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OPTIMIZATION OF MACHINE PARAMETERS FOR SUNFLOWER THRESHER USING FRICTION DRUM

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ABSTRACT

A pedal-operated sunflower thresher was designed and constructed at the Agric. Eng. Dept. of Mansoura University and at Agric. Eng. Res. Inst., (AERI) Egypt. The machine performance was evaluated for optimal design parameters via three levels of the pressure surface press on friction drum (2.0, 4.0 and 6.0 kg/cm^2), four levels of friction drum speed (2.8, 3.7, 4.9 and 6.9 m/s), different radial curves of pressure surface (330, 345, and 365 mm) and different resting times of sunflower head inside threshing chamber (5, 10, and 15 sec). The sort of sunflower plant used to evaluate the prototype was Helianthus Annuus L.

The performance of threshing machine was evaluated for its threshing efficiency, cleaning efficiency, visible seed damage, threshing capacity and specific energy consumption. Threshing efficiency recorded 98.4 % in case radial curve 345 mm and friction drum speed of 6.9 m/s at time consuming 5sec under high pressure 6kg/cm^2. The minimum values of visible seed damage were 0.45, 0.65 and 0.86% corresponding to radial curves 330, 345 and 365 mm respectively occurred at low pressure and low friction drum speed at threshing time 5 sec. Cleaning efficiency increased by values 97.9, 96.8 and 96.8 % while increases threshing time by 5, 10, and 15 occurred at lower pressure and large radial curve with using high friction drum speed. While, threshing capacity recorded 212 kg/h at high pressure occurred at radial curve 345 mm high friction drum speed and high pressure 6 kg/cm^2. But the specific energy consumption increases by 4.6, 4.8 and 5.2 kW.h/ton while pressure increases by 2, 4 and 6kg/cm^2 at low radial curve of 345mm.

INTRODUCTION

Oil crop are considered one of the important source of nutrition for millions of people all over the world. Plants oil are found in several crops such as soybeans, palm-seed, sunflower, rape seed, cotton seed, peanut, coconut, olives, sesame, castor, flax seed and maize. Sunflower is an important oil crop in the world. Its ranks are the second after soybeans with respect to oil production. It can be cultivated in the new reclaimed areas, and is adaptable to a wide variation of soil and climatic condition (Keshta *et al.*, 1993). The world production of oil seeds is about 391 million ton whereas; oil vegetable production represents about 2.61 million toms. On other hand, oil crops planting area in Middle East reaches about 165.9 thousands hectare, while the total production of oil seeds represents 974.5 thousands ton and the oil vegetable production represents 1513.5 thousands ton. In Egypt, the sunflower planting area reaches about 11.83 thousands hectare gives the total seeds production about 29.08 thousands ton with yield capacity of 2457 kg/ha. The ministry of agric. expected to excesses the planting area of sunflower to 775 thousands hectare in year of 2010 (The Arab Agriculture Statistics Yearbook in 2007).

Mohsenin (1986) indicated that the friction force is directly proportional to the actual contact area, the friction force depends on the sliding velocity of the contacting surfaces and the friction force may be regarded as being composed of two main components a force required to deform and sometimes shear the asperities of contacting surfaces, and a force required to overcome adhesion or cohesion between the surfaces. Thompson and Ross (1983) determined the coefficient of friction of wheat on steel surfaces and observed an increase with moisture content, but at higher moisture contents the threshing efficiency decreased. Rizivi *et al.* (1993) investigated threshing unit for a sunflower thresher. The performances of breakage were evaluated against different drum types (peg, rasp-bar, and rubber-strip), three drums speeds (400-500-600 rpm) and three different of concave clearance (2.2, 4.4 and 6.3 cm). They found the peg type cylinder with a speed range of 400 to 500 rpm and a concave clearance range of 2.2 to 3.0 cm may be used for get the best results of sunflower threshing. Bhutta *et al.* (1997) compared the performance of a locally sunflower thresher with combine harvester. The locally sunflower thresher had an output capacity of 447 kg/h with a threshing efficiency of 97.3% and breakage of 4.87%. The combine harvesting with threshing drum consists of 8 rasp bars of 104 cm length and 60 cm diameter had an output capacity of 1000 Kg/h with a threshing efficiency of 98.7% and breakage of 0.26% using basic principle adopted for cereal threshers. On the others hand, Anil *et al.* (1998) designed and developed a prototype threshing machine for sunflower seeds. They test results indicated that the optimal thresher performance was achieved at 9 to 13% moisture content, 180 Kg/h feed rate and 500 rpm cylinder speed.

