermore, words are not enough to describe how grateful I am to my project supervisor Prof. J. A. AKPOBI. Sir, I am grateful for your patience, your support, your tolerance and your guidance on this project.

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ABSTRACT

In this study, we focused on the design and fabrication of a yam pounding machine that performs the hygienic processing of pounded yam, eliminates the laborious process involved in pounding yam and to minimize the time for processing pounded yam. The machine was fabricated using mild steel, stainless steel, pulleys, belt and shaft. A type A43 belt was used (V-belt), the depth of the bowl is 425mm, length, width and thickness of the beater is 148 x 51 x 16 mm. The diameter of the driving pulley is 70mm and the diameter of the driven pulley is 210mm. The length and breathe of 650mm by 760mm. The result from the testing showed that the yam pounding machine produced a hygienic and well processed pounded yam in a lesser time. It totally eliminated the laborious involved in pounding. The efficiency of the machine was 88.171% which is fair for a locally fabricated machine. Given that some percentage was lost due to the vibration from the motor.

CHAPTER ONE

1.0. Introduction

One of major tantamount desire of human beings is to search for better alternative in accomplishing a given task, most especially those tasks that are highly energetic and energy demanding in every facet of live. One of the keyed driving forces that better the existence of human beings is the replacement of human energy with machine such as pounded yam machine. This is one of the ways of eliminating human effort, through the development of yam pounding machine. Yam is the oldest known recipes to man, it is a tuber crop which belong to the class of carbohydrates and has been a part of the African meal edible consumed as a meal in African countries. Yam is the common name for the species in the genius Dioscorea (family Dioscorea ceae). The sweet potato (ipomeas batatos) has traditionally been referred to as yam in part of the United States and Canada, but it is not part of the dioscoreaceae family. The word yam came from portugues name or Spanish name which both ultimately derive form the wolofwordnjom, meaning "to sample" or taste". In other Africa languages it can also mean "to eat" e.g yam and nyama in Hausa (Miguouna et al, 2003). They are perennial herbaceous vines cultivate for the consumption of their starchy tubers in Africa, Asia, Latin American and Oceania. They are used in a fashion similar to potatoes and sweet potatoes, (Bransmilleretal, 2003). There are over Nigeria, and each has different language in wage name for yam "Isu" is the Yoruba translation or "Iyam" when it is been prepared to be consumed as main source for dinner. The yam is a versatile tuber crop which has various derivation products after processed into a dessert recipe. Yam is the staple crop of the Igbo people of Nigeria, in their language it is known as "Iji" yam is commemorated by part of the country having Iri-ji or Iwa festival in the southern Nigeria and new yam festival in the south western pounded yam is kind of food liked by more than 80%

Nigerians, everyone want to eat yam in its pounded processed form. However, due to much energy in healthy state required in getting the require texture, makes it difficult for most people to get it discarded as part of their meal menu in some family and this has limited the consumption rate of pounding the yam. It involves the use of mortar and paste. In a bid to reduce the labor involved in yam pounding came the manufacturing of Habert mixer, the Kenwood mixer and Hammer mill in early 1975. These intended yam pounders failed due to some limitations in their operational functions. The Habert and Kenwood mixers had almost the same operational principle and they had been identified for poor pounding due to the flapping (moving up and down) of their stirrer or mixer which is keyed to the electric rotating shaft. In addition to the poor pounding of both pounders, the Habert mixer was found to heat excessively and as a result, the machine has to be stopped intermittently for cooling purpose this cooling time takes up to ten minutes and this makes the machine inefficient since the pounding temperature has to be constant throughout the pounding process in order to obtain a fine textured pounded yam.

1.1 Background of study

It should be noted that the method employed in preparing food determines in the long run its level of acceptance by the people. For example, our European counterparts have difficulties in accepting our local food simply because they consider the method of preparation to be cruel and unhygienic. Secondly, women liberation and involvement in the work force has completely displaced the concept of full time housewife thereby making it imperative for a mechanized and modernized method of food preparation; hence, this present study and research.

1.2 Statement of problem

The problems or setback in this project is the difficulties in finding the design of the project, secondly sourcing of the materials and component used for the project were difficult to find . before now this could have been a challenge.

1.3 Aim

This design is aimed at replacing the old, laborious, and cruel method of pounding yam to a more hygienic and mechanized means. This does not only reduce the labor involved in pounding yam but also reduces the time of pounding and ensures cleanliness, efficiency and safety. Many engineers are developing the fabrication of this machine and different operational principle has been employed. While some are employing complex design, others are using very expensive material thereby making the finished product expensive for avenge home. That is to say, that in this research, we consider seriously one of the major factors in selection of materials (cost) thereby employing low cost materials without compromising standard, reliability, safety and durability. Another purpose for the design was to eliminate the noise and vibrations associated with the traditional method of pounding (pounding with mortar and pestle).

1.4 Objective

- Develop a machine to enhance the hygienic processing of yam for both domestic and commercial consumption
- Develop a pounding machine that will be powered by electric current and convert this through the operation of an electric motor to the rotation of a shaft, that is connected

directly to the motor, a pounding blade is attached to the shaft and the rotating effect of the shaft cause the pounding blade to pound.

- Develop a pounding machine that will pound in few minutes
- Aid easy packaging of pounded yam
- To eliminate the tedious and laborious indigenous process of preparing pounded yam

1.5 Significance of the project

They pounding machine plays vital role as it helps in replacing drudged or stress initiated into human system after pounding has taken place, the machine will also help to the physically disable individuals as well as the aged to pound yam, since less effort will be required in its operation. Another significant role this research plays is that, it will make ways for further research to the design and fabrication of yam pounding machine. The machine consists of a shaft, pulleys, belt, bearings, electric motor, yam beaters, bowl and the frame. The machine is developed to enhance the hygienic processing of yam for both domestic and commercial consumption, while eliminating the tedious and laborious indigenous process of preparing pounded yam**.** So need for machine that will pound yam to this needed quality with less human effort and time becomes expedient. the main objective of this work therefore is to develop a reliable and efficient yam pounding machine that would be easy to operate and maintain.

1.6 Scope of the project

The design and fabrication is considered with only a working model (prototype) commercialization and market feedback is not inclusive in the study. Problem definition is covered in order to realize the purpose of the project. Literature review of past work on this project work was also examined in order to understand the areas that need improvement.

CHAPTER TWO

LITERATURE REVIEW

Pounding is a house hold name in South-West Nigeria as well as some other parts of the African continent, although, there are a number of produce or materials or food items that can be pounded, the most popular one is that of pounding yam. Pounded yam is a staple food consumed by almost every tribe in Nigeria. The indigenous process of production is very laborious. It requires physical pounding by two or more men or women, depending on the quantity, in mortars with pistols. Yam has been subjected to a lot of tests and processes to get the best method that will produce pounded yam that will have the same taste and texture as the one produced through the local laborious process. The ancient and traditional method of pounding is carried out through the use of wooden mortar and pestle. The mortar has a large cup like form and is placed on a flat base, the boiled yam is poured into the mortar bowl then the wooden pestle is use to beat and knead the yam into the required form. The technological advance in the yam pounding industries is described in the subsequent sections in this chapter. The starting material for the pounding operation is yam, the yam undergo series of processes, but before we proceed, let us discuss on the word "yam".(Omotoyosi, 2011).

2.1 Yam: The starting material of pounded yam production

Root crop (Pierre-Marie, 1998). Yam tuber which is the raw material of pounded yam, it is greatly known in most part of the world. Although concentrated in Nigeria, the largest producer of yam in the world, the yam eating-zones stretches from western Cote d'Ivoire to Cameroon. This plant is characterized by a great degree of natural genetic diversity adapted to a wide range of production conditions within the region (DEGRAS, 1986). Yam varieties generally achiev high yields (10 to 20 tonnes per hectare) and many have excellent storage properties in contrast to cassava. They generally have more stringent growing requirements than cassava as concerns both soil quality (high potassium level is needed) and cultivation techniques. Yam growing also has high cost in terms of plant material. Using the traditional method, up to one-third of the harvest must be retained for use as seed-yam (PierreMarie, 1998). Yam has been relatively neglected by agricultural researchers and up to date result that can raise productivity have been far limited compared to cassava the other major root crop (Pierre-Marie, 1998). A diagram is been illustrated in Figure 2.1 to show a tuber of yam.

Figure 2.1 Yam tuber

Yams are excellent source of potassium, with twice the amount as found in a multi-sized banana. They are also a good source of Vitamin C, B6, foliate, iron, and magnesium. Yams are high in starch and contain an enzyme, alpha amylase, which converts starch to sugar as the tuber matures, is stored, or when heated. According to research at Brigham Young University, curing yams by storing them at 29oC (85oF) for four to six days immediately after harvest, increases the concentration of this enzyme (bringhamyounguniversity.com). Curing also appears to heal small surface scratches, decreasing the risk of rotting. Raw yams, like lima beans, contain glycosides, natural chemicals that breakdown into hydrogen cyanide in the stomach or when it is heated.

