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IMPACT OF HAMMERING TOOL AND SIEVE'S PERFORATIONS DIAMETER ON SOME MECHANICAL AND VOLUMETRIC TRAITS OF CORN GRINDING PROCESS

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Abstract

The research included studying the hammering tool type and the sieves' 1 and 2 perforations diameter impact of the hammer grinder, on some technical traits of the grinding process. Whereby a conventional hammer and two types of ring chain of different weights, along with three sieve's perforations diameter of 4, 6 and 8mm were adopted .the studied indicators were: specific productivity, specific energy, ground fineness and geometric mean diameter. The results were recorded as follows: chain 2 for the highest specific productivity 4.53 and the least specific productivity 0.26. chain 1 for the best ground fineness 5.567 .the best sieve's perforations- diameter of 765 micron. Sieves diameter was 8mm for the highest specific diameter of 4.71 kg / kwh and the least specific energy of 0.22 kwh/kg .the sieve of 4 mm for the best ground fineness of 5.507 and the best / the least geometric mean diameter of 753 µm. the interaction between the chain 2 and sieves perforations diameter of 8mm recorded the highest specific productivity of 5.97 kg /kwh and the least specific energy 0.17 kwh/kg. The best ground fineness was 5.319 recorded with chain 1 and the perforations diameter of 4 mm, thus the best geometric mean diameter was 749 µm.

Keywords: Geometric mean diameter, ground fineness, hammer grinder.

Introduction

Corn is considered among the primary crops around the world, in terms of importance, because it's used as a food for the humans or a fodder for livestock alike., in comparison with other grains Corn is considered as the prominent grains-crop that is used as fodder due to its production increasing (Mail, 2016) and (Al-Aqidi, 2006). Younis *et al.* (2006) mentioned that Hammer grinding is used for grains grinding, to prepare animal fodder. Grinding is done by hitting the grains with hammers that is rotating in high rotational velocity, powered from an electric engine by means of pulleys and belts. Sutowaski (2017) clarified that modern production systems aim to increasing work quality and proceeding production in high efficiency. Kumar and Vettivel (2014) stated that grinding grains requires high energy for each production unit due to the force and friction required for cracking the grains, and the specific energy of grinding is measured through calculating the power consumption per each weight unit. Ahmed *et al.* (2006), mentioned that among the primary parameters which affect the specific productivity of the grinder, is perforations diameter of the used sieves. Good band *et al.* (2002) stated that there are more diligent categories which are used for expressing the mash being fine or coarse, among it is the Average geometrical diameter (Dg), for what is constructed on those categories of recommendations for the purpose of livestock performance enhancing. Ahmed *et al.* (2001) that the perforations diameter of the sieves have a significant impact on the particles - Average geometric diameter, moreover they stated that the perforations diameter of the sieves have a significant impact on the mash fineness degree, whereby increasing the sieves-perforations diameter led to decreasing fineness of the grinding. The research aims to studying the impact of hammering tool andsieve's perforations- diameter in the traits, such as production, energy and the fineness of the material grinded particles.

Materials and Methods

The research was conducted in two parts; the first was done in the mechanical workshop, which is belonged to the department of agricultural machines and equipment – college of agricultural engineering sciences – university of Baghdad. The second was done in the laboratories of college of agriculture –University of Diyala 2018.

Corn grains were used, bought from a local grain silos. A hammer grinder locally manufactured of the following specifications was adopted: rotational speed 3000 rpm, voltage 220 v, number of hammers 8 and hammer - disk diameter 16 cm. the grinder is fixed on metal standers equipped with wheels. Three types of hammering tools were also adopted: chain1, chain 2 and a conventional hammer. Three types of grinder sieves' perforations diameter of 4, 6, 8 mm. a factorial experiment was conducted according to complete randomized design (C R D) in three replications, SAS program (2012) was used to analyze the data statistically.

The studied traits were calculated as follows:

Specific capacity (kg/kwh)

Productivity In the first part was done using a digital scale and a digital watch, after operating the grinder according to a fixed time per each experimental unit. Whereby the specific energy was conducted according to the following equation suggested by Pfost and Headly (1971).

S.c = C/P ………..kg / kwh.

Where

C : productivity kg/h

P : consumed power kw

Specific Energy (kwh / kg)

The specific energy was calculated during grinding process, whereby the consumed current by the grinder engine was calculated by using clamp meter by using the following equation suggested by Payne (1997).

