Performance Evaluation of Disc Attrition Mill

BY:

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CERTIFICATION

This is to certify that this project title, **Performance Evaluation of Disc Attrition Mill** Submitted by **Ajao Faruk Babatunde** with Matric number **ND/23/ABE/FT/0003** was carried out under my Supervision at the Department of Agricultural and Bio-environmental Engineering Technology, Institute of Technology, Kwara State Polytechnic, Ilorin. This Project report has been read and approved having met the requirement for the award of National Diploma (ND) in Agricultural and Bio-environmental Engineering Technology.

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DEDICATION

This project is dedicated to Almighty the most Beneficient, the Most merciful.

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ABSTRACT

The attrition mill developed in the department was evaluated using grains as a sample. The evaluation was carried out at various moisture content of the grains used. Evaluation was carried out at both dry and wet grinding basis. The purpose of this study was to evaluate the performance of a multi-crop size reduction machine, specifically an attrition mill, for use in agricultural applications. The machine was tested on various crops, including maize, wheat, and sorghum, millet to determine its efficiency in reducing particle size. The result obtained showed that the machine perform and operate well at low moisture content for dry grinding. The highest average efficiency of the machine was 60% at 10% moisture content and lowest at 11% moisture content. The feed rate used to test the fabricated machine do not show any significant variation on the machine efficiency. Base on the impressive performance of the attrition mill developed at 60% and evaluated. The study highly recommended this crop size reduction machine to small, medium and large scale crop processors in Nigeria especially those at rural area where crop processing is still a major problems facing the rural farmers. The results of the study showed that the attrition mill was highly effective in reducing particle size across all crops tested, with an average particle size reduction of 75%. The machine was able to achieve this level of reduction while maintaining a high throughput rate, making it a viable option for large-scale agricultural operations. In addition to its effectiveness in reducing particle size, the attrition mill was also found to be highly efficient in terms of energy consumption. The study found that the machine consumed significantly less energy than other size reduction equipments, making it a more sustainable option for crop producers and processors. Overall, the results of this study shows that the multi-crop size reduction machine, attrition mill, is highly effective and efficient option for reducing particle size in various agricultural applications. Further research is recommended to determine its operation with Tractor P.T.O power sources. The study recommended the use of high quality locally available materials for this kind of machine design to allowed durability in its usage. Further study of this machine is highly recommended.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Back ground to the study

Grains are small hard, dry or wet seeds with or without its fruit layers, harvested for human or animal consumption (Bab cock, 1976). The two main types of commercial Grain crops are cereals such as mated sorghum millet wheat and rice, and legumes such as cow peas groundnut and soya beans, After being harvested, dry grains are more durable than other staple food such as starchy fruits (Plantains, bread fruits, e.tc.) and tubers (sweet, potatoes, cassava, e.t.c.). Hence this durability has made grains well suited to industrial agriculture since they can be harvested transported and stored for long periods of time. Grain size reduction occurs by the grinding of maize, beans, melon, millet sorghum and other grains crops. Traditionally, in some parts of the world till date size reduction of grans is accomplished by grinding the grain between two stones. The oldest known grain size reduction equipment are saddler stones (Williams and Rosentrater 2007) These stones were used to crush the grain and produce cease flour (Thomas and Fiippov 1999).

According to cupid (1992), grinding of grains has been in practiced for long when a pestle and a mortar was introduced for grain size reduction. Brain and rotter (2006) reported that in the mid nineteenth century gran size reduction machines were invented began to replace traditional stone grinders.

According to Brenna, (2002) the various types of size reduction machines are crushers' grinders and cutting machines. These machines comprise essentially of an electric motor or prime, mover, belt pulley transmission shaft, hopper, mills, spiral conveyor and stands. Machine like crushers are used for coarse reduction. These machines are operated by compression and can break large lumps of very hard materials grains. Grinders are described as a variety of size reduction machines for intermediate duty. The products obtained from a crusher are often fed to a grinder to reduce the particle to powder. The common types of grinders are hammer mills, rolling compression machines, attrition mills and tumbling mills.

In layman's language, processing refers to the act of converting any material from one from to another i. e raw material to finished product in agriculture, crop processing -machinery is used to trans from grains and other produce from their raw from to the refined and edible from, These machines do not only reduce or saved time of operation but also saves the labour cost, it has been observed that grains tend to last from season to season hence we can't digest them raw. Grains must be flaked, grounded or popped before being consumed. And with the use of size reduction machines crop processing, it reduces the quantity of the wastage to a greater level (Brain and Rottger, 2006). One of the major type of processed grain that is widely wed in our present society is flour is a powder made by grinding uncooked cereal grains. It is the main ingredients of bread which is a staple for many cultures. Wheat flour is one of the most important ingredients in Nigeria and other various North African culture it is defining ingredients in their styles of breed and pastries. Size reduction machines to be easier compared to traditional method of size reduction and as well alleviate the problem we encounter when reducing the size of grains (Akinyetun, 2018).

1.2 Problem statement

Size reduction of grains is one of the oldest cultural techniques of humanity. There are two different traditional techniques used in effecting size reduction of grains. The size reduction done by pounding the grains using motor and pestle and the size reduction done by grinding the grains between two stones (grinding stones). The method of pestle and mortar is widely used in West African country. The use of size reduction machine is one of the simplest moods of processing grains processing to the traditional methods of grains processing using stone mortar and pestle which is tedious and time work using mortar and pestle is demanding and thing and the use of grinding stone is very laborious. To solve this problem a machine is needed that can perform the giving operation within a short period of time with little effort it is affordable by average indigenous farmers in grain processing, sector. This evaluating the performance of this machine become necessary in view of its application.

i. Carryout performance evaluation of multi-crop size reduction machine in terms of grinding efficiency.

ii. Determine the milling efficiency of the machine for both dry and wet grinding.

iii. Determine the milling capacity of the machine in (kg/min) for both wet and dry grinding.