2.2 Yam varieties

Yams are economically useful plants belonging to genus Dioscorea (Coursey, 1967). There are many varieties of yam which are differentiated by varying characteristics such as the direction of stem twines (clockwise or counter clockwise), the shape and colour of the leaves, stem and tubers, and the cooking quality of the tubers. The yam tuber is economically the most important part of the plant. The structure is extremely variable, depending on the species. Most yam tubers however are more or less cylindrical in shape and weighs of individual tubers range from 200g to 50kg (Asiedu, 1989). The early work of the agricultural department of Nigeria generally recognized six main groups or species. These are as follows:

- Dioscorea rotundata (White Yam)
- Dioscorea cayenesis (Yellow Yam)
- Dioscorea alata (Water Yam)
- Dioscorea dumetorium (Trifoliate Yam)
- Dioscorea esculenta (Chinese Yam)
- Dioscorea bulbifera (Potato Yam)

2.3 Existing pounding machine

The energy conversion of kinetic energy into electrical (Gbasouzor et al, 2016) designed and developed a motorized yam pounder for pounding yam, this research was considered because of the importance of pounded yam in Africa particularly in Nigeria and because of the time and energy wasted using the traditional mortar and pestle method of yam pounding. The research work aimed at eliminating the labor involved in the traditional method of pounding. This development work sought to enterprise a yam pounder that pounds yam right from the peeled cooked stage in a pounding vessel with the help of an electric motor that transmits power through rotary motion together with the help of shaft. Rakesh S. Ambade, et al , 2007. developed a machine that requires some initial force to rotate the inconstant loads in circular motion. After that it worked on the gravitational force in which the weights from the higher elevation fall down due to the gravitational effect and hence the lower loads were drawn up due to the drive of upper load and hence the chain continued for some time period. The procedure utilized a gravity energy conversion unit to convert the gravity potential energy into the kinetic energy. The gravity energy conversion unit formed positive torques by the outward spreading single direction swing arms and reduced the negative torques by conjoining with the folding action of the single directional swing arms, so as to perform a long stretch, effective and continuous energy conversion of gravity potential energy into kinetic energy. Next, the kinetic energy was transmitted to a power generating unit to accomplish another energy conversion of kinetic energy into electrical energy. And lastly a power supply system was used to transmit the electric energy out. (Digvijay S Jadhav, et al. 2016). studied current inventions and found that the gravity power generation mechanism of the present invention utilized a gravity energy conversion unit which could provide a continuous and stable operation to continuously convert the gravity potential energy into the kinetic energy and then into electric energy so as to perform a long-time, effective and stable energy output. The present invention not only was independently generating electricity but could be connected in parallel to the Wind power and the solar power generation systems to generate electricity. Thus in their project they studied a power generation mechanism that produced power from gravity having a simplified structure as well as is Eco friendly and which would overcome the present difficulties of pollution and global warming faced by other power generation methods. (Srivastava, et al. 2012) by their experiment, found that at high rpm the weight generated huge centrifugal force due to which the generation unit started to wobble. Large amount of energy was lost to overcome this centrifugal force; hence system was advantageous for low rpm generation units. Dnyaneshwar Jagzap in 2018 researched on Vaibhav Gravity Engine (VGE), which is gravitational force based engine and it worked on constant gravitational force. The working principle is largely based on fundamental law of “constant force creates or generates constant energy” and “force is directly proportional to energy. Vaibhav Gravity Engine (VGE) is based on gravity feedback and gravity shielding technique. Ideally, it can become source of constant energy on any of the planets. VGE working also reveals the fundamental physical laws i.e. “Force is directly proportional to Energy” and “Constant force creates or generates constant energy” The engines working also demonstrates any unidirectional force like magnetic force (either of south or north poles of magnet) can also produce or generate constant energy. A diagram was illustrated in Figure 2.3 as shown below.

Figure 2.3 A pounding machine using a level system

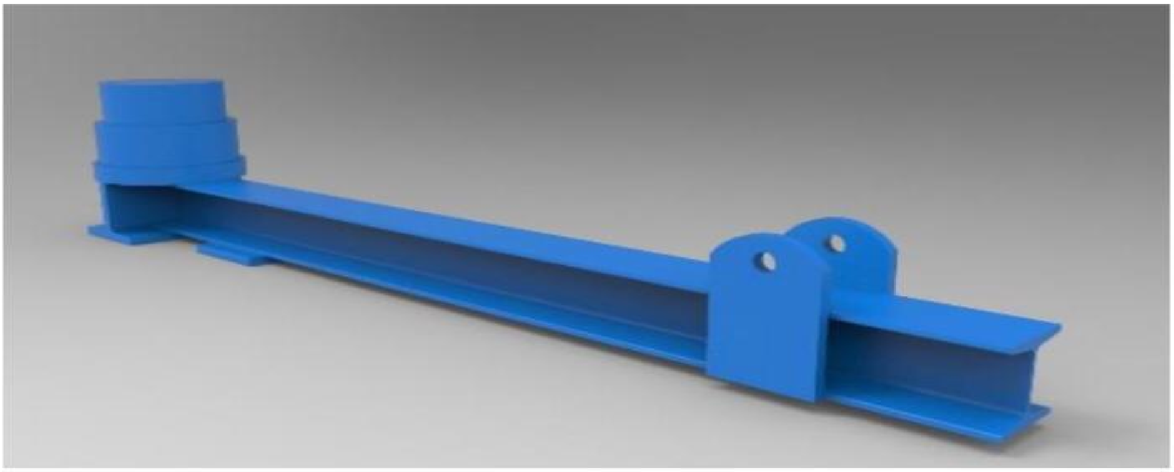


Figure 2.4 the lever and dead weight of the machine

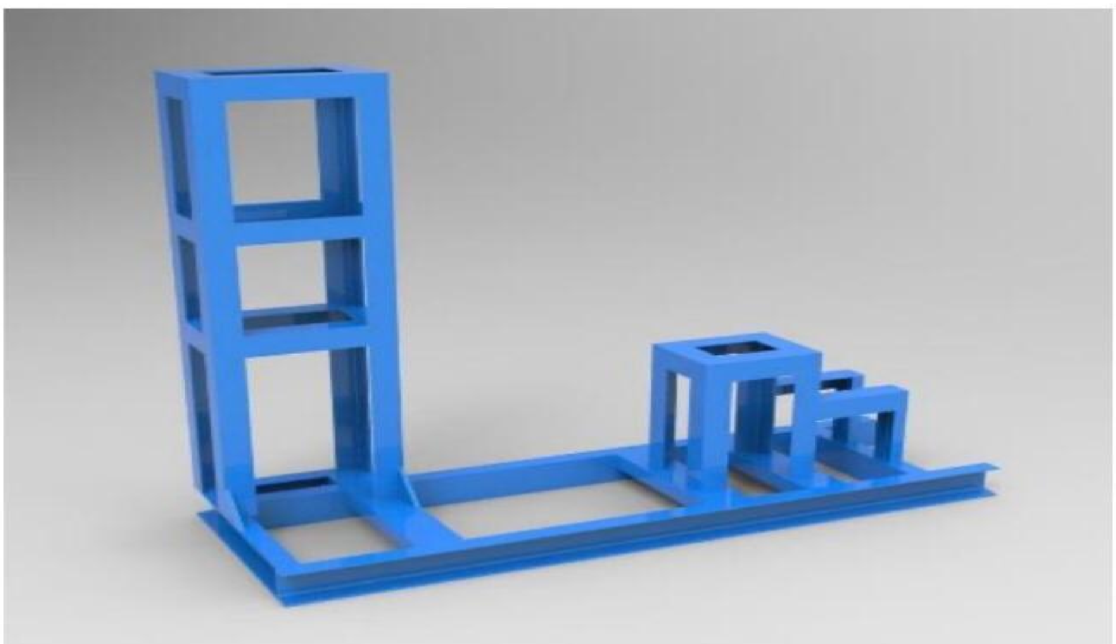


Figure 2.5 Supporting Structure of the Machine

Ordash et al,(2008) designed a pounding machine that beats using the process of cutting to pieces as well as crushing and turning to produce the natural taste. The yam pounding machine was designed and developed to hygienically process yam and it was designed to pound from kilograms to kilograms weight of cooked yams for both domestic and commercial consumption. The machine consists of the following major components: the shaft, pulleys, belt, bearings, electric motor, yam beaters, bowl and the frame. The yam beaters or blades were located on the upper edge of the shaft which was connected to the electric motor via a V – belt and pulley system. During the pounding operation, the slices of already cooked yam are loaded into the pot-like pounding chamber and covered with the pounding chamber cover. The electric motor transmits power through the V - belt to shaft, as the shaft rotates it actuates the yam beaters, which start pounding the yams in the yam pounding chamber. The pot or pounding chamber bears the bigger pulley so as to reduce the speed of the electric motor to a desired pounding speed of 100 rpm.

