MANUFACTURED AND EVALUATION OF CORN SHELLER SUITABLE FOR EGYPTIAN FARMER

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ABSTRACT

A power-operated corn sheller was manufactured to investigate the effect of corn moisture content, drum rotary speed on the percentage of damaged kernels, undamaged kernels, losses of kernels as well as shelling efficiency and machine productivity. The experiments were conducted at four levels of kernels moisture content of 12,2, 13.3, 14.5and 16 % and four drum rotary speeds of 220 , 280, 340 and 400 rpm (23.02, 29.31, 35.9 and 41.9 m/s). The results indicated that, increasing drum speed lead to increase each of damaged kernels, losses kernels and machine productivity. On the other side, increasing drum speed tends to decrease the undamaged kernels and machine efficiency. The least value of damaged kernels (1.5%) and the highest values of undamaged kernels (98.5%) and machine efficiency (96.3%) were obtained at moisture content of 13.3%. While increasing moisture content lead to increase the losses kernels and decrease machine productivity.

INTRODUCTION

Corn is considered as one of the most important cereal crops in Egypt. It is used in human feeding, industrial aspects for producing corn oil, starch and dry food for animal, more recently, fuel. The total planted area is 1.9 million feddans (0.8 million hectares) and the total production reaches up to 6.3 million tons with an average yield of (3.32) ton/ fed. (**Agric. Exetn. Iss., 2012**). Shelling of corn in general is carried out by using three different methods: manual, semi-mechanical and mechanical. Up to now most of shelling corn in Egypt is essentially carried out manually. Manually shelling of corn is very slow process and requires much time and labor, but it cases minimum losses and seed damage compared with mechanical shelling. **Liao et al. (1994)** stated that, machine vision systems have been developed for detection of corn kernel breakage and have shown promising results.

