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Effects of concave clearance and rotor speed affecting maize shelling performance

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Abstract

Presently, there is a development of a maize shelling machine fitted with a tractor. Therefore, it is necessary to study design factors. This research therefore aimed at studying the suitable of concave clearance and rotor speed for disc pegs. This research assessed the shelling performance of concave clearance and rotor speed by Shelling Efficiency (SE), Total Losses (TL), Grain Breakage (GB) from four levels of concave clearance including 15, 20, 25, and 30 mm and three levels of rotor speed including 6, 10 and 14 m/s. The results showed that the increasing concave clearance affected the TE decreased, but the TL increased, whereas concave clearance did not affect GB. The increasing rotor speed affected the TE and GB increased, but the TL decreased to the drum speed, which the suitable concave clearance, not more than 20 mm and the rotor speed, not less than 10 m/s.

Keywords: Drum, Maize shelling, Shelling performance

1. Introduction

Animal feed maize is an important economic crop in the world. In 2018/19, the demand for animal feed maize peaked at 1,100 million plants, an increase of 3.26 percent compared to 2017/18. Thailand imported a total of approximately 154,000 tons of animal feed maize. The value is approximately 900 million baht due to the use of maize as a raw material in production. Especially the animal feed industry whose demand has increased until now [1].

At present, rice combine harvesters have been converted to maize combine harvesters. which can store maize completely within itself [2-3], making the machine large, heavy, expensive, and suitable for large flat areas The planting areas in Thailand include large, small planting plots and hillside areas. Therefore, a small, lightweight harvesting machine is required to harvest maize appropriately in each area.

Later, a tractor-mounted maize sheller was developed. Using a sheller with a length not exceeding 900 mm. Although maize shellers have been developed, there are still problems with the loss and breakage of seeds that are quite high [2, 4] which is in the maize sheller set.

From the research study of Ukatu [5], which used shellers with pegs tooth characteristics and shellers that were modified with a curved shape, it was found that the modified soybean shellers had high efficiency. And there are fewer broken seeds than peg tooth shellers. From the study, it can be seen that There are quite a few studies of shellers used in maize shelling. Therefore, this study aims to determine the distance between the tip of the cracker tines and the cracker grate. and sheller speed that affects maize shelling performance for disc peg shellers to increase efficiency. and reduce losses incurred from shelling maize to feed animals.

2. Materials and methods

2.1 Equipment

This test uses unhulled Pacific 999 maize. Seed moisture ranged from 18 to 24, cob moisture ranged from 31 to 45, and shell moisture ranged from 18 to 20% shell base using the axial flow maize sheller of the Applied Engineering Research Group for Important Economic Crops of the Northeast. Using disc pegs, the length of the sheller is 900 mm, the diameter is 300 mm, the height is 65 mm, the distance between the shells is 100 mm, the length of the sheller is 1,900 mm, width 1,830 mm, height 1,600 mm. The power source is an electric motor of 5.59 kW. As shown in Figure 1, tests were conducted in the operating building.

Figure 1. Drum and maize shelling unit

2.2 Factors used in testing

This study used 4 distances between the tips of the crackers and the cracker screen, namely 15, 20, 25 and 30 mm, used a constant cracker speed of 10 m/s, then tested at 3 levels of cracker speed: 6, 10 and 14 m/s using a constant feed rate of 1750 kg/h, a constant crescent fin angle of 87 degrees with a distance between the crescent fin angles of 270 mm using a Randomized Complete Block Design (RCBD) test plan. 3 repetitions of each.

