Design and Fabrication of Miller Grinding Machine

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Abstract

This study was carried out on the redesign and fabrication of a miller with suction end designed, fabricated and single test carried out. The tests were carried out by equating the conventional hammer mill with the new miller with end-suction. The primary test results obtained using grains show that the productivity of a conventional hammer mill and ability to produce an output of specific size is low when compared with the output of the new hammer mill. This would expand storage possibilities for the grains, deep and broaden the available food choices for all Nigerians and enhance food security. The grinder consists of a 400mm width and 1200mm in length capacity hopper, a machine housing, a blower with 13.35m/s air speed, a twister, set of hammers that effect the size reduction of the materials been fed, 15cm width rotor pulley, a shaft of 390mm in length and a magnetic mesh that separate metal filings from the grounded food stuff. The Miller Grinding Machine has the Power capacity of 15hp and a rotational speed of 3000 rpm.

Keywords: **Design, Fabrication, Analysis**

I. Introduction

This work is made to reduce the stress and increase in value that is related with the use of manual method of grinding both in domestic and commercial grinding which have need of a lot of man power. With fast developing technological advancement, this innovation is primarily geared towards minimizing the use of manpower and some stress-free in grinding, this new innovation is made in such a way that it will give a good and perfect grinding, also to make the work speedy and at the same time phase out the use of manual grinding method. According to Science Teachers Association of Nigeria (STAN) (1991), the processing machines or equipment are the equipment used for processing harvested food crops into forms that they could be readily consumed, sold or stored for future cultivation. This study is based on observation by professionals for increase in production output, and then the need for a production machine should be incorporated into grinding of grains, cereals, etc.

One of the goals of engineering technology is to give training and impact the necessary skills to individual who shall be self- reliant economically. There are numerous evidences in research literature showing that most product of mechanical engineering programs in Nigeria are not proficient technically, especially in the area of design and construction (Udofia, 2002; Unanaowo, 2005). All civilizations that feed more or less completely from cereals were enforced to develop technology for grinding grain crops. Possibly the most wide-ranging application of grinding in the food industry is in the milling of the grains to make flour, but it is used in many other processes, such as in the grinding of corn, for the manufacture of corn starch, grinding of cassava, grinding of millet. Grains are defined as a small, hard, dry seeds, with or without its fruit layers, harvested for human or animal consumption. Babcock, P. G., ed. 1976. The Gehl Company produced the first grain grinding hammer mill in the 1920s. It dominated the market for 30 years, during which time it also developed a portable truck mounted mill.

In 1990, Carl Bielenberg of Appropriate Technology International (ATI) began developing a screenless hammer mill. His prototype separated flour from larger particles through an opening in the circumference of the grinding chamber. Flour passed through the opposite side of the rotating blades while the larger pieces continued inside the chamber.

II. Miller Grinding Machine

Miller Grinder offer extremely aggressive mashing product by rotary action of a hardened steel hammer strap rotating in a steel closure. Product escapes the mill only when it is small enough to pass through the holes in heavy duty steel screen, which are identical and available with a range hole sizing. Pleasant mill grain offer commercial grain mill and general grinding equipment for a wide range of grinding needs. Most dry materials can be grind with Stone Burr Mill and dry, wet and oily materials can be grind with Iron Burr Mills. Application includes grinding of wheat, corn, soya beans, buck wheat, oath, hulls, spices, coffee, oil seed, egg shells, bones, roots, hulling of sun flowers, walnut, etc.

All commercial mills are fully adjustable for texture, fine flour to mill texture or “cracked grain” and are suitable for human consumption or animal feed.

Advantage of Hammer Commercial Mill

a. It is durable and it can grind/crush different types of materials at high angular velocity.
b. It helps to reduce stress and makes improves speed rate of work and It gives a good finish after grinding of the grain
c. This Design and Fabrication of a Commercial Grinding Mill It is more reliable and stronger than the manual type of grinding mill.

III. Design and Construction Methodology

Design is the transformation of concepts and ideas into useful machinery (Bernard et al., 1999). The procedures in the design and construction of the modified miller grinder are explained. Theoretical design and material selection. The selection of materials and methods of construction of the miller are based on the preliminary investigation, design and the drawing of the machine components carried out.

