Design of Multi-Purpose Crushing Machine for Processing of Food Grains an Overview

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Abstract

Crushing of farm produce for simple storage and consumption is still a problem in most rural areas. Large amount of food crops are wasted annually as a result of unavailability of storage facilities. This needs the design of a multi-purpose crusher to save crushing energy with less grain losses, is the main aim of this study. The components of the designed crushing machine are a hopper, crushing chamber, shaft, hammers, screen, bearings, discharge outlet and a 2HP electric motor.

Keywords: *Crushing, size reduction, Food Grains, Husk Removal, Crushing loss, Design*

1. Introduction

One of the slogans by the World Health Organization (WHO) on world health dated "From farm to plate, make food safe". Before agricultural product leaves the farm to become edible food, number of processes is involved in making this possible. This process is the transformation of raw material, by physical means into food. The agricultural produce are usually present in range of sizes, often too large to be handle and must be minimized in size for simple handling to be processing and storage.

In general the term "minimization of size" means cut, crush, grind and milling. The minimization of size is achieved by means of mechanical process keeping no change in chemical properties of the material, and same in size and shape of the individual grains or units of the end product is usually desired but rarely attained. Many processes such as cutting of fruit and vegetables for preserving, shredding sweet potatoes for drying, chopping corn fodder, grinding grains for livestock feed, and milling flour are classified under size minimization and can be achieved through the use of a crusher. Crushers are usually used to reduce the size and shape of materials so that they can be efficiently used for the purpose considered. Crushing is the oldest technique in reducing solid materials into smaller particles. During olden days, grinding of food grains was done by women; it was carried out mainly in two fashions;

- By heavily striking the grains (mortar and pestle) and secondly,
- By grinding done by crushing the grains between two grinding stone.

The traditional grinding stones used to grind whole or decorticated grain 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 sublime grains between the two stones. In other words, the operating principles of a crushing machine is by holding the material between two parallel or tangent solid surfaces, and in the process sufficient force is apply to rough the surfaces together to generate enough energy within the material being crushed (Orhorhoro et al., 2016).

By doing so the grains are reduced to smaller particles. Though using grinding stones are effective in grinding for domestic purpose, it may also prove to be very cumbersome if it is considered on a commercial scale, because it will be time-consuming and toilsome. Grinding of foodstuffs can be said to have started from the Stone Age (about 6700BC), man ground grains of wheat with rocks to make flour. By 5500 BC came the mill stone which has two large individual stones between which the wheat is ground to make flour. However, crushing of farm produce after

harvesting is one of the major food processing techniques employed to maintain taste, quality and effective food storage (Igbeka and Olumeko, 1996). Despite the very long efforts involved, non-mechanized system of agriculture continue to exist as the initial of processing farm produce after harvest , and this subjects factotum employed in this area to pain staking process in attempt to crush farm produce (such as melon, plantain, millet, groundnut maize etc.) into finished products available for sales and consumption. Particularly the rural areas, grinding stone, manual hand grinder or mortar and pestle is mainly used to achieve this purpose which normally consume a much more time and energy even with the low cost involved.

The well-known equipment which is used for shredding/grinding, in which the material are subjected to complex forces and then the output particles are used in the following operations from the pellet making technology is Crusher (Nwaigwe et al., 2012). The basic principle in locally made grinding machines is friction. In order to get reduced size , the two frictional surfaces of the grinding machines have to come together to crush the material between them (Maduako, 2005). Machines are developed to aid quick processing of agricultural materials and products (Hannah and Stephens, 2004), other technologies should be considered and employed to see that existing food machines are sustained for continuous preparation of available meals for the populace. Where necessary, modifications should be made to obsolete machines to ensure proper safeguarding of food items and also improve their reliability, example where carbon steel were used in machine development, they should be upgraded to stainless steel to remove the possibility of food contamination due to material corrosion (Gorham, 1994). , the major work of citizen of rural areas is agriculture. The industrial requirements for the use of these milling processes such as uninterrupted power supply, high technical skill, and reliability of the machines which are often not available to the farmers in most part of the rural areas have made it inconvenient for these farmers to produce livestock feeds and human food in large quantity. There is a need to consider which can overcome these high industrial requirements can be reduced by developing a modular machine that will ensure fine crushing of grains, nuts and farm products into small pieces. As a result, this work is aimed towards the development of crusher mill with economic efficiency and with mechanical simplicity.

