International Conference of Science, Engineering & Environmental Technology (ICONSEET), 5(5): 37 – 44, 2020
ISSN 0794-9650

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Design, Fabrication and Performance Evaluation of a Low Cost Cassava Mash Sifter Machine for Rural Dweller

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Abstract - For proper and effective removal of oversized grain fractions of cassava mash, it is essential to sieve before garification. However, traditional methods of cassava mash sieving induces drudgery, fatigue, and time wastage during the processing. So, there is need to developed sifting machine to improve the efficiency and reduce drudgery. The present study is to design and fabricate modern cassava sifter in another dimension, view and style to support and improve the existing produced type. The fabricated cassava sifter consists of a cylinder container of diameter 300mm placed around sieving system with sieving screen diameter of 237.5m and shaft of 20mm diameter and mash breaker diameter of 8mm connected to the shaft, supported by a metal base of 412mm by 362.5mm which connected to the collecting system of 287.5mm by 187.5mm. To a sieving system of known content capacity, cassava mash was fed into it and was driven either clockwise or anticlockwise manually by hand. The breaker joined to the rotating shaft broke large content of the mash into pieces. Cassava mash was sieved through continuous driving of the sieving system while the fine grain will be coming out as the sieving operation continues through the collecting system. This design consists of sieving system, cylindrical container, carrying base, collector and hand drive as a prime mover. The sifter has been tested and its efficiency was discovered to be approximately 77% and its sieving rate is 0.043kg/s.

Keywords: Breaker, Cassava, Fabricate, Mash, Sifter

1.0 Introduction

Cassava (*Manihot esculenta Crantz*) is almost entirely produced and consumed in developing countries. It is highly productive, tolerant of poor soils, periods of drought and is relatively disease free and resistant to pest. It provides a major source of energy for over 500 million people world-wide (FAO, 2000). Cassava is diversified into different food products and these products are available all year round thus making cassava an important staple food for many rural households in Nigeria (Onabolu, 2001). Gari is the most common of the Cassava products in Africa (Oluwole et al., 2004). It is a creamy-white, granular flour made from fermented, gelatinized fresh cassava tubers with a slightly fermented flavour and a slightly sour taste (ARSO, 2012). Cassava is the most perishable of roots and tubers and may deteriorate within two to three days after harvesting and the major limitation of cassava is its rapid post-harvest physiological deterioration, which often begins within 24 hours after harvest, in the words of Adzimah and Gbadam (2009).

Moreover, the roots need to have the cyanogenic glucocides reduced to a level which is acceptable and safe for consumption, for this reason, Cassava is commonly sold in the form of gari, farinha, cassava bread, etc, as a processed food. Processing tasks include: peeling, washing, grating, fermentation, dewatering, sifting, frying, cooling and storage of gari. The resulting cassava mash, after peeling, washing, grating, fermentation and dewatering, is a conglomeration of particles bonded into a lump. Sieving is a necessary operation, it is not only reducing the lump into fine particles (undersize) which pass through the sieve, it separates the coarse unwanted particles (oversize) which are discarded after each batch of sieving.

Additionally, Sifting is a vital part of cassava processing and various designs have been made which have not sufficiently satisfied the customers. The manual method has its accompanying inconvenience to the person doing it because it entails the use of hand to scrub the mash against the sieve; therefore, a better way of alleviating all these inconvenience is to use a hand levered machine which reduces the drudgery of sieving.

The design of the sieving machine plays a vital role in producing “garri” from both unroasted and roasted cassava that has been processed in large quantities. In order to process and produce garri for human consumption, a modified form of garri sieving machine was designed and constructed using some suitable materials in order to remove the possibility of contaminating the garri which is common in the manual sieving method.

Olawale *et al* (2014) designed a sieving machine driven by pedal. The machine is used for sieving dewatered grated cassava. The mechanism of the machine is similar to that of the bicycle in which rotational motion is transmitted to the sieving machine from the pedal so that useful mechanical work can be done. However, human effort is required to drive the machine manually through the pedal.

Okegbile *et al* (2014) designed a pedal driven pulverizing and sieving machine for dewatered grated cassava. Most of the recent development in mechanizing the process of pulverization and sieving requires an electric motor powered by electricity. This source of power is becoming increasingly scarce and expensive in most developing countries. There is therefore the need to have a human driven machine that can be used for pulverization and sieving operation.

