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IMPROVING THE FIELD PERFORMANCE OF THE DISINTEGRATOR TAPER-PINS HAMMER MILL

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ABSTRACT

Disintegrator taper-pins hammer mills are designed for milling of grain into flour or to act as part of a feed preparation system. This mills is easy to operate, maintain and it can do excellent work without much heating but they are somewhat producing a coarse meal. The main factor limits the application of this type of hammer mills is their production of a wide range of particle sizes (non- homogenous fineness degree of milled products). This type of production could be used only for direct feeding, but it is not appropriate for processing the pelleted feeds. So, it is difficult and costly to obtain fine grinding form without repeat the grinding process for two or three times depending upon the fineness requirement, which in turn, increase grinding power and energy requirements. This research aims to improve the performance of the disintegrator taper-pins hammer mill, through a mechanical vibrating feeding unite to accurately facilitate the grains feeding rate during the grinding process, especially when the grains contains higher ratio of damaged seeds and/or higher moisture content. The study also aims to examine the effect of some operating parameters on the modified machine productivity, power and energy requirements. Milled quality in term of (particle size distribution and fineness degrees) during the milling operation was also considered. The results revealed that, the optimum values for the operation conditions were obtained at hammers speed of 39.6 m/s and mill feeding rate of 0.4 ton/h. At these levels, the best results of productivity rate (ton/h), power consumption (kW) and energy requirements (kWh/ton) were obtained. When corn milling for direct feeding, the mill should be operated at optimum operational conditions with sieve size more than 4.8 mm. Meanwhile, sieve sizes of 3.2 and 4.8 mm may be used when corn milling for processing of pelleted feeds. Theoretical analysis results reveled that, the optimum power required for operating the machine must be not less than 3.26 kW. These results proved that, the proper operating parameters corresponded with theoretical considerations as the relevant for machine operation.

INTRODUCTION

Increasing poultry and animal production is one realistic means of increasing the production of animal protein to meet greater demand due to population pressure. In line with the rapid growth of the poultry and animal production, the feed industry has also been growing very quickly. Feeding is one of the most serious problems facing poultry and animal producers, which consumed more than 75 % from the total cost of production. Hammer mill prevalence in our small Egyptian village to prepare poultry and animal diet because it is more suitable for grinding various kinds of grains, work with any friable material and fiber such as spices, sugar and chemicals. Its simplicity, easy to operation and low maintenance cost. Nowadays, there are a shortage in poultry and animal feedstuff with about 3.5 million ton /year (Academy of Sci. Res. and Tech., 2006), and with dramatic increase in the cost of animal feeds. The Egyptian growers tend to use small-scale milling machines to produce their needs of animal feeds. Hence, for better utilization, a great importance should be given to evaluate and improve this type of mills.

Martin (1983) and Earle (1985) mentioned that for efficient grinding, the energy applied to the material should exceed the minimum energy needed to rupture the material by as small margin as possible. Hammer mill speed should be ranged between 40-50 m/s using a pulverizing mechanism (impact and shear). They added that ingredient with widely varying particle sizes are more difficult to mix properly, and large particles tend to segregate from smaller ones during subsequent handling after mixing.

According to the Egyptian standard specification for prepared animal feeds and feedstuffs (1987), feeds are sized into four categories as follows:

Size (1) < 2 mm in diameter ranked (powder or mash) which was used for all types of young poultry and birds. Size (2) from 2 - 5 mm in diameter, which was used for adult rabbits, goats and fishes. Size (3) from 5 to 10 mm in diameter for small animals (< 6 months). Size (4) from 10 to 22 mm in diameter for large animals (> 6 months).

David (1990) stated that the degree of fineness required for all cattle is 6.5 mm, for sheep from 3.0 - 12.5 mm, and from 3.0 - 4.0 mm for poultry. He added that many factors affecting the milling process. Some of these factors are related to physical and mechanical characteristics of the material and others are connected with the milling machine itself. For instance and according to preference the number of hammers on a rotating shaft, their size, arrangement, and sharpness, and the speed of rotation, are important variables in grinding capacity and the appearance of the product. While, Ensminger *et al.* (1990) showed that very fine grinding makes feeds dusty and lower palatability. However, fine grinding may be desirable when pelleting is to follow.

Bosoi, *et al.*, (1991) showed that the milling process may be done by the hammers which are either flat or wedge shaped. Moreover, the force applied to the wedge results in great pressure at the cutting edge against the material; this leads to breakdown the bond between individual particles of the material, separation and formation of one or two cutting planes

Hashish *et al.* (1994) and Hassan (1994) showed that grinding capacity increased and grinding energy decreased as fineness of grinding increased by increasing screen size from 3.2 mm to 6.35 mm, which in turn gave an increase of 68.1% in mill capacity and a decrease of 55 % in milling energy.