A sunflower threshing unit was designed and fabricated by Salokhe *et al.* (2005) to study the effect of machine and crop variables and to accumulate enough information for the best possible design of the thresher. Three concave holes size, four concave clearances and four drum speeds were studied. Test results indicated that the concave with the holes size of 11x60 mm gave the optimum sunflower threshing. The overall capacity values obtained with 29 and 35mm concave clearance were not significantly different from one another but, there was a significant difference at each drum speed. The threshing efficiency varied from 99.94 to 100%. The grain damage and grain loss figures were less than 1.5 and 1.0% respectively at drum speeds of 675 to 875rpm and 29 to 35mm concave clearance. The percentage of materials other than grain (MOG) separated through the concave clearance was lower than the percentages with other concave clearance. The lowest specific energy consumption was obtained with a 35mm concave clearances at all drum speeds. The best combination of drum speed, concave clearance and concave hole size to obtain high output capacity, high threshing efficiency, low grain damage, low grain losses and low specific energy consumption was a combination of 750 to 850 rpm drum speed (10.9 to 12.4 m/s), 35 mm concave clearance and the concave hole size of 11x60 mm.

A local device for separating sunflower that would utilize both centrifugal and gravitational force was developed by Lotfy (2009). The separation process was possible without crushing sunflower heads and thus, decreased the power consumption with minimum environmental pollution and low separation cost. The study was conducted on the effect of different beater types (spike-tooth, angle-bar and knives), inner cone speeds (7.24, 9.11, 12.9 and 15.4 m/s) and seed moisture contents of 26.9, 21.2, 15.7 and 9.8 %. Separating clearance was content at 4/2 cm between the top and end of inner cone with outer cone. The calculated cost of separation showed the best results were with spike-tooth and 12.9 m/s inner cone speed. from 21.2 to 15.7% moisture content.

Small sunflower planting area demands on threshing machinery after manual harvesting because manual threshing are still carried out with great consumption of time and cost. The mechanical threshing problem summarized in causing damage for seeds and existence some of un-threshed seeds that are resulted in reduction the threshing efficiency and seeds quality. This problem obviously appeared during sunflower threshing that is due to nature of the seeds.

The aim of this paper is tray to optimize machine parameters of a pedal-operated sunflower threshing using friction drum. The performance of threshing machine is evaluated for its threshing efficiency, cleaning efficiency, visible seed damage, threshing capacity and specific energy consumption.

MATERIALS AND METHODS

The General Description of Proposed Design

A new design and devolvement of prototype as shown in figure 1 was used for sunflower threshing depending on frication force. It consists of the following parts:

The Frame: It is made of mild steel L section of "30 * 30 mm" which all components of threshing machine are connected on it. The main frame dimensions are 70 mm in length, 650 mm in width and 1590 mm high. The base of frame linked with four small wheels (ø =200mm).

Friction surface: The cylinder, with 500 mm length and 320 mm diameter made of 3 mm thickens mild steel sheet, is sheltered by two different types of friction surface. The cylinder equipped with main shaft of 254mm. The two ends of the main shaft are supplied with two ball bearings. The motion transmitted by "V" belt and tow pulleys. The small one connected with electric motor (0.74kW) and the bigger was linked with drum shaft, that equipped with three pulleys has different diameter of 160, 216 and 282 mm.

