

FABRICATION OF A SENSOR CONTROLLED PLANTAIN SLICING MACHINE

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Abstract

A plantain chips slicing machine was fabricated and tested. This is perhaps a major advancement in the development of plantain chips. This plantain slicer consists of feeding chute, cutting blade, power transmission mechanism, a discharge tray, base support and frame, and a control design microcontroller. The result of the design of this slicing machine showed that maintenance cost is cheap, slicing time of plantain chips was reduced, operation of the machine does not require special skill, the machine is easy and safe to operate, and it is free of noise and vibration. The cutting action is controlled through a sensor which sends a signal to the cutting blade as soon as there are plantains to be sliced since there are four feeding chutes; power is transmitted to the cutting blade. As soon as there are no plantain the power is cut off. The slicing method is continuous with four slicing blades provided inside the cutting chamber and energy for loading and unloading is reduced since feeding chute and collecting bucket are provided. The machine was designed to meet the demand of small scale and medium scale industries but can also be used for domestic purposes which also include the slicing of cucumbers. The machine works on centripetal and centrifugal forces. The chip thicknesses, for both ripe and unripe plantain was found to be significantly uniform with a mean thickness of 2.00 mm. This slicer has slicing efficiency of about a 73.8 % and 81.93 % for ripe and unripe plantain respectively. Machine maintenance is simple; it requires proper cleaning after use. The added advantage of hygiene is also present and economic benefit for local plantain processors in the use of the machine.

Keywords: Plantain chips; Feeding chute; Cutting blade; Sensor.

Introduction

Plantain and other banana species are perennial crops that are staple and starchy in nature (Tchango *et al.*, 1999).

Globally, plantains and bananas are one of the most important staple foods, cultivated in large scale of about 10 million hectares of land, with an annual yield of 88 million tons. Its ability to produce fruits all through the year as well as its low labour requirements, when compared to other crops like potatoes, yam cassava, cowpea and rice makes it attract farmers to engage in its production and trade (Frison and Sharrock 1998).

Plantain is also a tropical plant that requires a warm humid climate to grow successfully. A mean temperature of 26.7°C, rainfall of 100 mm/month and a deep, well drained friable loamy soil with adequate organic matter is the ideal condition for its cultivation (Tchango *et al.*, 1999). Plantain is taken in various forms such as fried plantain, boiled plantain, roasted

plantain, baked plantain, and plantain chips. Plantains can also be processed into dough (Amala) by peeling, slicing, air drying, milling into flour and preparing with boiled water to form dough which is served with vegetable stew. Slightly ripe plantain can also be roasted and served as snack (booli). In some part of West Africa, plantain are fermented into beer and wine (Tchango *et al.*, 1999). Plantain peels are used as feed for livestock as well as for soap production. The leaves can be used for packaging foods and as roofing materials. (Akinyemi *et al.*, 2010).

Plantain slicing is a size reduction process that involves the application of shearing force on plantain with the aid of a cutter blade or knife to shear through the plantain to obtain a minimum deformation and rupture of the cell wall. The cutter blade could either be a reciprocating or rotary motion. In some rare cases, the blades are made stationary while materials travel against it and gets sliced in the process (Sonawane *et al.*, 2011). Obeng (2004) developed a

mechanized slicer that slices plantain into chips of relatively uniform thickness and improved speed when compared to manual knife slicing. It completely slices a single plantain for duration of about 5 to 7 seconds, depending on the length. The chip thickness produced by this machine ranges between 2.5mm and 3.5mm. The major components of the machine are; series of a 2mm curved stainless steel blades arranged in such a distance to represent the required chip thickness, a wooden mesher and a container positioned beneath the cutter blades for collecting the sliced chips.

Limitations

- a.) There exists a large variation in chip thickness.
- b.) Ripened and over-ripened chips tend to stick to the mesher and the edges of the blades.
- c.) The thin stainless steel blades tend to bend during cutting action and hence, altering blade interval and chip thickness.
- d.) There is difficulty in removing and sharpening of blades.