S.E = P/C....................kwh/ kg

Where by:

P : the consumed power kw

C : productivity kg/h

Geometric mean diameter,(μm)

In the second part to calculate the results, the samples were taken of 100 gm per each unit. The sieving process was conducted by using 9 sieves, organised in descending order, from the biggest in diameter to the smallest then the pan according to Istivan (1980). Whereby the samples were weighted in each sieve, and then recorded. The Geometric mean diameter was calculated according to the equation suggested by Rudunitski (1990):

$$Dg = Log^{-1} [\Sigma(wiLog\,\overline{D}\,i) / \Sigma wi]$$

Where:

Wi: particles weight in the sieve (i) gm.

$\overline{D}$ i: Geometric mean diameter of the particles in the sieve (i) micron.

$\overline{D}\,i = (Di * (Di+1))^{0.5}$

I : the sieve number

Di : the diameter of the sieve perforations micron.

Di+1 : the perforations diameter of the next sieve bigger than the sieve (i) that is on the top in sequence /order.

Fineness material

The ground fineness was calculated according to the equation suggested by Caeedac (1999):

$$Fm = 1f_1+2f_2+3f_3+\ldots\ldots\ldots..+7f_7$$

Where:

F_1 : the gained weight as percentage of the last sieve

F_2 : the gained weight as percentage of the sieve that is before the last one 1 ,2 , 3 : constants .

Results and Discussions

The specific productivity (Kg/Kwh)

Table (1) Shows the impact of hammer tool and the diameter of the sieve on the grinder productivity. Whereby the hammer tool showed a significant impact on the specific productivity. The chain 2, and the conventional hammer recorded an increasing in specific productivity, in comparison with chain 1 of 4.53 and 3.39 kg /kwh respectively .that's due to the fact that chain 2 and the conventional hammer weigh 0.79 and 0.42 gm, in other word means heavier than Chain 1, which weighs 0.28 gm. That enables to fragmentize the particles better during hammering process, because of the heavier tool weight. Table (1) also shows that increasing the sieve's perforations- diameter from 4 to 6 the 8 mm led to a specific increasing impact on specific productivity, from 1.89 to 4.06 then 4.71 kg /kwh, that's due to the fact that the period of ground material exit /getting out is shorter, along with increasing the sieve's perforations diameter. hence that's led to less period of time spent being inside the grinder machine, further more that's led to less specific energy consumption because of a reverse relationship between the consumed power and the specific productivity, Al- Shemari. (2012).

Table 1 : Impact of hammer tool and sieve's perforations-diameter on productivity

Type of hammering tool	Diameter of sieve-perforations (mm)			Average of tool impact
	4	6	8	
Chain 1	1.76 f	2.84 def	3.62 cde	2.74 B
Chain 2	2.49 ef	5.15 ab	5.97 d	4.53 A
hammer	1.43 f	4.20 bcd	4.54 bc	3.39 A
Average of perforations impact	1.89 B	4.06 A	4.71B	
L.S.D P< 0.05				
Hammering tool: 0.81	sieve perforations: 0.81		interaction: 1.41	

The interaction between hammering tool and sieve perforations had a significant impact on specific energy, whereby the highest productivity recorded 5.97 kg/kwh with the hammering chain 2 and sieve's perforations 8mm. While the least productivity recoded 1.43 kg / kwh with the conventional hammer an perforations 4mm.

Specific Energy (kwh/kg)

Table (2) shows the impact of hammering tool and sieve perforations in specific energy. It's obvious that the significant impact of hammering tool on specific energy recorded with chain 1of 0.43 kwh/kg, and the least recorded with chain 2of 0.26kwh/kg. That's due to the fact of using chain 1 accompanied by the least specific productivity which results in decreasing the consumed specific energy to the minimum, While the chain 2 achieved the highest quality output, which reduced the quality energy consumed to the lowest levels .table (2) shows increasing sieve's perforations diameter from 4 to 6 then 8mm, the specific energy decreased from 0.61 to 0.25 then to 0.22 kwh/kg. That's due to the fact that increasing the perforations diameter makes the exiting ground, get out with a higher speed, which led to increasing the productivity along with specific energy decreasing because of a reverse relationship that bounds them. That is in coherent with Ahmed (2001), Al- Shemari (2012).

