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Full Length Paper

Performance Analysis of a Fabricated Multi- Purpose Hammer Milling Machine

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Abstract

The performance analysis of a multi-purpose Hammer milling machine was carried out on a fabricated milling machine. This research became very necessary as a result of increase in agricultural activities in the country, which has led to high rise in local demand of animal and human feeds like - Millet, dried maize, cassava and plantain to flour for human consumption as widely used in Nigeria. The machine can also be used for grinding poultry and fish feeds. The hammer mill after testing was found to have an efficiency of 93.4%, it is dust free and has self-cleaning mechanism. As a result of proper air circulation in the chamber, there is no effect on the content and no excessive heat generated during milling process. The machine after testing functioned optimally. The power rating of the electric motor is 5.5kw and the speed was observed to be constant at 2000rpm. The machine was used to grind dry grains, dry vegetable, dry yam, and dry cassava into different grate in powdery form for human consumption in form of flakes. Animal feeds are also produced using the machine. This is achieved by changing the sieve to control the particle size. The machine is easy to operate and has a simple maintenance procedure that can easily be carried out by an unskilled person.

Keywords: Hammer mill, performance analysis, electric motor.

1.0 INTRODUCTION

A multi-purpose Hammer milling machine was constructed from locally source material, as presented in Figure 1. The construction process was carried out at the Department of Mechanical Engineering of the Petroleum Training Institute Effurun, Nigeria. The component part is made up of the following major parts, Casing, shaft and beaters, sieve, blower, chute, cyclone, feed hopper, Base, and electric motor. When tested empty it works perfectly as expected. The testing was done using different dry food products that it was intended to handle like, maize, millet, wheat, dry-tubers of cassava and yam, pepper, dry vegetables and animal feeds. It works as expected. The machine is very useful to people of northern Nigeria as most of their food ingredients are dry and are grind before preparation. After the test with the above product the result was satisfactory and readings were recorded and tabulated. To guard against quick deterioration for optimum efficiency of the machine to meet the anticipated expected life span. The machine should be maintenance to avoid break down or reduction in production downtime, minimize expensive maintenance cost and ensure prompt delivery of products to customers. The maintenance required on this machine is daily cleaning and lubrication of the bearings.

2.0 REVIEW OF LITERATURE

Hammer mills are specially designed for grinding grains into powder by impact [1]. The system is designed such that there is a hopper solution where the materials are channeled into a packing hopper which is usually at the top of the hammer mill, the inflow is usually controlled with the help of a small gate which is designed to allow available grains enter into the grinding chamber

[2]. Grains are normally fed into the hammer's path via the front plate, but they can also be fed via the cover plate. The hammers also have an effect on the grains, which are crushed to allow them to move through the open screen underneath the hammers. The powdery type of the materials comes in the form of powders after this phase, and the flour formed falls either by gravity into the chamber or outlet hopper below, or is forced into a collecting bowl by air flow velocity created by rotating hammers and blade [4]. The hammers and the blender blades mounted on the main shaft generate airflow fan effect within the grinding chamber [5]. Generally, hammer mills parts include a large cylindrical chamber, the main shaft on which several rows of free-swinging hammers blades are installed at one end and at the other a pulley drives powered by a prime mover (electric motor /generator). The hammers revolve in the grinding chamber underlain with perforated metal screen through which the flour is collected. It has been known that the mill's speed must be proportional to its size, as small mills rotate at a faster rate than larger mills. Some hammer mills have cylindrical screens, but most modern designs have screens that cover the lower periphery, such as half of the grinding chamber or less, allowing for fast screen replacement [6-8]. Short shafts with beater bars are inserted between pitch circles of two plates on which the grains are impacted [9] the plate mill was one of the first mechanical mills to be built, and it is still widely used in West Africa, especially in Nigeria. Its operating system has a shear feature rather than a compression component. The main components of this mill are two circular cast iron plates, one fixed and the other rotating, mounted to face each other with an adjustable narrow gap in between [10].