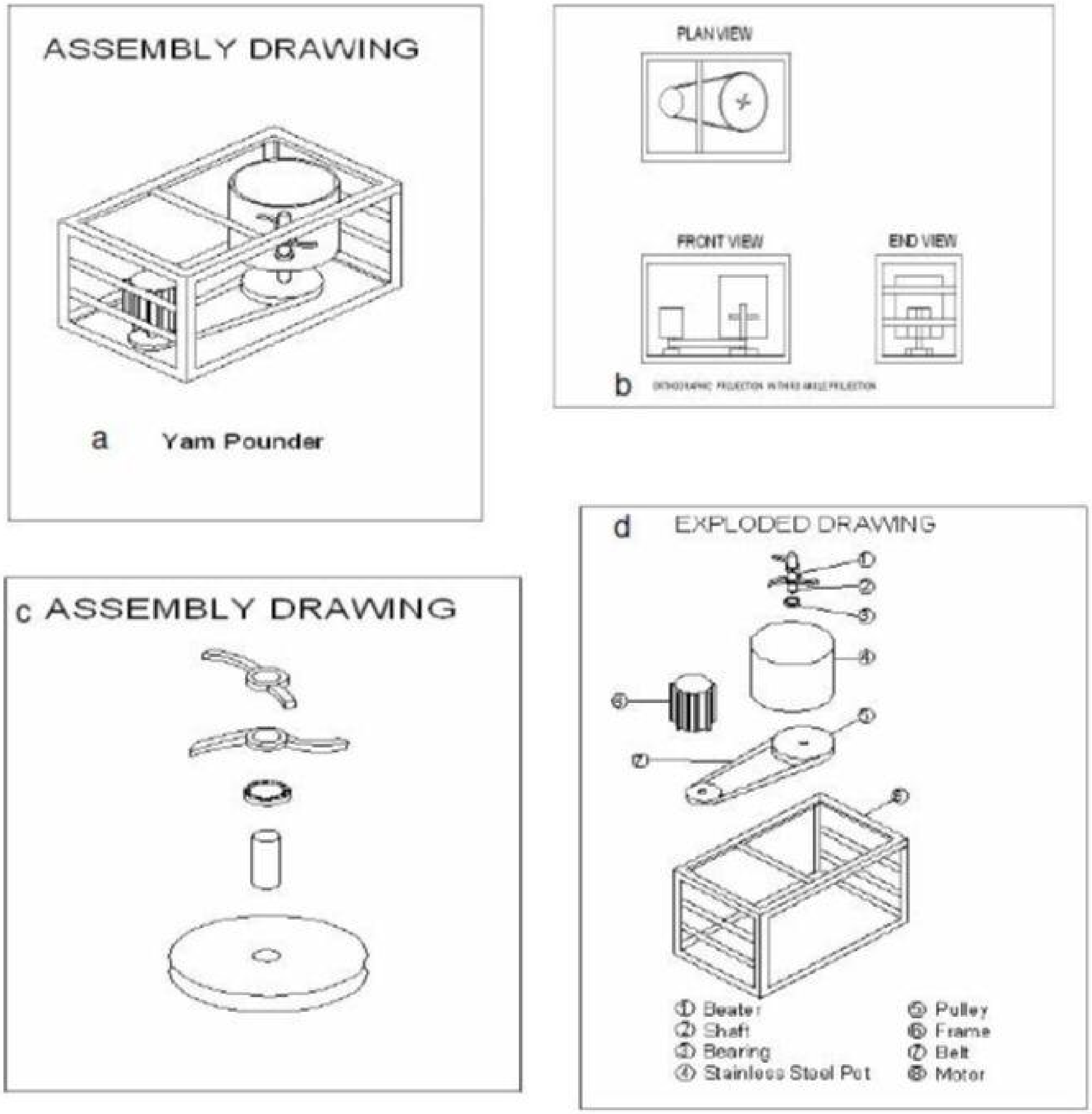


Figure 2.6 Component of the yam pounding machine

The yam pounding machine is designed and developed to hygienically process yam and it is designed to pound variable weight of cooked yams for domestic consumption. The machine consists of the following major components: the shaft, bearings, automatic gear electric motor, yam beater, bowl and the frame. The yam beater or blade is located on the upper edge of the shaft which is connected directly to the electric motor system. During the pounding operation, the slices of already cooked yam is loaded into the pot-like pounding chamber and covered with the pounding chamber cover. The electric motor transmits power directly to the shaft through its armature section, as the shaft rotates it actuates the yam beater, which starts pounding the yams in the yam pounding chamber. The pot or pounding chamber bears the shaft and the beaters. The operational stages in yam pounding include; washing the yam tuber, peeling, slicing, parboiling and pounding using the pounding machine before packing the pounded yam as shown in Figure 2.7.

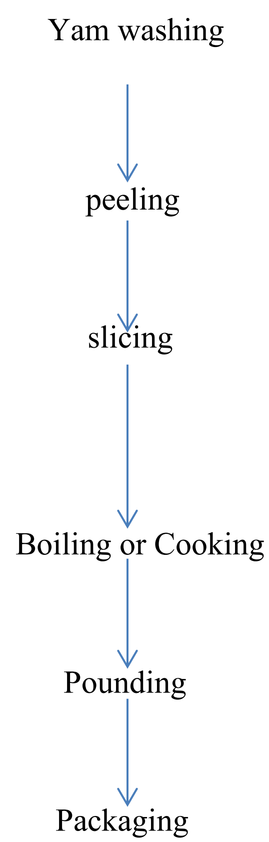


Figure 2.7 Flow diagram for yam pounding

At present there exists different makes of yam pounding machine. One type cooks and pounds while another pounds only. The problem associated with them is that they are expensive to operate and acquire and most of them are not hygienic. In this design yam can be boiled using steam and thereafter pounded. The processed pounded yam reasonably ductile, and has the required texture. en.wikipedia.com records that some earlier African designers designed a pounding machine, but it had the local pestle and the local mortal, It was just that the reciprocating motion was mechanized; other work has been the use of hydraulic press and rotating bowl to provide the necessary turning and mixing. A diagram is been shown in Figure 2.8

Figure 2.8 Early African pounding machine

This yam pounder is always cool, retro yam pounder from National – now Panasonic. It was developed in 1963. It does a mean pounding job, but it is very hard to find. It also has a tendency to over-pound so the product comes out a little soft to the touch. But when it is left for a few minutes it hardens right up to proper “okele” texture. The machine was successful though overpounds “fufu” the other paste product form cassava but was not able to produce the required texture of pounded yam. This design helped in making the production of pounding yam easy but it had a short coming listed below.

- It was very hard to find and now in extinction
- It only pounds fufu and cannot pound our desired pounded yam
- It over pounds the fufu
- Its product is always too soft to touch and has to be left for few minutes before solidifying which makes the desired fufu cold.

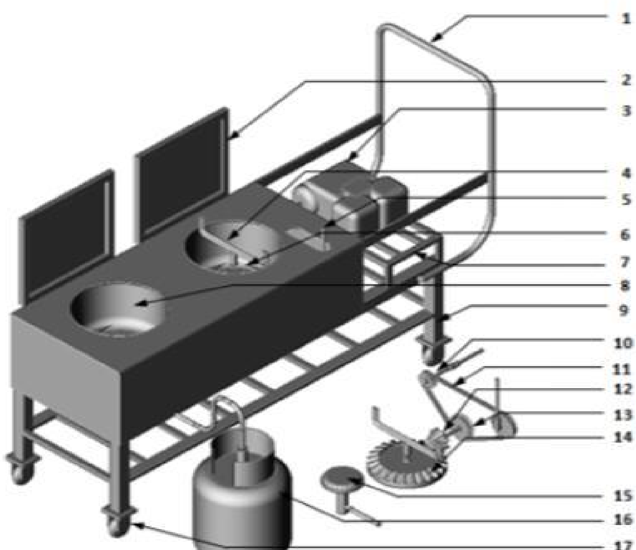
A diagram is illustrated in figure 2.9 to show the Panasonic yam pounder for fufu production.

Figure2.9: Panasonic yam pounder for fufu production

(Onuoha et al , 2019). Did a design and fabrication of a yam pounding machine since the consumption of pounded yam is one of the major meal in Nigeria it is consumed domestically and mostly in many important occasions. It is a delicacy that commands respect and preference and often ranked topmost in a typical Nigerian menu list. Pounded yam is consumed with individual choice of soup such as ogbono, ewedu and spinach with egusi soup. Pounded Yam is thus an authentic African food and the presentation of it with ogbono or egusi soup to visitors in Igbo and Yoruba lands in Nigeria for example, is considered a great act of love and respect. Its medicinal use as a heart stimulant is attributed to its chemical composition, which consists of alkaloids of saponin and sapogenin (Wikipedia). The machines had no adjustable electric motor base for proper tensioning and some were not adequately ventilated resulting to overheating of the electric motor. Presently the developed pounding machines operate with electric motor that uses only electric current. This power supply is not suitable in Nigeria and as such people do not find it easily to use it when needed for pounding yam. Worst still, 96% of the rural area in Nigeria where yam cultivation is carried out does not have electricity. In a bid to overcome the identified twin problems of yam pounding machines and electric power supply in Nigeria, a cost effective yam pounder that uses petrol (I.C) engine and gas cooker for dual purposes of cooking and pounding yam respectively becomes necessary. The general objectives of this project as shown in figure 2.10, 2.11, 2.12 are to design, fabricate and test yam pounding machine that uses petrol engine and gas cooker as power sources.