Pressure surface: It is considering the surface that covered the angle of threshing cylinder of 180° and takes the arc shape. It fabricated from mild steel sheets of 3 mm thickens. It can be carried two heads of sunflower plant during thrashing operation with dissimilar diameter. To easy catching the head of sunflower on the pressure surface a numbers of needles were distributed which taking four circles shapes with diameters of 50, 100, 150 and 250mm.

Elevator unit: the main job of elevator unit is rise up the pressure surface to press the head of sunflower on the friction drum. It was placed on the right side of machine and consists of pedal, wire and tow roller. The rollers are similar in size and made from steel sheet with outer and inner diameters of 50 and 40 mm respectively which, they rotating by two bearing and rod of 25 mm diameter welded on the pressure surface frame as shown in figure 1. The wire attached the motion of pedal with the two rollers and with the pair of the link that welded on the machine frame in closed system as shown in figure 1.

Power transmission: A 0.74kW single–phase AC motor having 950 rpm was used to drive the thrashing machine.

Seed receptacle unit: It was made of galvanized sheet metal with rectangular shape (650mm length and 450 mm width) that fixed in inclination level with angle of 15 degree to make seeds motion easier. At the end of receptacle surface the seeds collected in plastic package.

The specification of sunflower:-

The sunflower variety is used in this study is Helianthus annuus L. and characteristics of sunflower plant and seed are tabulated in table (1).

Table 1: The average of properties of sunflower

Variety	Head dia., cm	Head thickness, cm	1000 seed mass, g	Seed length, mm	Seed width, cm	Seed yield, g/head
Helianthus annuus L	18.5± 1.05	3.3± 0.34	80 ± 5.2	9.25 ±0.12	3.75±0.11	165±15.5

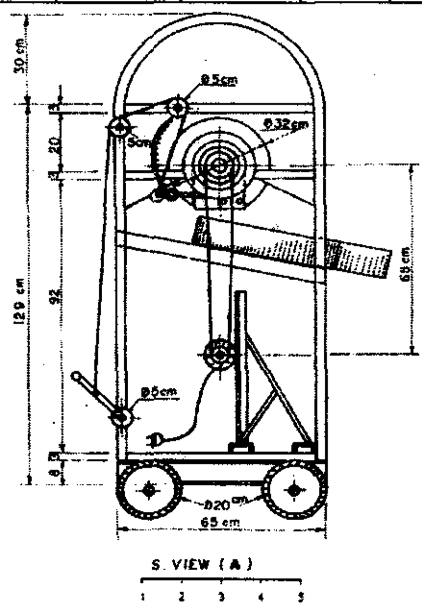

Fig. (1): The pedal-operated sunflower thresher.

Experimental procedure:-

Field experiments were carried in region Nubaria at Agric. Eng. Res. Inst., (AERI) Egypt. To fulfill the objective of this research work some of the parameters taken into consideration as follows:-

1- Four different of friction drum speeds "V_1=2.8; V_2=3.7; V_3=4.9 and V_4=6.9 m/s which recorded 336, 441, 588 and 830 rpm respectively. The friction drum speeds were regulated using different pulleys diameters that set on the friction surface shaft.

2- The pressure surface can be change its position relative to the friction drum by sliding guide. Increasing the span of sliding guide increases the arches of pressure surface. Under experiment three radicals curved levels of pressure surface where regulated namely, R_1= 330, R_2= 345 and R_3= 365 mm.
3- Threshing machine was operated under three levels of pressure P_1, P_2 and P_3 which generated by pedal elevator unit. During threshing operating, the pressure surface press on the friction drum with homogeneous forces that threshing the head of sunflower only. The pressure gauge is used to measurement pressure effective. Three levels of pressure forces where supplied to pressure surface namely, P_1=2, P_2=4 and P_3=6 kg/cm^2.
4- To study the effect of resting times on machine performance, threshing machine was operated at three waiting time (resting time) T_1,T_2 and T_3. Resting time is the time that required to separate all seed from sunflower head. Threshing time divided to three level namely, T_1=5, T_2=10 and T_3= 15 sec.
5- All experiments were carried out under constant dray moisture of sunflower (18± 2.46% for head and 9 ±1.13% for seed).