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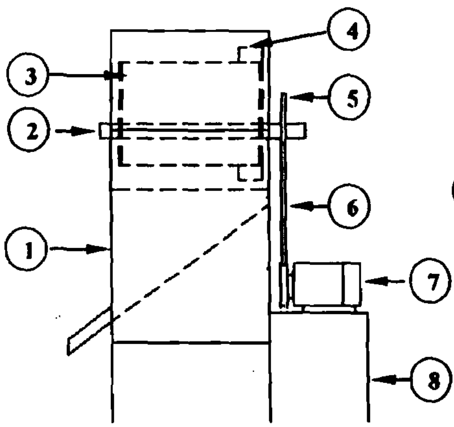
Most machine vision systems are designed to classify corn kernels into two or more damage categories, such as no damage, minor damage, and severe damage. One problem with this approach is that mechanical damage occurs on a continuous scale from hairline cracks and tiny spots of pericarp missing to complete breakage, which makes separation of damaged kernels difficult. It would be useful to have machine vision systems that determine the damage level on a continuous scale that is proportional to the damage severity. **Ajav and Igbeka (1995)** tested the performance of corn sheller using an international standard code to study the general qualities and design of sheller. The results show that the shelling efficiency of the sheller varies with moisture content, speed of the shelling unit and feed rate. The machine has a shelling efficiency of 98%, 95% and 94% when shelling corn with moisture contents of 11, 20 and 25% , respectively. The sheller has a cleaning efficiency of 93, 87 and 85% when shelling corn with moisture content of 11, 20 and 25% respectively , with a shelling unit speed of 400 rpm and fan unit speed of 750 rpm. The sheller has a capacity of 260 kg/h. The performance tests proved that the sheller performs best at shelling unit speed of 450 rpm with minimum losses and high efficiency. **Metwalli et al. (1995a)** compared between two maize shelling drums, triangle raspbar and triangle spike-tooth. Five drum speeds, four clearance ratios and five kernel moisture contents were tested to estimate grain damage and unshelled grain. Triangle rasp-bar drum is strongly recommended for its good performance. The grain damage, unshelled grain, and shelling efficiency were 3.86 % , 1.95 % and 96.2 % respectively, at 10.26 m/s drum speed, 1.8 to 2.1 (inlet clearance / outlet clearance) for 18 to 20 % moisture contents as condition of the triangle rasp-bar drum. **Metwalli et al. (1995 b)** manufactured and constructed a small suitable corn shelling machine from local materials to suit the demands of Egyptian farmers. A comparison test of machine was carried out on the manufactured machine compared with another small French shelling machine. The test performance includes unshelled grain, grain damage and economical operating cost. The performance of the machines was influenced by both drum speed and concave clearance ratio at different moisture contents during shelling corn ears. The manufactured machine was developed to be suitable as possible for different grain crops with a minimum adjustments by using a rasp-bar cylinder. The manufactured machine was found to be better in shelling efficiency and grain damage. **Abd EL-Maksoud (1996)** studied some factors affected the performance of new established small corn sheller at three levels of kernels moisture content and four corn varieties. He found that, the optimum shelling efficiency was 97.5 % at kernels moisture content 18% (w.b) and speed 280 – 320 rpm for all varieties. The minimum total losses (6 – 10 %) was obtained when speed ranged from (280 to 600 rpm) and the same kernel moisture content for most corn varieties. **Kumar and Parvathi (1998)** studied the energy expenditure of woman laborers for corn shelling using tubular, modified tubular and hand operated corn sheller. The energy expenditure was compared with the traditional method of shelling. Three female subjects with similar anthropometric parameters were selected to operate the corn sheller. It was estimated that the average energy expenditure for operating of the different manual sellers was 5-6 k cal/min. The output of the hand operated corn sheller was 23 kg/h , 92% higher than the hand operated, modified tubular and tubular corn sheller saved energy expenditure by 80, 60 and 52 %, respectively, compared to the traditional method. The energy requirement to operate these sheller without fatigue was 2200 k cal/day. **Ng et al.(1998)** stated that machine vision algorithms were developed for measuring corn kernel mechanical damage and mold damage. Mechanical damage was determined using both single–kernel and batch analysis by extracting from kernel images the damage area stained by green dye and by calculating the percentage of total projected kernel surface area that was stained green. Mold damage was determined using single–kernel analysis by isolating the moldy area on kernel images and by calculating the percentage of total projected kernel surface area covered by mold. The vision system demonstrated high accuracy and consistency for both mechanical and mold damage measurements. The standard deviation for machine vision system measurements was less than 5% of the mean value, which is substantially smaller than for other damage measurement methods. **Vishwanatha (2005)** stated that traditionally, maize shelling is carried out as manual operation where maize kernels are separated from the cob by pressing on the grains with the thumbs. According to the operator's ability about 10 kg of maize grains are separated per hour. Another simple and common shelling methods are rubbing two ears of maize against each other. Threshing of maize with hand-held tools (wooden or slotted metal cylinders) output up to 20 kg/h can be achieved. The small disk shellers like hand-driven or powered machine, which commonly required two operators to obtain 150 to 300 kg/h . Another threshing methods followed in tropical countries involves putting cobs in bags and beating them with sticks, outputs achieved prove attractive but bags deteriorate rapidly. **Zaalouk (2013)** developed a small corn Sheller for rural dweller at operated by using an electric motor. The results revealed that, with increase of operating speed shelling efficiency decreased and productivity, unshelled percentage, kernels damage percentage and power consumption with all sizes of corn cobs increased. The heights shelling efficiency and sheller productivity of (99.65 ,99.61 , and 99.48%) and (94.38 , 127.02 and 138 kg/h) at operating speeds 229, 275 and 330 rpm respectively with all sizes corn cob. It is recommended that the operating of the corn sheller was 275 rpm to achieve average shelling efficiency of 99.35 % unshelled kernels of 0.65 % damage kernels of 5.25 %, productivity of 98.8 kg/h and average total cost (operating cost + criterion cost) of 112.40L.E/ton for sum the sizes corn cob. The total cost (unit cost + criterion cost) of 382.72L.E/Mg were high when operating the corn sheller manually. The objectives of the present study are to manufacture a corn sheller suitable for Egyptian farmer and evaluate its performance under different operational parameters.