2.3 Indicators

The results of the study of the distance between the tip of the sheller tines and the sheller grate and the speed of the maize sheller without shelling included: Shelling efficiency Total losses and the amount of broken seeds Calculated according to the standards of the RNAM Test Code [6]. It is the ratio between the weight of the maize kernels at the cob exit and the weight of the maize without the cob at the cob exit to the weight of the total maize kernels fed. This can be calculated from Equation 1:

$$SE = [(A+B)/WT] \times 100 \quad (1)$$

where SE is the shelling efficiency (%), A is the weight of the total maize kernels at the kernel exit (g), B is the weight of the kernels not attached to the cob at the cob and husk exit (g), and WT is the weight. of total seed fed (g), total losses It is the ratio between the weight of the seeds falling off the cob and those attached to the cob that exit the cob and shell outlets to the weight of all input seeds, as shown in Equation 2:

$$TL = [(M1+M2)/WT] \times 100 \quad (2)$$

Where TL is the total loss (%), M1 is the weight of the seeds that fall off the cob at the cob exit, M2 is the weight of the seeds stuck at the cob and shell exit. The amount of broken kernels is the ratio between the weight of the broken kernels of maize on the support rail after cleaning obtained from sampling 1 kg of seeds to the weight of the maize kernels sampled for broken kernels, as shown in Equation 3:

$$GB = [(Mb)/WR] \times 100 \quad (3)$$

Where GB is the amount of broken kernels (%), Mb is the total weight of broken kernels (kg), WR is the weight of the kernels after cleaning that was sampled for broken kernels.

3. Results and discussion

The distance between the tip of the sheller tines and the sheller screen that affects the efficiency of shelling animal feed maize without peeling consists of Shelling efficiency Total losses from sheller sets and the amount of broken seeds The average shelling efficiency ranged from 98.43% to 99.51%. The average total sheller loss ranged from 2.42% to 4.82% and the average broken grain amount ranged from 0.85% to 1.01% as shown in Table 1. Due to the increase in the distance between the tip of the cracker's teeth and the grate creates a gap between the teeth and the grate. This causes some maize to not be shelled. Therefore, the efficiency of cracking is reduced. But the total losses increased. This is because the force of hitting the maize against the sieve is reduced. This causes the beaten maize kernels to stick to the cob and be expelled through the straw chute. Therefore, causing the total loss to increase as well. And in terms of the amount of broken kernels, the highest value was 1.01%, possibly due to the speed of shelling being too high. Resulting in high seed breakage as well.

From the study of the efficiency in chipping the distance between the tip of the chipper teeth and the chipping grid at a distance of 15 mm, it was found that the average chipping efficiency was as high as 99.51%. When considering the distance of 30 mm, it was found that the average chipping efficiency decreased by as much as 97.99% due to the increased distance between the tip of the husker and the husker grid, causing the maize to be less affected by the force of the husker tines. Resulting in decreased efficiency as well. As for the total loss from chipping at a distance of 15 mm, it was found that the average total loss was equal to 2.42%. When considering the distance of 30 mm, it was found that the total loss from chipping increased to 4.82% due to the distance. The increase makes the cracker's tines unable to hit the maize. This results in high total losses from shelling [2, 7] as shown in Figure 1.

Table 1 Effect of concave clearance on threshing efficiency, total losses and grain breakage

concave clearance (mm)	TE	TL	GB
	(%)	(%)	(%)
15	99.51±0.26	2.42±0.72	0.85±0.30
20	99.39±0.32	2.90±0.71	0.93±0.11
25	98.43±0.32	3.70±0.24	0.94±0.07
30	97.99±0.50	4.82±1.16	1.01±0.50

Notation: Shelling Efficiency (SE), Total Losses (TL), Grain Breakage (GB)