1.4 Justification of the study

The design and evaluating grains size reduction machine will be efficient and will facilitate speedy grinding of grains and other food crop classes. It can be affordable by farmers which will enhance production on a large scale and to improve the economic and the country as a whole by neglecting imported size reduction machine of grains

1.5 Scope of the study

This research limits its study on the evaluation of the performances of the machine on the grinding of grains. This study aimed to determine the grinding efficiency and capacity using individual cereal crops

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Size reduction operation

The general term "size reduction" includes cutting, crushing slicking and grinding or milling. The reduction in size is brought about by mechanical means without change in chemical properties of the material. The processes such as cutting of fruits or vegetables for canning, shredding sweat potatoes for drying, grinding grains for livestock feed, and milling are classified under size reduction and can be achieved through the use of a size reduction machine. According to Orhorhoro et al. (2016), size reduction machines are used to reduce the size and shape of materials to be used efficiently for the purpose intended for.

During early civilization, grinding of food grains was dominantly practiced by women, it was carried out mainly in two fashions;

i. By pounding the grains using mortar and pestle

ii. By grinding the grains between two grinding stones

The pestle and mortar are widely use in the West-Africa sub-region. The traditional grinding stones used to grind whole or decorticated grains into flour, primarily consists of a flat large stone which is placed on the ground and a smaller stone held by the person to perform grinding, by smashing grains between the two stones (Okafor, 2014). The operating principle of size reduction machine is by holding the material between two parallel to tangent solid surfaces and sufficient force is apply to the surfaces together to generate enough energy within the material been reduced (Orhorhoro et al., 2016). By so doing, the grains are reduced into smaller sizes and shapes.

2.2 Size reduction machines

According to Brenna et al., (2002), the various types of size reduction machines are crushers, grinders and cutting machines. The various types of sizes reduction machines are:

a. Crushers such as jaw crushers, gyratory crushers and crushing rolls or smooth-roll crushers

b. Grinding machine such as hammer mills, roller compression mills, attrition mills and revolving mills

c. Cutting machines such as knife cutter

These machines work in distinctly different ways. Crushers works on the principle of slow compression action while grinders employ impact and attrition, sometimes combined with compression. A cutting action is characteristics of cutlers, dices, and slitters.

2.3 Performance evaluation of size reduction machines

2.3.1 Crushing machines

For large quantities of solids, the low speed machine like crushers are used for course reduction. The common types are jaw crushes, gyratory crushers, smooth-roll machines are operate by compression and can break large lumps of very hard materials, as in the primary and secondary reduction of very hard materials

2.3.1.1 Jaw crushers

In a jaw crusher, feed is admitted between two jaws. These two jaws are set to form a "V shape opening at the top. One jaw is fixed or anvil, which is nearly vertical and does not move and the other is swinging jaw, reciprocates in a horizontal plane. The swinging jaw makes an angle of 20° to 30° with the fixed jaw and driven by an eccentric unit, thereby produce compressive force to lumps caught between the jaws. After required reduction they drop out the bottom of the machine. The jaws open and close 250 to 400 times per minute (Hle Cabe et al., 2003).

2.3.1.2 Gyratory crushers

In a gyratory crusher, jaws between in which the feed is admitted is circular jaws. The materials are being crushed at some point at all times in gyratory crusher. It consists of a funnel shaped casing, open at the top and a conical crushing head gyrates inside the casing. An eccentric unit drives the bottom end of the shaft which gyrates the crushing head. Therefore, the bottom of the crushing heads moves toward, and then away from the stationary walls. Solids are caught in the V-shaped between the head and the casing and are repeatedly broken until they pass from the discharge. The crushing head is free to rotate on the shaft and turns slowly because of friction with the materials being crushed. The speed of the crushing head is in range of 125 to 425 gyrations per minute. The discharge 125 to 425 gyrations per minute. The discharge from a gyratory crusher is continues instead of intermittent as in jaw crusher (Brennan et al., 2002).

2.3.1.3 **Smooth-roll crushers:** Two heavy smooth-faced metal rolls rotating on parallel horizontal axes are the working elements of the smooth-roll crusher. The rolls rotate toward each other at the same speed. Feed materials are caught between the rolls and broken in compression and then drop out below. The rolls have relatively narrow faces and are large in diameter, so that these can "nip" moderately large lumps. Typical rolls are 600mm in diameter with a 300mm face to 2000mm in diameter with a 914mm face speed of the roll range from 50 to 300.pm. Smooth-roll crushers are secondary crushers, with feeds 12 to 75mm in size and products 12 to 1mm

2.3.2 **Grinding machines**

The term grinder describes a variety of size reduction machines for inter mediate duty. The product obtained from a crusher is often fed to a grinder to further reduces the particles to powder or fitness. The common types of grinders are hammer mills, rolling-compression machines, attrition mills and tumbling mills.

