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Article

Development of Drums for an Axial Flow Maize Shelling Unit

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Abstract. Shelling drums have an important effect on the performance of machinery used in maize harvesting. This study was aimed to develop axial flow drums for a maize shelling unit. They were 900 mm long and 300 mm in diameter. Comparative maize shelling experiments were carried out with peg-toothed (A), peg-rasp bar-toothed (B), peg-rectangular-toothed (C), and disc peg (D) drums with four levels of concave clearance (CC), 15, 20, 25, and 30 mm and three rotor speeds (RS), 6, 10, and 14 m/s. The results showed that the CC had a significant effect on the shelling efficiency (SE) and total losses (TL), while grain breakage (GB) was not significant. Furthermore, no interaction was found between the power requirements (P) and the specific energy consumption (SEC), the SE, and the GB. However, interaction between TL, P, and SEC was found with various drum types and the CC. The RS was found to have a significant effect on the SE, TL, GB, P, and SEC with different drum types. Moreover, the interaction between the drum types and the RS affected shelling at the α=0.05 level. Furthermore, it was found that the Type D drum had higher performance in shelling maize.

Keywords: Drum types, maize shelling unit, threshing unit.

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1. Introduction

Maize is an economically important crop used by the world's animal feed industry [1, 2]. Also, it can be extracted and made into food and industrial products such as starch, oil, glue, and industrial alcohol [3, 4, 5]. Further processing increases the value of maize [6].

Currently, the demand for maize is increasing, arising from the expansion of the animal husbandry and animal feed industries, as well as from the practice of using maize as a raw material to create sources of energy such as fuel ethanol and biodiesel [7, 8]. As its demand increases, cultivation area has to be expanded to meet production demand. The United States, China, and Brazil are the leading maize producing countries in the world, harvesting approximately 563 of the 717 million metric tons produced annually [5]. When maize is sold, moisture content can be high, which can yield low-quality products. Therefore, farmers have to carefully maintain the quality of their maize [9, 10] especially during harvesting and shelling, which is an important process that affects maize transport, manufacturing, storage, and trading [11].

Most maize shelling in Asia is done using peg-tooth shelling machines, which have been modified from threshing machinery [11]. Maize shelling can be done in two ways that are using mechanical and manual type. Most non-peeling maize shelling uses peg teeth, which results in high total losses and grain breakage. Therefore, to increase the maize shelling performance in axial flow, adjustments can be made that can affect the threshing efficiency, total losses, and grain breakage.

Axial flow rice threshers have been modified to shell maize and serve as multi-functional combine harvesters [11, 12]. These modifications resulted in large, heavyweight and expensive machinery that is suitable for large flat and some hillside sloped areas. Lightweight harvesting machinery is required in other areas.

A maize shelling machine was developed that could be installed on a tractor with a shelling unit having a length not exceeding 900 mm. Although such maize shelling machines have been developed, high threshing loss and grain breakage are still big problems [11, 13, 14].

Chuan-Udom et al. [15] studied peg-tooth spacing and guide vane inclination. They found that both the peg-tooth clearance and guide vane inclination affect losses. Chuan Udom [11] studied the operation of Thai threshers to determine the factors that affect maize shelling losses. He found that both the guide vane inclination and the moisture content impact losses. Saeng-ong et al. [13] found that increasing the guide vane inclination and rotor speed resulted in decreased losses. Srison et al. [12, 14] studied the design factors that had affected losses and operating factors for an axial-flow corn shelling unit. It was found that moisture content affected grain breakage and power requirements, that the feed rate affected power requirements, and that rotor speed impacted total losses, grain breakage and power requirements. Moreover, it was found that the peg tooth clearance, concave rod clearance, and concave clearance affected the total losses. From a study of the concave design for high-moisture corn by Steponavičius et al. [16] it found that increases in concave clearance resulted in greater total losses.

Sudajan et al. [17] studied the influence of various drum types and their effects on sunflower threshing. It was found that the rasp bar drum was highly efficient and that the amount of grain breakage was less than found with a peg-tooth drum. Ukatu [18] studied a modified threshing unit for soya beans and discovered that a high-efficiency modified drum showed less grain breakage than a peg-toothed drum. FAO [19] reported that present world production is about 594 million tons grain, but 1% of grain losses has cost about 136 million USD. Therefore, this research was aimed to studying the development of drums for an axial flow maize shelling unit types to increase the shelling efficiency, reduce the total losses and grain breakage. This would be beneficial to agricultural machinery users, operators, and manufacturers of shelling equipment to reduce harvesting losses.

2. Material and Methods

2.1. Maize Shelling Unit

This study was conducted using an axial flow maize shelling machine at the Applied Engineering for Important Crops of the Northeast Research Group of Khon Kaen University in Thailand. This machine is shown in Fig. 1. The shelling unit was 900 mm long and 300 mm in diameter. The unit was fitted with a 5.59 kW electric motor that could be used to control rotor speed. The concave surface was made from a curved steel bar, while the bottom had a chute for the grain with nine slots, each 100 mm in width. The guide vane inclination could be adjusted and the feed rate of the conveyor belt controlled. The four types of shelling units described above, A-D, were utilized.

Fig. 1. Maize shelling machine.

All of the maize shelling units were 900 mm in length, 300 mm in diameter, with peg teeth for shelling (11 mm in diameter and 65 mm long), and four shelling bars, as shown in Fig. 2.

The peg-toothed (A) shelling unit had 40 teeth with a 100 mm spacing.

The peg-rasp bar-toothed (B) shelling unit had a 225 mm long rasp that was 45 mm wide and a height of 27.50 mm. Additionally, there were a total of 12 pieces.