El-Hadidi *et al.* (1997) concluded that the consumed energy kW.h/ton was reduced 3.2 times by using burr mill compared with swinging beaters hammer mill and 1.5 times using rigid beaters and disintegrator hammer mills. Medium fineness degree of 3.0 - 4.2 mm was increased using burr mill and disintegrator hammer mill compared with other mills types.

Hunt (2001) and Hasting (2003) stated that the grinding impact is most efficient with the dry and low-fat ingredients. While, the solid materials may be reduced the size by impact and shear forces. Excessive size reduction can lead to wasted electrical energy, unnecessary wear on mechanical equipment and possible digestive problems in livestock and poultry.

El-Ashhab and Deraz, (2002) and El-Ashhab *et al.* (2003) showed that the machine capacity ranged between 0.35 t/h for grinding date stone without treatment and 0.41 ton/h, for the treated samples. The coarse fineness degree may be varies from 45 to 60%.

Williams and Rosentrater (2004) and Rosentrater and Williams (2005) reported that grinding of ingredients generally improves feed digestibility, acceptability, mixing properties and palatability. The mill includes the processes of attrition and impact, although these actions are limited if the material is easily reduced by cutting and the screen limiting discharge has large perforations.

Yousef (2005) reported that the power requirement of grinding operation increased as the feeding rates increased, while it decreased with increasing the screen opening size. The best results of power consumption obtained at 2200-rpm hammer speed, 550 kg/h feeding rate and screen opening sizes of 6 and 9 mm for soybean and maize crops respectively.

Hegazy (2006) adapted a fixed beaters-type hammer mill, for grain crusher to be suitable for date pits crushing. The crusher was modified by adding hammers with edge angles of 22.5 degree on the longitudinal axis. the experimental results show that the optimum operating conditions of modified crusher were found at hammers speed of 44.21 m/s, hammer edge angle of 22.5 degree and sieve size of 7.94 mm that gave the best results of productivity rate, power and energy consumption. While, Abd Elmotalb and Bejo (2009) showed that the machine productivity and power requirement of grinding operation increased as hammer revolving speed increased from 20.1 to 44.2 m/s at any screen hole diameter. The fineness degree of the milled product increased as screen hole diameter decreased from 2 to 7 mm.

Elshal *et al.* (2010) reported that the proper conditions for operating the hammer mill to produce pelleting feed were 33.56 m/s drum speed, 10% moisture content, 5 mm concave clearance and 5 mm hammer thickness. At these levels, a higher fineness degree was obtained.

Buhler (2011) stated that the design and placement of hammers is determined by operating parameters such as rotor speed, motor horsepower, and open area in the screen. Optimal hammer design will provide maximum contact with the feed ingredient. Impact is the primary force used in a hammer mill. Anything, which increases the chance of a collision between a hammer and a target; increases the magnitude of the collision; or improves material take-away, provides an advantage in particle size reduction. The magnitude of the collisions can be escalated by increasing hammers speed.

Particle size of the milled product varying as the input grains between the two disc surfaces of the disintegrator taper-pins hammer mill. Therefore, minimizing the irregular feeding will improve the performance of the pulverizing mechanism to obtain a well ground feeds.

The main objectives of this research work were to:

1. Modify a small grain-milling machine (disintegrator taper-pins hammer mill type) through using accurate mechanical feeding unit to improve the machine performance. Test and evaluate the modified machine during grain milling to determine the optimum operating conditions.
2. Studying the effect of some operating parameters such as, hammer revolving speed, feeding rate and sieve size, on the milling productivity, power and energy requirements. Milled quality in terms of (Particle size dis. and fineness degree) during milling process was also considered.

MATERIALS AND METHODS

To fulfill the objectives of this study, a grain milling machine (disintegrator taper-pins hammer mill), was modified and tested at the workshop of Agric, Engineering Research Institute (AEnRI) Dokki, Giza. Cooperation with international company for animal feeds. This type of mill was selected because it is easy to operate, maintain and it can do excellent work without much heating and generally used for feed preparations.

Theoretical Analysis:

A theoretical analysis was developed and discussed to associate the parameters involved in feed milling and analyze the behavior of particles and force acting on them during the milling operation.

In milling process, the material is stressed by the action of mechanical parts of the grinding machine and initially the stress is absorbed internally by the material as strain energy. When the local strain energy exceeds a critical level, which is a function of the material, fracture occurs along lines of weakness and the stored energy is released (Earle, 1985 and Buhler 2011).

As shown in fig. (1). The machine consisting of two circular discs one is fixed with four circular rows fingers (taper pins), while a runner disc with three circular rows fingers is mounted on a horizontal shaft coupled with electric motor.