Machine performance:

Machine performance was estimated according to **Singh and Joshi, 1981)** as follows:

Threshing efficiency:

Threshing efficiency was determined on the basis of threshed and un-threshed seeds. All detached seeds from sunflower head were collected and weighted with the help of digital balance. After finishing from threshing process, the seeds that were still in sunflower heads cleaned and weighted using the same digital balance. These seeds know as un-threshed seeds. Threshing efficiency was determined using the following expression:

Threshing efficiency, % = 100% - un-threshed seeds%
Un-threshed seed, % = (c/d) × 100

Where,

C = mass of un-threshed seed, g
D= mass of total seed, g

Seed damage:

Breakage percent (visible damage of seed) can be expressed as a percentage of broken seed related to the total quantity of seeds. The breakage percentage was determined by the following equation:-

Seed damage, %= (seed damage mass / total seeds mass) x 100

Cleaning efficiency:

To determine the cleaning efficiency, sample of seed along was collocated and weighted. Later on it was cleaned manually and weighted. The cleaning efficiency was determined using the following relationship:-

Cleaning efficiency % = (E/F) × 100

Where,

E = mass of clean seed in the sample, g

F = mass of sample weight, g

RESULTS AND DISCUSSION

Threshing efficiency

As shown in Fig. (2), the threshing efficiency increased with increase pressure force of pressure surface on friction drum at all three levels of P_1= 2.0 kg/cm^2, P_2= 4.0 kg/cm^2 and P_3= 6.0 kg/cm^2 for all drum speed levels. It may be due to separating seeds from sunflower heads is easy at higher pressure. Effect of pressure surface was influence on extraction seeds significantly. Also we found that. the threshing efficiency recorded 98.4% at highest pressure (6.0 kg/cm^2)and with friction drum speed of 6.9 m/s

It can be observed from Fig. 3 that, at the pressure force on pressure surface of 6.0 kg/cm^2, the threshing efficiency increased with threshing time (resting of sunflower head time) up to 5.0 sec at each of V_1=2.8; V_2=3.7and V_4=6.9 m/s. While, this relation is visa versa at friction drum speed of V_3=4.9 m/s. The maximum thereafter achieving about 98.6% during resting time of 15 sec. At fixed value of friction drum speed of 6.9m/s, the threshing efficiency increased with resting times up to 15sec (Fig. 4). Generally, threshing efficiency increased with increases friction drum speed. Separating seeds from heads was higher at maximum peripheral speed of friction surface. It could be noticed that threshing efficiency, % is in reversible relationship with radial curve. On other hand, threshing efficiency recorded high value at threshing time 15 sec there were 93.4, 94.7, 96.4 and 98.4% occurred at high pressure and radial curve "R_2" corresponding to friction drum speed 2.8, 3.7, 4.9 and 6.9 m/s respectively.

Visible seed damage percentage

The maximum values for visible seed damage (Figs. 6 to 9) were 1.04, 1.33, 1.64 and 2.02% occurred at high pressure and radial curve R_2 corresponding to friction drum speed 2.8, 3.7, 4.9, 6.9 m/s respectively.

It was observed that, radial curved is in directly relationship with visible seed damage at different factor. Noticed that visible seed damage increased with increases threshing time. Seed damage recorded minimum values at threshing time 5 second occurred at smaller radial curve R_1 and lower pressure P_1 with friction drum speed V_1. Visible seed damage varied from 0.45 to 2.02% for all testing conditions. Noticed visible seed damage percentage, % increased with increases friction drum speed. A higher peripheral speed causing more injuries to the seeds this could be explained that increasing speed caused increasing friction action which damaged seeds.