The peg-rectangular-toothed (C) shelling unit was 225 mm long, 50 mm wide with a height of 27.50 mm. Furthermore, it had six pieces with two teeth, while the other six pieces had three teeth that were 20 mm wide and 50 mm long.

The disc peg (D) shelling unit had 11 mm thick pegs with a 100 mm spacing. The radius of the curvature of the pegs was 50 mm.

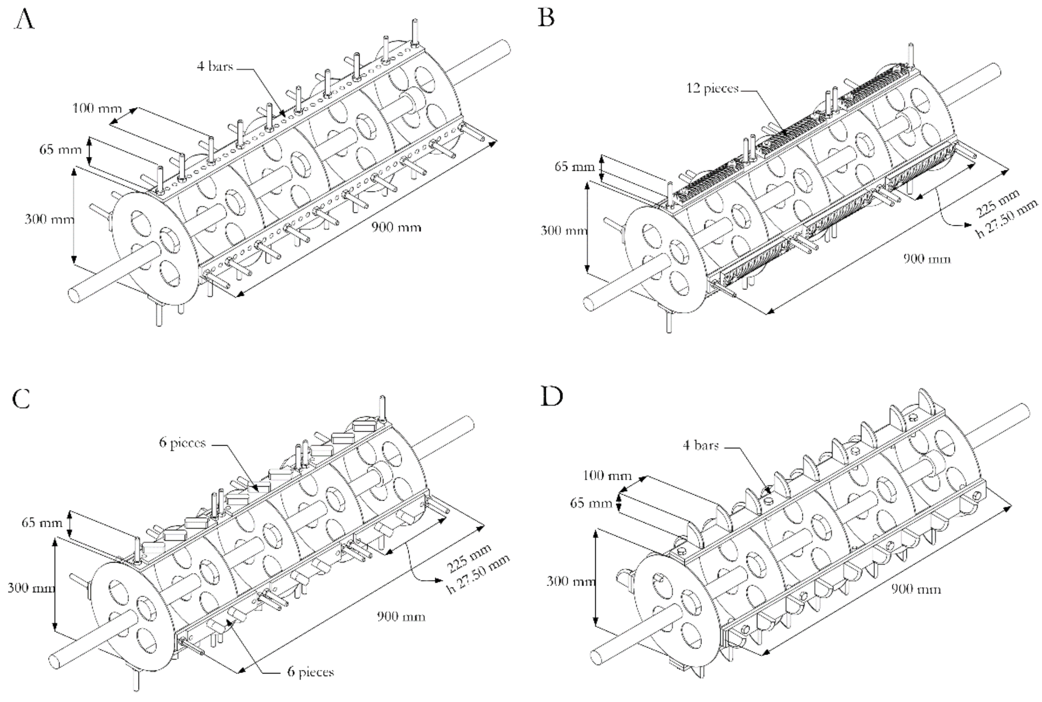

Fig. 2. Structural design of four thresher types: Peg-toothed (A), Peg-Rasp bar-toothed (B), Peg-Rectangular-toothed (C), and Disc pegs (D).

2.2. Shelling Drum Types

Each type of drum shelling unit had its own shelling mechanism. Drum A is a common style used by entrepreneurs and farmers. It was modified from an axial flow rice thresher [11].

Drum B had peg teeth. It was used to remove maize husks. After husks were removed, maize was shelled using a rasp bar drum to remove grain from the cobs.

Drum C was similar to Drum B, but it use a round steel part that removed husks from the maize and caused grains to fall off of the cobs [20].

Drum D rotated, impacting the grain with a force (F), acting along a line (L) as shown in Fig. 3(a). This results in a high force imparted by the peg (P) and to the maize grain. From Fig. 3(b), it can be seen that peg P_D has a curved shape, which impacts the grain at a force of impact (F') and acting along line (L'), which is inclined to

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the horizontal at an angle θ. This causes less impact force between the peg P_D and subsequently less grain damage [18].

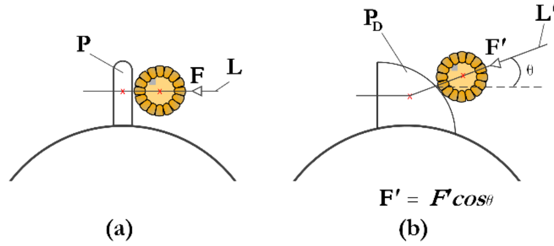

Fig. 3. The principles of direct (a) and oblique impact (b): L and L' lines of impact; F and F', impact force of straight peg P and curved peg P_D on maize: θ, angle of F'.

2.3. Factors Studied and Experimental Design

Drum types and concave clearance (CC) affecting performance. To find a suitable CC, four drum shapes were tested with four levels of CC (15, 20, 25, and 30 mm.), a constant rotor speed (RS) of 10 m/s, a constant guide vane inclination (87 degrees), and a constant feed rate of 1.75 t/hr.

Drum types and RS affecting performance. To find a suitable RS, the four drum shapes, three levels of RS (6, 10 and 14 m/s.) were examined with a constant CC of 15 mm, a constant guide vane inclination of 87 degrees, and a constant feed rate at 1.75 t/hr. In experiments examining the effects of drum type, concave clearance and rotor speed, the parameter values used are suitable for maize harvesting [11, 12, 13]. For these tests, a factorial in Randomized Complete Block Design [RCBD (4x4)] with three replicates.

2.4. Testing Method

Each test used 10 kg of maize. All data were collected based on the discharged maize cobs at the maize husk outlet. The materials were separated and cleaned to determine the weight of the grain. This was used to determine the shelling unit efficiency and the shelling unit losses. A 1 kg sample was randomly taken from the chute to determine the weight of broken grains. In these experiments, the power (P) and SEC values for shelling were measured using a torque sensor (SG Link Model; Lord Micro Strain; Williston, VT, USA).

