PROPER DESIGN AND EVALUATION OF A MACHINE FOR SEPARATING SEED PEA PODS

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ABSTRACT

Continuation for unbinding of separating and cleaning seed pea problem and completion spread our investigations in 2008 at 15 Annual Conference of the Miser Society of Agricultural Engineering. The obtained results in this work had been activated and we have done the final design and fabricated in a Workshop in Kafr El-Sheikh Governorate to produce the first specialized machine for separating and cleaning seed pea. Cylinder design with special specifications was used to reduce the exposure of pea seed to impact during the torsion motion. The design used traditional separating theory that helped in seed separation and accelerating the discharge of empty pods and skin from separating chamber to prevent covering and blockage of the concave sieve. After that the mixture of separating fall on oscillating sieve to separate the seed from pods skin. The machine was tested and evaluated under four drum speeds of 8.83, 10.60, 12.36 and 14.13 m/s (375, 450, 525 and 600 r.p.m), three feed rates 6.0, 9.0, 12.0 kg/min, three oscillating shaker speed of 150, 225 and 300 r.p.m (15.7, 23.55 and 31.4 rad/s) and three sieve slope angles of 15, 20, 25 moisture content of 76 % for pods. Machine productivity, separating efficiency, cleaning efficiency, seed losses, seed damage and specific energy had been determined.

The results show that, specialized was suitable for separating seed peas with low drum speed 450 r.p.m (10.60 m/s) and 6.0 kg/min feed rate with oscillating shaker 225 r.p.m and sieve slop angle 20. Machine productivity, separating efficiency, cleaning efficiency, seed losses, seed damage and specific energy were 3.40 kg/min, 94.16%, 96.00%, 4.68 %, 1.46% and 11.446 kW.h/ton, respectively.

INTRODUCTION

Pea is considered one of the most important crops in the world being a principal source of the national income and feeding. It is considered one of the most important food and a vital source of proteins. It is also one of the vegetables that is rich in carbohydrates. There are two purposes to plant pea, firstly for seed pea and sondly for dry pea. The total plantation area of seed pea in Egypt reached 64260 fed. Produced a 4.354 ton per fed., http://faostat.fao.org (2008). In Egypt, three quarters of the plantation area for seed pea production and the other quarter for dry pea. The separating of seed pea manually (pods collection and seeds separation) is very hard and expensive and needs more workers and time, especially at manufacturing and freezing. The seed pea is sensitive for weather condition before and after harvesting so, it needs quickly separation and separating in order to be suit for human consumption. The color loss in seed pea is affected by moisture loss in addition to high temperature. The greatest values of moisture loss and color changes are during the first 6 to 10 hours after harvest, Prussia *et al,*

(1990). In this case, we need to transport the vine to the factory where stationary separate and feeding of stationary separate manually.

From the above mentioned and for replacing the mechanical separating seed pea seed instead of the manual separation method, there were two extreme choices that faced the authors of the present study. The first was to import separation seed pea seed machine and with some modifications make it suitable for the Egyptian conditions. The sond was to design and manufacture specialized machine for separating and cleaning seed from skin, which could be exchangeable according to the used seed properties. The later choice was to be seen a better approach.

The ultimate purpose of separating operation is to recover the seed free from residues with minimum losses and maximum efficiency. The main factors affecting separating and cleaning operation may be summarized as follows: types of separating, concave clearance, feed rate, moisture content and the power requirements.

Sharma and Devnani (1980) noticed that soybean feed rate and seed out put increased with the increase in drum tip speed and concave clearance. The seed out put was dependent upon crop variables rather than machine variables.

Abd El-Hameed, (1994) noticed that increasing the drum speed increased separating efficiency. The maximum separating efficiency was obtained by using metal spike drum, hole concave type and drum -concave clearance.

Sayed-Ahmed (2004) found that, the seed losses for watermelon increased by increasing drum speed and feed rate. While the seed damage decreased by increasing feed rate and decreased by increasing the drum speed. He added the feed rates and drum speed have positive relationship with power requirements.