1.1 Machine Operation

In this the power is to be transmitted by using belt drive and the pulleys attached, rectangular hammers attached to the rotating shaft in the grinding chamber. Agricultural produce which should be dried is introduced into the hopper which directs the movement of the produce via a passage called neck into the grinding chamber. Small clearance is provided between rotating hammers and the drum wall which allows the striking of the agricultural product against the drum causing the product to shatter into pieces. The grinding occurs in the grinding drum as the swinging of the hammers continues to hit the particles of the product against the walls of the drum. The product which has been broken to pieces continues to hit against themselves and the hammers which are positioned such that none of the particles escape being hit. The reduction in size of the pieces continues further as the produce are forced to pass tiny holes on the sieve which are at the lower part of the grinding chamber passing through the outlet. The base is highly rigid to support the weight and damp the vibration of the complete unit.

2. Methodology

The frame of machine fabricated using angle bar to provide rigidity and stability required to withstand various loads acting on the machine and also vibrations which resulting due to the loading effects. The components of shaft were made from mild steel because it can be easily rolled and drawn into shape and also have low cost and easily available in the market. Mild steel has greater strength provide it better advantages. A number of factors were taken into account, some of which are; mechanical properties such as load and stress consideration, strength and rigidity of the design, motion of parts, selection of material and more importantly ergonomics (man and machine relationship) was carefully considered in the design. However, more concentrate on grain size reduction which is the main function of the multipurpose crusher.

2.1 Design Parameters

The following parameters were taken into consideration during the design of the multi-purpose crushing machine for processing of food grains.

2.1.1 Determination of Shaft Speed

The transmission system which used is belt transmission via a pulley (specifically v-belt selection), where the torque generated by electric motor called as driver. Thus, to calculate the shaft speed, the following parameters were considered.

$D_1/D_2=N_2/N_1$ i.e. $N_2= D_1 N_1 /D$

2.1.2 Determination of the Belt Contact Angle

The belt contact angle is given by

$$\sin\beta = (R-r)/C$$

The wrap angle for the pulleys are given by;

$$\alpha_1 = 180 + 2 \sin^{-1}(R-r/C)$$

$$\alpha_2 = 180 + 2 \sin^{-1}(R-r/C)$$

2.1.3 Determination of Belt Tension

The belt tension can be finding out by following method.

Maximum tension in belt is

$$T = A \times \sigma$$

Centrifugal tension in belt

$$T_C = mv^2$$

To get tension in slack side, the relationship can be used

$$2.3 \log (T_1/T_2) = \mu\theta\operatorname{cosec}\beta$$

But, mv^2 = centrifugal force acting on the belt.

$$T_1 = T-T_C$$

The belt velocity (Linear velocity) (V) is given by using

$$V = \Pi dN/60$$

2.1.4 Torque and Power Transmitted to the shaft

Power transmitted to the shaft is given by

$$P = (T_1-T_2)\, V$$

The torque acting on the driving pulley is given by

$$T = (T_1 - T_2)\, r_1$$

2.1.5 Determination of the Hammer weight

From the equation,

W_h = mhg

2.1.6 Centrifugal Force Exerted by the Hammer

Centrifugal force exerted by the hammer can be determined by using:

F= mv/r

The angular velocity of the hammer is

ω = ΠrN/60

2.1.7 Shaft Design

The design of power transmitting shaft is nothing but determination of the correct shaft diameter to get satisfactory strength and rigidity, during its operation under various loading and working conditions.