Material Selection

The selection of the materials for any component part depends on the condition it will be subjected to during service. It is also depends on the manufacturing processes involves and the durability of the components in question. The manufacturing processes used in the project were mainly machining and lathe and shaping operations which includes (turning, threading, shaping, facing and drilling) for this reason different material were selected as the basic material.

Properties of Materials

The common properties required for materials for them to be suitable for manufacturing methods are:

i. Elasticity: a material which returns to its original shape after being deformed by a force.
ii. Plasticity: is the ability of metal to change its shape owing to some external pressure and retains the new shape after the force has been removed.
iii. Brittle: this is a material which has little ductility and does not neck down easily before fracture.
iv. Malleability: a malleable material is capable of deformation without failure under compressive loads. It follows that part made by cold forming process such as cold stamping of coining must be malleable. Non-malleable are said to be cold short.
v. Toughness: a material which can withstand shock loads is said to be tough. This is more usually a requirement of the functional needs of parts than of the process by which they are to be made.
vi. Hardness: is the measure of its ability to withstand scratching, wear and abrasive.
vii. Strength: the ability of metal to withstand tensile load before breaking.

Safety Precaution

Safety could just be regarded as self-conciseness, many accident in the engineering workshop are caused by negligence, carelessness or wrong approach on the part of the workman. Consequently the need for self-consciousness in the workshop cannot be overemphasized. In carrying out this project the safety rules to the production processes were carefully observed.

IV. **Discussion of Miller Grinder with Close Suction**

The final conception design of the new hammer mill end suction arose from consideration of many concepts involving the use of feed, hammers, milling chamber and shaft coupled to a high-speed electronic motor through two V-belts. The following machine elements are shaft namely free swing hammers, collars, a mechanical separator. Other cross-sectional pipes are taken to the settlement chamber of the cyclone. The particle size distribution of the output of the machines indicates that while the conventional hammer mill produce particles in the coarse, medium and fine categories, the new hammer mill produce particles in the fine category for the maize grain that were tested.

The output affirms the performance of the mechanical separator which ensures that only particles of a size desired by the user or client are obtained from the new hammer mill. The incorporation of a feedback mechanism that returns uncrushed and coarse material back to the crushing chamber for more fracturing assist in ensuring that only fine particles are obtained from the machine. These features of the new hammer mill are very important because they ensure that products of high quality and desired specification are obtained. Thus the crushing and pulverization of solid minerals and agricultural products can be accomplished efficiently. The figures below shows the top view, front view, side view and isometric and orthographic block of new fabricated hammer mill.