Sonawane *et al.*, (2011), designed and fabricated an electric power operated plantain chipping machine for use in small and medium scale plantain chipping industries. The machine is equipped with a feeder assembly, an electric motor, a cutter plate and a base support. The feeder assembly is made up of a push plate for pushing the plantain to the cutter blade, a push rod and a spring. The cutter plate is made up of three stainless steel blades which are powered by an electric motor rotating at a speed of 360 rpm through a V-belt. The machine has an efficiency of 93% and a mean thickness of 2.0mm (having ± 0.2 mm maximum mean deviation).

Limitations

- a.) It could only slice a few plantains at a time
- b.) Some over-ripened plantain tends to stick to the blade while some are whirled to other parts of the cutter section.

Okafor (2013) designed a plantain slicer for small scale industries. It is made up of a cutter chamber, an electric motor and a feed and discharge mechanism. The cutter chamber consists of a stainless steel blade, a flywheel and a connecting rod. The Geneva and the conveyor make up the feed and discharge mechanism. The machine was developed to slice a single plantain in 4 seconds during a single revolution of the input shaft. The machine efficiency is 73.8%.

Limitations

- a.) Chip thickness cannot be varied or controlled.

- b.) Irregularities were observed in chip thickness due to the momentary fluctuations between the time of cut and the time the conveyor moves.

In view of these, it is necessary to design a plantain slicing machine which will slice a finger of raw plantain within a short time, cost effective, slice uniformly and works only when plantain are fed into the machine. Therefore, a sensor was incorporated to sense plantain when it is fed into the feeding chute and starts the machine and the machine stops when there is no presence of plantain in the feeding chute. However, the above methods are observed to have some common features such as the slicing unit, the feeding chute, the base frame for support, as well as the motor to power the machine. The design is therefore an improved form of the manually operated versions.

Methodology

The design analysis of the machine involves critical analysis of the stresses in the machine, according to Ibhado (2012), with the individual components weight standing out as a factor, also considering the bending moments with the geometric properties and weight of the individual components being its centre of emphasis.

This analysis was done in order to establish definite parameters for the machine structure system or process to be designed, considering limitation and constraint posed by material requirements, economic consideration, aesthetic, features and other engineering considerations.

The following design considerations of the plantain slicing machine were made:

- i.) The plantain slicing machine saves time, energy and be efficient in productivity.
- ii.) The fabricated machine provides adequate safety and reduce drudgery in slicing of food items and should also be simple in operation and ease to maintain.
- iii.) In material selection for fabrication, careful selection of material was taken into consideration to avoid contamination of food items that may lead to food poisoning.
- iv.) All parts of the machine and product contains surfaces was free from crevices which may harbor bacteria and virus.
- v.) The machine could be operated or used by anyone without pre-training.

Material selection is vital and important factor in the design and fabrication of machines both for domestic and industrial applications. This is because the strength and durability of the machine and its ability to withstand failure lies on the physical and

mechanical properties of the materials used. Therefore, a sound knowledge of the physical and mechanical properties of the selected materials for the fabrication of the machine was known.

Stainless Steel: This material was used in the fabrication for the cutting blades, the frame cover, the feeding chute and the discharge tray because it will be used to cut edible material.

Mild Steel: This was used in the fabrication of the stand or mainframe of the machine because of its physical and characteristic properties as a construction engineering material. All these materials are locally available.

Machine Description

The machine is made up of a support mechanism, a slicing unit, a feeder chute, a discharge tray and an electric motor. The support mechanism comprises a 43 mm by 43 mm mild steel angle iron which is used for the fabrication of the frame, and attachment of an electric motor. The frame is a 43 mm long, 47 mm wide and 43 mm high angle iron, welded firmly together with electric arc welding machine using gauge 12 mild steel electrode. The frame was designed for high strength, rigidity and vibration resistance, it holds or supports the entire component of the machine. The Frame cover was made from stainless steel sheet of 1.5 mm thickness with 43 mm length and 43 mm width.

The test was carried out in the Faculty of Engineering and Technology Workshop, Oyo State College of Agriculture and Technology, Igboora. The electric power was supplied to the machine via electric motor and test run for five minutes so as to study the behavior of the machine. It was observed during this process that blade rotated without wobbling and malfunctioning.