Plate 1. Fabrication process of yam pounding machine

Figure 10: Fabrication of yam pounding machine



S/N	DESCRIPTION	QTY	MAT	REM
1	MACHINE HANDLE	1	M.S	FAB
2	COVER	2	M.S	FAB
3	ELECTRIC MOTOR	1	M.S	PUR
4	POUNDING BLADE	1	M.S	FAB
5	GEAR HANDLE	1	M.S	FAB
6	POUNDING CHAMBER	1	M.S	FAB
7	ELECTRIC MOTOR SUPPORT	1	M.S	FAB
8	COOKING CHAMBER	1	M.S	FAB
9	FRAME	1	M.S	FAB
10	BEARING	5	M.S	PUR
11	BELT	1	RUB	PUR
12	BEVEL GEAR	1	M.S	PUR
13	PULLEY	3	M.S	PUR
14	SPUR GEAR	1	M.S	PUR
15	GAS BURNER HEAD	1	M.S	PUR
16	GAS CYLINDER	1	M.S	PUR
17	ROLLER	4	RUB	PUR
18	BOLT & NUT	20	M.S	PUR

Figure 2.11: The isometric view of the yam pounding machine

Figure 2.12: Developed pounding machine with chambers open

A simple and easy to maintain kitchen size yam pounding machine was developed, constructed and tested. The machine, powered by a 600 W electric motor was tested with two replaceable hammers; T-shaped and closed C-shaped hammers. The machine performed satisfactorily with the T-shaped hammer on yam slices not more than 40 mm in thickness. The products compared favourably with pounded yam produced with the traditional method. On the other hand, samples produced with the closed C-shaped hammers were generally unacceptable because they were full of lumps and unbroken yam pieces. Generally, the machine produced hot pounded yam within 45 seconds; hence, it is suitable for the present day nuclear families in the cities. A higher wattage electric motor rating would enhance its capacity as the machine tends to get stuck as soon as the yam turns into a thick paste if additional water is not sprinkled on it.(AbdulGaniy et al, 2007). A diagram showing the CAD view of the pounding ,machine was illustrated in Figure 2.8 and also Figure 2.9 shows the modified pounded yam machine.

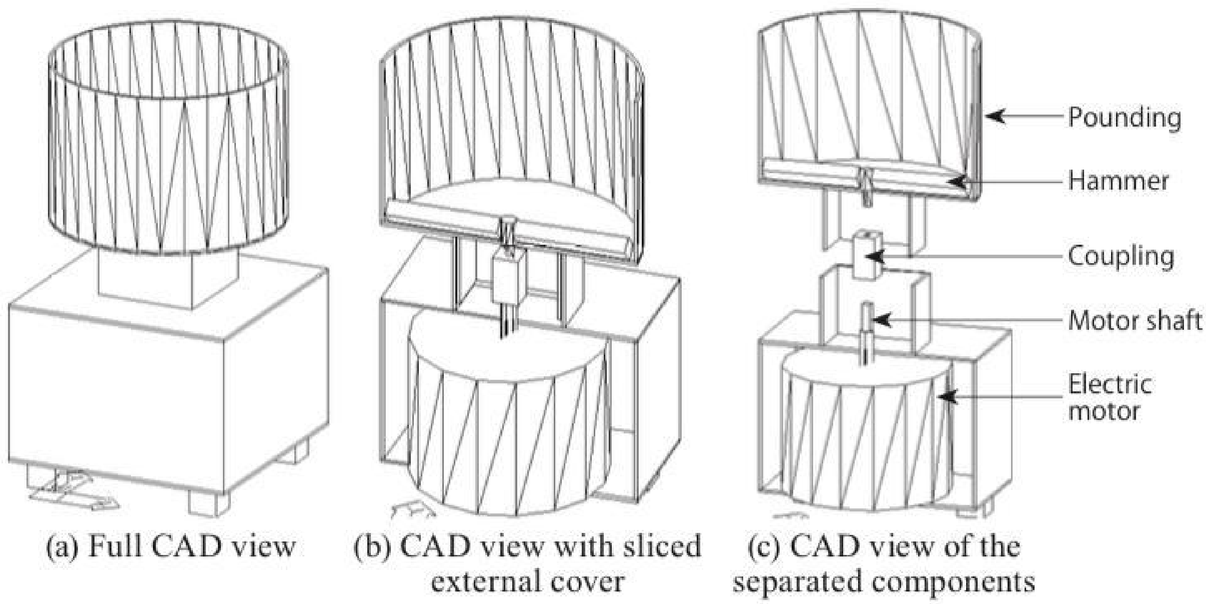


Figure 2.13: CAD view of the pounding machine

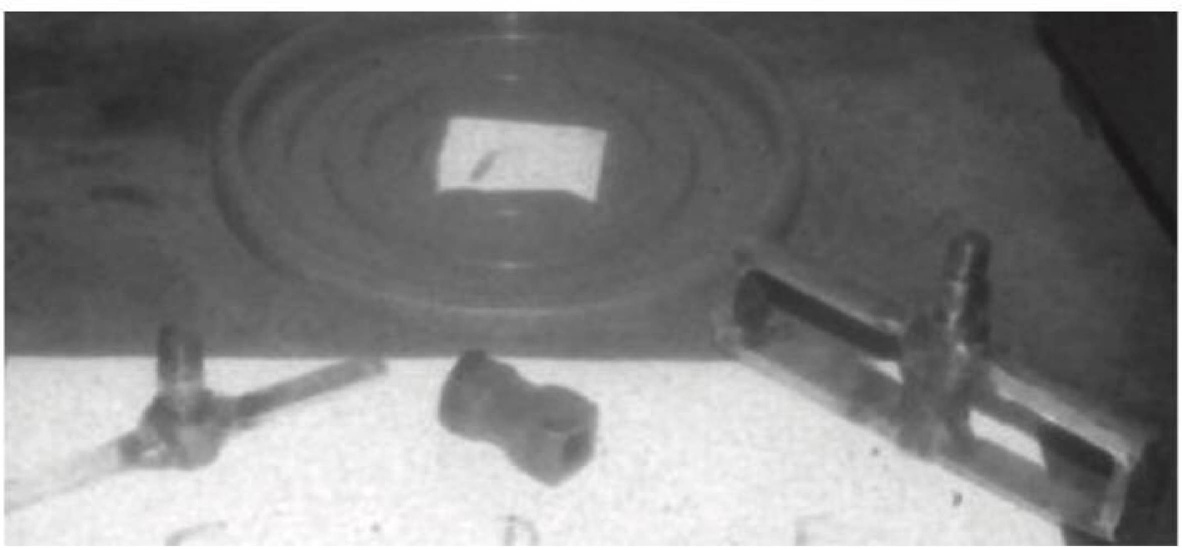


Figure 2.14 : Hammer and chamber cover

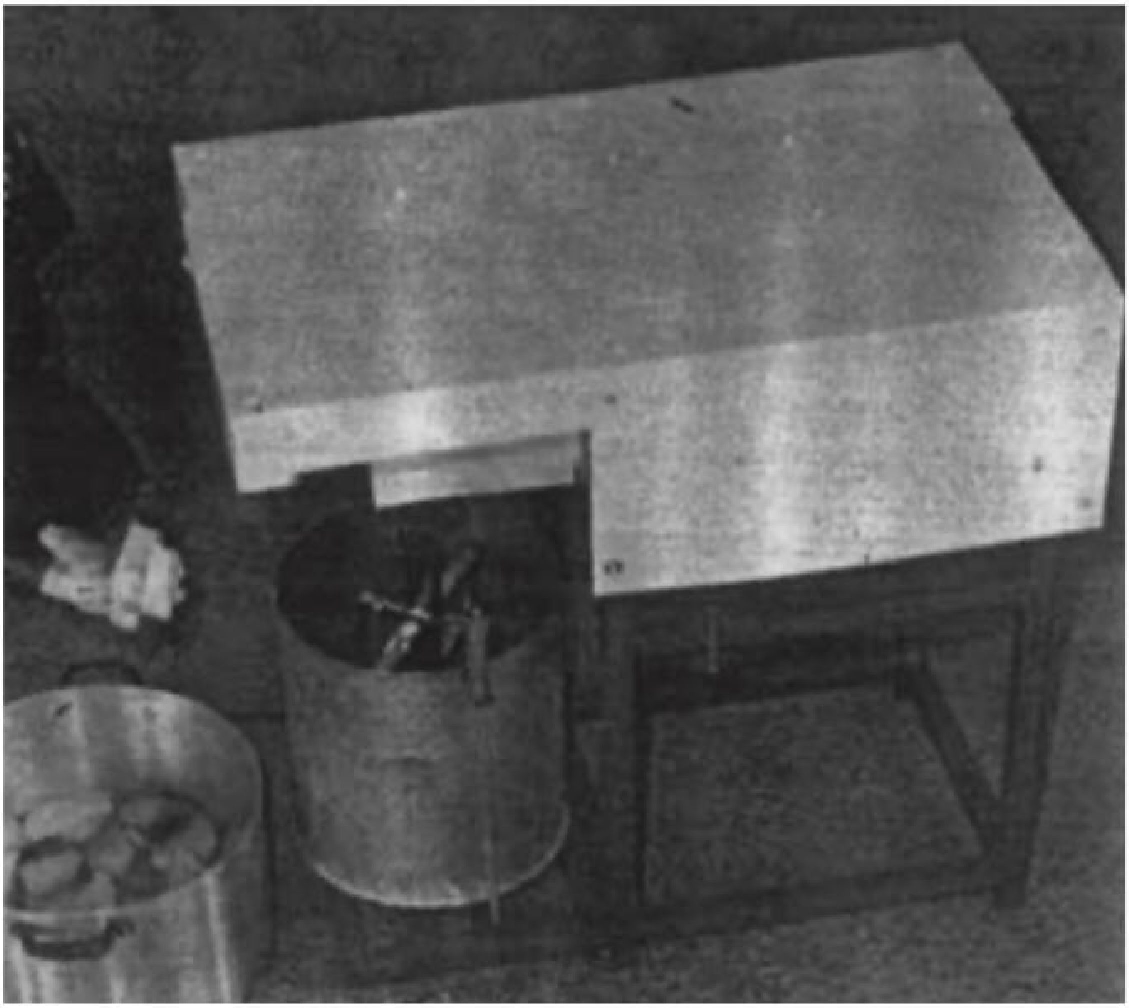


Figure 2.15: The fabricated design of the yam pounding machine

CHAPTER THREE

DESIGN METHODOLOGY AND ANALYSIS

3.1 Materials and Methods

The design was targeted towards achieving the following: producing a good quality machine for pounding yam, high probable efficiency, availability of raw materials and cost of the machine.