Shafts are usually circular in cross-section, and may either be hollow or solid.

The following are considered during shaft design;

• The diameter of the shaft

• Length of the shaft.

• Reaction on bearing resting on shafts.

• Size bearings.

• Bending and Tensional Moments.

2.1.8 Shaft Design Parameters

Shaft fitting is usually subjected to torsion, bending and axial loads. For torsional loads, the torsional stress T xy is;

T_{xy}= (M_{ef}/I) = ($16M_t/\Pi d^3$)

Considering bending of shaft;

Ss= (M_b/I) = ($32M_b/\Pi d^3$)

For a solid shaft having little or no axial loading, below equation can be used

$$d^3 = \frac{16}{\pi \sigma_c}\sqrt{(k_b M_b)^2 + (k_t M_t)^2}$$

2.1.8 Bending and Torsional Moments

One of the first steps in shaft design is to draw the bending moment diagram when loads acting on the shaft are in more than one axial plane. From the bending moment diagram, the torsional moment acting on the shaft can be determined by using;

$\mathbf{M_t = (T_1 – T_2) R}$

2.1.9 Grinding Drum Design

The drum has a cylindrical shape and the volume of a cylinder is given as;

Volume of cylinder = πr^2 h

3. Performance Test

The performance test of the machine will carried out after the fabrication was completed to check its functioning according to the design specifications. Dry maize will weighed using weight balance scale. Initially to get stable speed the machine was operated for three minutes. The dry maize will be inserted into it through the hopper for another five minutes to check for vibration, misalignment in the shaft connection, other irregularities of the machine and finally the check the performance of the machine. Use the stop watch to monitor the time. Series test were conducted with the machine, and the crushed maize collected into a scale, weighed and recorded using the weight balance scale.

This paper defines the design of food grain crushing machine to improve its efficiency and usage. The performance tests conducted indicated that high value of crushing efficiency is attainable.

3.2 Installing and operating guidelines

The following points should be considered during the installation of the machine

a) Machine should be installed on level ground
b) Machine should be installed at a well- ventilated spot
c) Machine should be installed near a source of natural light
d) Machine should be observed carefully before operation
e) Plug wire to socket and switch on the power supply

Figure 1 shows the isometric view of the multi-purpose crushing machine.

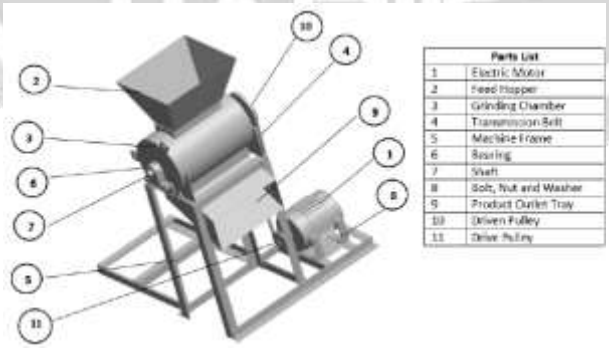

Figure 1: Isometric view of the Multi-Purpose Crushing Machine

4. Conclusion

The designed multi-purpose crushing machine reduced processing losses, produce will be flour dry flour, enhance greater consumer choice, ensure new markets for domestic crops, and reflect a more effective response to changing market requirements and increase food security. The components of the machine are shaft, hammers, bearing, chambers and electric motor. From the design consideration and analysis portability, reliability, safety, serviceability

and cost of construction were given due considerations. Most components were fabricated using locally sourced materials. The preliminary tests carried out on the operated crushing machine confirm that it operates satisfactory. The environmental pollution associated with the use of conventional hammer mills is removed. Machine is no life-threatening dangers or health hazards. It is hoped that the commercialization and wide spread application of the multipurpose crushing machine will contribute significantly to the growth of the agricultural and solid mineral processing industry.

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