The electric motor is attached with an 8 mm bolt to the side of the angle iron under the frame. The slicing unit comprises of the blade, and a connecting shaft. The blade is a removable 1.5 mm thick stainless steel sheet with a cutting knife bolted to it, and has a major diameter of 36 mm and a minor diameter of 20 mm, it was then divided into 12 equal parts like an ellipse and was further cut into 90 degrees to each other, bolted firmly to the connecting shaft as shown in Plate 2. Its basic function is to slice plantain, by reciprocation. The connecting shaft is machined into 25 mm diameter and it converts rotational motion from the electric motor to a reciprocating motion to power the blade. The sliced plantain is moved from the blade to the discharge tray. The discharge tray is the discharge point of the machine where sliced plantains are collected. It is made up of a stainless steel sheet

inclined at an angle of 30° to the horizontal such that sliced plantain falls by gravity to the collecting tray. The electric motor is the prime mover that supplied power to the shaft which is transferred to the blade. It is one phase motor rated 0.250 KW and a speed of 2700 rpm.

The plantain was peeled with a knife to remove its pericarp (outer cover). The peeled plantain was hand fed vertically into feeding chute through the hopper with the aid of a short wooden stick with a stopper, and the raw plantain was force into the cutter which slices it in the shortest possible time. In this case, it took 2-3 seconds, depending on the length, to slice a finger of raw plantain. During this process, sliced plantain (chips) passed through the discharged outlet.

Operation Principle

Power is transferred from the electric motor to the connecting shaft. The connecting shaft transmits power to the cutting blade. As the plantain is been fed through the feeding chute, the rotating blade slices it into the discharge tray and falls by gravity to a collecting vessel or tray placed beneath it. A sensor is placed in between the feeding chute and the cutting blade which operates the machine as soon as a plantain is fed into the feeding chute and cut off the power supply when the plantain finishes as shown in Figure 2.