From the hopper the grains stream is drops through the sliding gate, then the product stream is conveyed into the working space (grinding room) through the eye (hole) of the left hand disk (fixed disk).

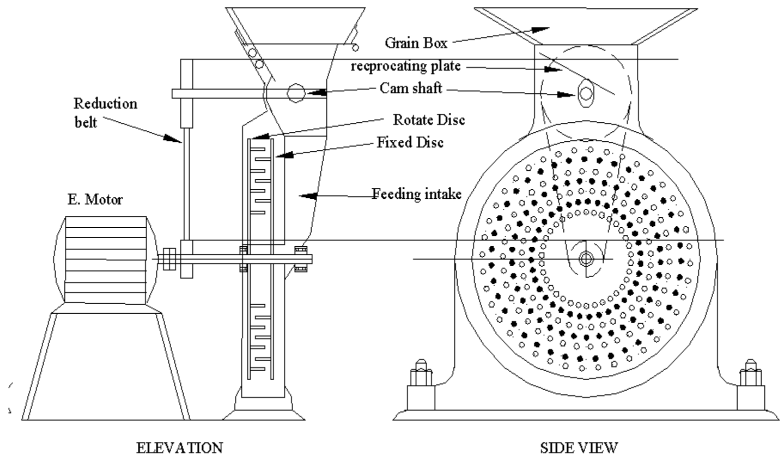

Fig. (1): Side view and elevation of the modified disintegrator taper-pins hammer mill.

Assuming that, the particle of material (grain) is delivered under its own weight to the grinding chamber Fig (2). It then falling on the moving taper-pin T1 receives an impact at tangent a1 with the speed $r_1\,\omega$, and meet the next fixed pin T2 that again strikes it at a tangent line a2 at which it lost its velocity, and dropped to the pin T3 moving in a contrary direction, with impact velocity of $r_3\,\omega$.

In this manner the product travels in a zigzag line to the out let, and the way of the product will be lie (a1,a2,a3,a4,a5, a6, and a7), then the grain gradually reduced and leave the working space in the shape of a product uniform size.

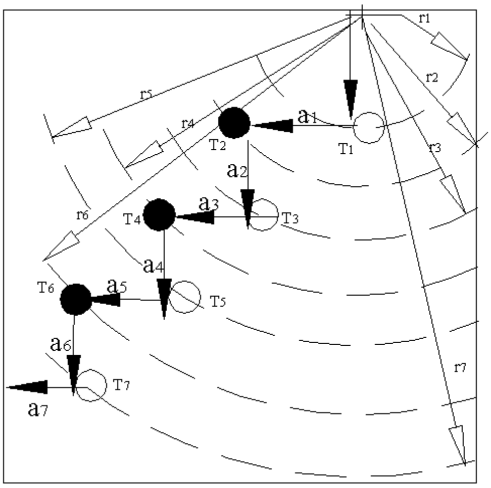

Fig. (2): The theoretical behavior of the grain during the milling process.

Considering, the speed of the free drops quite insignificant in comparison to the impact velocity of the pins.

The velocities of the impact T1, T2, T3, T4,… will accordingly be:

$$V_1 = r_1\ \omega \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$V_3 = r_3\ \omega = (r_1+2n)\ \omega \qquad \ldots\ldots\ldots\ldots\ldots (2)$$

$$V_5 = r_5\ \omega = (r_1+4n)\ \omega \qquad \ldots\ldots\ldots\ldots\ldots (3)$$

Where: V_1 *= velocity of the first raw pins, m/s*

V_3 *= velocity of the third raw pins, m/s*

V_5 *= velocity of the forth raw pins, m/s*

ω *= angular disc velocity, rad/s*

n = distance between two radial line (rows) of the pins, m.

Then. $$V = r_{avg.}\ \omega \qquad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where:

V *= velocity of the rotating disc (milling speed), m/s*

r_{avg}*= average disc radius, m*

ω *= disc angular velocity, rad/s.*

The power required to drive the working parts for milling operation is obtained as the sum of the power required for no-load operation of the machine and that for performing the required milling process. The no load power is the power required to overcome the friction resistance at the bearing. The power required for milling operation that depended on the quantity of the grain mass fed to the machine (Klenin et al, 1985).

According to, Srivastava *et al* (1985), Rotz and Muhtar (1991 and 992) the rotary power requirement for the machine was estimated using the following equation.

$$P_r = a + c \cdot F \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(5)}$$

Where:

P_r = *rotary power required, kW*
F = *material throughput rate, t/h*
a = *machine specific parameters, kW*
c = *machine specific parameters, kW.h/t*

If (F) is set equal to zero, equation (5) can be used to estimate the no-load power or propulsion power.

Under this study and by using the above equation, the motor power required for milling operation must be not less than 3.26 kW.