2.5. Indicator Values

The indicator values consisted of Shelling efficiency, total losses, grain breakage, power, and specific energy consumption calculations based on the Regional Network for Agricultural Machinery (RNAM) test codes [21].

SE is defined as the ratio of the weight of the grain and weight of the grain that is not on the cob to the weight of the grain collected under the threshing mesh after cleaning, as shown in Eq. (1).

$$SE = \frac{A+B}{W_T} \times 100 \quad (1)$$

where SE was the shelling efficiency (%), A is the grain weight of all the shelled grain at the main grain outlet, B was the weight of the shelled grain at husks and cobs outlet, and W_T is the weight of all the shelled and the unshelled grain. Shelling unit losses or total losses were calculated using Eq. (2).

$$TL = \frac{M_1+M_2}{W_T} \times 100 \quad (2)$$

where TL is the total losses from the shelling unit, M_1 was the grain weight of the shelled grain at the cob and husk outlet, and M_2 is the grain weight of the unshelled grain at the cob and husk outlet. GB is the ratio of broken grains, weighed after shelling, per the weight of grains sampled from the collection tray after cleaning, as seen Eq. (3).

$$GB = \frac{M_B}{W_R} \times 100 \quad (3)$$

where GB is grain breakage (%), M_B is the grain weight of all broken grains, and W_R is the random weight of shelled grain after cleaning. Power consumption (P), calculated from torque, is shown in Eq. (4).

$$P = \frac{2\pi \times n \times T}{60} \quad (4)$$

where P is power requirement (Watts), n is the rotor speed (rpm), and T is the electric motor torque (N-m). SEC was calculated using Eq. (5).

$$SEC = \frac{P}{FR} \quad (5)$$

where SEC is the specific energy consumption in W-hr/t, P is the required power in Watts, and FR is the feed rate of the feeder in t/hr.

2.6. Data Analysis

From the obtained factors, the shelling efficiency, total losses, grain breakage, power requirements, and specific energy consumption were used as the indicators in the statistical analysis. Then the results of the study were compared by Duncan's Multiple Range Test (DMRT). Also, the SPSS Statistics 19.0 was used as the program for the analysis.

3. Results and Discussion

3.1. Comparison of Each Drum Type

The variances for each drum type were analyzed to determine how concave clearance (CC) affected Shelling efficiency (SE), total losses (TL), grain breakage (GB), power requirements (P), and specific energy consumption (SEC). When the drum types were changed, the SE, TL, GB, P and SEC were significantly different. They were also affected when the CC was adjusted from 15 to 30 mm. The effects to both the SE and the TL were found to be statistically significant, which was consistent with findings of Srison et al. [14], found that the peg tooth clearance, concave rod clearance, and concave clearance had significantly affected to the shelling unit loss and power consumption, but had not affected to the grain breakage. The GB, P, and SEC were not statistically different. There was no interaction between drum type and CC with respect to SE and GB. Moreover, for TL, P, and SEC, there was interaction between drum type and CC. These results are shown in Table 1.

When the drum type and the rotor speed were changed, SE, TL, GB, P, and SEC were statistically different, which is consistent with results of Saeng-ong et al. [13] and Srison et al. [14], who found the increasing of rotor speed had affected the total loss decreased, but the grain breakage, power requirements, and specific energy consumption were increased. The interaction between the drum types and the rotor speeds (RS) is shown in Table 2.

Table 1. An Analysis of the variances of SE, TL, GB, P and SEC resulting from CC.

Source of Variation	**SE**	**TL**	**GB**	**P**	**SEC**
Drum type	117.849*	301.825*	8.069*	6.741*	6.754*
CC	10.274*	18.124*	0.258ns	1.163ns	1.171ns
Block	1.188ns	0.802ns	1.032ns	2.827ns	2.828ns
Drum type*CC	1.432ns	2.501*	0.931ns	3.343*	3.342*

ns = Not significant, * = Significant at $p < 0.05$

Table 2. An Analysis of variances of SE, TL, GB, P, and SEC resulting from RS.

Sources of Variation	SE	TL	GB	P	SEC
Drum type	451.365*	524.304*	15.882*	22.181*	22.199*
RS	550.802*	619.040*	58.213*	308.157*	308.294*
Block	0.501ns	0.018ns	0.804ns	2.317ns	2.318ns
Drum type*RS	44.804*	57.071*	4.426*	10.270*	10.277*

ns = Not significant, * = Significant at $p < 0.05$

After comparing the mean values using DMRT (Duncan's Multiple Range Test), adjusting the CC and changing the drum types affected maize shelling performance. It was found that when the CC was 15-30 mm, the Type A and D drums showed no statistically significant differences in the SE and TL. When examining the GB, it was found that Types B, D, and A drums were not statistically different and that the performance of Types A and C drums were not statistically different. However, the P and SEC of Types C and B drums, Types B and D drums, as well as Types A and D drums showed no statistical differences. In contrast, there was a significant statistical difference found between the Types A and C drums, as shown in Table 3.

Table 3. Comparative results of the statistical averages of SE, TL, GB, P, and SEC resulting from CC.

Drum Type	SE	TL	GB	P	SEC
Peg-toothed (A)	97.48a	3.75a	1.32ab	1179c	673c
Peg-Rasp bar-toothed (B)	88.40b	15.42b	1.18a	1125ab	642ab
Peg-rectangular-toothed (C)	83.29c	24.47c	1.65b	1086a	621a
Disc pegs (D)	98.83a	3.46a	0.93a	1164bc	665bc

The same letter denotes no statistical difference.