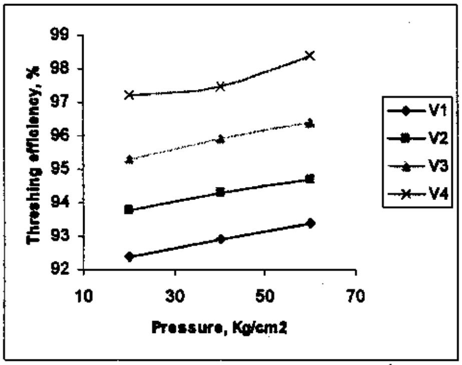

Fig. (2): Threshing efficiency via pressure surface.

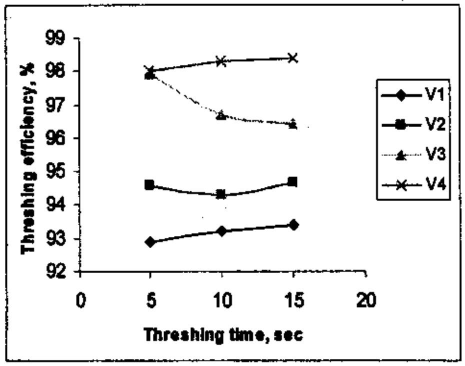

Fig. (3):Threshing efficiency via resting time.

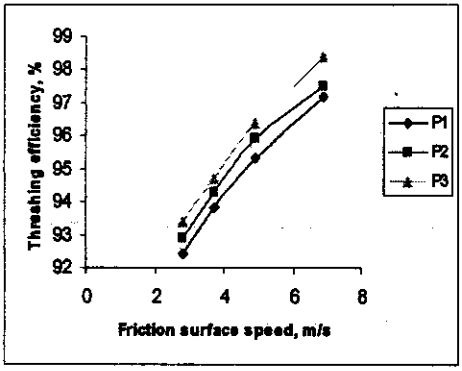

Fig. (4): Threshing efficiency via friction drum speed.

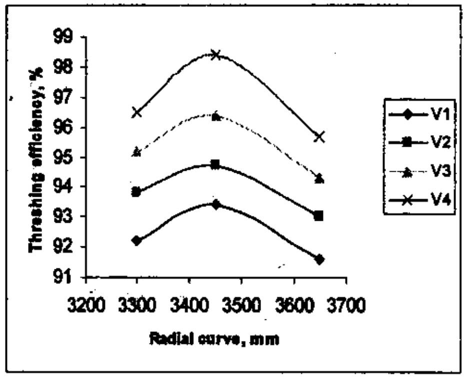

Fig. (5): Threshing efficiency via radial curve.

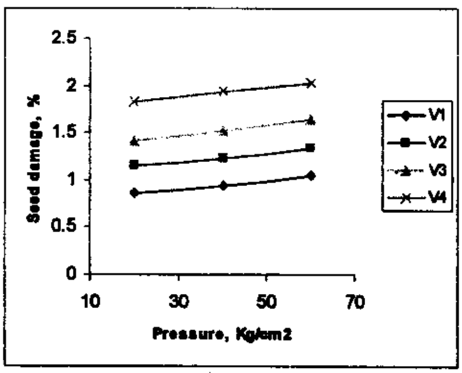

Fig. (6): Seed damage via pressure surface.

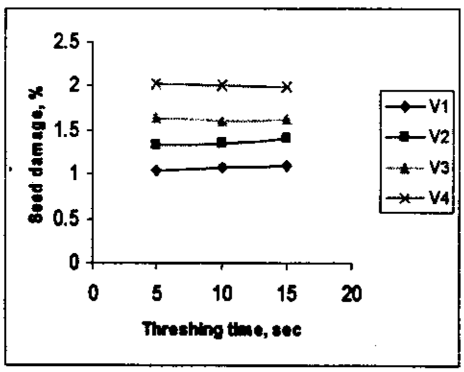

Fig. (7): Seed damage via resting time.