3.2 Material Selection Technique

The selection of materials depends on many features such as the intensity and type of stress to which the components are subjected to, whether it is flexible or rigid or it is to experience high temperature or corrosive action and how it leads itself to processes of manufacture, i.e. forging, machine etc. Therefore, the designer selection will be influenced the following factors:

1. Strength
2. Weight
3. Appearance
4. Manufacture
5. Cost of Production.

These will also determine the variation between success and failure of the machine. We can further classify the above factor into four main classes:

a. Service Requirements.
b. Construction Requirements.
c. Economic Requirements.
d. Maintenance Requirements.

3.2.1 Service Requirements

Before a material is chosen for construction, it must possess some distinct properties which it exhibits when put to play. These properties are generally referred to as the service requirement. Some of these properties which should be appreciable while the material is in service are:

a) Toughness.
b) Hardness.
c) Strength.
d) Stiffness.
e) Resistance to corrosion.
f) Conductivity and heat resistance.

3.2.2 Fabrication Requirements

For fabrication process, a material must possess some distinct properties; these are mainly forge-ability, malleability, ductility and weld-ability. Materials undergoing forge-ability are heated to a temperature close to its melting point then shaped to desired structure. For malleability, it's required that the material should be made into a sheet like form while ductility requires the material to be drawn into a wire form. Finally, weld-ability can be described as the ability of the material to be easily welded. Therefore, the materials must be able to be joined by the process of welding.

3.2.3 Economic Requirements

This is about the most important factor for the material selection because it determines the total cost of production which in turn affects the price of the product or retail cost and consumer choice. If the total cost of production is high, variably the price of the finished product will also be high. When the price of a product is high, consumers will seek for alternative cheap but similar goods. Bearing in mind that the two aims of production is, satisfying consumer wants and needs and also to make maximum profit, as a producer, one must judiciously select relatively cheap but reliable and appropriate materials for production. This will reduce the overhead cost of production therefore making it cheap in respect to other similar materials. Then we can comfortably harmonize the cost of production with the real price. One of the major considerations in engineering design is to design machines that are reliable, cost effective and the ability of the machine solving human problem. This was one our consideration in this project work.

3.3 Machine Components of the Machine

These are unit components of the machine that are assembled together to form the entire machine. The machine components include; the machine structural frame, trough, blade or impeller, pulleys, Belt, Rubber Fingers, pounding basin, bearings, shaft and the electric motor which was selected.

3.4 Design Factor

This refers to some characteristics which affects or influence the design of the machine or perhaps some of the components. However, out of the numerous factors that affected the design, only one or few will turn out to be the major factors and the minors ignored as they would have little or no effect in the design. These factors or characteristics are;

i. Thermal conductivity of the material.
ii. Strength of the materials used.

iii. Overall weight of the machine in order to achieve its portability and machine size.
iv. Ease of maintenance.
v. Noise and vibration.
vi. Resistance to corrosion attack.
vii. Finishing.

3.5 Design Dimension for the Machine

The component consists of an electric motor transmitting torque to the sheave by a belt. Torque is transmitted to shaft supported by on end shaft bearing assembly. The shaft drives the stainless steel beater. It also consist of a stationary cylindrical basin constructed to near circumference of the stainless steel beater. The frame of the machine is of over-all dimension of length 785mm breadth of 485mm, and height of 531mm for the pounding component. The frame was being constructed in such a way that it would provide support for the electric motor, shaft, pulley, belt, and bearings. The electric motor of capacity **1.5kW, 1440rpm** by capacity was installed to provide adequate setting. A sheave of **70mm** nominal diameter was fixed on the shaft of the motor which would transmit power to the shaft through the belt. The motor was being attached to the frame by using Hex head bolt and nut. The shaft of diameter **25mm** and length **595mm** was erected vertically at the centre of the main frame supported by two bearings and brazed at the top and bottom of the frame. Attached to the shaft is a driven sheave of diameter **210mm** which reduces the actual speed of the electric motor because it is greater than the sheave of the motor. The yam beater was then joined to the walls of the basins. The beater was joined to the shaft end by using hexagonal bolt. The pounding basin is a cylinder which has a top diameter of 508mm, bottom diameter of 400mm and a height of 450mm. The basin was developed from Stainless Steel.

The pounding basin is a cylinder which has a top and bottom diameter of 280mm, and a height of 184mm alongside a steel thickness of 10mm. The basin was developed from Stainless Steel. The top and the bottom of the basin are concentric with the beater. A hole of diameter 26mm was drilled through the bottom of the basin for the entry of the shaft. The beater was of length 190mm and width 20mm.

3.7 Materials Selection for the Machine

The choices of the material and component used here are based on the consideration of the following factors, cost analysis of the material, durability of the materials, availability of the materials, properties of the material such as; physical properties, thermal properties, relative properties, chemical properties and mechanical properties.

Table 3.1: Materials Used and Selection Criteria

S/N	MATERIALS USED	SELECTION CRITERIA
1.	Stainless Steel	It has a very high resistance to corrosion, Workability
2.	Angle bar	It is very rugged and easily to fabricate.
3.	Electric Motor	To transmit the torque, with aid of V-belt.
4.	Bolt and nut	It is used to couple the drum and frame together
5.	Paint	To enhance the resistance to corrosion

3.8 Construction Technique of the Machine

The following operation sequences were undertaken in the fabrication of the dual component machine, measurement and marking out, cutting of material, welding, grinding, and drilling operation. And the following tools were used: Hack saw, Scriber, Try-square, Measuring tape, Welding Machine, Grinding Machine and Drilling Machine.

Operation Sequence includes:

3.8.1 Measurement and Marking Out: The measurements were used according to the design specification and the marking out was done accordingly.

3.8.2 Cutting of Materials: Sheet metal (stainless plate) of 10mm thickness, sheet metal (mild steel) 10mm thickness and angle iron were marked out according to the dimension. The cutting operation was carried out manually using shearing machine to cut angle bar, pipe and shaft while hand cutting machine is used to cut sheet metal manually.

3.8.3 Welding Operation: All materials being cut out were joined by the use of arc welding machine.

3.8.4 Grinding Operation: Contours on the welded joints of the work piece were smoothened using grinding machine. It is the operation in which all welded area and rough surfaces are slightly grinded for smooth and aesthetes surface finishing. The welded joint were slightly grinded, because too much of grinding will weaken the strength of the bond.

3.8.5 Drilling Operation: The drum, rotating plate and the base of the machine were drilled accordingly, using drilling machine with (21mm) drill bit.

3.9 Description of Part of the pounding Component of the Machine

The part of the machine includes the Outer drum, Upside, Pounding Beater, Bearing, Main Frame, and Output Chute (Yam water drainage), Electric motor, and Main shaft, Driven Pulley, Driving pulley, V-Belt.

3.10 Parts and Operation of Yam Pounding Component

The yam pounding Component is designed and developed to hygienically process yam and it is designed to pound variable weight of cooked yams for domestic consumption. The machine consists of the following major components: the shaft, bearings, automatic gear electric motor, yam beater, bowl and the frame.

The yam beater or blade is located on the upper edge of the shaft which is connected directly to the electric motor system. During the pounding operation, the slices of already cooked yam is loaded into the pot-like pounding chamber and covered with the pounding chamber cover. The electric motor transmits power directly to the shaft through its armature section, as the shaft rotates it actuates the yam beater, which starts pounding the yams in the yam pounding chamber. The pot or pounding chamber bears the shaft and the beaters. The operational stages in yam pounding include; washing the yam tuber, peeling, slicing, parboiling and pounding using the pounding machine before packing the pounded yam as shown in Figure 7 (Toyosi Craig, 2011).

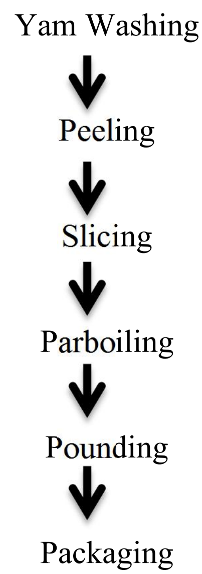


Figure 3.1: Flow diagram for Yam Pounding (Odior and Orsarh, 2010)

3.12.1 Yam Beaters

The yam beaters are two blades made of stainless steel material and they are the main components for pounding of the yam. These are two bars crafted, designed and joined together at angle 180° to each other at the centre and they rotate together through angle 360° while pounding the cooked slices of yam. The Beaters are attached to the connecting rod with a circular portion.