2.3.2.1 **Hammer mills:** These mills consists of a high-speed motor rotating inside a cylindrical casing. The shaft is usually kept horizontal. Feed is admitted to the mill from the top of the casing. Materials are broken and fall out through a screen at bottom. The materials are broken by sets of swinging hammers attached to a motor disk. A particle of feed entering into grinding zone cannot escape being struck by the hammers. It make into pieces which fly against a stationary anvil plate inside the casing and break into smaller fragments. These in turn are rubbed into powder by the hammers and pushed through a screen that covers the discharge opening (Lowrison, 1990).

2.3.2.2 **Rolling-compression machines**:- In such mill the feed material are caught and crushed between a roller member and the face of a grinding ring or casing. The most common types are roiling-ring pulverizes, bowl mills and rollers mills. In the roller mill, cylindrical rollers are vertical which press outward with a huge force against a stationary anvil ring or bull ring (Harriott, 2001). They are driven at medium speeds in a circular motion. Plows takes the materials from the floor of the mill and put them between the ring and the rolls, where the size reduction takes place. Product is taken out of the mill by a stream of air to a classified separator, ator, from which oversize materials are returned to the mill for further reduction. In a bowl mill and some roller mills the bowl or ring is driven; the rollers rotate on stationary axes, which may be vertical or horizontal.

2.3.2.3 **Attrition mills:-** In attrition mills materials of soft solids are rubbed between the grooved flat faces of rotating circular disks. These mills are also known as burr or plate mills. The axis of the discs may be horizontal or vertical. In a single-runner mill one disk plate is stationary while other rotates and in a double-runner machine both disks rotate at high speed in opposite directions. Feed materials are admitted through an opening in the - hub of one of the disks and it passes outward through the narrow gap between the disks and the discharge from the periphery into a stationery casing.

The width of the gap is adjustable, within limits. One grinding plate is mounted with spring so that the disks can separate if unbreakable materials gets into the mill. Single runner mills consists of buhr stone for breaking solids, double-runner mills are used to process softer feeds and grind to finer products than single-runner mills. Air is often drawn through the mills to remove the product and prevent choking. The diameter of disks in a single-runner mill is 250 to 1400mm, rotating at 350 to 700.pm disk in double-runner mills rotate at about 1200 to 7000.pm Attrition grinds from ½ to 8ton/h to products that will pass a 200-mesh screen. The power requirements depends on the property of the feed and the degree of size reduction accomplished and is much higher as comparable to other mills and crushers (Loncin and Merson, 2004). In general, power requirement is between 8 and 80kwh per ton of product.

2.3.2.4 **Revolving mills:-** Revolving mill is also known as tumbling mill. It contains a cylindrical shell, which rotate lowly about a horizontal axis and filled to about half its volume with a solid grinding medium. The shell is usually made up of steel line with high carbon steel plate. In tumbling mills feed may be admitted in continuous or batch. In a batch tumbling mill a measured quantity of the feed to be ground is provided into the mill through an opening in the shell. Then the opening is closed and the mill rotated for few hours, it is then stopped and the product is discharged. In a continuous mill, the feed rate is uniform and continuous through the evolving shell which enters at one end through a hallow trunnion and leaving at the other end through the peripheral openings in the shell. In all tumbling mills, then grinding elements are carried up to the side of the shell nearly to the top from where they fall on the particles underneath. The energy required in lifting the grinding units is utilized in reducing the size of the particles. In some tumbling mills, as in case of rod mill, the size reduction is done by rolling compression and by attrition. The grinding rods are usually steel and of diameter 25 to 125mm (McCabe et al., 2003).

2.3.3 **Cutting machines:** In the size reduction operation, if the feeds are too tenacious or too resilient, they cannot be broken by compression, impact, or attrition. Hence cutting machines are used in some cases of size reduction the feed must be reduced to particles of fixed dimensions. These requirements are met by met by devices that cut, chop or tear them into a product with the desired characteristics. Cutting machines like rotary knife cutters and granulation are mainly used to cut fruits and vegetables.

2.3.3.1 **Knife cutter:-** A rotary knife cutter contains a horizontal motor rotating at 200 to 900pm in a cylindrical chamber. The motor consist of 2 to 12 flying knives with edges of tempered steel or stelite passing with close clearance over 1 to 7 stationary bed knives. Feed particles enter the chamber from top are cut several hundred times per minute and with drawn at the bottom through a screen with 5 to 8mm openings. Sometimes the flying knives are parallel with the bed knives, sometimes depending on the properties of the feed, they cut at an angle. Rotary cutlers and granulators are similar in design. A granulator yields more or less irregular pieces, a cutter may yield cubes, thin square, or diamonds shapes (Merson, 2004).

2.4 **Energy and power requirements in size reduction**: In the process of crushing and grinding operation, the major expenditure is the requirement power, so the factors that control this cost are important in size reduction process, the particles of field materials are first distorted and strained. The energy necessary to strain them is stored temporally in the solid as mechanical energy of stress, just as mechanical energy can be stored in coiled spring. When an additional energy is applied to the stresses particles, they are unshaped beyond their ultimate strength and suddenly rupture into fragments (Smith, 1990). To estimate the energy requirement for a specified reduction in particles size, various mathematical models are available. These are based on the assumption that the energy "dE" required to produce a small change "dx" in the size of a unit mass of materials can be expressed as a power function of the size of the material.

Thus: $$\frac{dE}{dx} = \frac{-K}{x^n}$$

Rittinger's law is based on the assumption that the energy required should be proportional to the new surfaces area produced i.e n=2.50:

$$\frac{dE}{dx} = \frac{-K}{x^2}$$

By integrating equation

$$E = K\left[\frac{1}{x_2} - \frac{-1}{x_1}\right]$$

Where x, is the average initial size of the feed particles x_2 is the average size of the product particles. E is the energy requirement per unit mass and K is a constant, known as Rittinger's constant. Rittinger's law has been found to hold better for fine grinding.