Materials:

Grains.

Yellow corn grains having a moisture content of 13.8 ± 0.5 % (wet basis) were used in this study.

The mill before modification.

A disintegrator taper-pins hammer mill-type was used to mill a yellow corn grains. The machine as shown in Fig (2) consists of a cylinder casing having two iron discs 350 mm diameter with steel taper pins, mounted on a horizontal shaft, these iron discs with steel taper pins are set in concentric circles, one of these discs being stationary and the other disc is revolving.

At the point close, the periphery of the discs is a screen of (3.2 mm or 4.8 mm diameter). Material is held in the grinding chamber until it is reduced to the size of the openings in the screen, then it passes through this screen to the outlet. A 3-phase electric motor 380 volt 5 hp (3.75 kW) was used for driving the machine.

Feeding process of the original machine is performed manually to control the width of the throat through a sliding gate fixed at the hopper bottom to control the grain dropping from the hopper depended on the product free fall. The grains are conveying from the tank to the working space through the eye of the stationary disc. The grain falling on the moving pins receives an impact, and strike to meet the next pin, which again strikes it.

The mill after modification.

The problem may be ascribed to the feeding system of the machine, which depended on the free fall of product to adjust the mill-feeding rate through manually sliding gate fixed at the hopper bottom to give the required feed rates. However, this technique is considered as simple common method but it is not capable to accurate the feeding rate especially when the materials contains a higher moisture content and higher damaged seeds, which in turn increase the irregular feeding and decreases the milling capacity and efficiency.

Adjusting the input grains between the two discs surfaces of the machine, this turned on the form of particle size of the milled product. Therefore, minimizing the irregular feeding will improve the performance of the pulverizing mechanism to obtain a well ground feeds. To accurate, the feeding rate during grinding seeds contains higher moisture content or higher damaged seeds, a vibratory feeder driven by eccentric bushing (cam), which can be shifted along the cam-rotating shaft, to vibrate the shaker box. The power was transmitted from the source to the camshaft of the vibratory feeder by means of V belt and pulleys. From the hopper the material drops through sliding plate at the hopper bottom over the shaker box then the product stream is conveyed into the working space, through the feeding hole.

Experimental Conditions:

During the experiments, the main variables were taken according to the relevant studies, as follows:

- Four grain feeding rates (0.30, 0.35, 0.40 and 0.45 ton/h).
- Four hammer revolving speeds 29.3, 34.4, 39.6 and 44.7 m/s (1600, 1880, 2160 and 2440 rpm).
- Two sieve opening sizes 3.2 mm (1/8 inch) and 4.8 mm (3/16 inch).

Procedures and measurements:

- Before milling operation, the hopper was filled with corn grains. Then, the gate opening to give the optimum-feeding rate (at which the quantity of the product delivered per second is proportionate to the quantity following into the mill).
- The machine was run before feeding any material to the hammer.
- During corn milling, the consumed time from the moment of full dropping until the end time was measured. Samples were taken periodically from the machine outlet, packed in polyethylene sacks, and stored, until different examinations and analysis were carried out.
- After milling the amount of grounded corn were noted, then the machine productivity (ton/h) and power (kW) and energy (kWh/ton) were estimated for each test. The milled quality as fineness degree was also considered.
- Each experiment was repeated four times and the mean of each data point was considered.

Corn Grains Moisture Content.

Moisture content of the corn samples were performed according to AOAC (1996).The standard air oven method using 25 g sample placed in air oven at 130 C for 16 hours was used to determine the corn moisture content.

Mill Productivity:

Mill productivity (M_P) was calculated using the following formula:

$$\text{Mill productivity } (M_P) = M_W / t \;\ldots\ldots\ldots\ldots\ldots\; (\text{ton/h})$$

Where:

M_W = milled weight, (ton);

t = the time consumed in operation (h).

Power consumed and Energy requirements:

Total consumed power (kW) under machine working load was estimated by using Wattmeter (700-k type) having an accuracy of ± 1%. Then, the power was estimated from the knowledge of line current strength in Amperes (I) and potential difference values. Then the power of the machine (P) was then estimated according to (Kurt, 1979) as follow:

Total consumed power under machine working load (P)..... kW

$$P = \sqrt{3} \,.\, I.\, V.\, \eta \,.\, \cos \Theta / 1000 \ldots \; \text{kW}$$

$$\text{No Load power} = \sqrt{3} \,.\, I.\, V.\, \eta \,.\, \cos \Theta / 1000 \;\ldots\; kW$$

$$\text{Useful power} = (\text{Load} - \text{No Load}) \ldots\ldots\ldots\ldots\ldots \; KW$$

Where:

I = line current strength in Amperes;

V = potential difference (voltage) being equal to 380 V;

η = mechanical efficiency (assumed to be 95 %);

$\cos \Theta$ = power factor (was taken as 85%).