3.12.2 Pounding Bowl

The pounding bowl is a stainless steel structured bowl which consists of the yam beaters which perform the pounding operation in a chamber of the bowl.

3.12.3 Machine Frame

The machine frame forms the housing of the whole components, excluding the pounding bowl and the beaters which are located on top the frame. It has to be rigid to withstand all the forces generated in the components during the pounding operation. It was constructed using the angle bar.

3.13 Design Calculations of the Machine

Certain calculations were made on certain parameters so as to make correct choices in selecting them. Design calculations were carried out on the following: Sheave (Pulley), Belt, Shaft, Yam Beater.

3.13.1 Sheave System

The sheave system comprises of two sheaves. The bigger, being the driven, is mounted on the shaft and the smaller sheave, the driver, is mounted on the electric motor. Since the diameter of the sheave on the motor is smaller, then there is reduction in speed (rpm) on transmission to the larger sheave attached to the shaft. The speed of the motor is 1440 rpm. In order to calculate the speed that would be transmitted to the shaft, the following analyses were been carried out:

$$\mathbf{N_1D_1 = N_2D_2} \qquad (3.1)$$

Where:

N_1= Speed of the motor, 1440 rpm,

D_1= Diameter of the motor sheave, 70 mm,

N_2= Speed of the shaft/shaft sheave,

D_2= Diameter of the shaft sheave, 210 mm

$$N_2 = \frac{N_1 D_1}{D_2}$$

$$N2 = 1440 \times \frac{70}{210}$$

$$N_2 = 100{,}800/210 = 480\ rpm$$

Therefore, the speed that the motor will transmit to the shaft/shaft sheave through the belt is 480 rpm, although a variable speed controller would be incorporated in the entire function of the machine to vary the speed of the machine.

3.13.2 Belt Design and Selection

A belt and pulley system was used to transmit the power and torque from electric motor section to both the plucking chamber and the yam pounding section.

b = 12mm, t = 8mm, w/l = 1.06

D_1 = diameter of driving pulley, 70mm

D_2 = Diameter of driven pulley, 210mm.

P_{belt} = 1250kg/m^3

P = 746 Watts.

Rotational Speed of driver pulley, N_1 = 1440rpm

S_s = 3.0MPa

$\mu = 0.25$

Groove angle of pulley = 30° = 2β

Length of belt,

$$\mathbf{L} = \frac{\pi(D_1 + D_2)}{2} + 2C + \left(\frac{(D_1 + D_2)^2}{4C}\right) \quad (3.2)$$

But C = Unknown

$$\mathbf{C = max}\left(\frac{3D_1}{2} + \frac{D_2}{2}\right) \quad (3.3)$$

$$= \max\left(\frac{3 \times 70}{2} + \frac{210}{2}\right) = \mathbf{210mm.}$$

We use a centre distance of 250mm.

$$\text{L} = \frac{\pi(70 + 210)}{2} + 2 \times 250 + \left(\frac{(70 + 210)^2}{4 \times 250}\right) = \mathbf{1018mm}$$

A standard belt is then chosen as the nearest match is 1026 mm which is type **A43 belt.**

Tension on tight side of belt T_1:

$$\mathbf{T_1 = btS_s} \quad (3.4)$$

$$T_1 = 0.012 \times 0.008 \times 3.0 \times 10^6 = \mathbf{288N.}$$

3.13.3 Angle of Wrap

$$\boldsymbol{\theta_1 = 180 - 2\alpha,}$$

$$\boldsymbol{\theta_2 = 180 + 2\alpha} \quad (3.5)$$

$$\textbf{Sin } \boldsymbol{\alpha} = \left[\frac{d_2 - d_1}{2C}\right] \quad (3.6)$$

$$= \left[\frac{210-70}{2\times 250}\right] = 0.28.$$

α = Sin-1(0.28) 16.260°

$\theta_1 = 180 - 2(16.260) =$ **147.48°** and

$\theta_2 = 180 + 2(16.260) =$ **212.52°.**

Tension on slack Side of belt T_2:

To evaluate the tension on the slack side, we use the relationship:

$$2.3\log\left(\frac{T_1}{T_2}\right) = \mu\theta_1 \text{cosec}\beta \quad (3.7)$$

$$2.3\log\left(\frac{T_1}{T_2}\right) = 0.25\text{x } 147.4 \text{ x } \frac{\pi}{180}\text{cosec } (15)$$

$$\mathbf{T_2 = 23.94N}$$

$T_1 = 288N$, $T_2 = 23.94N$.

Power transmitted through the belt:

$$\mathbf{P = (T_1 - T_2)\ V} \quad (3.8)$$

$$= (T_1 - T_2)\frac{\pi DN}{60}$$

$$= (288 - 23.94)\ \frac{\pi \times 1440 \times 70}{60}$$

= 1392.969 Watts.

Bearing Design and Selection

The single row deep groove ball bearing was chosen because of its high load carrying capacity and suitability for high running speed. Considering the diameter of the shaft which is 25mm, a bearing of bore 25mm was then used for this calculation. The specific static load rating or capacity C_o (Arvid, 1945).

$$Co = \frac{1}{5} \times ko \times i \times z \cos \alpha Dw^2 \qquad (3.9)$$

Where:

C_o = Specific Static Load rating or Capacity (Pillow Block Bearing) = 10kN (Arvid, 1945).

Ko = Bearing factor

D_w = Diameter of the ball =?

α = Nominal angle of contact = 25° (Arvid, 1945)

i = Number of rows of ball in any one bearing = 1 (Khurmi and Gupta, 2005)

D_w = Diameter of the ball

z = Number of balls per row in the groove = 6

$$Ko = \frac{RA}{Dw} = \frac{633.21}{26.034} = 31.6 \qquad (3.10)$$

RA= bearing load = 633.21N (From shaft analysis, equation 20)

Equation 64 is ball diameter computation formula

$$Dw = \sqrt{\left(\frac{Co \times 5}{Ko \times i \times z \cos \alpha}\right)} \quad \text{(Budynas et al, 2008)} \tag{3.11}$$

$$\text{Dw} = \sqrt{\frac{10000 \times 5}{31.6 \times 1 \times 6 \times \cos\ 25°}}$$

Dw **= 13.13mm**

Then the maximum bearing load Q_{max} becomes:

$Q_{max} = K_o \times D_w^2$ (Arvid, 1945)

$Q_{max} = 31.6 \times 172.41$

$Q_{max} =$ **5.5KN**

The single row deep groove ball bearing which is also known as a pillow block bearing with an inner diameter of 25mm and outer diameter of 55mm, then was chosen under these set of criteria

I. High load carrying capacity up to 5.5KN
II. suitability for high running speed
III. Considering the calculated diameter of the shaft as 25mm, a bearing of bore 25mm was then used for this calculation.

3.13.4 Yam Beater Design

Evaluation of forces acting on the beater

L= Length =148 mm; 0.162 m

W= Width= 51 mm; 0.051 m

T= Thickness= 16 mm; 0.0010m

$V = L \times W \times T$

V= 0.162 $\times$ 0.051 $\times$ 0.0016 = 0.00083 m^3

Beater Material: Stainless Steel, Density of Stainless Steel: ρ = 7500kg/m^3 (BSSA, 2009)

Weight of beater:

$$\text{Mass (M)} = (\text{Density} \times \text{Volume}) \tag{3.12}$$

M = 7500 $\times$ 0.00083 = $\mathbf{0.6115kg}$

$$Weight\ (W_b) = mass \times g\ (g = 9.81)$$

0.6225 $\times$ 9.81 = **6.1 *N***

W_1=W_2= the weight of two pounding blade (because they are of the same material and same size)

$F_1 = W_1$ = **6.1 *N***

(F1 and F2 being the respective forces at point 1 and point 2)

Area of beater surface in contact with yam:

$$\text{A} = \frac{1}{2}(a + b)h = \frac{1}{2}(0.03+0.026) \times 0.08 = \mathbf{0.0024\ m^2} \tag{3.13}$$

Volume occupied by beater:

$$V = At = 0.0024 \times 0.005 = \mathbf{0.000012\ m^3} \quad (3.14)$$

Effect of yam on the beater:

Osueke C.O, 2010, experimented and determined the density to be 1250kg/m3 and 1950kg/m3, before and after boiling respectively.

A piece of Yam with dimensions L=40mm, B=40mm, H=40mm is used for this analysis.

Volume of yam piece = $(40/1000)^3 = 0.0000064m^3$

Density of boiled yam: 1950kg/m3

Mass of the piece of yam:

$$\rho \text{ x } v = 1950 \text{ x } 0.000064 = \mathbf{0.1248kg}$$

There can be a maximum of two (2) pieces of yam on the beater, hence

Mass of 2 pieces of yam = 2 x 0.1248 = **0.2496kg**

Weight of 2 pieces of yam = 0.2496 x 9.81 = **2.449N**

Total weight of beater with yam on it:

Total weight = weight of beater + weight of 2 pieces of yam

Total weight = 0.942 + 2.449 = **3.391N**

Determination of crushing pressure and force acting on beaters surface

$$P = \frac{F}{A}; F = P_y \times A \quad (3.15)$$

$$P_y = \rho_b gh \quad (3.16)$$

Where P_y = Crushing Pressure, h = height of the yam.

The machine is designed to pound an average of tuber of Yam. Experimentally, a tuber was cut into pieces of 40mm cube, into a total of 44pieces.