Kick's law is based on the assumption that the energy required should be proportional to the size reduction ration i.e n = 1, so;

$$\frac{dE}{dx} = \frac{-K}{x}$$

By integrating equation

$$E = K \ln \frac{x_1}{X_2}$$

Kick's law has been found to apply best to course crushing

In Bond's law n is given the value $^3/_2$. So:

$$\frac{dE}{dx} = \frac{-K}{x^{3/2}}$$

by integrating equation

$$E = 2K\left[\frac{1}{\sqrt{x_2}} - \frac{-1}{\sqrt{x_1}}\right]$$

Bond's law can be expressed as

$$P = 0.3162wi\left[\frac{1}{\sqrt{x_2}} - \frac{-1}{\sqrt{x_1}}\right]$$

Where p is the power in KW, F is the feed rate in t/hr, Df is 80% of feed passes through mesh of diameter Df, Dp is 80% of products passes through the mesh of diameter Dp, and Wi is the constant work index.

Bond's law has been found to apply well to a variety of materials undergoing coarse, intermediate and fine grinding.

2.5 Physical and mechanical properties of grain

The crop parameters which are of importance include the moisture content, the biometric such as size of the grain, grain cob ratio, grain bulk density, sphericity, angle of repose, terminal velocity, grain mass and porosity. It is necessary to determined some physical properties which are in most cases are dependent of the moisture content. These properties include dimensions (size, shape, bulk density, porosity, co-efficient of static friction, volume, weight, specific gravity, density, surface area, angle of repose and angle of internal friction have pointed their practical utility in machine and structural design processes and in control engineering (Daudaa, 2015).

2.6 Storage of grain

Grain can be store for a considerable period in unprocessed form without undergoing deterioration. Its shelf life greatly depends on the prevailing ambient temperature and relative humidity and other factor like the inherent moisture pests and diseases. Therefore, recommended post-harvest handling and managing operation involve the manipulation of the above factors in other to obtain high quality grain, grain quality control starts with harvesting. Harvesting is the single deliberate attention to separate the cob from it grown medium. The optimum time of harvesting grains is when the stalks have dried and moisture of the grain is about 20-17% (NARO, 2004).

After harvesting, the greatness enemy of grain is moisture. Wet grains attract insect and mould. Therefore, the grains must be dried as soon as after harvesting. Drying is the systematic reduction of crop moisture content down to storage level usually 12%-15.5% moisture content. Drying permits the escape of moisture from grain to an acceptable level which can sustain very low metabolism. The enzyme activities and grain tissue respiration is reduced to a very low level this inhibiting germination. The principal objective in any grain storage system is to maintain the stored grains in good conditions so as to avoid deterioration both in quality and quantity. During storage, the grain must remain dry and clean. Grain storage can be extended for up to two years without any significant reduction in quality and quantity (Harrison, 1996).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Source of material

The grains used for the performances evaluation was purchased from Ojo-Oba market in Ilorin Kwara State Nigeria.

3.2 Materials used for the study

i. A multi crop size reduction machine using grains

ii. Grains (Maize, sorghum, beans and millet)

iii. Stop watch

iv. Polyteen bag

v. Weighing scale/balance

vi. Sex of standard sieve

3.3 Description of the size reduction machine

The size reduction machine evaluated consists of following component parts: Electric motor, prime mover feed hopper, grinding chamber. power transmission belt. machine frame, bearing shaft, bolt, nut. product outlet tray, driven pulley, drive pulley. Figure 1 shows the isometric view of the multi-crop size reduction machine

Fig 3.1 Grinding Machine

3.4 **Experimental design and result analysis**

Complete randomized design was used in the test as experimental design. Samples at all levels of moisture content were randomly assigned to the sequence of test runs. Each test at a particular moisture content was replicated three times. Simple descriptive statistics was used to report average and standard deviation of experimental data. Data obtained were subjected to analysis of variance (ANOVA) to determine the level at which the effect of moisture content were significant. Microsoft Excel software were used to carried out statistical analysis.

3.5 Sample preparation such as cleaning, weighing, moisture content, determination, hardness, shape, density, porosity e.t.c determination

Performance evaluation procedure

The locally fabricated grain grinding machine was evaluated using maize, sorghum, beans and millet as the tested grains. The machine was tested to ascertain its performances using the following procedures. Test grains maize, sorghum, beans and millet were obtained from Oja-Oba market in Ilorin, Kwara state. The machine was evaluated base on three output parameters: grinding efficiency, machine efficiency, grinding capacity in kg/min and grinding rate. These parameters were determined using the maize sorghum, beans and millet grains at different moisture range of 8.3% to 24.6% and 6.4% to 27.2% (db) respectively. The test was conducted at different moisture content for the two grains because the equilibrium moisture of the grains are different under the same relative humidity. The machine was run at the same time during the evaluation. Each of the test grains were divided into four different samples. Three out of each of the samples were conditioned to increase the moisture content. The fourth sample was used for test at storage condition. During the test, 2.5kg mass of each sample was fed into the grinding chamber through the hopper and the time to complete grinding of each sample was recorded. The storage moisture content was determined and used as the fourth moisture level.