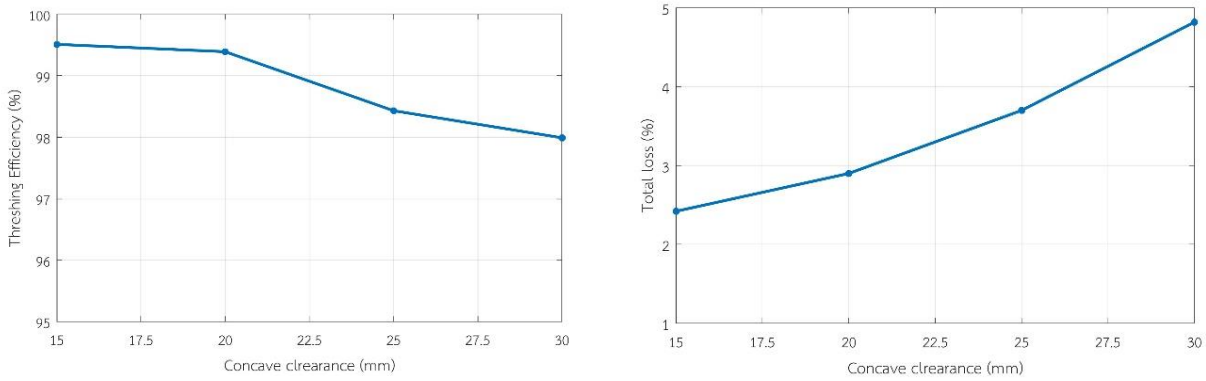

Figure 1 Threshing Efficiency (left) and Total loss (Right) of concave clearance on maize shelling performance

When adjusting the sheller at a distance of 15 mm, it was found that the average amount of broken seeds was 0.85%, respectively. When considering the distance between the tip of the sheller teeth and the screen at a distance of 30 mm, it was found that the average amount of broken seeds was 1.01% due to the distance. The increase causes the tip of the cracker to hit the tip of the maize kernel. This causes shear stress, resulting in the amount of broken kernels as shown in Figure 2.

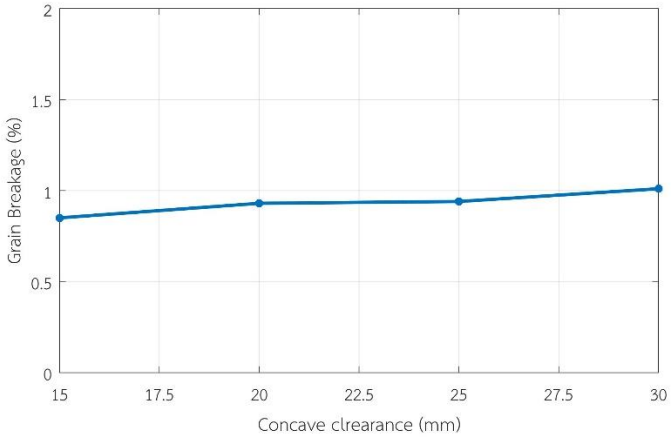

Figure 2 Grain Breakage of concave clearance on maize shelling performance

From the study of sheller speed that affects the efficiency of shelling animal feed maize without shelling. It was found that the average shelling efficiency was 95.29% to 99.79%, the average total loss from the sheller ranged from 1.34% to 6.75%, and the average broken grain amount ranged from 0.38% to 0.73%, as shown in Table 2, due to the increased rotational speed. Makes the cracker's tines hit the maize violently. Therefore, the efficiency in cracking is high. and results in reduced total losses from shelling. But at the same time, it also causes the amount of broken seeds resulting from cracking to increase.

Table 2 effect of Rotor Speed on Threshing Efficiency, Total Losses and Grain Breakage

Rotor Speed (m/s)	TE	TL	GB
	(%)	(%)	(%)
6	95.29±0.45	6.75±0.57	0.38±0.03
10	99.29±0.08	2.51±0.35	0.47±0.14
14	99.79±0.05	1.34±0.04	0.73±0.07

Notation: Shelling Efficiency (SE), Total Losses (TL), Grain Breakage (GB)

When adjusting the speed of the sheller to 6 m/s, it was found that the average shelling efficiency was 95.29%. At the sheller speed of 14 m/s, it was found that the average shelling efficiency increased to 97.99% due to the increased sheller speed. causing a violent strike resulting in increased efficiency as well. Total loss from shelling at the sheller speed of 6 m/s, it was found that there was an average total loss of 6.75%. When considering the sheller speed of 14 m/s, it was found that the total loss from shelling decreased to 1.34%, but the amount of broken seeds more when the sheller speed was adjusted from 6 to 14 m/s, the average amount of broken kernels was 0.38% and 0.73%, respectively. This is because the increased sheller speed made the impact force on the maize more severe. This makes the maize fall off the cob well. As a result, the total losses from shelling are reduced as well. But the amount of broken kernels increased with the speed of the sheller [2, 4] as shown in Figure 3.