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When the RS was increased from 6 to 14 m/s, the differences in both the SE and TL of the Type D drum were significant compared to the Types A, B, and C drums. When considering GB, Type D and Type B drums were not significantly different. However, the P and SEC values of the Type C drum were significantly different from the Type A, B, and D drums, as shown in Table 4.

Table 4. Comparative results of the statistical averages of SE, TL, GB, P and SEC resulting from RS.

Drum Types	SE	TL	GB	P	SEC
Peg-toothed (A)	96.59b	6.12b	0.84b	1163c	664c
Peg-Rasp bar-toothed (B)	87.93c	17.66c	0.63a	1074b	613b
Peg-rectangular-toothed (C)	87.26c	19.71d	0.87b	978a	558a
Disc pegs (D)	98.13a	3.53a	0.53a	1066b	609b

The same letter denotes no statistical difference.

In Tables 3 and 4, it can be seen that the Type D drum had had better performance than the Type A drum. Given the curved shape of the Type D drum, the impact force on maize shelling was reduced [18] resulting in a higher SE value, but also resulting in decreases in TL, GB, P, and SEC.

3.2. Shelling Efficiency of the Drum Types

From studying the SE of each drum type with a CC at 15 mm, it was found that Types D, A, B, and C drums showed average SE of 99.51%, 98.61%, 91.51%, and 87.67% respectively. When considering a CC at 30 mm, it was found that Types D, A, B, and C drums had average decreases in the SE at 97.99%, 96.05%, 85.46%, and 78.20%, respectively. Due to the increased CC, the maize was less affected by shelling, which resulted in a decrease in SE (Fig. 4). The results related to Tunhaw et al. [22], who found that the increase of concave clearance had caused shelling efficiency decreased.

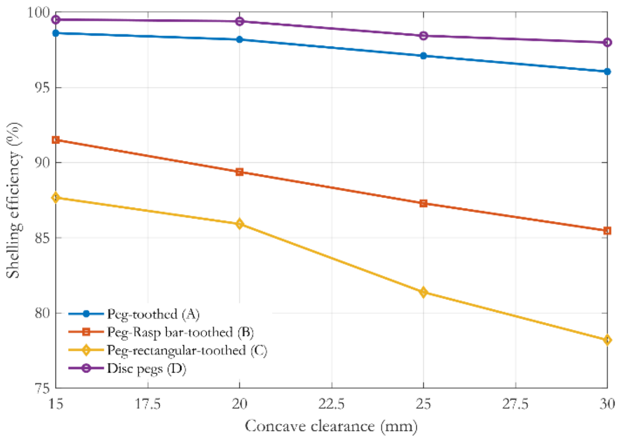

Fig. 4. The effect of concave clearance on shelling efficiency of various drum types.

At 6 m/ s RS, Types D, A, C, and B drums showed average SE of 95.29% , 92.02% , 80.56% , and 77.62% , respectively. At an RS of 14 m/s, it was found that Types D, A, B, and C drums had had average decreases in their SE of 99.79%, 99.28%, 94.28% and 93.81% respectively. This was due a higher impact force and a decreased resistance caused by an increased RS, resulting in a high in SE (Fig. 5). Yu et al. [23] found that the increase of drum rotation rate had tended shelling rates increased, and Simonyan [24] found that the increase of the threshing speed had resulted in the threshing efficiency increased.

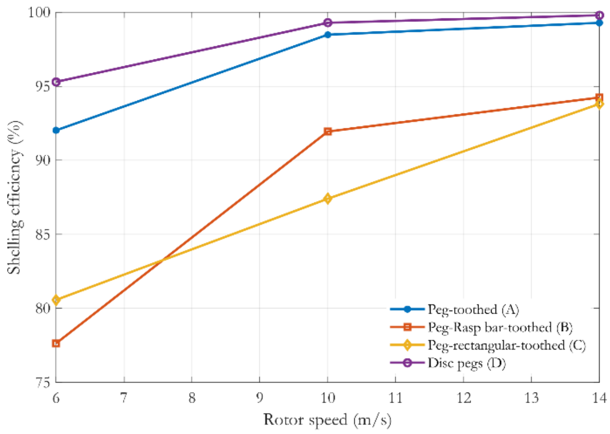

Fig. 5. The effect of rotor speed on threshing efficiency of various drum types.

3.3. Total Losses Due to Drum Type

Analysis of TL in maize shelling using each drum type with a CC at 15 mm showed that Types C, B, A, and D drums displayed average TL values of 20.01%, 10.44%, 2.98%, and 2.42% respectively. When considering a CC at 30 mm, it was found that drum types C, B, A, and D showed average increases in TL of 28.46%, 19.11%, 5.25%, and 4.82%, respectively. This was due to the increased CC when the maize was unshelled, which resulted in an increase in TL as shown in Fig. 6. The results related to Petkevichius et al. [25], who found that the concave clearance had influenced to the shelling losses of grains. Moreover, Steponavičius et al. [16], discovers that the decrease of concave clearance had resulted in the threshing loss decreased, and Pishgar-Komleh et al. [26] also found that the drum speed had a significantly affected on threshing losses.

The rotor speed test at 6 m/s showed that Types B, C, A, and D drums had had an average TL of 32.87 %, 28.43%, 13.46%, and 6.75% respectively. When the shelling RS was adjusted to 14 m/s, it was found that Types C, B, A, and D drums had indicated an average decrease in TL values of 11.24%, 8.79%, 1.98%, and 1.34%, respectively. This was due to the increased RS, which causes a higher impact force, better shelling and thus decreased TL as shown in Fig. 7. The results related to Srison, et al. [14] found that the increase rotor speed had resulted in the total loss decreased.