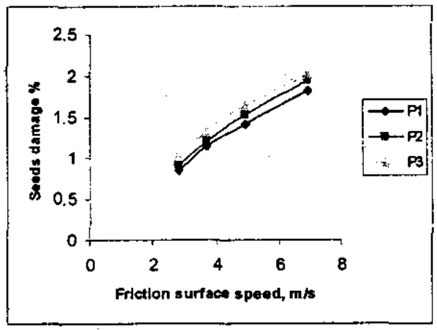

Fig. (8): Seeds damage via friction drum speed.

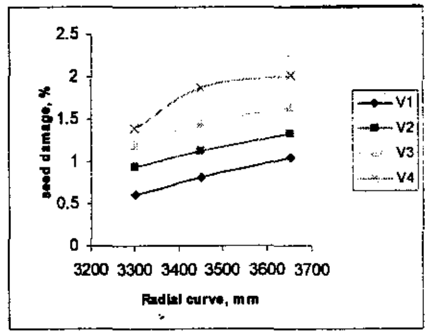

Fig. (9): Seeds damage via radial curve.

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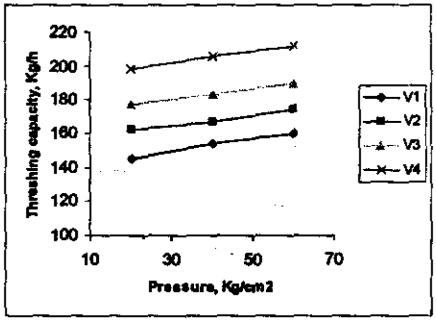

Fig. (16): Threshing capacity via pressure surface.

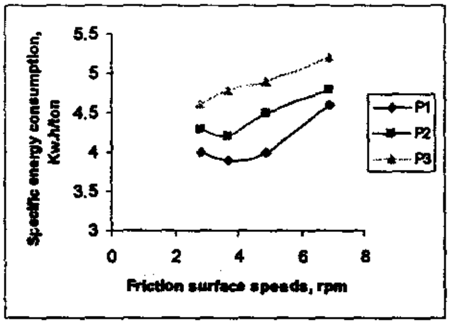

Fig. (17): Specific energy consumption via friction drum speed.

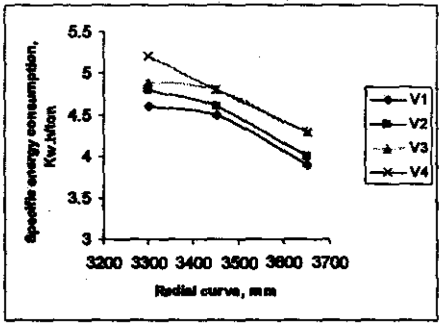

Fig. (18): Specific energy consumption via radial curve.

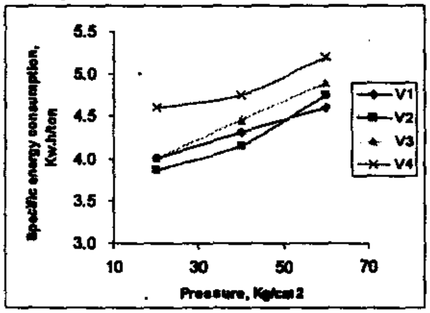

Fig. (19): Specific energy consumption via pressure surface.

Cleaning efficiency

Threshing efficiency is in reversible relationship with threshing efficiency at different factor. Cleaning efficiency increased with decreased pressure surface forces from P_3 to P_1 (Figs. 10 to 13). Pressure forces which produced from pedal during threshing operating friction action generated from rubber lyres separated seeds from head and continued removes chaff from heads, so by increasing pressure cleaning efficiency decreased. On other hand, cleaning efficiency was poor (less than 90%) at high speed occurred at high pressure and radial curve R_1 at threshing time T_2. From Fig. 12, it was noted that increased radial curve caused increases cleaning efficiency. Maximum value of cleaning efficiency 97.9% occurred at large radial curve R_1. Cleaning efficiency increased by values 97.9, 96.8 and 96.8 % while increases threshing time by T_1, T_2 and T_3 occurred at lower pressure and large radial curve with using high friction drum speed.