MATERIALS AND METHODS

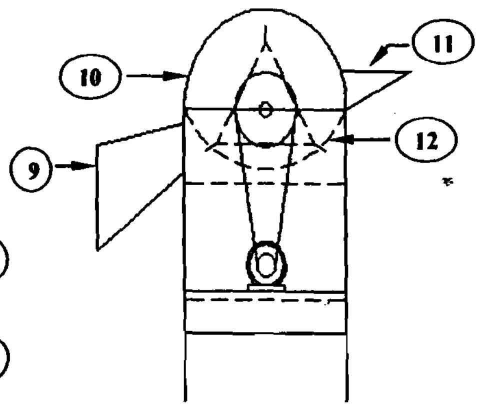
This study aimed essentially to construct and evaluate a power-operated corn sheller. The new mechanical sheller was constructed at the Agric. Eng. Dept., Faculty of Agric., Suez Canal Univ. The experiments were carried out at the Experimental Farm of Faculty of Agriculture, Suez Canal University.

Corn sheller

The sheller consists of an iron drum have an equal sided triangle whose sides measure 400 mm and length of 600 mm assembled on an axial shaft of 30mm diameter rested on two bearings fixed on the frame that have dimensions of 75 x75 x 115 cm. The drum is divided into two zones. The first zone facing cob inlet opening. At the end of the drum, hammers were fixed to expel the cob from outlet opening. The sheller concave were made from iron sheet of 1mm thickness pierced to hole of 16 mm diameter and fitted under the drum at space of 50 mm. Two pulleys (40 and 160 mm diameters) fixed on each of motor and drum shaft respectively. The electric motor (2 hp or 1.5 kW) connected by Inverter device (AC650 series) to provide or reduce the rotary speed of the electric motor. Under the cob inlet opening fan was fixed having six blades to clean the kernels from dust as shown in **fig.(1)**



Side view



Elevation

No		No. off	No		No. off
1	Frame of machine	1	7	Electric motor	1
2	Shaft	1	8	Stand of motor	1
3	Drum	1	9	Expel opening	1
4	hammers	3	10	Cover	1
5	Transmission pulleys	2	11	Feeding opening	1
6	Conveyor belt	1	12	concave	1

Fig. 1. The side view and elevation of the corn sheller.

Corn variety.

yellow Corn hybrid 352 was used in this study.

Experimental conditions.

The corn Sheller was tested to study some parameters affecting on the shelling operation as follows:

1- Four rotary speeds of 220, 280, 340 and 400 rpm (23.02, 29.31, 35.9, and 41.9 m/sec.)

2- Four levels of moisture content of (12.2, 13.3, 14.5 and 16 %.)

Measurements.

The corn sheller performance was studied through:-

* Damaged and undamaged kernels percentage.
* Losses kernels percentage.
* Shelling efficiency.
* Machine productivity.

Damaged and undamaged kernels percentage.

Three random samples of corn kernels were taken after shelling operation. Each sample was weighted and was divided into two portions, damaged kernels and un-damaged kernels. The percentage of the each portion was calculated as follows:

$$D_k = (M_1 / M) \times 100 \qquad (1)$$

$$UD_k = (M_2 / M) \times 100 \qquad (2)$$

Where's:

D_k = damaged kernels, %.

UD_k = undamaged kernels, %.

M_1 = mass of damaged kernels, kg.

M_2 = mass of undamaged kernels, kg.

M = total mass of separating kernels, kg.

Losses kernels percentage.

Three samples of corn kernels were fed into the sheller. After completed shelling operation the unshelled (losses) kernels from the ears were shelled manually and weighted. The percentage of the shelling losses was calculated as follows:

$$Lk = (M_3 / M) \times 100 \quad (3)$$

Where's:

Lk = losses kernels , %.

M_3 = mass of un-separating kernels, kg.