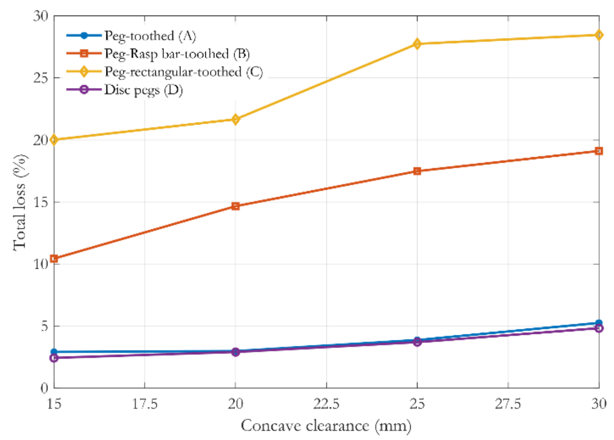

Fig. 6. The effect of concave clearance on total losses of various drum types.

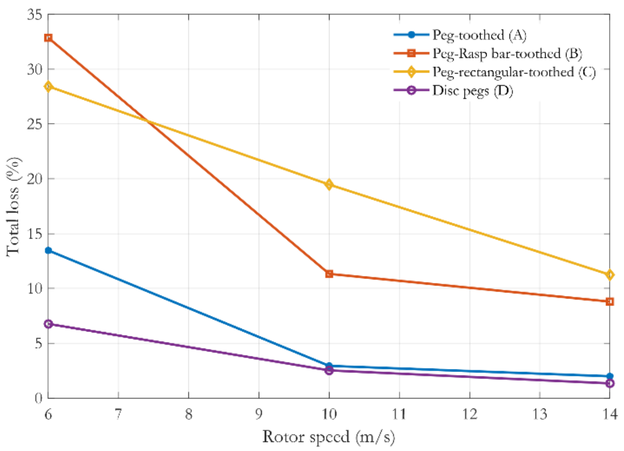

Fig. 7. The effect of rotor speed on total losses of various drum types.

3.4. Grain Breakage Using Various Drum Types

A concave clearance test with the drum types at 15 mm showed that Types C, A, B, and D drums had average GB values of 1.85%, 1.51%, 0.99%, and 0.85%, respectively. After the shelling CC was adjusted to 30 mm, it was found that Types C, B, A, and D drums had average GB values of 1.59%, 1.35%, 1.29%, and 1.01%, respectively. This was due to the lack of effect of increased CC on the GB as shown in Fig. 8. The results related to Wacker [27], and Kiniulil et al. [28], who also found that the concave clearance had not significantly different in the grain damage.

For the RS tests with various drum types at 6 m/s, it was shown that Types A, C, B, and D drums had average GB values of 0.59%, 0.45%, 0.39%, and 0.38%, respectively. After the shelling RS was adjusted to 14 m/s, Types A, C, B, and D drums showed average increases in the GB of 1.27%, 1.24%, 0.77%, and 0.73%, respectively. This occurred since increases in RS caused higher impact forces. Strong impact between the shelling teeth and the maize resulted in increased GB as shown in Fig. 9. Pishgar-Komleh et al. [26] and Špokas et al. [29], found that the drum speed had significantly affected the grain damage. Chansrakoo & Chuan-Udom [30] who also concluded that an increased rotor speed has a significant effect on grain breakage.

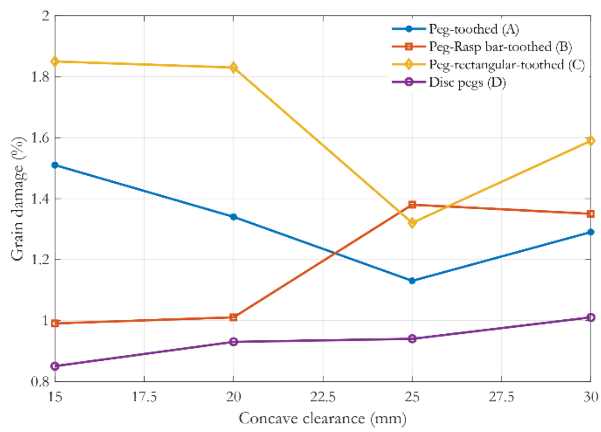

Fig. 8. The effect of concave clearance on grain breakage of various drum types.

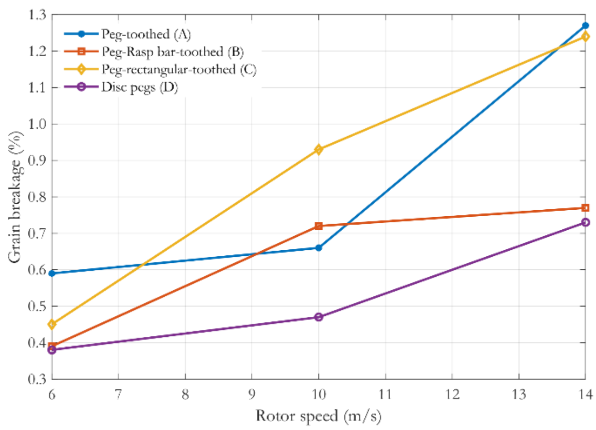

Fig. 9. The effect of rotor speed on grain breakage of various drum types.

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3.5. Power Consumption Using Various Drum Types

When adjusting the CC of various drum types to 15 mm, Types A, D, B, and C drums showed average P values of 1,187, 1,153, 1,145, and 1,077 W, respectively. When the shelling CC was increased to 30 mm, it was found that Types D, A, C, and B drums had average P values of 1,172, 1,157, 1,068, and 1,101 W, respectively. Increasing the CC did not affect the P as shown in Fig. 10.