When in contact, the plates are splined on one face to grind by shear mechanism by friction. The grains pouring into the mill's center are sheared by frictional force between the grooves of the two spinning plates. The grooves become narrower as the grains pass closer to the plate edges [11]. As a result, the grooves of the plates, which are similar to the old style fabricated for stone mills, minimize the grain sizes. The diameters of the plates vary and they are normally aligned vertically, but in mills powered by a diesel engine, it is more convenient to align them horizontally. Plate mills run at a standard speed of 2500 to 3500 rpm, but the friction between the plates and overheating reduces the speed of the mill accordingly [12].

3.0 MATERIALS AND METHODS

Specification of the locally fabricated multi-purpose hammer milling machine
1. Number of beaters 14 2. Length of the beaters 140mm 3. Clearance from sieve 40mm
4. Hole size of sieve 3mm 5. Sieve width 230mm 6. Diameter of rotor with beaters 178mm
7. Maximum rotor speed 1740 (rpm) 8. Collection tank (cylone) size

Figure 1: A Multi-Purpose Hammer Milling Machine.

3.1 Operation of the System

The testing operation of the hammer milling machine start with weighing (kg) the material to be grind and record the readings, start the machine before feeding it into the hoper. The material enters the machine grinding zone through a gravity feed slide hopper to control the feed material, the component is crushed between the hammers and passes through the sieve. The milled material continuously sucked by a powerful blower and conveyed through a pipe into the cyclone for bagging. The blower maintains a constant air flow in the mill chamber, because of which the product being crushed remains cool and the sieve remains cleans, thus increasing the output. Particle size of the milled material can be varied over a large range by using the sieve at the appropriate openings. While grinding time taken to grind dry cassava, maize and dry plantain was recorded. After the grinding the product was weight again and recorded to ascertain the difference in weight and losses calculated, then histograms of weight of product input, output, and time taken was plotted and the average efficiency of the machine determined.

4. PERFORMANCE TEST

Testing is a vital step in the process of machine development. After the design and construction, testing is necessary in order to determine the performance of the machine and expose defect for further work possible improvement. The machine was test run to determine its workability and efficiency. Instruments used are; Stop watch, weighing scale and sack.

4.1. Test 1: Using dry cassava Tuber.

An average weight of 5kg of dry cassava was fed into the hopper and the hammer mill was switched on. The milling time was noted. This was repeated for five times and averages was calculated. The same procedure was repeated using an average weight of 5kg of dry maize and plantain, it was milled to fine power.

Table 1: Milling test results for dry cassava (cassava flour)

Test S/N	Weigh of cassava Before milling (kg)	weight of cassava four after milling(kg)	Time (min)	Losses (kg)	Percentage output efficiency by weight (%)	Percentage Losses by weight (%)
1	5	4.7	15	0.06	94	6
2	4	3.7	13	0.075	92.5	7.5
3	5	4.7	15	0.06	94	6
4	5	4.7	14	0.06	94	6
5	4	3.7	12	0.075	92.5	7.5
Average	4.6	4.3	13	0.066	93.4	6.6

After milling an average input of 4.6kg of dry cassava there is there an average output of 4.29kg which is 93.4% and an average loss of 0.30kg this is equivalent to 6.6% as depicted in table 1.

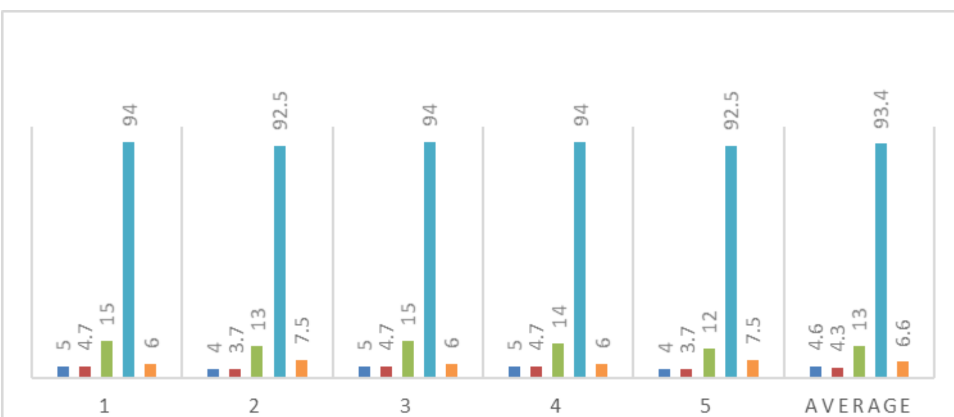

Figure 2:.Histogram of results in table 1.