P_y = 1950 x 9.81 x 0.051 = **975.6N/m2**

F = 975.6 x 0.0024 = **23414.4N**

To crush 22 pieces of yam by RHS of beater; F = 2.34144 x 22 = **51.5N**

Turning Effect and Power Requirement:

Torque Computation:

F = T x D (3.17)

Where T = Torque, F = Force, D = Distance from centre of pivot

Torque from weight of beater with yam weight inclusive

T = 2.34 x (0.04 + 0.0125) = **0.177975Nm**

Torque from force acting on the surface of the beater

T = 40.4008 x (0.04 + 0.0125) = **2.121Nm**

Torque of RHS of beater = 0.177975 + 2.121 = **2.299Nm**

Total Torque of beater = 2 x 2.299 = **4.598Nm**

Power Requirement:

This is given as:

$$\text{Power (P)} = \frac{2\pi NT}{60} \tag{3.18}$$

Where N = speed of revolution and T = Torque

Using a speed reduction factor of 1:3; $N = \frac{Motor\ Speed}{3} = \frac{1440}{3} =$ **480rpm.**

$P = \frac{2 \times \pi \times 480 \times 4.598}{60} =$ **231.121Watts.**

Hence considering the factor of safety 1.5, the minimum power requirement for the design; =231.121 ×1.5=346.681 Therefore, based on the above calculations an electric motor of 1 hp with speed 1440 rpm, phase 3 and voltage of 440 V was chosen.

CHAPTER FOUR

RESULT AND DISCUSSION

We tested the yam pounding machine using two different species of cooked yam which are white yam and water yam. Both yams weighed approximately 3.2 kg and 2.8kg. They were cut into smaller sizes, peeled, washed and cooked for a period of 30 minutes. After cooking, the yam was transferred in to the pounding bowl and with the aid of electricity the machine was operated to pound the yam for a stipulated time which differed for both species of yam. The test for hardness was conducted manually on both species of yam by stopping the machine intermittently in order for us to achieve a desired texture. The results of the test are shown in Table 4.1 below;

TABLE 4.1

SERIAL NUMBER	YAM SPECIMEN	POUNDING TIME (MIN)	TEST FOR HARDNESS TIME(SEC)	TOTAL POUNDING TIME(MIN)	TEXTURE OF YAM
1	White yam	3:20	40	4	Starchy
2	Water yam	1:20	40	2	Semi-Starchy

Furthermore, it took the white yam three minutes twenty seconds (3:20) to pound and test for hardness took forty seconds (40). The water yam took one minute twenty seconds (1:20) to pound and the test for hardness took the same time as that of the white yam (40 seconds). From the results of the testing carried out it was equally observed that the indigenous and laborious process of preparing pounded yam was completely eliminated.

Pounding Efficiency

After pounding, both yams were weighed which gave us 2.9kg for the white yam and 2.4kg for the water yam. The pounding efficiency can be determined by dividing the mass of the pounded yam by the initial mass of the yam multiplied by 100. Since we have two yam specimens we use the formula for both yam specimens and find the average efficiency.

$$\text{Pounding efficiency} = \frac{\text{mass of the pounded yam}}{\text{Initial mass of the yam}} \times 100\ \%$$

For white yam,

$$\text{Pounding efficiency} = \frac{2.9}{3.2} \times 100$$

$$= 90.625\%$$

For water yam,

$$\text{Pounding efficiency} = \frac{2.4}{2.8} \times 100$$

$$= 85.714\%$$

$$\text{Pounding efficiency of the machine} = \frac{90.625 + 85.714}{2}$$

$$= 88.171\ \%$$

The pounding efficiency of the machine after calculation was gotten as 88.171% which is fair for a locally fabricated yam pounding machine.

CHAPTER FIVE

CONCLUSIONS

The yam pounding machine fabricated with an efficiency of 88.171% was able to carry out a hygienic yam pounding process there by eliminating food contamination. Furthermore, we were able to completely eliminate the

tedious and laborious process involved in pounding yam. Compared to the indigenous method, we were able to time minimize the time taken in processing pounded yam and produce a pounded yam with a nice texture. Producing this machine on a large scale will provide an opportunity for making pounded yam in large quantities with reduced time of processing and also reducing the cost of labour for restaurants and canteens. Also, the issue of overheating which was a problem in previous prototypes was totally eliminated in this machine by creating a vent in the chamber of the electric motor making the motor cool itself by the speed generated.

5.1 Recommendations

One of the challenges face during the testing was the cooking of the yam for a while before pounding it. It is recommended that a boiler should be incorporated in future designs to ease the stress of boiling the yam since the machine is powered by electricity it will save cost and time.

Another major challenge faced was the inability to vary the speed of the motor. It is suggested that a variable speed drive be incorporated in future designs to allow users regulate the speed to achieve the kind of pounded yam texture they need.

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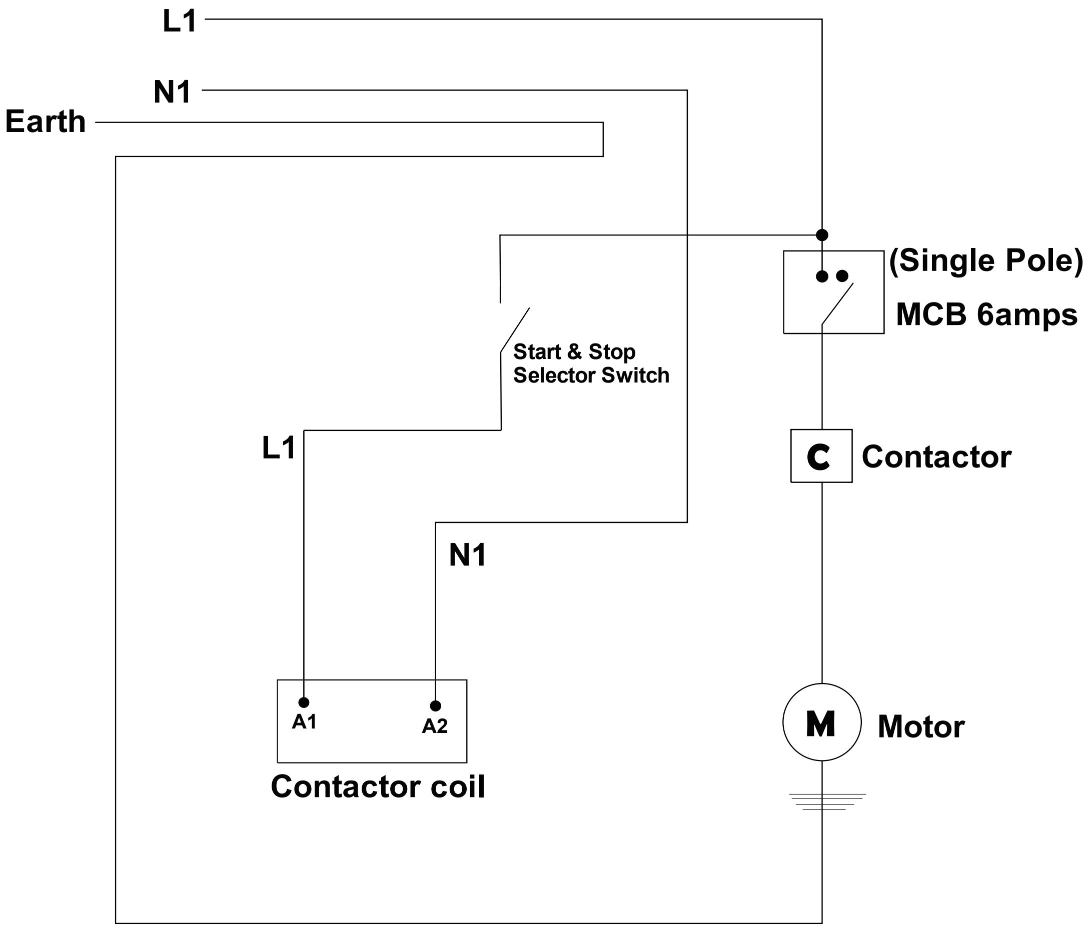