Gummert (1991) showed that the feed rate is significantly affecting power requirement. The function of the investigated range is proximately linear and if feed rate is doubled, power requirements are 2.5 times higher.

Mohamed (1994) indicated that the relationship between the power required and feed rate was an increment proportional, with increasing feed rate, the power increased. He also reported that unseparated seed losses were significantly affected by the applied power, where increasing power decreased unseparated seed losses. The same author noticed that the power required during separating operation was increased by increasing crop moisture content.

El-Haddad *et al.,* (2008) showed that the consumed power, kW was increased by increasing cylinder speed and feed rate while the unit-energy (kW.h/ton.), consumption increased by increasing cylinder speed and decreased by increasing the feeding rate.

Sharma and Devnani (1980) reported that separating efficiency increased with the increase of cylinder speed but decreased with the increase of feed rate and concave clearance. They also added that, energy consumption was directly proportional to cylinder speed and feed rate and remained constant at selected concave clearance. At higher speeds, the visible seed damage was 5% and the germination percentage was low.

El-Haddad (2000) stated that the separating efficiency increased with the increase of drum speed and the decrease of feed rate. The maximum separating efficiency was 99.76% at drum speed 21.25 m/s (1400 r.p.m), and feed rate 15 kg/min.

Therefore, the aim of present study was to design and manufacture specialized machine for seed separation from seed pods. The present study covers the following main objective: a) Locally fabricated the machine to perform pod separating by rubbing and impact with torsion motion and cleaning processes. b) Evaluation the separation performance of the fabricated machine under different design and operation parameters.

MATERIAL AND METHODS

Prototype structural design:

The present study included a design and manufacture specialized machine for separating and cleaning seed peas to satisfy the Egyptian farmers requirements and factories of packaging, enveloping and freezing. It was constructed in private Workshop in Kafr El-Sheikh Governorate. The experimental work was carried out at Food Technology Res., Inst., Sakha Branch, Kafr El-Sheikh Governorate, during winter season of 2007- 2008. The machine consisted of three main stions feeder, separating and cleaning unit.

The first unit is the mechanical feeding for separation cylinder that help in steadiness entry of pods and exposure to regular impact with cylinder knives.

The sond unit contains of the separating cylinder, 45 cm diameter and 60 cm. long that is spike teeth type. The dimensions of the tooth are 7 cm long 5 cm. width at the bottom and 0.6 cm thickness. The spacing between two teeth is 4.5 cm. The separating cylinder is mounted on two ball bearings fixed on steel frame by two studs for each ball bearing. The perforated concave is located under the cylinder and contains with 15 mm. in diameter. The clearance between the separating cylinder and the concave is 1.5 cm. The seed separating operation would continue from the feeding first until the drum ends, as the knives are fixed helical shape where the seed separation reach its maximum due to the shape of the knives and its arrangement on the drum without damage. Separating is accomplished by a combination of impact and rubbing with torsion action as shown in Figs. 1 and 2.

The third unit is the cleaning one. The oscillating screen consists of an upper screen and lower sliding surface for seeds, hanged on four adjustable link rods. The upper screen is used for separating pods skin from seed. The lower sliding surface is 3 and 9 cm from the front and rear respectively below the upper screen. Seed and small skin fall down through the concave to the upper screen contains small openings, 12 mm diameter. The separated material reaches the oscillating screen end; all seed has been separated from pods skin. And drops through the upper screen, skin go out. At the end clean seed drops on a pan and pass through spout screen 12 mm holes diameter to the seed output. The source of power was electric motor, 2.25 kW. (3 hp)