Ovat and Odey (2018). Developed and executed a motorized gari sieving machine with new features added, such as lumps breaker, aluminum sieving chamber to prevent corrosion and rusting, guardson running parts incorporated to ensure the safety of the operator and improve machine life and the use of link in place of Cams and Followers. The test result shows an overall efficiency of 78%.

Adetunji *et al* (2013) designed and developed another sifting machine. This machine runs on a single phase 1Hp electric motor at a speed of 1400 revolution per minute (rpm). The result obtained from the performance evaluation shows that it has a sieving efficiency of 92.5%. This shows an improvement in the performance of the machine when compared to previous machines developed.

However, Cassava processing thus deserves attention in order to meet the local and international demand for cassava products and the rate of producing fine grain products using traditional methods has become very low against increasing demand for fine grain products. Also, over reliance on imported cassava shifter machine is not economical and this has polarized and affected the income of farmer and those that invested in the business, this has gone in long way resulting in hike in price of garri and other cassava products; research efforts in this area have resulted in the production of several prototypes with relatively low sieving efficiencies and quality performance. Hence, in a bid to improve the quality of cassava shifter machine, efforts should be continuous in order to enhance better performance. This major reason among many others prompted emergence of this study. The main objective of this research work is to design modern cassava sifter in another dimension, view and style to support and improve productivity.

2.0 Materials and Methods

The design of cassava mash sifter requires a careful consideration of the choice of materials to be used. The materials used for each part were selected based on the physical and chemical properties of the cassava mash to be sifted, machinability of the material, corrosion resistance and cost.

2.1 List of materials used for the Fabrication

The materials used in the fabrication of cassava mash shifting machine include but not limited to mild steel plate, galvanized steel plate, mild steel angle iron, mild steel flat bar, mild steel pipe, steel iron rod, steel plate, stainless screen, ball bearing. Some of the major components of the designed cassava mash shifter machine are cassava lump breaking and sieving machine which consist mainly of the following components namely main frame, lump breaking pot, sieving chamber, discharge outlet, pulleys, shaft etc. Some of these items are described below;

- Main frame: This is the main unit of the machine on which every other components of the machine are supported. It is fabricated with high strength material that will withstand vibration. Mild steel angle rod is selected. It is to be welded together to make for rigidity.
- Lump breaker: This comprises of the driving shaft, spikes and spikes holder. It is designed with the use of a 20mm mild steel shaft. 10mm mild steel rod is welded on the shaft to serve as spikes that will provide the whirling effect. They are all contained in a pot casted with Stainless to prevent corrosion.
- Sieving chamber: The sieving chamber is designed with stainless steel to prevent corrosion and subsequent rusting of the sieving chamber. It is a circle trough of considerable depth to prevent spilling. It is casted and holes are drilled on it.

2.2 Principle of Operation

To a sieving system of known content capacity, cassava mash was fed into it and was driven either clockwise or anticlockwise manually by hand. The breaker joined to the rotating shaft broke large content of the mash into pieces. Cassava mash was sieved through continuous driving of the sieving system while the fine grain will be coming out as the sieving operation continues through the collecting system

2.3 Description of the Machine

Cassava sifter consist of a cylinder container of diameter 300mm placed around sieving system with sieving screen diameter of 237.5m, shaft of 20mm diameter and mash breaker diameter of 8mm connected to the shaft, supported by a metal base of 412mm by 362.5mm which connected to the collecting system of 287.5mm by 187.5mm.

2.4 Fabrication Procedures

(1) The angle iron was cut into various dimension of 412.5mm, 375mm and 362.5mm and joined together for welding.

(2) Mild steel of 412.5mm by 375mm was marked for covering of the base and sitting of the sieving mechanism.

(3) To determine the diameter of the cylinder container of diameter 300mm, the area was calculated by using $A = \pi d^2/4$ and, 943mm by 275.5 mm was marked and taken it to rolling machine and rolled it to shaped and area of the sieving system was also calculated and Iron rod of 8mm was used to support it for its housing

(4) The mild steel of 412.5mm and 375mm for covering and dropping of the fine grains was centered point and punched at different point and taken to drilling machine in order to drill and bore it for dropping of fine grains into collecting system.