Shelling efficiency (η):

Shelling efficiency of the mechanical sheller was estimated according to the following formula:

$$\eta = [1 - (L\,k,\% + D\,k,\%)] \quad (4)$$

Machine productivity (MP):

Time of shelling was measured by means of a stopwatch (T, min) to determine the machine productivity in Mg/h. The machine productivity was calculated as follow:

$$MP = (M / T) \times 60 \quad (5)$$

ESULTS AND DISCUSSION

The discussion will cover the obtained results under the following heads:

Effect of drum speed on the thresher at different levels of moisture content.

Fig. (2) illustrated the effect of drum speed on the damaged kernels percentage at different levels of moisture content. There is a positive relationship between the drum speed and damaged kernels percentage. Increasing drum speed lead to increase damaged kernels percentage. Increasing drum speed from 220, 280, 340 to 400 rpm tends to increase the average of damaged kernels from 1.93, 2.58, 3.45 to 4.5% at different levels of moisture content. The highest value of damaged kernels was 5.0% obtained at drum speed of 400 rpm and kernels moisture content of 16.0%. While the lowest value of damaged kernels was 1.5% obtained at drum speed of 220 rpm and kernels moisture content of 13.3%. Fig. (3) showed the effect of drum speed on the undamaged kernels percentage at different levels of moisture content. There is an inverse relationship between the drum speed and undamaged kernels percentage. Increasing drum speed lead to decrease undamaged kernels percentage. Increasing drum speed from 220, 280, 340 to 400 rpm tends to decrease the average of undamaged kernels from 98.1, 97.43, 96.55 to 95.5% at different levels of moisture content. The highest value of undamaged kernels was 98.5% obtained at drum speed of 220 rpm and kernels moisture content of 13.3%. While the lowest value of undamaged kernels was 95.0% obtained at drum speed of 400 rpm and kernels moisture content of 16.0%.

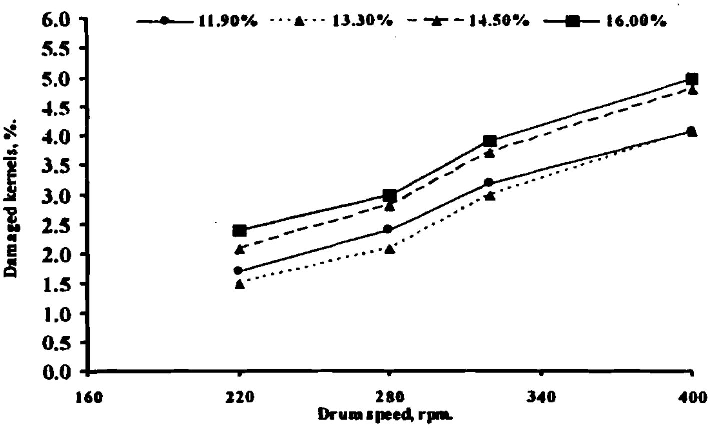


Fig. (2): Effect of drum speed on the damaged kernels percentage at different levels of moisture content.

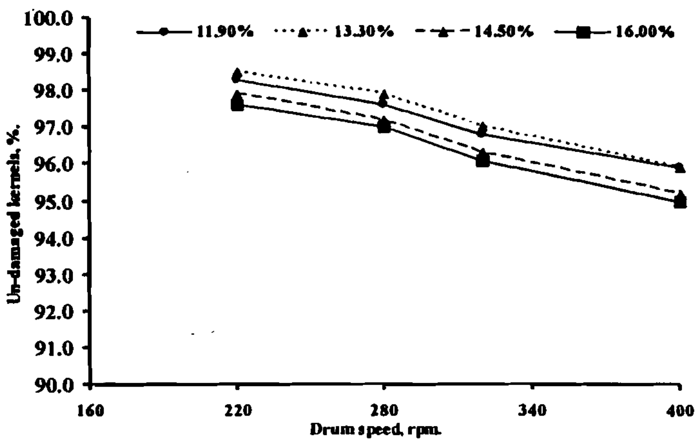


Fig. (3): Effect of drum speed on the undamaged kernels percentage at different levels of moisture content.