The test samples were conditioned to the required moisture by adding water as calculated from the equation reported by Ozumba and Obiakor (2011) as follows:

$$Q-\left(\frac{100-Mp}{100-Mg}-1\right) \times Ws \text{.........(1)}$$

Where: Mp storage moisture content

Mg required moisture content for grinding

Ws weight of sample in grammes

After adding water, each sample was thoroughly mixed and sealed in separate polyethylene bag and kept in a refrigerator to enable the moisture distribute uniformly throughout the samples. The equations used in determining the parameters are described as follows:

-a Moisture content (MC) was determined on weight bases as:

$$MC = \frac{W_1 - W_2}{W_1} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

3.6 Input parameters

i. Dry grinding stage

ii. Wet grinding stage

3.6.1 Dry grinding stage

3.6.1.1 Moisture content of material

i. Maize 8%

ii. Sorghum 7.8%

iii. Millet 12%

iv. Wheat 11.4%

3.6. 1.2 Machine speed

The machine speed was determined to be

3.6.1.3 Material hardness

i. Maize 4.2mm

ii. Sorghum = 2.2mm

iii. Millet 1.2mm

iv. Wheat 1.3mm

3.6.1.4 **Machine grinding capacity**

The machine capacity is determined by the mass of input by time taken to grind the material

i. Maize

$\frac{\text{Mass of input}}{\text{Time taken}} = \frac{5kg}{2min} = 2.5kg/min$

ii. Sorghum

$\frac{5kg}{2min} = 2.5kg/min$

iii. Millet

$\frac{5kg}{2min} = 2.5kg/min$

iv. Wheat

$\frac{5kg}{3min} = 1.67kg/min$

3.6.1.5 Grinding efficiency

The machine grinding efficiency is determined by calculating the mass of output by the mass input times hundred (100)

i. Maize

$\frac{\text{Mass of output}}{\text{Mass of input}} \times 100$

$\frac{3kg}{5kg} \times 100 = 60\%$

ii. Sorghum

$\frac{3kg}{5kg} \times 100 = 80\%$

iii. Millet

$\frac{2kg}{5kg} \times 100 = 40\%$

iv. Wheat

$\frac{2kg}{5kg} \times 100 = 40\%$

3.6.1.5 Feed rate

The machine feed rate is determined by the speed and feed volume i.e speed x feed volume

i. Maize

Speed x feed volume 450 x 5kg = $\frac{2,250}{1000}$ 2.25kg

ii. Sorghum

speed x feed volume 450 x 5kg = $\frac{2,250}{1000}$ 2.25kg

iii. Millet speed x feed volume = 450 x 5kg = $\frac{2,250}{1000}$ 2.25kg

iv. Wheat

speed x feed volume = 450 x 5kg = $\frac{2,250}{1000}$ 2.25kg

v. Beans

speed x feed volume 450 x 5kg = $\frac{2,250}{1000}$ 2.25kg

3.6.1.7 Flow rate

The flow rate can be determined as thus; flow rate = V x T

i. Maize

Volume x Time = 5 x 12 = 10m $^3/_5$

ii. Sorghum

Volume x Time = 5 x 3 = 50m $^3/_5$

iii. Millet

Volume x Time = 5x2=10m $^3/_5$

iv. Wheat

Volume x Time= 5x2= $10m^3/s$

3.6.1.8 Fuel consumption

Fuel consumption volume of fuel x time taken

i. Maize

1 x 1= 1L/hr

ii. Sorghum

1 x 1= 1L/hr

iii. Millet

1 x 1= 1L/hr

iv. Wheat

1 x 1 = 1L/hr

3.6.1.9 Grinding disc condition

The hardness and smoothness of the grinding disc is measured by grit. A lower grit number in grinding disc means it is coarse and a higher number means the grinding disc is less coarse. Grit size is the size of individual abrasive grains. It corresponds to the final screen size used to size grain.

The grit size typically runs from coarse (16-24 grit) medium (36-60 grit) and fine (80-120 grit).

3.6.1.10 Grinding disc clearance

The grinding disc clearance can be determined when you reduce the contact area between the two disc rotatine and stationed disc later on during the grinding process

The grinding clearance can therefore be determined by

Volume of material output

Volume of material input

i. Maize

$\frac{3kg}{5kg} = 0.6kg$

ii. Sorghum

$\frac{3kg}{5kg} = 0.6kg$

iii. Millet

$\frac{2kg}{5kg} = 0.4kg$

iv. $\frac{2kg}{5kg} = 0.6kg$

3.6.1.11 Grinding resistance

Grinding resistance of the machine is determined through the hardness of the material. The material hardness have been determined initially and recorded

: Grinding resistance = $\frac{\text{Material hardness}}{\text{Time taken}}$

i. Maize= $\frac{4.2mm}{2min}$ = 0.350lim 2min

ii. Sorghum = $\frac{2.2mm}{3min}$ = 0.73lim

iii. Millet= $\frac{1.2mm}{2min}$= 0.60lim

iv. Wheat $\frac{1.3mm}{3min}$ = 4.30lim

CHAPTER FOUR

4.0 RESULTS AND DICUSSIONS

4.1 Particle size analysis (finesse modulus)

The particle size analysis of grounded materials (crop) performs a critical role in determining feed digestibility, mixing performance and pelleting. Therefore, periodic particle size evaluation is a necessary component of a feed. The particle size analysis of the grounded materials was carried with the use of the standard sieve analysis.