(5) Mash breaker was joined to the rotating shaft also the sieving system, furthermore, piece of flat bar was also joined to the edges of the sieving system for balancing the rotating of the system when driven.

(6) Galvanized plate was marked out to make out the collecting system.

(7) Hand prime mover was made to the shaft to drive the mechanism for operation and as the sieving system moves in direction of either clockwise or anticlockwise, the fine grains continues to come out from the collecting system.

2.5 Design Analysis

a. Calculation on Supporting Base

The weight of the cylindrical container is 15kg =147.15N
The machine diagram represents by calculating the reaction

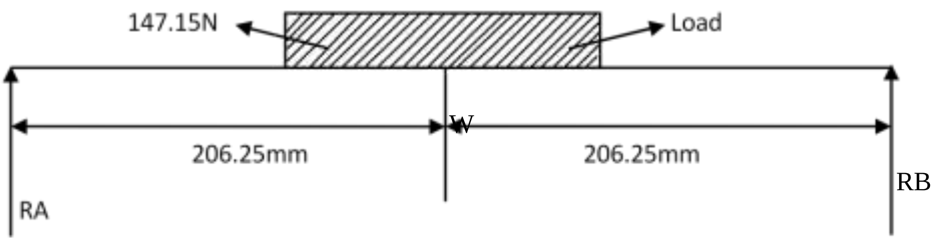

Figure 1: Diagram Represents Calculation of Reaction

b. Calculation for the Cylinder Container

Volume of a cylinder = $\pi r^2 l$.

Where r = radius (mm), L = length (mm) and the volume is $17.44m^3$

The Output Capacity (Kg/Hr)

Where the total mass of cassava mash is 0.74kg and total time taken is 181seconds, $Qc = \frac{totalcassavamash}{totaltimetaken} = \frac{0.74\ X\ 3600}{181}$

= 14.71kg/hr$\simeq 15kg/hr$

c. Calculation for Power

$Power = \frac{Workdone}{Time}$, Work done = F x S, Where F = mg, F = 7.259N, Where S = displacement,

W = 2.177J

To calculate $for\ Power$

$$P = \frac{workdone}{timetaken} = \frac{2.177}{181} = 0.012\ joules/S$$

d. Calculation for Torque

$$T = \frac{60\ x\ P}{2\pi N}\ (Gupter\ \&\ \text{Khurmi 2005})$$

$T = 114.87Nm$

Where N = Speed of driven pulley and P = Designed power

e. Calculation for the Efficiency

$Efficiency = \frac{totalmassofthegrains}{totamassofcssavamash} X\ 100 = 77.027\%$