For the RS test with the various drum types at 6 m/s, it was found that Types D, A, B, and C drums had average P values of 895, 796, 789, and 734 W, respectively. After shelling, the RS was adjusted to 14 m/s. Types A, D, B, and C drums displayed average increases in the P values to 1,500, 1,245, 1,245, and 1,151 W, respectively. The reason for this was that increased RS values result in higher impact forces. This in turn, resulted in increased P values as shown in Fig. 11. Saeng-ong et al. [13], Srison et al. [14], and El-Desukey et al. [31], discovers that the increase of rotor speed had tended to increase the energy requirements.

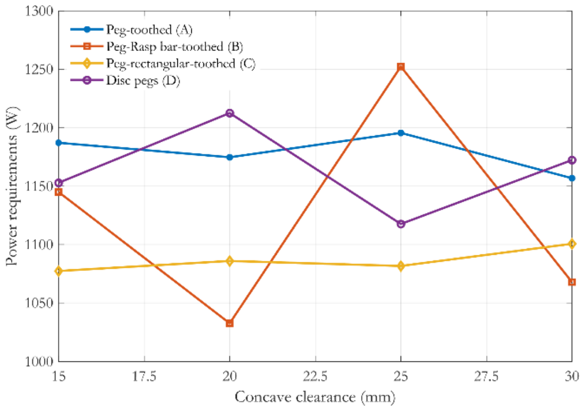

Fig. 10. The effect of concave clearance on the power requirements of various drum types.

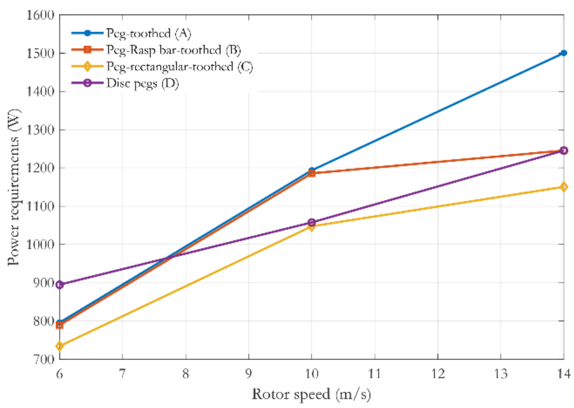

Fig. 11. The effect of rotor speed on power requirements of various drum types.

3.6. Specific Energy Consumption of Various Drum Types

When adjusting the CC to 15 mm, Types A, D, B, and C drums had average SEC values of 678, 659, 654, and 615 W-hr/t, respectively. When the shelling CC was changed to 30 mm, it was found that Types D, A, C, and B drums had average SEC values of 670, 661, 629, and 610 W-hr/t, respectively. Adjusting the CC did not affect the SEC as shown in Fig. 12.

For the RS test at 6 m/s, it was seen that Types D, A, B, and C drums had average P values of 511, 455, 451, and 419 W-hr/t, respectively. After adjusting the shelling RS to 14 m/s, it was found that Types A, D, B, and C drums had an average increase in SEC to values of 857, 711, 711, and 657 W-hr/t, respectively. This was due to the increased RS, which has a strong impact on maize shelling resulting in an increase in the SEC as shown in Fig. 13. The results related to Saeng-ong et al. [13] who found that the increase of rotor speed had tended to increase the specific energy consumption increased.

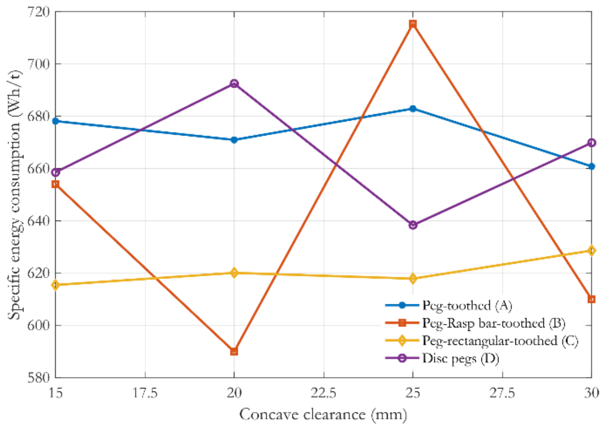

Fig. 12. The effect of concave clearance on the specific energy consumption of various drum types.

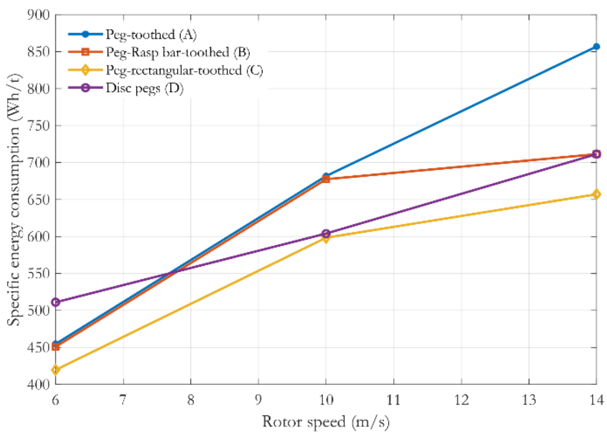

Fig. 13. The effect of rotor speed on specific energy consumption of various drum types.