Specific energy requirements in (kWh/ton) were calculated using the following equation:

Specific energy req. = power consumed, kW / Machine productivity, ton/h.

Particle Size Distribution:

The corn granulation and sieve analyses were determined using a laboratory automatic sieve shaker (PaSakha Teraoka – type SNF-7 Japan made) according to ASAE Standard S319.3 (ASAE St., 2001) as follows:

After milling, samples were analyzed for particle size by sieving triplicate samples of 100 grams of milled material that was placed on the top of sieves and the shaker was run for 10 minutes, using a sieve series of 1.18; 1.70; 2.36; 3.35 and 4.75 mm round holes respectively. After each test period, the percentage of through and overtails were recorded.

RESULTS AND DISCUSSION

In order to evaluate the modified machine performance, as well as milling efficiency during actual milling tests, the different criteria of milled corn, such as quality properties of milled products (fineness degree) and other factors related to machine productivity, power and energy requirements during milling operation must be taken into consideration.

Mill Productivity:

In general, it can be seen that, mill productivity were always increased gradually as the speed of hammer mill increased from 29.3 to 39.6 m/s, as well as the machine productivity at any sieve size, tends to increase slightly as hammer speed increased from 39.6 to 44.7 m/s.

The data indicated that the machine productivity increased gradually as mill feeding rate increased from 0.30 to 0.45 ton/h. However, this increase in machine productivity was always higher when milling with 4.8 mm sieve size comparing with the productivity using 3.2 mm sieve size, as shown in Fig. (3).

The data revealed that at any feeding rate from 0.30 to 0.45 ton/h, the productivity rate of the mill increased gradually as the hammer speeds and sieve size increased. On the other words, at 0.45 ton/h of hammers feeding rate, the results indicated that increasing hammer speeds from 29.3 to 44.7 m/s cause a corresponding increase in the mill productivity from 0.343 to 0.396 and from 0.363 to 0.400 ton/h at sieve size of 3.2 and 4.8 mm, respectively. This increase in machine productivity may be attributed to combined effect of shear and impact forces of working organs on the materials during milling process of corn grains. On the other words, these increases in machine productivity may be ascribed to increase of cutting efficiency for hammers due to the machine act as a hammer cutter mill, beside reduce the time needed for corn grinding.

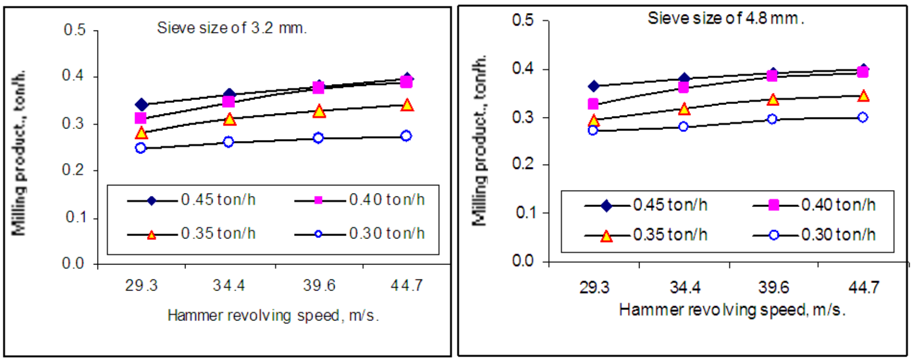

Fig. (3): Mill productivity as affected by different hammer speeds, and different feeding rates at 3.2 and 4.8 mm sieve size.

Power and Energy Requirements:

Figs (4 and 5) show the power and energy requirements as affected by different hammers speeds, hammer feeding rate and size of sieve openings. The data indicated that increasing hammer speeds from 20.10 to 44.21 m/s cause a corresponding increase in the power consumed as, loaded and useful power (kW) for both sieve sizes under study (3.2 and 4.8 mm). While, the power required for operating the mill empty (no-load) did not increase as the milling speed increased. On the other words, the horsepower of empty mill is a straight-line function.

It can be seen that, the consumed power increased gradually with increasing the amount of corn grains feeding rate from 0.30 to 0.45 ton/h. It can be also noticed that the maximum values of consumed power were recorded during milling of 0.45 ton/h feeding rate at 44.7 m/s hammer speed. However, this increase in consumed power was always higher when milling with 3.2 mm sieve size comparing with the milling power consumed using 4.8 mm sieve size, as shown in Figure, 4 which were 3.86 and 3.88 kW for 3.2 and 4.8 mm sieve size, respectively.