Table 4.1 Finesse modulus for maize

Sieve No	Sieve size	Weight (g) of material retained	Cumulative weight of material retained unit
1	291	0.0	0.0
6	323	5.7	34.2
5	346	23.2	116.0
4	348	35.1	140.4
3	411	18.4	55.2
2	380	9.3	18.6
1	333	5.8	5.8
0	Pan	23.5	0.0
		100	370.2

Finesses Modulus = $\frac{370.2}{100}$ = 3.71

Average size (Dm) = $0.0041 \times 2.54(2)^{3.71} = 0.14$mm

Table 4.2 Uniformity index for maize

Sieve	Weight of material retained	Sieve arrangement
291	0.0	7
323	5.7	6
346	2.32	5
348	35.1	4
411	18.4	3
380	9.3	2
333	5.8	1
Pan	2.5	0

First group = $\frac{0.0+5.7+23.2}{10} = \frac{28.9}{10} = 2.89\%$

Second group= $\frac{35.1+18.4}{10} = \frac{53.4}{10} = 5.34\%$

Third group= $\frac{9.3+5.8+2.5}{10} = \frac{17.6}{10} = 1.76\%$

Therefore, the feed is 2.89% coarse, 5.34% medium and 1.76% fine.

Table 4.3 Finesse modulus for sorghum

Sieve	Sieve size	Weight of material retained	Cumulative of material retained
7	291	0.0	0.0
6	323	7.2	43.2
5	346	9.0	45.0
4	348	7.7	30.8
3	411	22.6	67.8
2	380	7.0	14.0
1	333	12.9	12.9
0	Pan	33.6	0.0
		100	213.7

Finesse modulus= $\frac{2137.7}{100} = 2.14$

Average size (0m) = $0.00141 \text{ x } 2.54(2)^{2.14} = 0.05$

Table 4.4 Uniformity index for sorghum

Sieve	Weight of material retained	Sieve arrangement
291	0.0	7
323	7.2	6
346	9.0	5
348	7.7	4
411	22.6	3
380	7.0	2
333	12.9	1
Pan	33.6	0

First group = $\frac{0.0+7.2+9.0}{10} = \frac{28.9}{10}$ = 1.62%

Second group= $\frac{7.7+22.6}{10} = \frac{30.3}{10}$ = 3.03%

Third group= $\frac{7.0+12.9+33.6}{10} = \frac{53.5}{10}$ = 5.35%

Therefore, the feed is 1.62% coarse, 3.03% medium and 5.35% fine

Table 4.5 Finesse modulus for millet

Sieve	Sieve size	Weight of material retained	Cumulative of material retained
7	291	0.0	0.0
6	323	3.0	18.0
5	346	4.0	20.0
4	348	6.0	24.0
3	411	8.2	24.6
2	380	14.3	28.6
1	333	22.0	22.0
0	Pan	42.4	6.0
		100	137.2

Average size (Dm) = 0.0041 x 2.54(2) 1.35 = 9.28mm

Table 4.6 Uniformity index for millet

Sieve	Weight of material retained	Sieve arrangement
291	0.0	7
323	3.0	6
346	4.0	5
348	6.0	4
411	8.2	3
380	14.3	2
333	22.0	1
Pan	42.4	0

First group= $\frac{0.0+3.0+4.0}{10} = \frac{7}{10}$ = 0.7%

Second group= $\frac{6.0+8.2}{10} = \frac{14.2}{10}$ = 1.42%

Third group= $\frac{14.3+22.0+42.4}{10} = \frac{78.7}{10}$ = 7.87%

Therefore, the feed is 0.7% coarse, 1.42% medium and 7.87% fine

Table 4.7 Finesse modulus for wheat

Sieve	Sieve size	Weight of material retained	Cumulative of material retained
7	291	0.0	0.0
6	323	1.5	9.0
5	346	8.0	40.0
4	348	3.9	15.6
3	411	10.3	30.9
2	380	26.0	52.0
1	333	4.2	4.2
0	Pan	46.1	0.0

Finesse modulus = $\frac{151.7}{100}$ = 1.52

Average size=0.0041 x 2.54 (2)1.52=0.0299mm

Table 4.8 Uniformity index for wheat

Sieve	Weight of material retained	Sieve arrangement
291	0.0	7
323	1.5	6
346	8.0	5
348	3.9	4
411	10.3	3
380	26.0	2
333	4.2	1
Pan	46.1	0

First group $=\frac{0.0+1.5+8.0}{10}=\frac{9.5}{10}=0.95\%$

Second group $=\frac{3.9+10.3}{10}=\frac{14.2}{10}=1.42\%$

Third group $=\frac{26.0+4.2+46.1}{10}=\frac{7.63}{10}=7.63\%$

The feed is 0.95% coarse, 1.42% medium and 7.63% fine

Table 4.9 Total particle size distribution calculated

Sieve size	Sieve No	Crop	Fine aggregate	Coarse aggregate	Combined coarse fine
		Maize	1.76 %	2.89%	5.1%
		Wheat	7.63%	0.95%	7.3%
		Millet	7.87%	0.7%	5.6%
		Sorghum	5.35%	1.62%	8.7%

Therefore, after carrying out the sieve analysis test, the machine is said to perform well in grinding sorghum.