Plate 1: Fabricated slicing machine



Plate 2: Blade assembly

Orthographic View of the Fabricated Machine

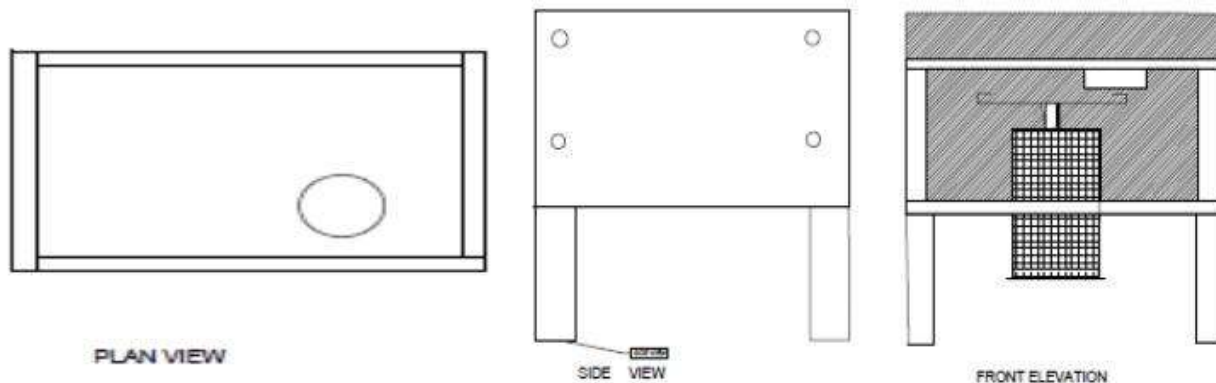


Figure. 1: The orthographic drawing of the machine

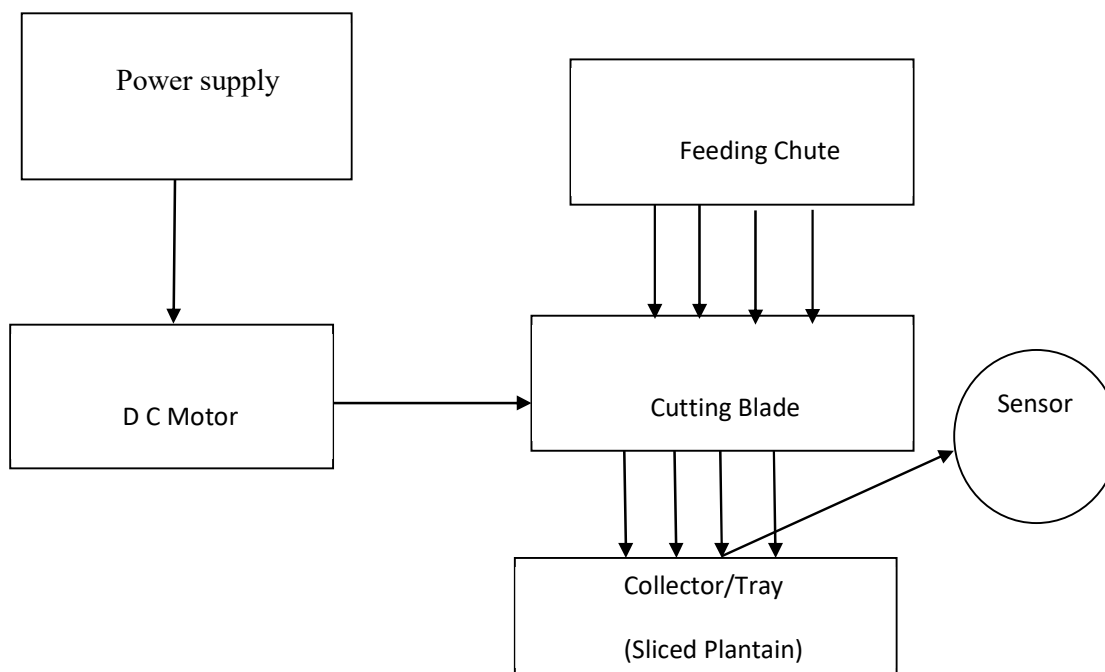


Figure 2: Design of a Sensor controlled Plantain slicing machine in block diagram

Results

With plantain slicer, the problems of safety, quality and quantity of sliced plantain associated with manual slicing and existing slicer has been eliminated. The plantain slicer is user friendly and does not require any special skill to operate. Tests were carried out to analyze its performance and output capacity. Results from these tests indicate a slicing efficiency of 73.8 % and 81.93 % for ripe and unripe plantain fingers respectively.

Efficiency

The machine was operated for 12minutes which gave a total of 1770 plantain chips. The machine was

designed to give an average of 12 slices in 3seconds. Thus, 10 minutes production time would give a total of 2400 plantain chips.

$$\text{Efficiency} = (1770/2400) \times 100 = 73.75\% = 73.8\%$$

The maximum efficiency of the machine was obtained at moderate cutter speed of 2900 rpm for both ripe and unripe plantain fingers. This meets the requirements of both medium and large scale plantain chip processing industries. The chip thicknesses, for both ripen and unripe plantain was found to be significantly uniform with a mean thickness of 2.00 mm. The efficiency of the machine for unripe plantain (81.93 %) was higher than that of a ripe plantain (73.80 %)



due to high moisture and damageable nature of ripen plantain slices.

In addition, the equipment is required to be properly maintained and kept clean to provide a more reliable and longer service life. This plantain slicer is recommended for small and medium scale production.

Conclusion

The plantain slicing machine in Plate 1 was designed to produce fine and neat slices of plantain. Moreover, the machine was found to consume less energy as compared to other machines hence reducing cost and maximizing profit. It also proves suitable in many different areas, such as, food processing industries. The slicer stops working when the sensor senses no plantain in the feeding chute and starts work as soon as plantain are fed into the feeding chute. The sensor sends signal to the electric motor then cut the power or starts the machine.

With the fabricated plantain slicer in Plate 1, the problems of safety, quality and quantity of sliced plantain associated with manual slicing and existing slicer has been eliminated. The plantain slicer is user friendly and does not require any special skill to operate.

Recommendation

Further work should be done to power the machine with solar.

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