transmitted through a series of V-belts to the major component, feeder, separating unit and cleaning unit as shown in Fig. 1. The specification of the machine are listed in Table 1.
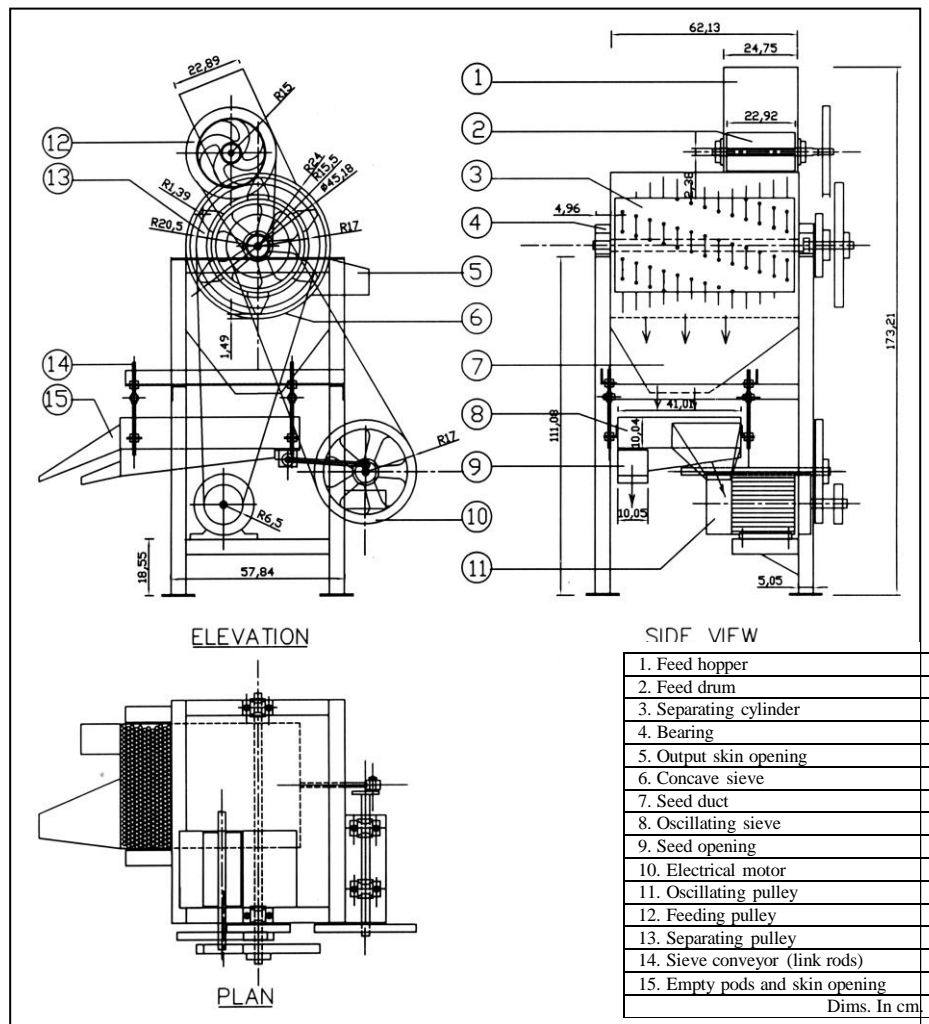

| 1. Feed hopper |
| 2. Feed drum |
| 3. Separating cylinder |
| 4. Bearing |
| 5. Output skin opening |
| 6. Concave sieve |
| 7. Seed duct |
| 8. Oscillating sieve |
| 9. Seed opening |
| 10. Electrical motor |
| 11. Oscillating pulley |
| 12. Feeding pulley |
| 13. Separating pulley |
| 14. Sieve conveyor (link rods) |
| 15. Empty pods and skin opening |
| Dims. In cm |

Fig. 1: A schematic diagram of the machine for separating seed peas.

Physical properties such as size, shape, density and number of pea seeds per pod are important is separation and design the machine. The main physical properties of pea seeds were indicated in Table 2 as follows:

1. Size:

The geometric mean diameter of peas used in the test was 9.41 ± 0.68 mm and varied from 8.98 to 9.85 mm.