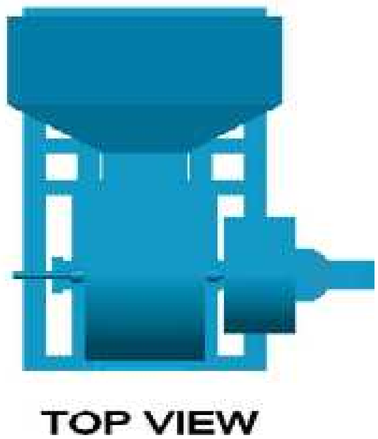

Figure 4.1 Top view of hammer grinding mill

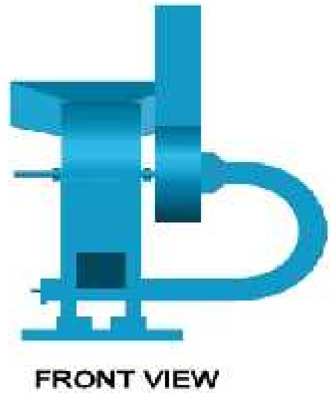

Figure 4.2 Front view of hammer grinding mill

Figure 4.3 Side view of hammer grinding mill

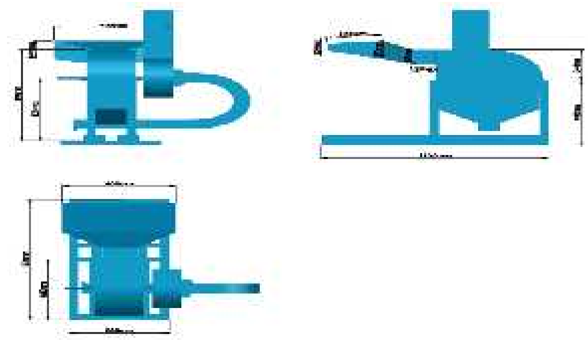

Figure 4.4 hammer grinder isometric drawing

V. Working Principle of Mallet Mill with Close Suction

The innovative material is fed into the hammer mill through the feed hopper. The feed hopper is chamfered to facilitate unidirectional flow of the row materials by gravity to the milling hollow. Where, the hammers strike the material which breaks into small piece each time there is a successful hit.

The crushed material is prevented from leaving the milling chamber until it has been reduced to fine particles on subsequent impact by the hammer by the unique action of the mechanical separator. The mechanical separator is a rotor having two equal arm chamfered at the ends. It is housed in a frustum chamber that is mounted in a way that its inlet is larger than the outlet. The separator rotates at the same speed as the shaft which is directly coupled to it as shaft rotates at high speed, the blades of the separator from a practically close system at low pressure with the frustum end and only very fine particles of the pulverized material can pass through the larger particle or uncrushed material are recycled to the crushing chamber.

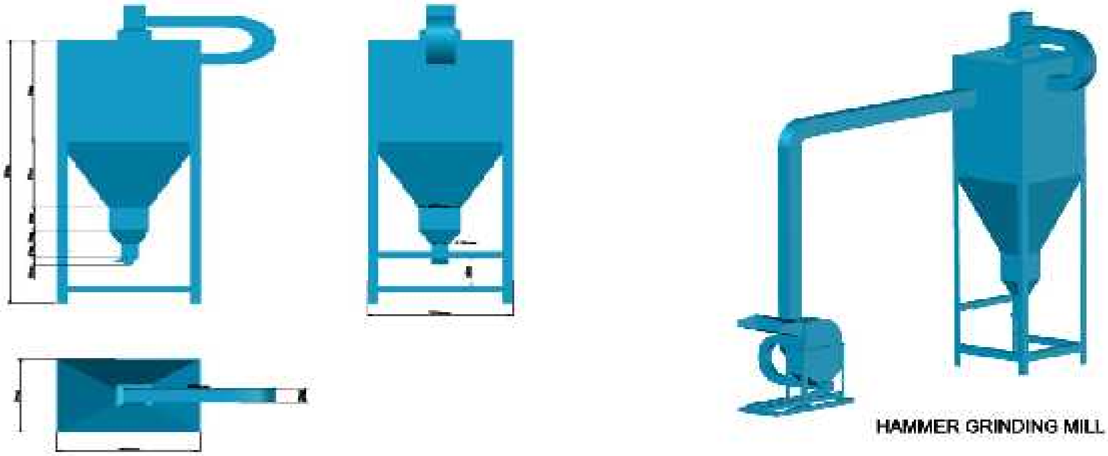

Figure 4.5 hopper isometric drawing

VI. Detail Design

This section attempts to show the basic equations used in the design of the hammer mill and the principles adopted. The major component of the machine includes the shaft, bearing, mechanical separator, cyclone casing and electric motor.

The shaft

It is assumed that the shaft is subjected to the both axial and tangential forces. The diameter of the shaft diameter is determined using the soderberg criterion and maximum shear stress theory.

Thus

$$\frac{\sigma_y}{FS} = \frac{32}{\pi d_{sh}^3}\left[\left(\frac{K_f \sigma_u M}{\sigma_e}\right)^2 + T_m^2\right]^{1/2}$$ .... (1) [Hall,et al,1998]

Where

Fs = factor of safety
K_f = actual stress concentration factor
σu = ultimate tensile stress
M = bending moment
σe = endurance limit of material
Tm = mean torque
dsh = shaft diameter

The Hammer

The centrifugal force on the hammer, Fh is given by

$F_h = N_h M_h r_h \omega_h^2$ ……………………………………….(2) [hammah and stephens, 2004]