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3.7. Cumulative Separated Grain of Drum Types

The cumulative separated grain was examined when the CC was 15 mm, the RS was 10 m/s and the grain was moving through the concave section in the first 0.1 to 0.3 m of the shelling unit length. It was found that the cumulative separated grain ranged from 32.53% to 47.17%, and from 31.91% to 45.17% respectively. This was due to grain to falling out of the feeding zone as the maize was being shelled. A separation zone existed between 0.4 to 0.9 m, where the amounts of shelled and separated grains decreased as the length was increased as shown in Fig. 14 and 15. The results related to Chuan-Udom [32], who found that the increase of drum length had resulted in the amounts of shelled and grains decreased.

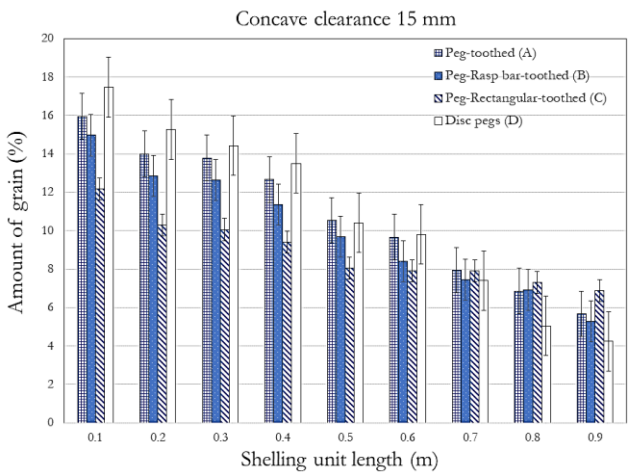

Fig. 14. The effect of concave clearance on amount of cumulative grain of various drum types.

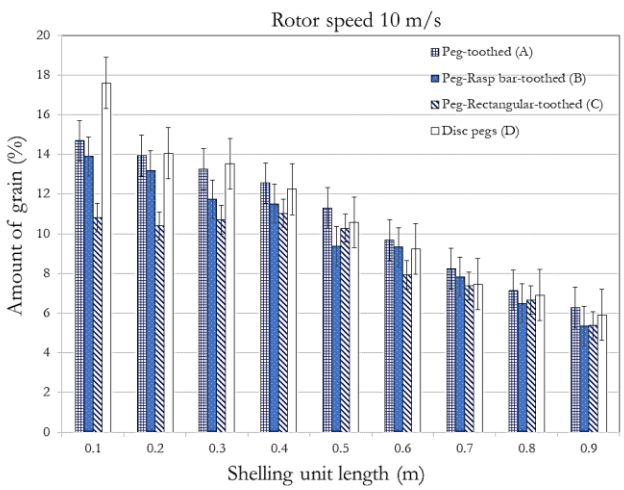

Fig. 15. The effect of rotor speed on amount of cumulative grain of various drum types.

The amount of accumulated grain increased linearly in the feed zone (0.0-0.3 m of shelling unit). After this, there was a separation zone (0.4-0.9 m into the shelling), in which non-linear accumulation was observed as shown in Fig. 16 and Fig. 17. The results related to Chuan-Udom [32], who found that the cumulative straw increased during the feeding zone and when the concave rod clearance was large. Zhong et al. [33], found that the accumulative threshed grain rate had been increased alongside increasing arc length of the concave. Zhong et al. [34], also found that the cumulative ratio had been increased along the threshing drum.

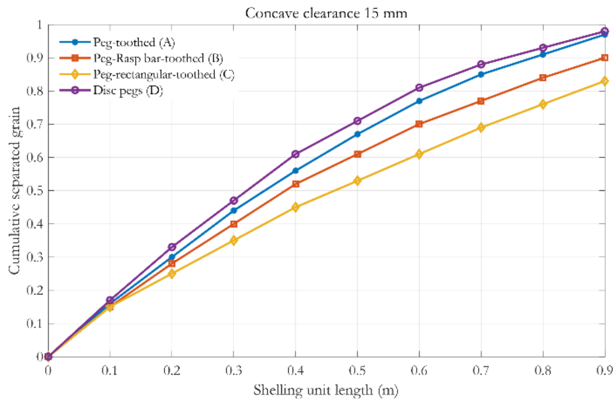

Fig. 16. The effect of concave clearance on amount of cumulative grain of various drum types.

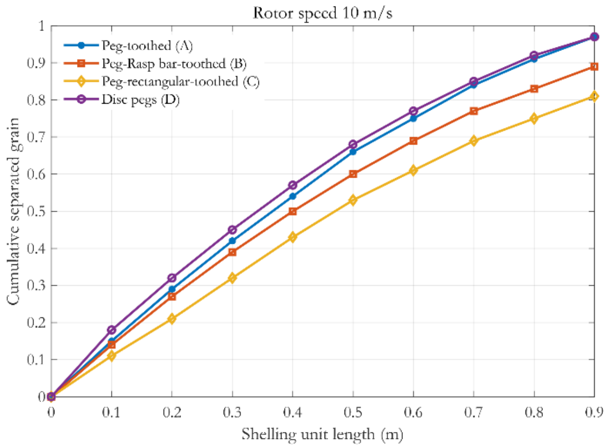

Fig. 17. The effect of rotor speed on amount of cumulative grain of various drum types.

3.8. Cumulative Separated Husks and Cobs of Drum Types

Based on an analysis of the amounts of husks and cobs that fell through the concave portion of the sheller at a CC of 15 mm and RS at 10 m/s, the amounts of husks and cobs gradually decreased in the first 0.1 to 0.3 m of the shelling unit. This occurred since there are zones for feeding and shelling. Much material fell through the concave section, resulting in large amounts husks and cobs from this position. After the feeding zone (0.4 to 0.9 m of the shelling unit), there was no more input material, representing the section of the machine where shelling and separation was accomplished. Therefore, the amounts of husks and cobs gradually decreased as shown in Fig. 18 and Fig. 19.