For input number 1 of 5kg (left), output of 4.7kg (middle in maroon), time taken to mill 15(min), efficiency at 94% and losses of 6% for dry cassava. This was done for input 2 to5 and the average taken as shown in figure 2.

Average efficiency = 93.4%, Average output = 93.4% of 4.6 = 4.29kg, Average loss = 6.6%

Average loss = 6.6% of 4.6 = 0.30kg

Test 3 **2a:** Milling of Maize

Table 2a: Milling test results for dried maize (maize flour).

Test S/N	weight of maize before milling (kg)	weight of maize four after milling (kg)	Time (min)	Losses (kg)	Percentage output efficiency by weight (%)	Percentage losses by weight (%)
1	6	5.1	17	0.15	85	15
2	5	4.7	14	0.06	94	6
3	4	3.8	12	0.05	95	5
4	5	4.8	15	0.04	96	4
5	5	4.7	15	0.06	94	6
Average	5	4.62	14.6	0.072	92.8	7.2

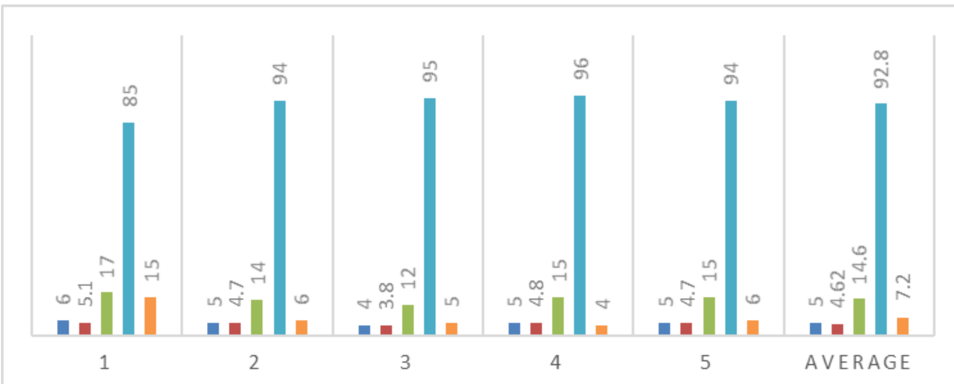

Figure 3.2a: Histogram of results in table 3.2a.

An input 6kg, output 5.1kg and average time taken 17mins, efficiency85%, losses (15%). For maize test 1 to 5 and the averages are shown in fig.3.2a.

After the first milling the smoothness of the flour is not enough as maize is hard, so it need to be recycle for re-milling and the initial output is now retuned into the hoper for re milling. Table 3.2b.

Test 2b. Re-milling of maize.

Table 3.2b: Re-milling test results for maize

Test S/N	weight of maize flour before recycling (kg)	weight of maize flour after recycling (kg)	Time (min)	Losses (kg)	Percentage output efficiency by weight (%)	Percentage losses by weight (%)
1	5.1	4.9	16	0.04	96	4
2	4.7	4.4	13	0.06	94	6
3	3.8	3.5	10	0.08	92	8
4	4.8	4.6	13	0.04	96	4
5	4.7	4.5	13	0.04	96	4
Average	4.62	4.38	13	0.052	94.8	5.2

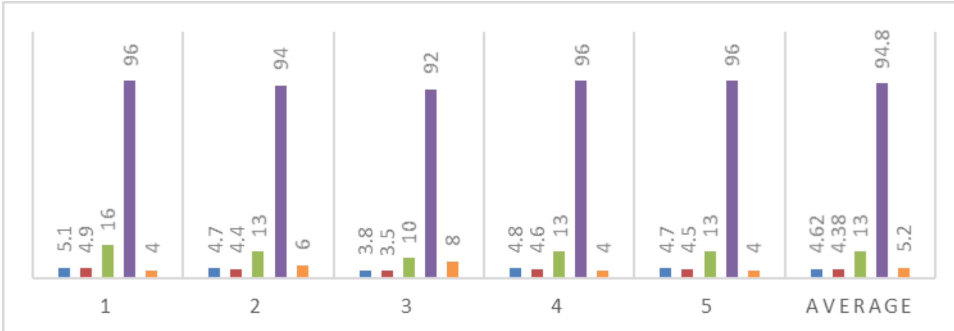

Figure 3.2b: Histogram of re-milling table 3.2b.