Threshing capacity

From Figs. 14 to 16, it is observed that the threshing capacity is gradually increasing as pressures forces of pressure surface increasing. There were 198, 206 and 212 kg/h corresponding to pressure 2, 4 and 6 kg/cm^2 respectively that occurred at high friction drum speed V_4 and radial curve R_2. Threshing capacity recorded minimum value 134 kg/h at lower friction drum speed and higher radial curve R_3. Also, it can be seen that the friction drum speed significantly effect on threshing capacity. It may be due to increasing friction drum speed caused removed more seed from heads by friction action which generated from rubberized drums. More increases of radial curve up 345 mm caused decreased threshing capacity, on other hand reducing it under same value lead to decreases threshing efficiency. It could be recommended that radial curve 345 mm gave high threshing capacity.

Specific energy consumption

It was found that specific energy consumption increases by 4.6, 4.8 and 5.2 kW.h/ton while pressure increases by 2, 4 and 6 kg/cm^2 at low radial curve. It can be seen influence pressure surface on specific energy consumption significantly. Increasing in specific energy consumption is due to increases resistance between rubber and seeds. It was noticed that, specific energy consumption, kW.h/ton increased with increases friction drum speed from V_1 to V_4. maximum value specific energy consumption 5.2 kW.h/ton occurred at high friction drum speed. Observed that minimum specific energy consumption 3.7 kw.h/ton occurred at radial curve 365 mm under low pressure 2 kg/cm^2 for speeds V_1 and V_2. Therefore decreased radial curve up 345 mm caused decreases threshing capacity. It can be seen influence radial curve on specific energy consumption significantly.

CONCLUSIONS

Based on the finding of this study, following conclusions are made:

Threshing efficiency recorded highest value at threshing time 15sec occurred at high pressure P_3 = 6.0kg/cm^2 and radial curve R_2 = 345mm corresponding to friction drum speed of 6.9m/s. Seed damage recorded minimum values of 0.45 at threshing time 5 second occurred at smaller radial curve "R_1 = 330mm" and lower pressure "P_1 = 2.0kg/cm^2" with friction drum speed of V_1 = 2.8m/s. A higher peripheral speed causing more injuries to the seeds this could be explained that increasing speed caused increasing friction action which damaged seeds.

The highest threshing capacity was 212kg/h occurred at 6kg/cm^2 of pressure, 6.9 m/s friction drum speed and 345mm radial curve. Meanwhile, the minimum specific energy consumption was 3.7 kW.h/ton occurred at radial curve 365mm under low pressure 2kg/cm^2 and at friction drum speeds of 2.8m/s or at 3.7m/s. Based on previous results. The final recommended to realized higher threshing and cleaning efficiency, lesser seed damage and specific energy consumption using pressure 6kg/cm^2, radial curve 345mm, and friction drum speed 6.9m/s by threshing time 5sec at moisture content about 18% for heads and 9 % for seeds.

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التقرير السنوي للتنمية الزراعية في الوطن العربي ٢٠٠٧ م جامعة الدول العربية. المنظمة العربية للتنمية الزراعية الخرطوم – السودان.

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عوامل التشغيل المثلى لآلة دراس دوار الشمس باستخدام اسطوانة احتكاك

زكريا إبراهيم إسماعيل و محمد نصر صالح الحناوي

قسم الهندسة الزراعية – كلية الزراعة – جامعة المنصورة

يعد محصول دوار الشمس من أهم مصادر زيت الطعام في معظم الدول العربية وذلك لارتفاع نسبة الزيت في بذوره حيث تصل إلى ٥٥ %. تصل المساحة المنزرعة من محصول دوار الشمس بمصر إلى ١١,٨٣ الف هكتار وذلك بإنتاج ٢٩,٠٨ ألف طن من البذور. ويهدف هذا البحث إلي حل مشكلة دراس دوار الشمس وذلك من خلال تصنيع آلة لدراس أقراص دوار الشمس تعتمد في تفريطها على استخدام قوى الاحتكاك وروعي في تصنيعها أن تلائم المزارع المصري من حيث المساحة وظروفه المادية. وتتكون الآلة المصنعة من الأجزاء التالية :