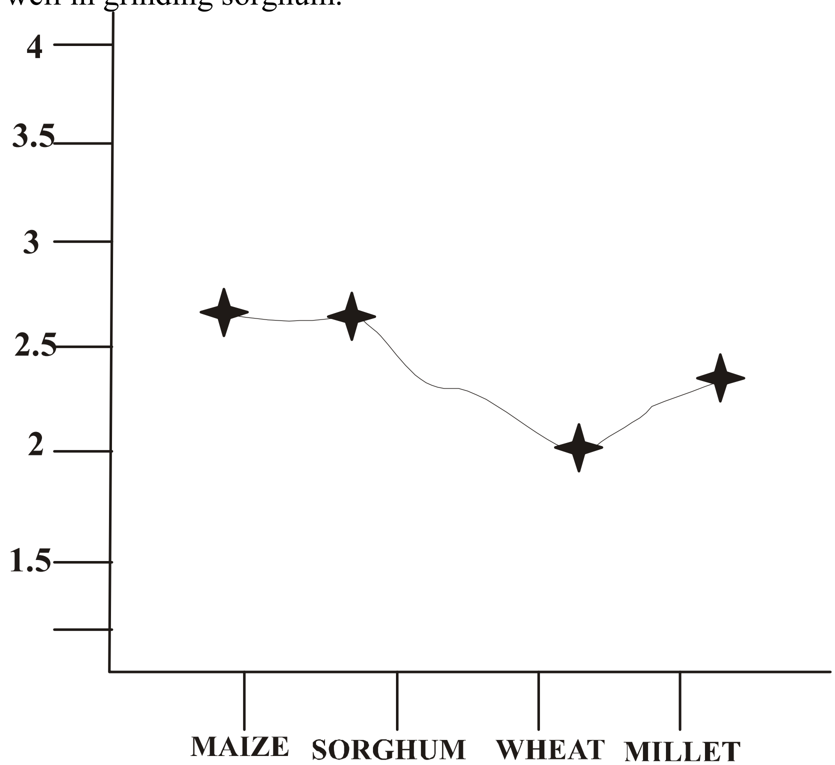

Fig 4.1 Machine grinding capacity curve

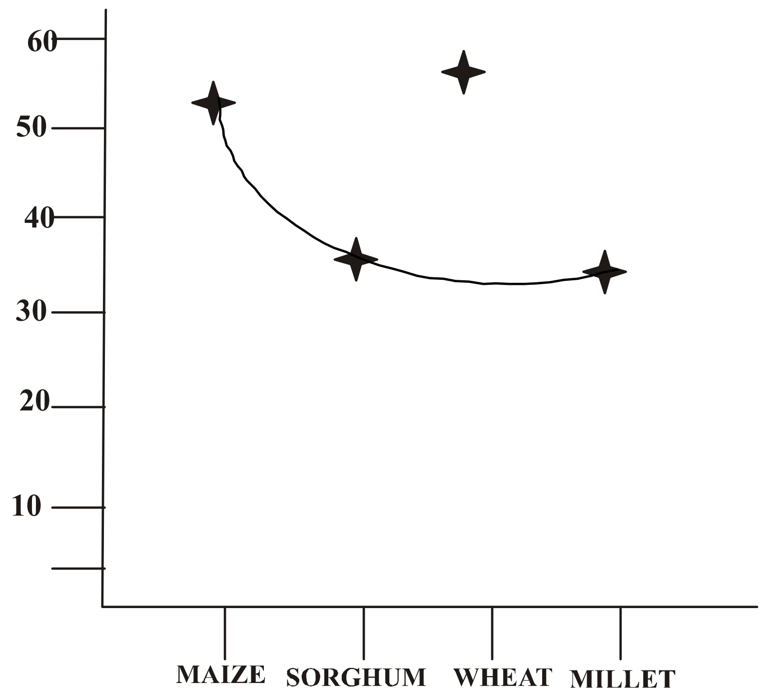

Fig 4.2 Machine grinding efficiency curve

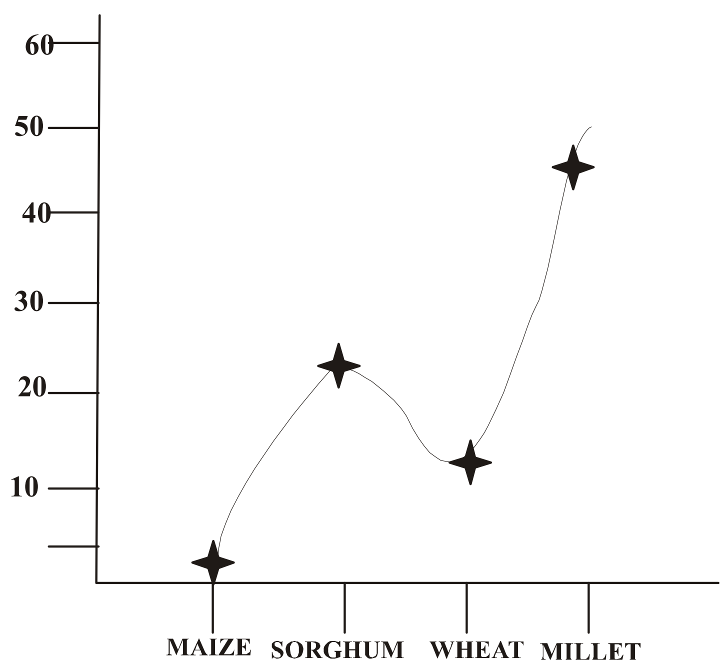

Fig 4.3 Grinding resistance curve

Fig 4.4 Grinding Machine

Fig 4.5 Student working on the wet grinding

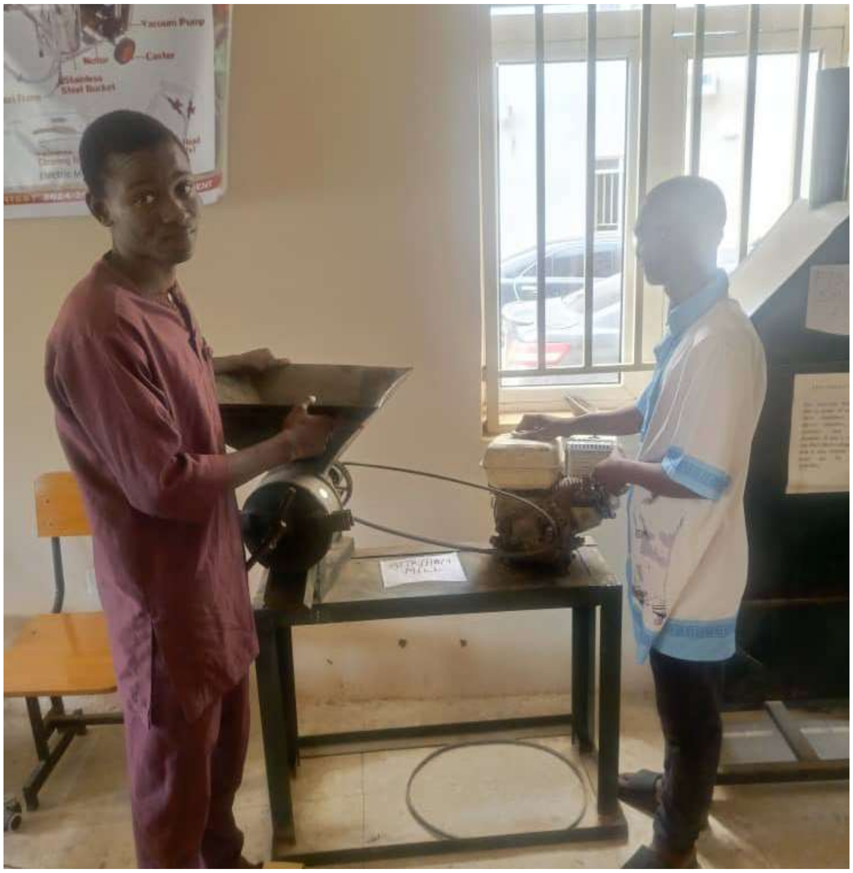

Fig 4.6 Student working on the dry grinding

Fig 4.7 Sieve Analysis

Fig 4.8 Moisture Analyzer

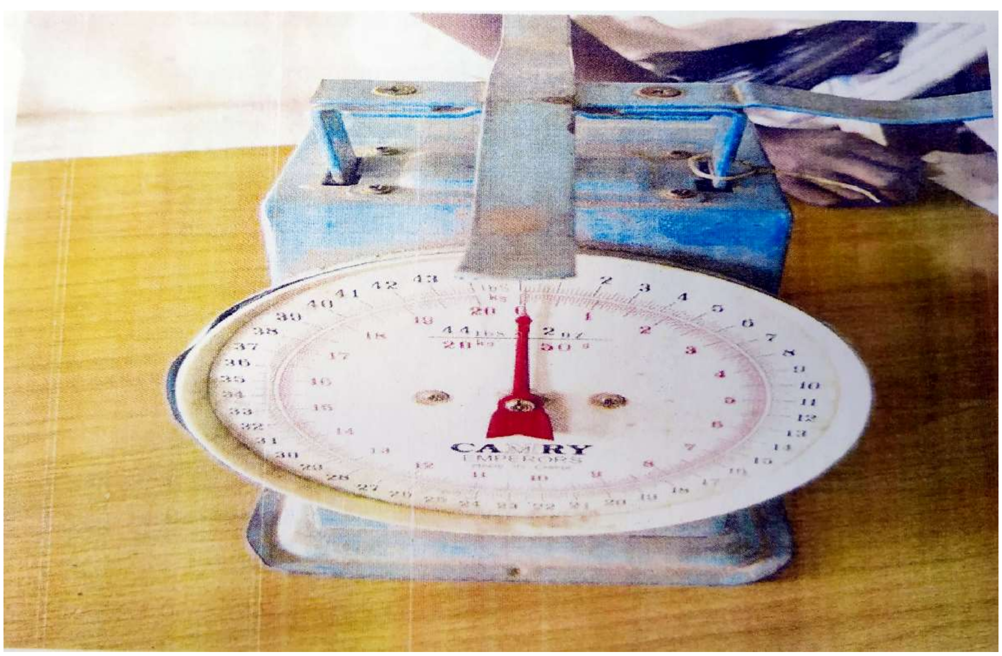

Fig 4.9 Weighing Scale

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMEDATIONS

5.1 Conclusions

The attrition mill developed in the department was evaluated using grains as a sample. The evaluation was carried out at various moisture content of the grains used. Evaluation was carried out at both dry and wet grinding basis. The result obtained showed that the machine perform and operate well at low moisture content for dry grinding. The highest average efficiency of the machine was 60% at 10% moisture content and lowest at 11% moisture content. The feed rate used to test the fabricated machine do not show any significant variation on the machine efficiency.

5.2 Recommendation

Base on the impressive performance of the attrition mill developed and evaluated. The study highly recommended this crop size reduction machine to small, medium and large scale crop processors in Nigeria especially at rural area where crop processing is still a major problems facing the rural farmers.

More so, the study recommended the use of high quality locally available materials for this kind of machine design to allowed durability in its usage. Further study of this machine is highly recommended.

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