2. Shape: The sphericity of peas was 0.912 ± 0.016 and varied from 0.890 to 0.943. The seed shape index was calculated according to (Buyanov and Voronyuk, 1985).

Table 1: Specifications of the machine for separating seed peas

Items	Specifications
Dimensions:	
Length × width × height	115 × 86 × 173 cm
Mass	250 kg
Source of power	Electric motor 2.25 kW (3 hp)
Separating cylinder:	
Cylinder Type: Dimensions:	Spike tooth Length 60 cm, diameter 45 and
Spike tooth:	
Number of spike	78
Length	7 cm
The distance between two spike tooth	4.5 cm
Length of the cylinder	60 cm
Diameter of the cylinder	45 cm
Concave	Perforated sheet metal 3 mm thickness with round holes of 15 mm dia. and part from concave is opened and included hole 12 ×12 cm
Skin output opening	25 × 10 cm
Seed output opening	10 × 8 cm
Feeding opening	23 cm wide, 25 cm long
Eccentric stroke of the screen	2.5 cm
Holes diameter of oscillating screen (flat screen)	1.5 cm
The number of circular concave holes	12 per 10 × 10 cm^2
Seed cleaning system	Dynamic separation based on oscillating screen

Fig. 2: Prototype of the machine for separating seed peas.

Table 2: Main characteristics of the tested pea crop at moisture content 76.5%

Characteristics	Average ± Sd
1. Dimensions:	
a) Pea pod	
- Length, cm	13.51 ± 1.39
- Thickness peel, mm	1.395 ± 0.09
b) Pea seed	
- Major diameter of pea seed, mm	9.34 ± 0.56
- Minor diameter of pea seed, mm	8.90 ± 0.68
2. Mass:	
- Mass of pea pod, g/pod	7.26 ± 1.80
- Mass of seeds per pod, g	3.49 ± 1.19
- Mass of peel per pod, g	3.62 ± 1.14
3. Density:	
- The density of peas, g/mm^3	1.075 ± 0.014
- The density of pods g/mm^3	1.006 ± 0.0 17
4. Number of seeds per pod	7.53 ± 1.67

3. Density:

Peas (separated peas) and pods (pods remaining after separating) were different in density. The density of peas is slightly higher than that for pods. The density of peas was 1.075 ± 0.014 g/mm^3 while that of pods was 1.006 ± 0.017 g/mm^3.

Experimental treatments:

Four different separating drum speeds of 375, 450, 525 and 600 r.p.m (8.83, 10.60, 12.36 and 14.13 m/s), three feed of 6, 9 and 12 kg/min and four different cleaning shaker speed of 150; 225 and 300 r.p.m (15.7, 23.55 and 31.4 rad/s) were used at concave clearances 15 mm and three sieve slop angle of 15, 20 and 25 degree.

Measurements:

The moisture content of green pea variety (*Master B*) was measured and reached about 76.63% (wet basis) in pods during the experiment. During performance of the separating machine, the following items were measured.

Unseparated seed loss: Unseparated seed loss was calculated according to the following formula:

$$\text{Unseparated seed} = \frac{\text{Mass of unseparated seed in sample, g}}{\text{Mass of total seed in sample, g}} \times 100 \text{ --------------- (1)}$$

Seed losses: The seeds that found mixed with peels for each treatment was manually picked and weighted. Hence the percentages of seed losses were determined using the following relationship:

$$\text{Seed losses, \%} = \frac{M_1}{M_1 + M_2} \times 100 \text{ -- (2)}$$

Where:

M_1 = Mass of seed mixed with the expelled peels, g.

M_2 = Mass of clean seeds from output opening, g.

Seed damage:

The seed damage percentage was determined by separating the broken seed from a weight of 50 grams sample taken randomly from the separated seed.