Table 2 : Shows the impact of hammering tool and sieve-perforations on the specific energy

Type of hammering tool	Diameter of sieve-perforations (mm)			Average of tool impact
	4	6	8	
Chain 1	0.67 ab	0.35 c	0.27 c	0.43 A
Chain 2	0.42 bc	0.19 c	0.17 c	0.26 B
hammer	0.76 a	0.23 c	0.22 c	0.40 AB
Average of perforations impact	0.61 A	0.25 B	0.40 AB	
L.S.D P< 0.05				
Hammering tool: 0.14	sieve perforations: 0.14	interaction: 2.25		

Table (2) shows that the interaction between the hammering tool and the sieves perforations have a significant impact on the specific energy. Whereby the chain 2and the sieve 8 mm Outperformed with least specific energy of 0.17 kwh/kg, while the highest specific energy recorded 0.76 kwh/kg with the conventional hammering tool and the sieves perforations 4mm.

Fineness of the Material

Table (3) shows the significant impact of hammering tool on ground fineness. Whereby chain 1recorded the best ground fineness of 5.567 in comparison with chain 2and the conventional hammer, where they both recorded 6.446 and 6.129 respectively. That's due to the fact that chain 1is lighter in weight, hence, in comparison with the other two heavier hammers, chain 1has a more flexibility during expanding/stretching throughout grinding process. the sieves' perforations had a significant impact on ground fineness, moreover when increasing sieves' perforations diameter from 4 to 6 then to 8 mm led to, increase the ground coarseness from 5.507 to 6.084 then 6.555 respectively, because the smaller sieves' perforations block the seeds until reaching a certain diameter, so that it can pass throughout the sieve's perforations, hence, that's made the seeds more vulnerable to a longer hammering period of time, which results in more fineness, Al-Shemari. (2013).

Table 3 : Impact of hammering tool and sieve diameter on ground fineness

Type of hammering tool	Diameter of sieve-perforations (mm)			Average of tool impact
	4	6	8	
Chain 1	5.319 d	5.596 cd	5.786 cd	5.567 B
Chain 2	5.651 cd	6.505 b	7.184a	6.446 A
hammer	5.550 d	6.150 bc	6.687 ab	6.129 A
Average of perforations impact	5.550 c	6.084 B	6.555A	
L.S.D P< 0.05				
Hammering tool: 0.325	sieve perforations: 0.325	interaction: 0.563		

The interaction between hammering tool and sieves' perforations had a significant impact on ground fineness. The interaction between chain 1and sieve's diameter 4mm, recorded the highest fineness of 5.319, while the interaction between chain 2and sieves' perforations 8mm recorded the least ground fineness of

7.184. Whereby the lowest numbers are the highest in fineness and vice versa the highest numbers are the lowest in fineness, Ahmed (2001).

Geometric Mean Diameter (µm)

Table (4) shows a significant impact of hammering tool on Geometric Mean Diameter, whereby chain 1 recorded the best Geometric mean diameter, of 765 micron, while the conventional hammer, and chain 2recorded 771 and 781 micron respectively. That's why chain 1recorded the best ground fineness in comparison with the other two hammering tool, that's very obvious, because there is a positive relationship. increasing sieve's perforation from 4 to 6 then 8mm led to increase Geometric mean diameter from 753 to 775 then to 789 µm respectively. That's due to the smallest sieve's perforations diameter blocks the grains till they reach a certain diameter, so they can make it through, the sieve's perforations, that's results in a longer hammering period of time, subsequently lead to more fineness along with a decreased Geometric mean diameter. Pfost and Headly (1971); Ahmed (2001).Interaction between hammering tool and sieve's perforation diameter was cleared ,and the least and best Geometric mean diameter was 749 µm with chain 1and perforations diameter of 4mm, while the highest Geometric mean diameter was 801 µm with chain 2 and perforations diameter of 8 mm.

Table 4 : Shows the impact of hammering tool and sieve's perforations diameter on Geometric mean diameter

Type of hammering tool	Diameter of sieve-perforations (mm)			Average of tool impact
	4	6	8	
Chain **1**	749 f	767 de	780 bc	765 C
Chain **2**	760 ef	783 bc	801 a	781 A
hammer	750 f	776 cd	788 b	771 B
Average of perforations impact	753 C	775 B	789A	
L.S.D P< 0.05				
Hammering tool: 6.55	sieve perforations: 6.55		interaction: 11.35	

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