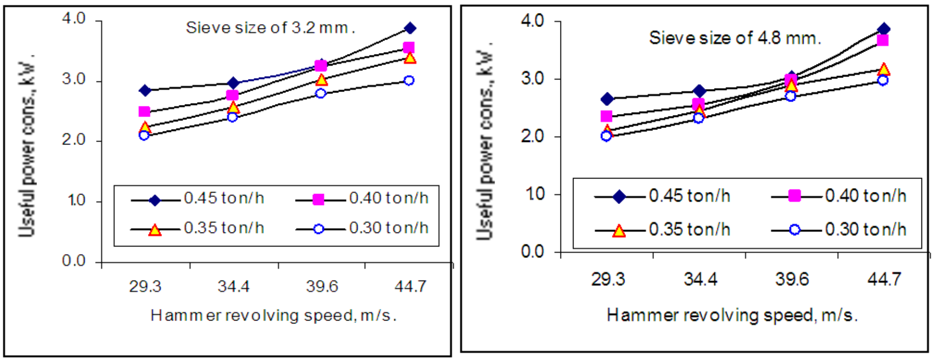

Fig. (4): Power consumed as affected by different hammer mill speeds, and different feeding rates at 3.2 and 4.8 mm sieve size.

The obtained results reveled that, increasing hammers speed from 29.3 to 44.7 m/s, and milling feeding rate from 0.30 to 0.45 ton/h, cause a corresponding increase in the milling power consumption from (2.078, 2.850), to (3.01, 3.88) at 3.2 mm sieve size. Under the same previous milling conditions and at sieve size of 4.8 mm, the milling power consumption increased from (1.99, 2.67) to (2.97, 3.86 kW).

It is remarkable that, the milling energy takes the opposite trend of milling power. I n other words, the specific energy requirements increased with decreasing the amount of corn grains feeding rate from 0.40 to 0.30 ton/h, and increased gradually as hammer revolving speed increased from 29.3 to 44.7 m/s. The maximum values of energy requairement were recorded during milling of 0.3 ton/h at 44.7 m/s, which were 10.945 and 9.966 kWh/ton for 3.2 and 4.2 mm sieve size, respectively. The minimum values of energy requairement were recorded during milling of 0.4 ton/h corn feeding rate.

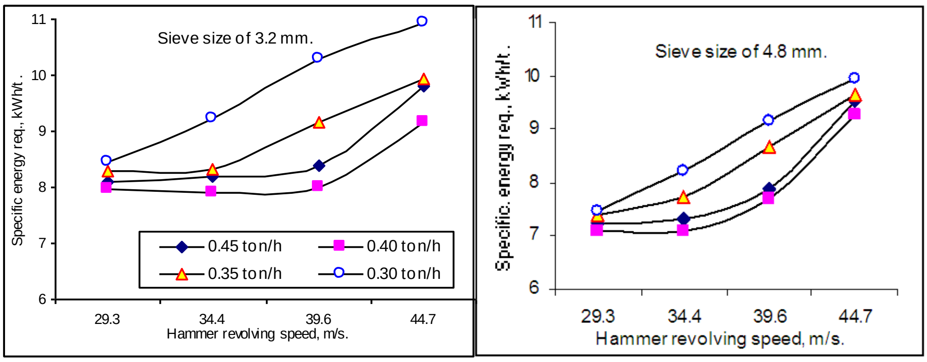

Fig. (5): Specific energy requirements as affected by different hammer mill speeds and different feeding rates at 3.2 and 4.8 mm sieve size.

As shown in figure (5), during milling operation at speed of 39.6 m/s, increaseing hammer feeding rate from 0.4 to 0.45 ton/h cause a slightly difference between the values of energy requairement, which were increased from 7.81 to 7.88 kWh/t for 3.2 mm sieve size, and from 8.30 to 8.377 kWh/ton for 4.8 mm sieve size, respectively. This is may be attributed to great increase in the power needed to corn milling at 0.45 ton/h feeding rate comparing with power needed to mill 0.40 ton/h feed rate at same speed (39.6 m/s). Therefore, the data of specific energy requirement at feeding rates of 0.45 ton/h and milling speed at 44.7 m/s, must be excluded from the energy calculation since it was found that the milling power of grains tends to increase extremely at these levels.

Generally, the experimental work showed that the best results were coupled with the interaction between treatments of 39.6 m/s hammer speed and 0.40 ton/h feed rate. These results proved that, the proper operating parameters corresponded with theoretical considerations as the relevant for machine operation, as shown in Fig. (4).

Particle size distribution and fineness degree percentage:

To throw light on the effect of mechanical action during milling process on the physical properties of milled corn. Fineness degree percentage should be taken in the considered as one of the most important functions to assessing the quality of the milled corn. Figure 6, illustrates the granulation data and fineness degree percentage of the milled corn as affected by the interactions between the studied factors.