الإطار: وهو متوازي مستطيلات بمقاس ٧٠ × ٦٥ × ١٥٩ سم مصنع من علب معدنية ٣ × ٣ × ٠,٣ سم وهو يعتبر الهيكل المحمل علية جميع لأجزاء الآلة. هذا الهيكل محمل على عجلات بحيث يسهل نقل الآلة من مكان لأخر.

وحدة الدراس: وهي مكونة من جزئين الجزء الأول هو سطح الاحتكاك وهو عبارة عن اسطوانة معدنية بقطر ٣٢ سم وطول ٥٠ سم مغطاة بثلاث شرائح من الكاوتش المحبب عرض الشريحة الواحدة ٢٠ سم. الاسطوانة محملة على كراسي تحميل وتأخذ حركتها طارتين الطارة الكبرى متعددة الأقطار (٢٨،٢ ، ٢١،٦ ، ١٦ ، ١١،٥ سم) متصلة بسطح الاحتكاك والطارة الصغرى ٥ سم متصلة بموتور الكهربي قدرته ١ حصان والحركة تنقل عن طريق سير حرف V.

الجزء الثاني يسمى السطح الضاغط: وهو عبارة عن سطح معدني مقوس الشكل يغطي ١٤٠ درجة من اسطوانة الاحتكاك بطول ٥٠ سم ويعتبر الجزء المسئول عن تثبيت القرص أثناء عملية التفريط. يمكن تغير نصف قطر التقوس وذلك عن طريق تحريك السطح الضاغط وذلك عن طريق مجاري داخلية تسمح بالحركة الإنزلاقية للسطح الضاغط.

وحدة الرفع: وهي الوحدة المسئولة عن رفع السطح الضاغط لتبدءا عملية التفريط وبعد الانتهاء تسمح بعودته مرة أخرى إلى وضعة. تتكون هذه الوحدة من مجموعة من البكر ورافعة وبدال مثبتة على الإطار الرئيسي. لكي لا يحدث تصادم بين السطح الضاغط وسطح الاحتكاك

وحدة الأمان والتحكم في الضغط: على ذلك. تتكون هذه الوحدة من قرصين الصلب احدهم مثبت بالسطح الضاغط ويتحرك داخل الأخر من خلال أدلة إنزلاقية.

وحدة استقبال البذور: وهي عبارة عن صندوق معدني بمقاس ٦١ × ٦٥ سم مثبت بزاوية قدرها ١٥ درجة لتيسير حركة البذور علية. تم اختبار أداء الآلة المصنعة عند ضغوط مختلفة ٢، ٤، ٦ كجم/سم^2، ولاربع سرعات محيطية ٢,٨ ، ٣,٧ ، ٤,٩ ، ٦,٩ م/ثانية ونصف قطر تقوس ٣٣٠، ٣٤٥، ٣٦٥مم وذلك عند أزمنة دراس مختلفة ٥ ، ١٠ ، ١٥ ثانية.

كانت أفضل النتائج للحصول على اعلي كفاءة دراس وكفاءة تنظيف، اقل نسبة بذور متحطمة وأعلى سعة دراس باقل قدرة مستهلكة، وكانت أفضل سرعة هي ٦،٩ م/ث عند ضغط قدرة ٤٠ كجم/سم^2 ونصف قطر تقوس ٣٤٥٠ مم خلال زمن دراس قدرة ٥ ثواني حيث بلغت سعة الدراس ٢١٢ كجم/ساعة والطاقة المستهلكة لدراس طن واحد ٥,٢ ك.وات.ساعة/طن وكانت تكلفة الساعة الواحدة ١١,٠١١ جنية/ساعة وكانت تكلفة دراس الطن الواحد ٥٢،٩٨ جنية/فدان.

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