Fig. (4) cleared the effect of drum speed on the losses kernels percentage at different levels of moisture content. There is a positive relationship between the drum speed and losses kernels percentage. Increasing drum speed lead to increase losses kernels percentage. Increasing drum speed from 220, 280, 340 to 400 rpm tends to increase the average of losses kernels from 2.55, 3.35, 4.33 to 5.48% at different levels of moisture content. The highest value of losses kernels was 6.2% obtained at drum speed of 400 rpm and kernels moisture content of 16.0%. While the lowest value of losses kernels was 2.1% obtained at drum speed of 220 rpm and kernels moisture content of 11.9%.

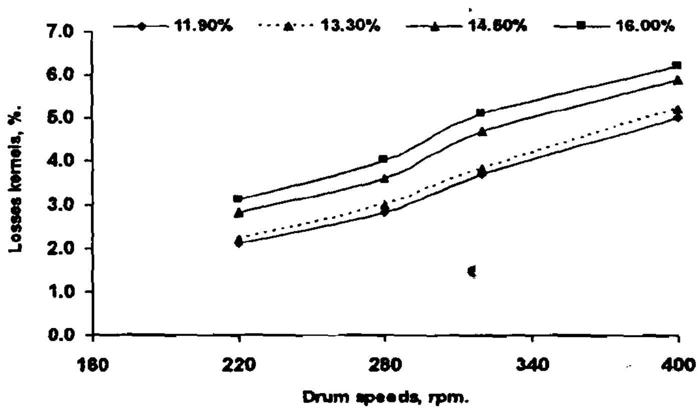


Fig. (4): Effect of drum speed on the losses kernels percentage at different levels of moisture content.

Fig. (5) described the effect of drum speed on the shelling efficiency at different levels of moisture content. There is an inverse relationship between the drum speed and shelling efficiency. Increasing drum speed lead to decrease shelling efficiency. Increasing drum speed from 220, 280, 340 to 400 rpm tends to decrease the average of shelling efficiency from 95.5, 94.1, 92.2 to 90% at different levels of moisture content. The highest value of shelling efficiency was 96.3% obtained at drum speed of 220 rpm and kernels moisture content of 13.3%. While the lowest value of shelling efficiency was 88.8% obtained at drum speed of 400 rpm and kernels moisture content of 16.0%.

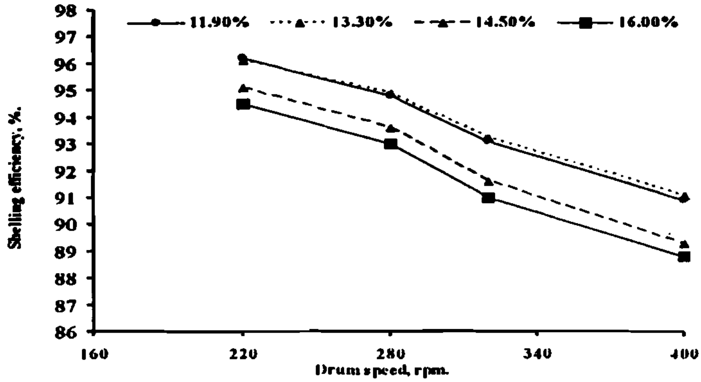


Fig. (5): Effect of drum speed on the shelling efficiency at different levels of moisture content.

Fig. (6) explained the effect of drum speed on the machine productivity at different levels of moisture content. There is a positive relationship between the drum speed and machine productivity. Increasing drum speed lead to increase machine productivity. Increasing drum speed from 220, 280, 340 to 400 rpm tends to increase the average of machine productivity from 0.218, 0.283, 0.355 to 0.433 Mg/h at different levels of moisture content. The highest value of machine productivity was 0.466 Mg/h obtained at drum speed of 400 rpm and kernels moisture content of 11.9%. While the lowest value of machine productivity was 0.195 Mg/h obtained at drum speed of 220 rpm and kernels moisture content of 16.0%.