$Efficiency\ \eta$ = 77%

Plate 1: Completed Cassava Shifting Machine

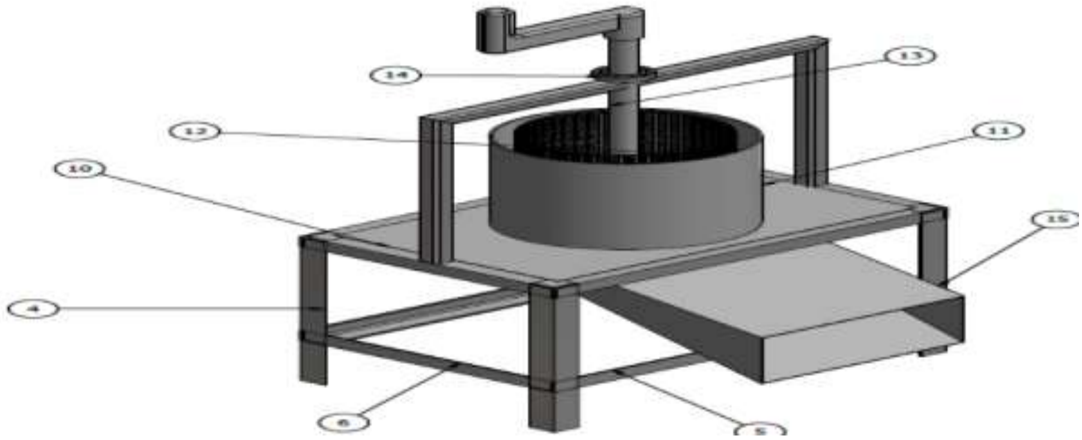

Figure 2: Cad Drawing of the Cassava Sifting Machine

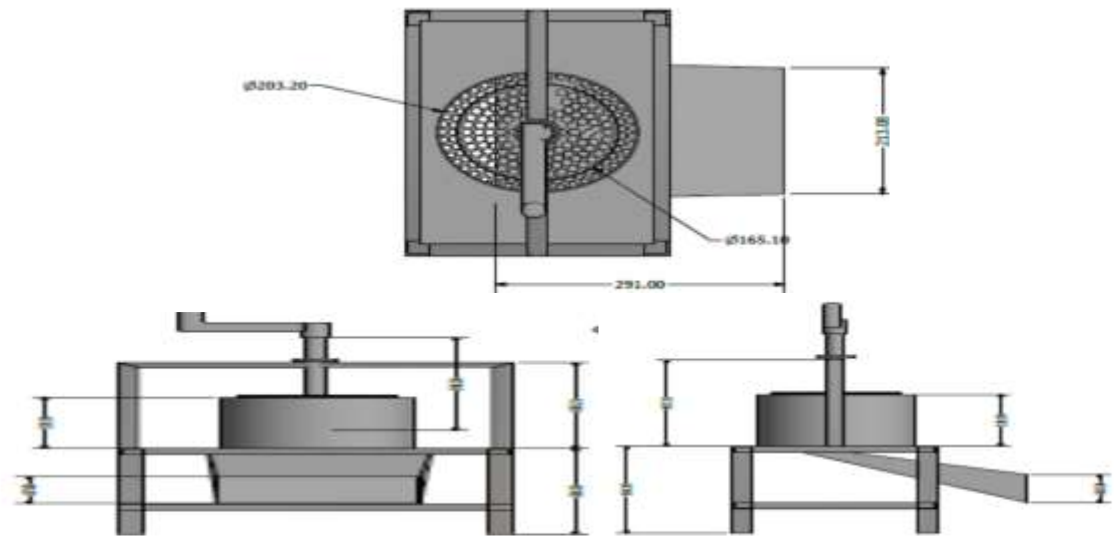

Figure 3: Orthographic Projections of the Cassava Sifting Machine

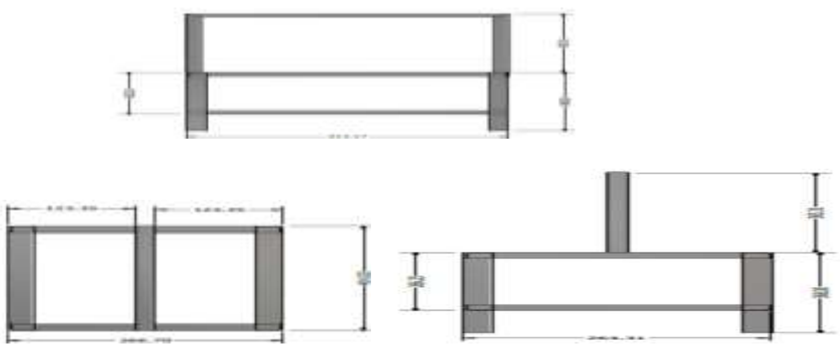

Figure 4: Working Drawing of the Cassava Sifting Machine

3.0 Results and Discussion

3.1 Test and Measurement

The cassava sifter was tested with a total cassava mash of 0.74kg in five operations, the various operations are; 0.05kg, 0.09kg, 0.15kg, 0.20kg, 0.25kg respectively. Each load was measured on a scale to determine each mass before performing the operation. Therefore, the mass of the fine grain was determined by the difference in mass of cassava mash and mass of the cassava coarse. And time of sieving was taken for each operation.

3.2 Result Performed by the Sifter shown below

At the completion of the fabrication and assemblage of the gari sieving machine, it was exposed to various tests and the results attained are tabulated below.