Fig. 3.2: A single line control diagram of the electrical system of the machine

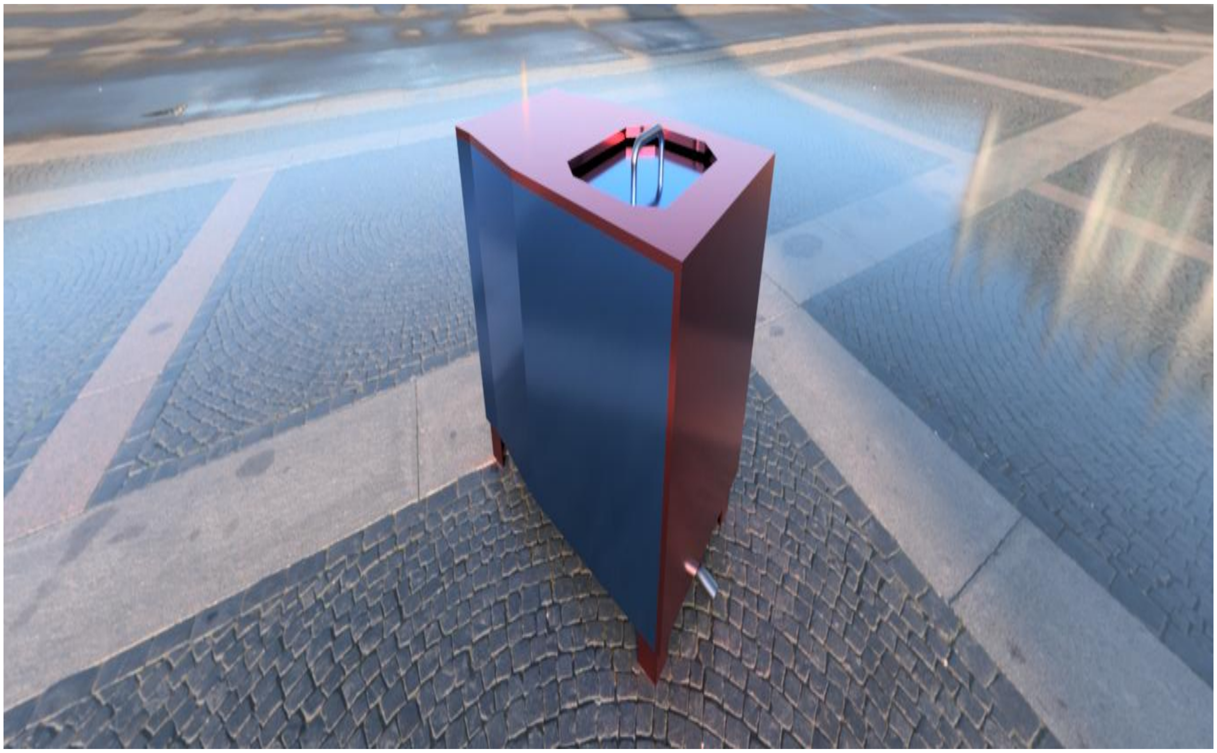

Fig 1: Rendered view of the yam pounding machine

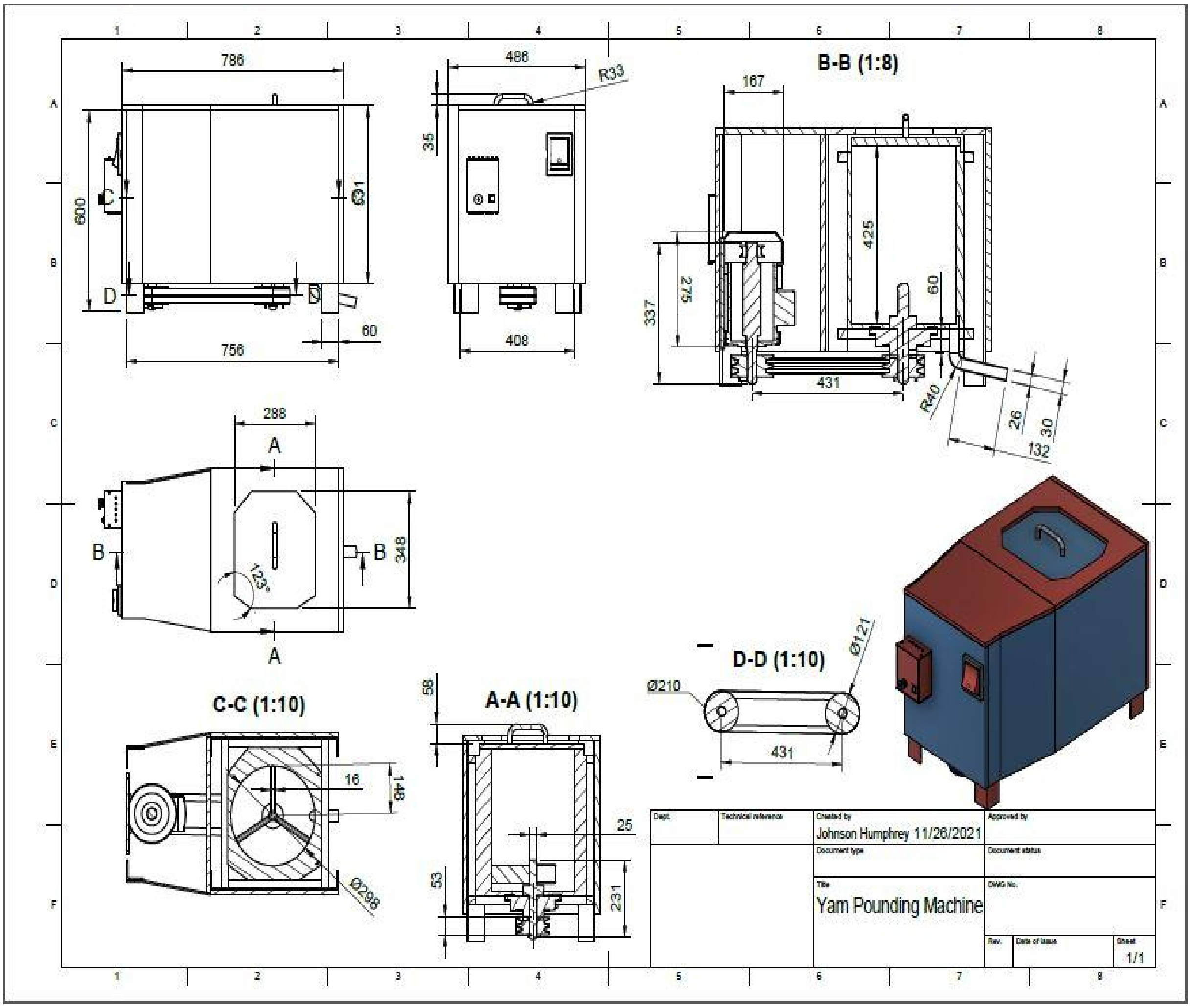

Fig 2: Orthographic and sectional view of the yam pounding machine

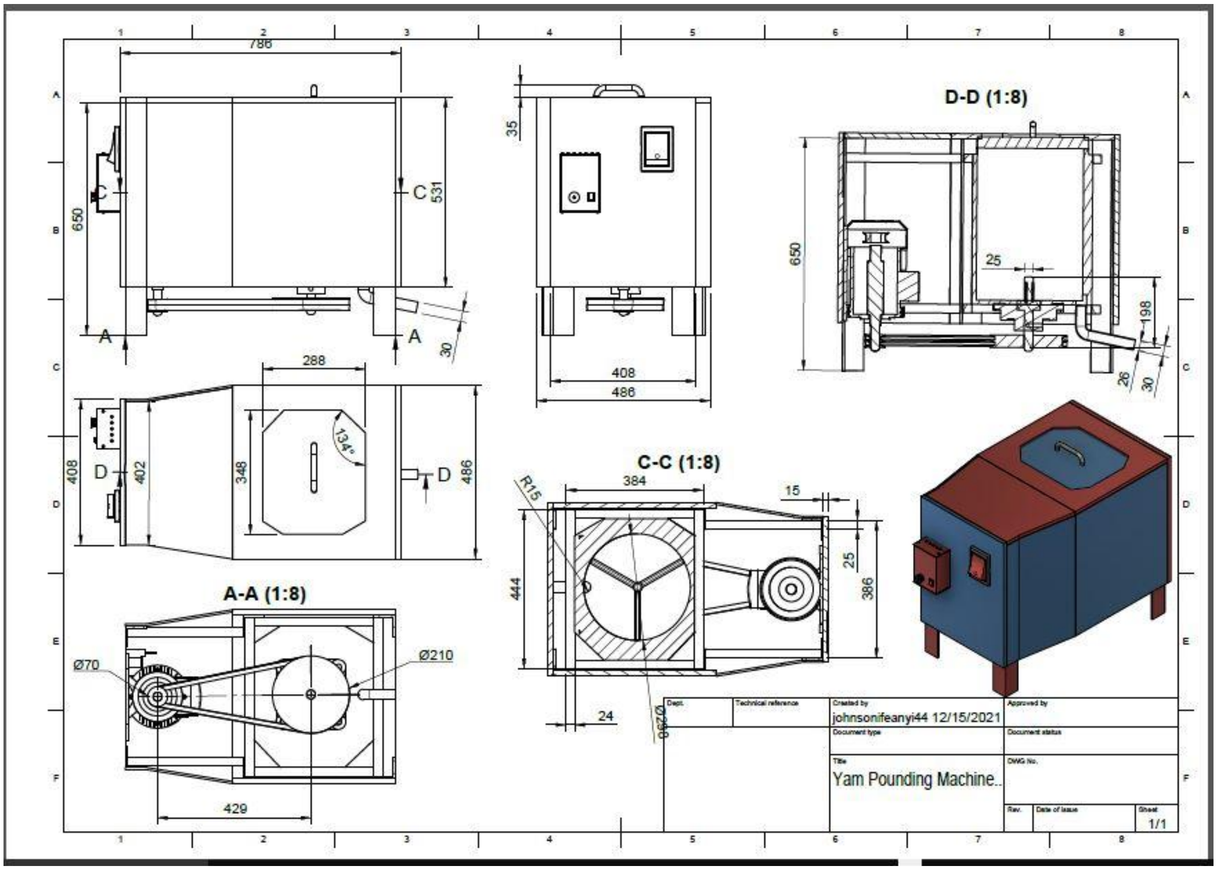

Fig 3: Orthographic and sectional view of the yam pounding machine.

APPENDIX