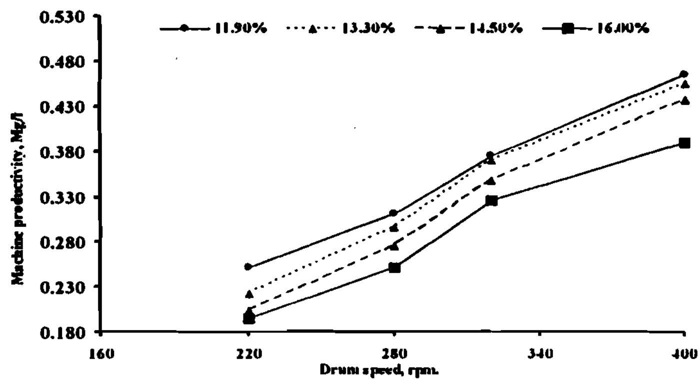


Fig. (6): Effect of drum speed on the machine productivity at different levels of moisture content.

Effect of moisture content on the thresher performance at different drum speeds.

Fig. (7) illustrated the effect of moisture content on the damaged kernels percentage at different drum speeds. The results indicated that the least value of damaged kernels of 1.5% was obtained at moisture content of 13.3%. It was increased with each increase in moisture content over this limit(13.3%). Also reducing the moisture content to be 11.9% resulted in marked increase in the damaged kernels percentage as compared with the moisture content of 13.3%. The highest value of damaged kernels was 5.0% obtained at moisture content of 16.0% and drum speed of 400 rpm.

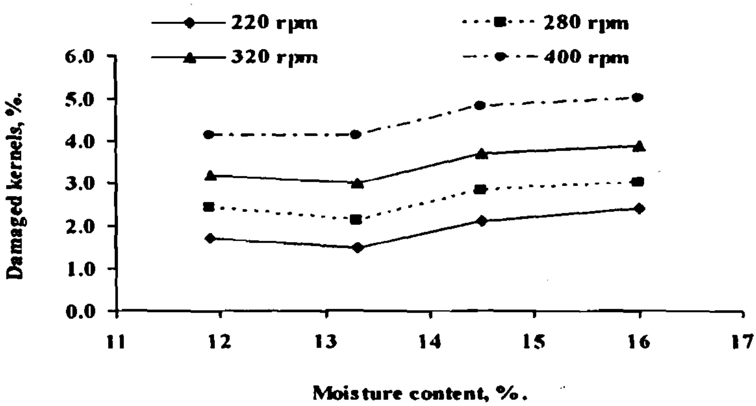


Fig. (7): Effect of moisture content on the damaged kernels percentage at different drum speeds.

Fig. (8) showed the effect of moisture content on the undamaged kernels percentage at different drum speeds. The results indicated that the highest value of damaged kernels of 98.5% was obtained at moisture content of 13.3%. It was decreased with each increase in moisture content over this limit(13.3%). Also reducing the moisture content to be 11.9% resulted in marked decrease in the undamaged kernels percentage as compared with the moisture content of 13.3%. The least value of undamaged kernels was 95.0% obtained at moisture content of 16.0% and drum speed of 400rpm.

Fig. (9) cleared the effect of moisture content on the losses kernels percentage at different drum speeds. There is a positive relationship between the moisture content and losses kernels. Increasing moisture content lead to increase losses kernels percentage. Increasing moisture content from 11.9, 13.3, 14.5 and 16.0% tends to increase the average of losses kernels from 3.4, 3.55, 4.25 and 4.6% at different drum speed. The highest value of losses kernels was 6.2% obtained at kernels moisture content of 16.0% and drum speed of 400 rpm. While the lowest value of losses kernels was 2.1% obtained at kernels moisture content of 11.9% and drum speed of 220 rpm.

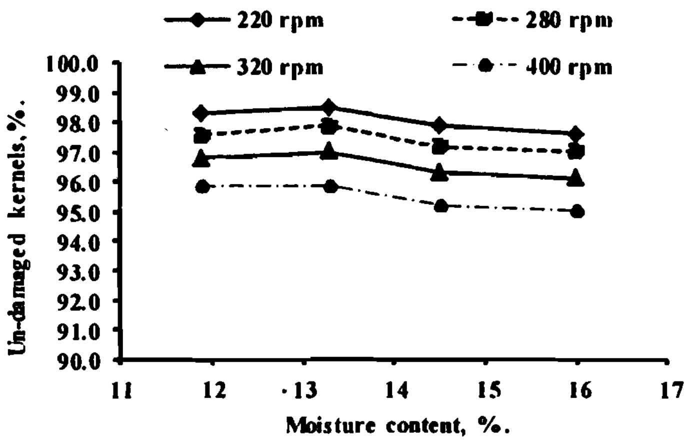


Fig. (8): Effect of moisture content on the undamaged kernels percentage at different drum speeds.