As described above, the results showed that the best results were associated with the interaction between treatments of 39.6 m/s hammer speed and 0.40 ton/h feed rate. At these levels, maximum milling productivity, and lowest power and energy requirement for sieve size of 3.2 and 4.8 mm were obtained. Therefore, the particle size distribution of milled corn was carried out under these levels (optimum operation conditions).

The results showed that, the highest degree of fineness percentage with regard to the fraction of particle size (less than 1.7 mm), were found to be increased with 3.2 mm sieve size comparing with the values of fineness degree produced with 4.8 mm sieve size. At similar operational conditions, the values of fineness degree percentage of coarse particle size (more than 4.47 mm) were higher using 4.8 mm sieve size compared with the values of fineness degree produced at 3.2 mm sieve size.

As shown in Fig. (6) the results revealed that a little increase was obtained for medium degree of fineness percentage (1.7 – 3.35 mm), which was 70.8 and 45 % for sieve size of 3.2 mm and 4.8 mm respectively. On the other words, During milling corn grains, at 39.6 m/s hammer speed and 0.4 ton/h feed rate, the fineness degree percentage of medium particles (1.7 – 3.35 mm) produced with 3.2 mm sieve size were increased with about 36.4 %, comparing with that values produced at 4.8 mm sieve size.

The obtained results reveled that as the percentage of fineness degree increased the power and energy consumptions increased. On the other words, the data revealed that as the fineness degree of fine particle size (<1.18 – 1.7 mm) increased from 86.3 to 61.0 % when using the sieve size of 4.8 mm and 3.2 mm respectively, the power consumptions increased with about 3.7 % while, energy consumptions increased with about 6.3 %, for sieve size of 3.2 mm and 4.8 mm respectively.

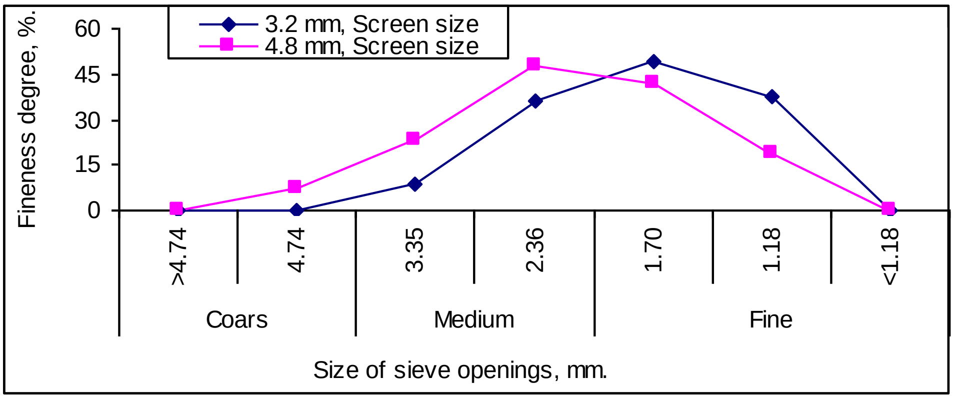

Fig. (8): Fineness degree of milled corn as affected by different hammer mill speeds and different feeding rate at 3.2 and 4.8 mm sieve size.

Hence, it can be concluded that, when corn milling for direct feeding, the mill should be operated at optimum operational conditions with sieve size more than 4.8 mm. Meanwhile, sieve sizes of 3.2 and 4.8 mm may be used when corn milling for processing of pelleted feeds.

Conclusions

1. The experimental results show that the best operating conditions of modified machine were found at hammers speed of 39.6 m/s, mill feeding rate of 0.4 ton/h and sieve size of 3.2 and 4.8 mm that gave the best results of productivity rate, power consumption and energy requirements.
2. As fineness degree of fine particle size (<1.18 – 1.7 mm) increased from 86.3 to 61.0 % using sieve size of 4.8 mm and 3.2 mm respectively, the power consumptions (kW) increased with about 3.7 % while, energy requirements (kWh/ton) increased with about 6.3 %, for sieve size of 3.2 mm and 4.8 mm respectively.
3. Milling corn grains, at 39.6 m/s hammer speed and 0.4 ton/h feed rate, the fineness degree percentage of medium particles (1.7 – 3.35 mm) produced with 3.2 mm sieve size were increased with about 36.4 %, comparing with that values produced at 4.8 mm sieve size.
4. The theoritical results reveled that, the the optimum motor powere required for operating the machine must be not less than 3.26 kW.