The average input was 4.62kg, output 4.38kg and the time taken was 13mins, losses further (5.2%) average during the re-milling (maize) test 1 to 5 is shown in fig.3.2b. Average efficiency in first milling plus efficiency in re-milling = 92.8 + 94.8/2 = 93.8%. Average input = 5 + 4.62/2 = 4.81kg. Average output = 93.8% of 4.81 = 4.511kg. Average losses = first milling loss + re-milling loss = 7.2 + 5.2/2 = 6.2%. Average percentage loss = 6.2% of 4.81 = 0.298kg.

Test 3: Using dry Plantain

Table 3:3 Milling test results for dry plantain (Amala flour)

Test S/N	weight of plantain before milling (kg)	weight of plantain four after milling (kg)	Time (min)	Losses (kg)	Percentage output efficiency by weight (%)	Percentage Losses by weight (%)
1	5	4.6	14	0.08	92	8
2	5	4.8	15	0.04	96	4
3	4	3.7	13	0.075	92.5	7.5
4	5	4.6	14	0.08	92	8
5	4	3.7	12	0.075	92.5	7.5
Average	4.6	4.28	13.6	0.07	93	7

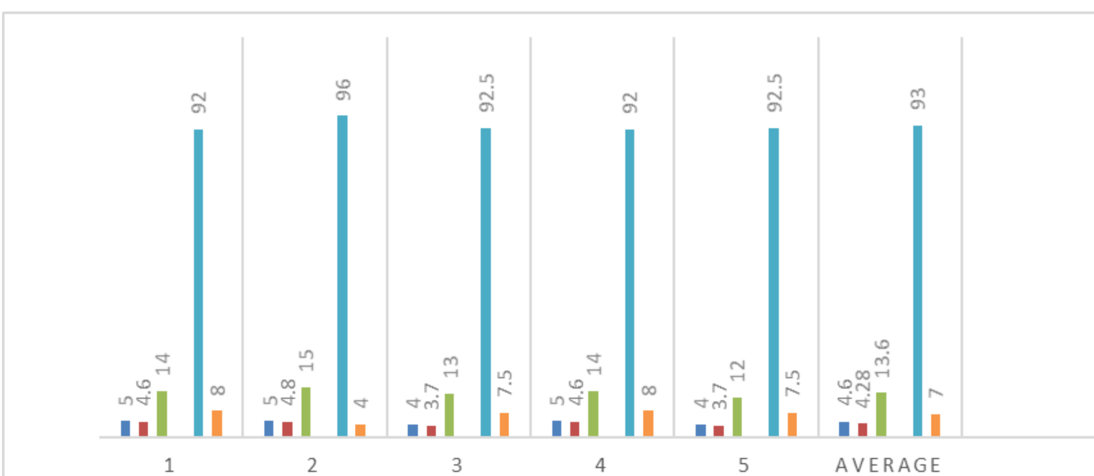

Figure 3.3 Histogram showing result of table 3.3.

For input one =5kg, output = 4.6kg, Time =14minutes, losses = 8%, efficiency 92%. And the averages are as depicted in fig.3.3 for test 1 to 5.

From test 1, 2, and 3 the average overall milling efficiency was calculated to be, 93 +94.8+93.4/3 = 93.4% and the average overall losses are 7+5.2+6.6/3 = 6.2%.

5.0 CONCLUSION

This research was conducted to support agricultural practices in Nigeria, and very useful during post harvesting of agricultural products. The research dwell on the performance analysis of a multi-purpose Hammer milling machine was carried out on a fabricated milling machine. Due to the increase in agricultural activities in the country the local demand of animal and human feeds like; Millet, dried maize, cassava and others. The test was carried out with; 5kg of dried cassava, 5kg of dried Plantain and 6kg of dry Maize. The machine operating at the same speed of 2000RPM. From the result obtained using the various products during the test. The machine, construction was a success as it was observed that the machine has an average efficiency of more than 93%, with an average loss of only 6.2% for the three products tested. The multi-purpose hammer milling machine fabrication was successful. It is useful in human and animal food processing small scale industries.

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