F_h = centrifugal force
N_h = number of hammer
M_h = mass of each hammer
r_h = radius of hammer
ω_h = angular velocity of hammer

Assuming inelastic impact between the hammers and material, the velocity of material Vm, given by

$$V_m = \sqrt{\frac{2F_h r_h}{m_m N_m}}$$ ………………………………………………………… (3a) [khurmi and Gupta 2007]

Or

$$V_m = \left(\frac{2F_h r_h}{m_m N_m}\right)^{1/2}$$ ……………………………(3b)

Where
V_m = velocity of material being milled
M_m = mass of material being milled
N_m = number of material impacted

The minimum width of hammer, wh to withstand the centrifugal force at impact is given by

$$W_h = \frac{d_h + F_h}{t_h \sigma_h}$$ ………(4b) [marrison and crossland 2000]

Where

W_h= width of hammer
d_h = diameter of hammer
t_h = thickness of hammer
σ_h = working stress of hammer

Mechanical Separator

Let assume that the loading is such that failure can only occur by shearing or bending of the blades.

a. Failure by bending of blades
   $F_b = \sigma_y t_b (w_b - d_b)$ …………….. (5)
b. Failure by shearing of blade
   $F_s = \tau t_b (w_b - d_b)$

Where

F_s= shear force

τ = shear stress of blade power required by machine

The power required by the hammer mill. P_{hm} is given by

$P_{hm} = T\omega$ ………………………..……….. (6) [Khurmi and Gupta, 2008]

P_{hm} = power

T = torque

ω= angular velocity

V-Belt and Pulley

The centrifugal tension, F_{bo} is given by $F_{bo} = m'_{be} V_{be}$ ………………………… (7)

Where

F_{bo} = centrifugal tension

m'_{be} = mass of belt per unit length

V_{be} = linear velocity of belt

The power transmitted by the belt P_{be}, is given by $P_{be} = (F_{t1} - F_{t2}) V_{be}$……………………… (8)

Where

P_{be} = Power transmitted

F_{t1} = tension on tight side of belt

F_{t2} = tension on slack side of belt

The turning moment on the pulley Mp is given by

$M_p = (F_{t1} - F_{t2}) r_p$ ………………………… (9) [Hamah and Stephen 2004]

Where

M_p = turning moment

r_p = radius of pulley

VII. Construction Procedures and Testing

In making any engineering component, different procedures are taken into consideration in order to come out with the good finishing product. First of all one must have the correct picture of how the finished product will look like. Then a convenient step-by-step method is chosen and followed, which will involve selection of tools and machine tools to be used in the process of production. Each component parts were constructed separately.

A new fabricated commercial hammer mill with end suction boost capacity has been produced. Almost component of the machine were fabricated using locally available raw material. The machine was tested using maize grains. To compare performance of the conventional hammer mill with that of new fabricated hammer mill, quantities 15kg of maize grain taken were fed into the respective machine hopper. The output of machine at the end of 1 minute of operation has given a quite output result. The power source of the mill is a three phase electric motor with power capacity of 15hp and a rotational speed of 3000 rpm.

VIII. Conclusion

This project has focused on the design fabrication and some little finding by testing of a new mallet mill with close suction. The major components of this new mallet mill are the sledge mallet, shaft, bearing, mechanical separator, enclosed suction, casing, pulley and electric motor. Most components of the mallet mills were produced using locally available materials. The environmental pollution associated with the use of conventional hammer mills is nearly eliminated in the new fabricated mallet mill with close suction. Thus there is no health hazard experienced during the test of new mallet machine. It is hoped that the commercialization and widespread application of the new mallet mill will contribute significantly to the growth of the agricultural and solid mineral processing plant in small and medium scale industry in Nigeria. Furthermore, the new mallet mill with close suction lift capability when used in processing grains that are abundantly produced in Nigeria would reduce markets for domestic cereals and legume crops, reflects a more effective response to changing market requirements and increases food security for Nigeria. Finally, the typical working principle is simple to understand. It only requires selecting an appropriate motor, crushing tack hammer and material you intend to crush.

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