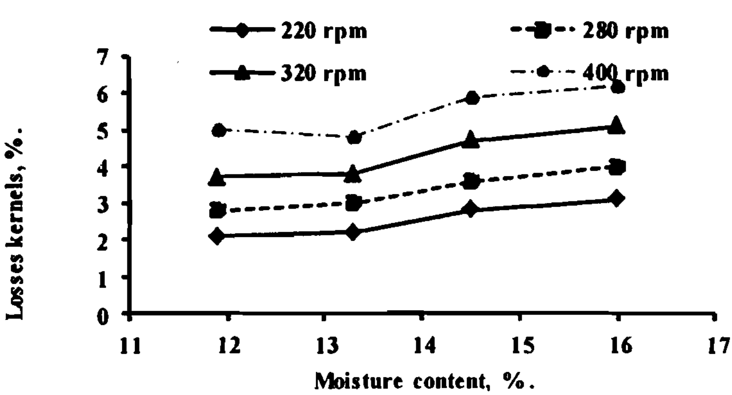


Fig. (9): Effect of moisture content on the losses kernels percentage at different drum speeds.

Fig. (10) described the effect of moisture content on the shelling efficiency at different drum speeds. The results indicated that the highest value of shelling efficiency of 96.3% was obtained at moisture content of 13.3%. It was decreased with each increase in moisture content over this limit(13.3%). Also reducing the moisture content to be 11.9% resulted in marked decrease in the shelling efficiency as compared with the moisture content of 13.3%. The least value of shelling efficiency was 88.8% obtained at moisture content of 16.0% and drum speed of 400rpm.

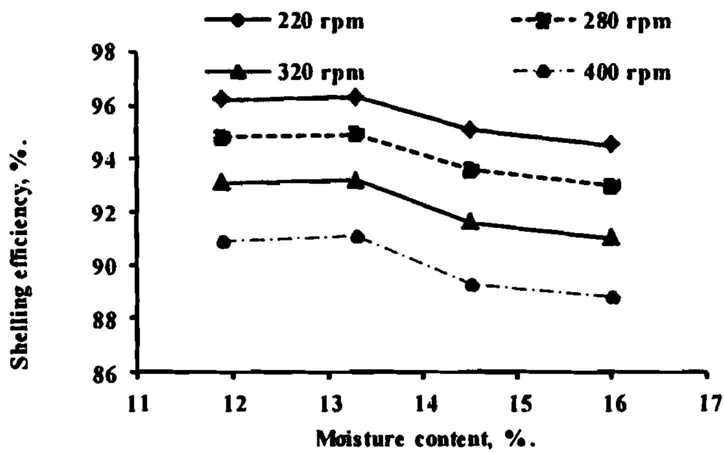


Fig. (10): Effect of moisture content on the shelling efficiency at different drum speeds.

Fig. (11) explained the effect of moisture content on the machine productivity at different drum speeds. There is an inverse relationship between the moisture content and machine productivity. Increasing moisture content lead to decrease the machine productivity. Increasing moisture content from 11.9, 13.3, 14.5 and 16.0% tends to decrease the average of machine productivity from 0.351, 0.336, 0.316 and 0.291 Mg/h at different drum speed. The highest value of machine productivity of 0.466 Mg/h was obtained at moisture content of 11.9% and drum speed of 400 rpm. While the least value of machine productivity of 0.195 Mg/h was obtained at moisture content of 16.0% and drum speed of 220rpm.