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تحسين الأداء الحقلي لآلة طحن الحبوب الدقاقة ذات البنوز

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- ينتشر بالسوق المصري أنواع كثيرة ومتعددة من آلات الجرش والطحن التي تستخدم على نطاق واسع بهدف طحن الذرة والحبوب المختلفة لتغذية الحيوان بمزارع الانتاج الحيوانى والداجني، وتختلف درجة جرش الحبوب تبعاً لنوع المجرشة المستخدمة ونظرية تشغيلها فمنها مايعمل بنظرية الضرب او بالقص او بهما معا ومنها مايعمل بنظرية السحق (الفرك والاحتكاك).
- تتميز المجارش الدقاقة بقبول كبير لدى المربين لإعداد الأعلاف، وذلك نظرا لسهولة تشغيلها وصيانتها، ولما كانت المطاحن المطرقية ذات البنوز تتميز بارتفاع إنتاجيتها وكفاءتها في طحن المواد التي تحتوي على ألياف عالية نسبيا كالشوفان والبهارات حيث يعتمد أداءها على التأثير المشترك للصدمة والقص، ولكن يعاب عليها عدم تجانس نواتج الطحن ويرجع ذلك الي تغير او تذبذب معدل تغذية الحبوب، مما أدي الي قصر إستخدامها في عمليات الطحن للتغذية المباشرة، وذلك نظرا لانخفاض خواص الجودة عند تصنيعها كأعلاف نظرا لعدم تجانس نواتج الطحن، لذا يلجأ المربين الي اعادة طحن المادة اكثر من مرة للوصول الى درجة النعومة المطلوبة مما يؤدى لارتفاع تكاليف الطاقة المستهلكة في الطحن.
- وتزود الطاحونة ببوابة منزلقة يتم تثبيتها أسفل خزان الحبوب للتحكم في معدلات تغذية الحبوب المراد طحنها. ورغم فعالية هذه الوسيلة إلا أنها غير كافية عند طحن حبوب بها نسبة كسر مرتفعة أو بها زيادة محتواها الرطوبي مما يعوق سريانها بشكل منتظم من القادوس إلى غرفة الجرش فيؤثر على أداء المجرشة ويقلل من جودة الطحن. لذا فإن تعديل نظام التغذية بالمجرشة سيزيد من دقة وكفاءة عملية الطحن. مما يشجع صغار المربين على اقتناء هذه النوعية من المعدات لتحل تدريجيا محل المطاحن المطرقية ذات السكاكين الثابتة او المتأرجحة التى تعمل بنظرية الضرب.
- يهدف هذا البحث إلي تطوير وتقييم طاحونة حبوب من النوع ألمطرقي ذات البنوز. تم تعديل نظام التغذية بالآلة بتزويدها بوحدة تغذية من النوع الهزاز تأخذ حركتها من عامود الإدارة لتزيد من دقة وكفاءة عملية التغذية. كما تم تقييم أداء الطاحونة بدراسة بعض العوامل التشغيلية المؤثرة على كفاءة عملية الطحن، واشتملت الدراسة على أربع مستويات لسرعة دوران المطارق 29.3 و 34.4 و 39.6 و 44.7 م/ث (1600 – 1880 – 2160 – 2440 لفة/د)، وأربع معدلات

لتغذية الحبوب (0.3- 0.35 – 0.4 – 0.45 طن/س)، ومقاسين لقطر فتحات غربال الطحـن (3.2 – 4.8 مم)، وأثر هذه العوامل على احتياجات الطاقة والقدرة المستهلكة، وإنتاجية الالة، ودرجة نعومة المجروش.

- أظهرت نتائج الدراسة المتحصل عليها أن العوامل المثلي لتشغيل الآلة كانت باستخدام سرعة قدرها 39.6 م/ث) ، ومعدل تغذية قدره (0.4 طن/س)، حيث أعطت آلة الجرش عند تشغيلها تحت هذه الظروف أعلى إنتاجية, وأقل طاقة مستهلكة. بالإضافة إلي تجانس واضح في درجات نعومة المنتج (مقاس الحبيبات) والتي تلائم التغذية المباشرة للدواجن أو تصنيعها كأعلاف مضغوطة.
- اتفقت نتائج التحليل النظري للآلة مع النتائج المتحصل عليها من التجارب العملية، حيث أظهرت النتائج ان قدرة المحرك اللازم لتشغيل الآلة يجب ألا تقل عن 3.26 كيلووات، وأن السرعة النظرية المثلي للتشغيل يجب ألا تزيد عن 40.2 م/ث.
- وتوصي الدراسة بضرورة استخدام غربال مقاس فتحاته اكبر من 4.8 مم عند طحن حبوب الذرة تجهيز الأعلاف المستخدمة في عمليات التغذية المباشرة.بينما يمكن استخدام غرابيل مقاس فتحاتها اقل من 4.8 مم عند طحن حبوب الذرة لتجهيز الاعلاف لتصنيعها في صورة مضغوطة.

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