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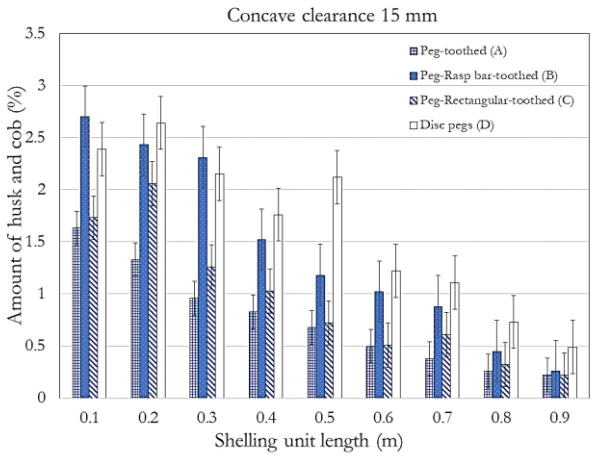

Fig. 18. The effect of concave clearance on the amount of cumulative husk and cob of various drum types.

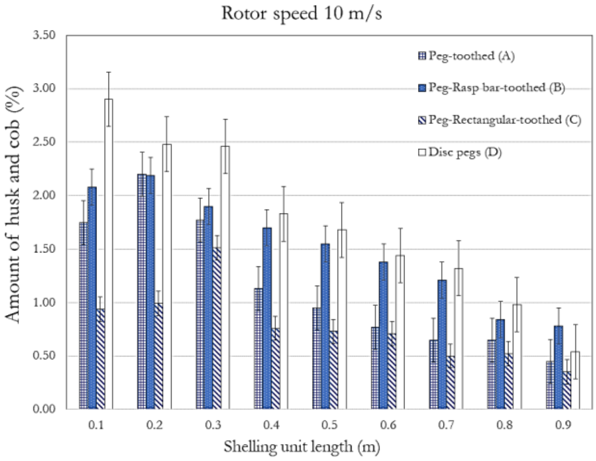

Fig. 19. The effect of rotor speed on the amount of cumulative husk and cob of various drum types.

The amounts of accumulated husks and cobs increased along the length of the shelling unit. The relationship of CC vs. RS is an inverted curve. This occurs since large material cannot pass through the concave section. When entering the separation area, the husks and cobs are removed resulting in size reduction, so that material can more easily pass through the concave to the chute for maize grain as shown in Fig. 20 and Fig. 21.

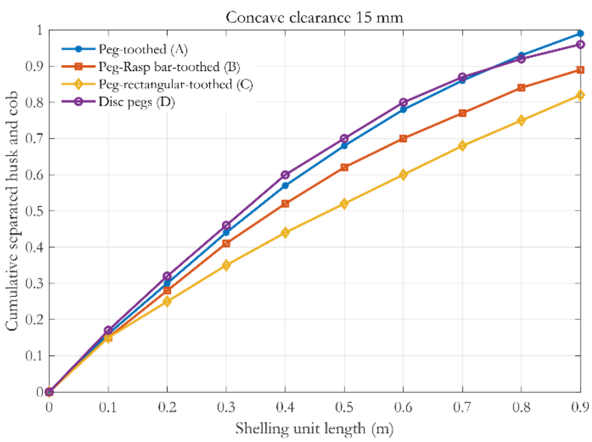

Fig. 20. The effect of concave clearance on the amount of cumulative husk and cob of various drum types.

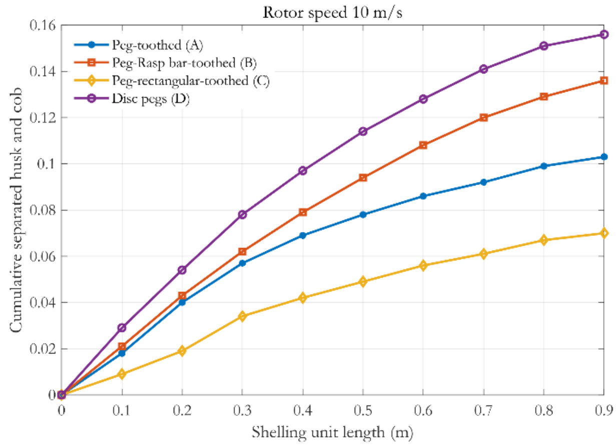

Fig. 21. The effect of rotor speed on the amount of cumulative husk and cob of various drum types.

4. Conclusions

Several conclusions can be drawn from the results of the current study. The concave clearance (CC), rotor speeds (RS), and types of drums affected the shelling efficiency (SE). Increases in the CC had affected the performance of shelling units using all drum types. Increased RS also affected the SE performance using all drum types. The shelling unit with the highest SE used a Type D drum.

The CC, RS, and drum type affected the total losses (TL). Furthermore, increased CC and RS values impacted the TL performance of units using all drum types. The shelling unit with the lowest TL used a Type D drum.

CC and drum type did not have an effect on grain breakage (GB) when the CC was increased. Increased RS affected GB performance of units with all drum types. The sheller with the lowest GB had a Type D drum.

CC and the drum type did not affect the power requirements (P) when the CC was increased. Increased RS affected the P requirements of using all drum types. The lowest power requirement, P, was for the shelling unit with a Type C drum.

CC and drum type did not impact the specific energy consumption (SEC) when the CC was increased. Increased RS affected the SEC performance of units will all drum types. The lowest SEC was with the Type C drum.

It was shown that for an axial flow shelling unit, the Type D drum had the best maize shelling performance. The shelling unit was 900 mm long and 300 mm in diameter.

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