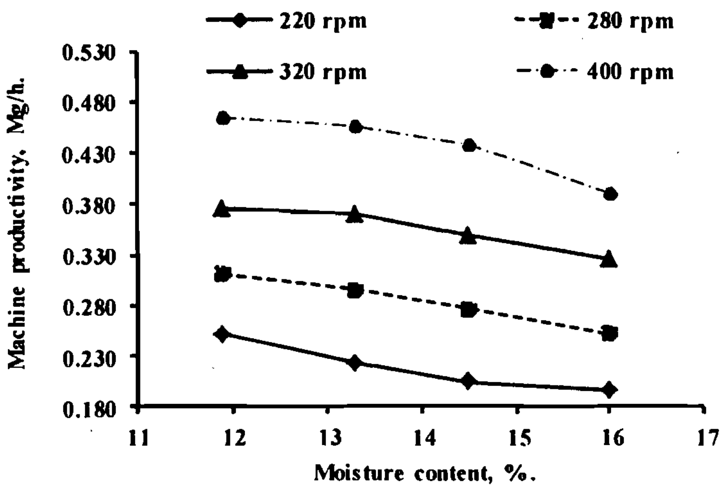


Fig. (11): Effect of moisture content on the machine productivity at different drum speeds.

CONCLUSION

The results in this study could be summarized in the following conclusion:

1- Increasing drum speed lead to increase each of damaged kernels, losses kernels and machine productivity.
2- Increasing drum speed tends to decrease the undamaged kernels and machine efficiency.
3- Increasing moisture content lead to increase the losses kernels and decrease machine productivity.
4- The least value of damaged kernels (1.5%) and the highest values of undamaged kernels (98.5%) and machine efficiency (96.3%) were obtained at moisture content of 13.3% and drum speed of 220 rpm.
5- The highest value of machine productivity was 0.466 Mg/h obtained at drum speed of 400 rpm and kernels moisture content of 11.9%.

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الملخص العربي

تصنيع وتقييم آلة ميكانيكية لتفريط الذرة تناسب المزارع المصري

محمد عطية ماضي*

تعتبر عملية تفريط الذرة من أهم عمليات ما بعد الحصاد وهى تجرى يدويا في مصر. والتفريط اليدوي عملية بطيئة جدا وتحتاج إلى وقت كبير وعمالة كثيرة ولكنها تعطى اقل نسبة فقد وتلف للحبوب إذا ما قورنت بالتفريط الآلي. لذالك تهدف هذه الدراسة إلى تطوير وتصنيع نموذج لآلة تفريط الذرة يناسب تفريط معظم الأصناف بأقل نسبة تلف وفقد للحبوب وتناسب المزارع الدقيقة.

تم تطوير وتصنيع هذه الآلة بورشة قسم الهندسة الزراعية بكلية الزراعة -جامعة قناة السويس.وتم اختبار الآلة والحصول على النتائج التالية.

١- زيادة السرعة الدورانيه للدرفيل أدى إلى زيادة نسبة التلف والفقد في الحبوب ونقص نسبة الحبوب السليمة وكفاءة التفريط.

٢- أكبر إنتاجية للآلة كانت عند سرعة دورا نيه ٤٠٠ لفة /دقيقة ومحتوى رطوبى ١١.٩%.

٣- أقل نسبة للحبوب التالفة (١.٥%) وأكبر نسبة للحبوب السليمة (٩٨.٥%) وإنتاجية للآلة (٩٦.٣%) كانت عند نسبة محتوى رطوبى ١٣.٣% وسرعة دورانيه للدرفيل ٢٢٠لفة /دقيقة.

٤- زيادة المحتوى الرطوبى أدى إلى زيادة مباشرة في نسبة الفقد ونقص في إنتاجية الآلة.

٥- زيادة المحتوى الرطوبى من ١١.٩% إلى ١٣.٣% أدى إلى نقص في نسبة التلف وزياد في نسبة الحبوب السليمة وكفاءة الآلة ومع أي زيادة في المحتوى الرطوبى أكثر من ١٣.٣% أدى إلى زيادة في نسبة التلف ونقص في نسبة الحبوب السليمة وكفاءة الآلة.

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