Table 1: Result Performance

Samples	Mass of cassava mash (kg)	Mass of fine grains(kg)	Mass of coarse (kg)	Time (s)	Sieving rate (kg/s)
1	0.050	0.030	0.020	18	0.067
2	0.090	0.065	0.025	25	0.038
3	0.150	0.105	0.045	37	0.043
4	0.200	0.160	0.040	45	0.025
5	0.250	0.210	0.040	54	0.019
Total	0.740	0.570	0.170	181	0.192

Table 1 shows the result of the different test samples according to the time taken for the sieving to be completed, the initial mass of the sample, the mass of fine grains, mass of coarse and the sieving rate of the machine at each given sample. The average values of the above parameters were calculated as shown. Summary of the tested samples on average basis shows that 0.15kg of gari sieved left a residue of 0.045kg. This indicated that 0.105kg of the sample was completely sieved out of the 0.15kg average mass. The average time taken for the sieving of the 0.15kg of the gari was 37 seconds which means that, the sieving rate of the machine is 0.043kg/s.

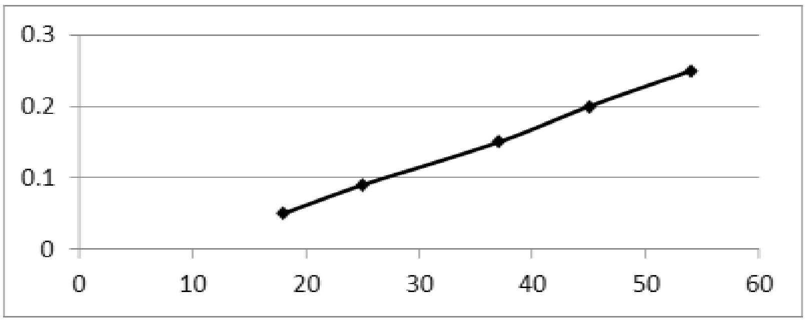

Figure 5: Graph of mass of cassava mash (kg) and time taken (sec)

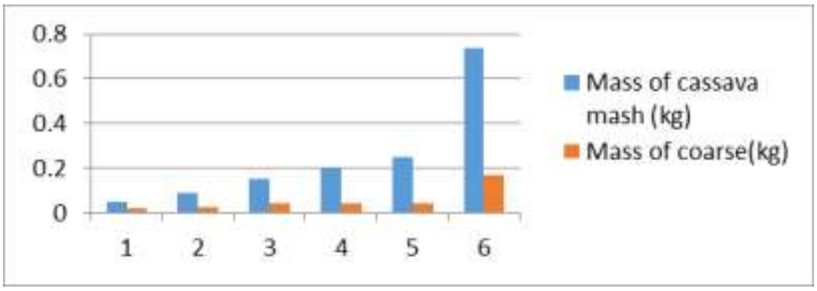

Figure 6: Graph of mass of cassava mash (kg) and mass of coarse (kg)

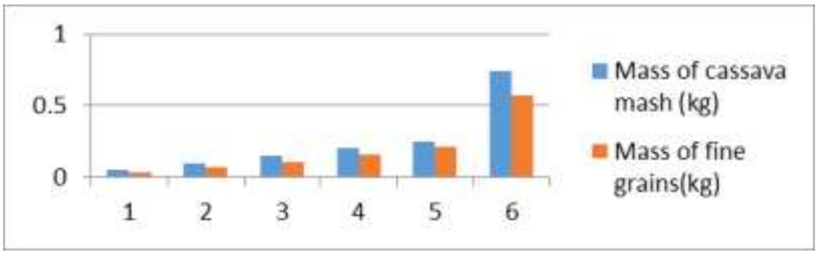

Figure 7: Graph of mass of cassava mash (kg) and mass of fine grains (kg)

Plate 2a: Sample of Cassava Mash before Sifting

Plate 2b: Sample of Sieved Cassava Mash

Plate 2c: Sample Collected from the Sieved Residue Outlet

4.0 Conclusion and Recommendations

Conclusion

This design consists of sieving system, cylindrical container, carrying base, collector and hand drive as a prime mover. The sifter has been tested and its efficiency was discovered to be approximately 77%. This is highly acceptable based on design from literature.

Recommendations

The following are recommended;

1. Prime mover such as electric motor or petrol engine can be added to the sifter to eliminate stress taken in production.
2. Further research should be made to further improve the efficiency of this machine, its affordability and compatibility.

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