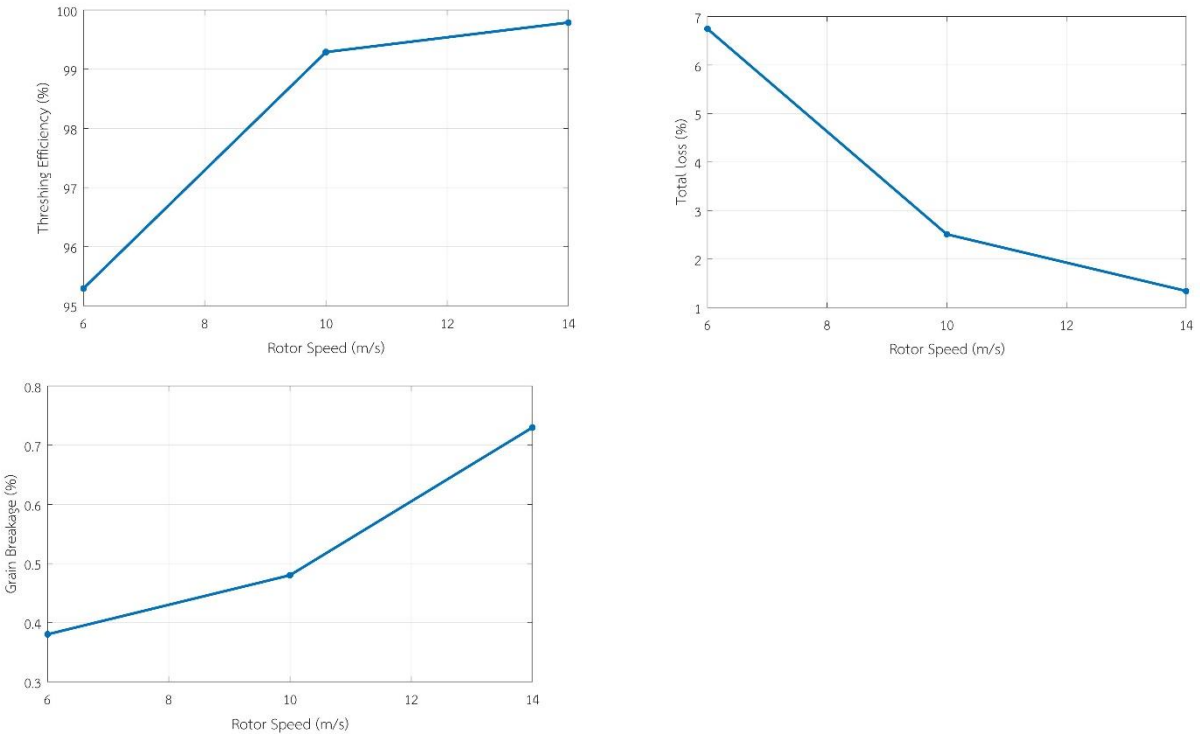

Figure 3 Threshing Efficiency (left), Total loss (Right) and Grain Breakage (Bottom) of rotor speed on maize shelling performance

4. Conclusions

From a study of the distance between the tip of the sheller tines and the sheller screen and the speed of the sheller that affect the efficiency of shelling animal feed maize without peeling, it was found that when the distance between the tip of the sheller tines and the sheller screen increased, it had an effect on the efficiency. reduce Total losses increased and had no effect on the amount of broken seeds When adjusting the speed of the sheller, it results in increased shelling efficiency. Total losses decreased and the amount of broken seeds increased with the rotational speed. The appropriate distance between the tips of the crackers and the cracker screen is not more than 20 mm and the speed around the crackers is not less than 10 m/s.

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