Cleaning efficiency:

Cleaning efficiency was estimated according to the following formula:

$$\text{Cleaning efficiency, \%} = \left[\frac{\text{Mass of cleaned seed in sample, g}}{\text{Total weight of seed in sample, g}} \right] \times 100 \quad \text{---------------- (3)}$$

Power requirement: An ammeter and voltameter were used for measuring current strength and potential difference, respectively before and during experiments. Readings of ampere (I) and volt (V) were taken before and during each treatment. The power consumption (W) was calculated from the values of Ampere (I) and Volt (V) by using the following formula Draxler et al., (1987)

$$\text{Power requirement (W)} = \sqrt{3} \text{ IV Cos } \phi \quad \text{------------------------------------- (5)}$$

Where:

I $\quad$ = current strength, Amperes;

V = potential difference, Volt, and

Cos ϕ $\quad$ = power factor, decimal (being equal 0.71).

Specific energy requirements (kW.h/Mg):

It was calculated by multiplying the consumed power (kW) by the time (h) and then dividing by the machine productivity (Mg).

RESULTS AND DISCUSSION

1. Machine productivity, kg/min:

Table (3) illustrates the machine productivity which was affected by drum speed and feed rate. The results indicated that the highest values of machine productivity were recorded with feed rate of 12 kg/min at any drum speed. Increasing the feed rate from 6 to 12 kg/min the machine productivity increased by 99.10 % at drum speed of 450 r.p.m. Also, it is obvious that the drum speed of 450 r.p.m achieved the highest values of machine productivity compared with the other speeds under all feed rates. This may be due to the increase of pods rubbing and impact with torsion motion.

2. Seed losses:

Table (3) and Fig. (3) show the effect of drum speed and feed rate on seed losses. The highest values of seed losses were obtained with feed rate of 12 kg/min. While the lowest values were recorded with 6 kg/min at all drum speeds. Increasing the feed rates from 6 to 12 kg/min increased the seed losses from 4.68 to 5.39% at drum speed of 450 r.p.m. The other drum speeds had the same trend. The lowest values of seed losses were obtained with 450 r.p.m drum speed comparison with other speeds (375, 525, 600 r.p.m). Increasing or decreasing the drum speed than 450 r.p.m tends to increase seed losses. This trend may be due to slow motion of the pods and seed at cylinder speed less the 450 r.p.m in separating chamber. At cylinder speed more than 450 r.p.m tends to increase the speed of pods and seed

accordingly increases the possibility of going out from separating chamber throw skin opening.

Table 3: Performance of the separating machine at different separating drum speed and feed rate

Drum speed, r.p.m, (m/s)	Feed rate, kg/min	Machine productivity, kg/min	Seed losses, %	Unseparating seed, %	Seed damage, %
375 (8.83)	6	3.38	6.12	7.6	0.92
	9	5.1	6.32	8.9	0.64
	12	6.57	7.29	10.27	0.38
450 (10.60)	6	3.4	4.68	5.84	1.46
	9	5.13	4.9	6.42	0.91
	12	6.78	5.39	8.23	0.56
525 (12.36)	6	3.3	6.9	3.05	2.98
	9	5.06	7.38	3.9	1.76
	12	6.56	8.77	5.65	1.28
600 (14.13)	6	3.23	8.04	0.63	6.93
	9	4.85	8.9	0.96	4.71
	12	6.45	10.08	1.64	3.5

3. Unseparating:

Table (3) and Fig. (3) illustrates unseparating seed which was affected by drum speed and feed rate. The highest values of unseparating seed were recorded with feed rate of 12 kg/min at any drum speed. Increasing the feed rate from 6 to 12 kg/min tends to increase the unseparating seed by 35.13% at drum speed of 375 r.p.m. On the other hand, the drum speed of 600 r.p.m gave the lowest values of unseparating seed compared with the other speeds under all feed rates. This trend may be because of increasing the impact force of knives and the kinetic energy of the seed, which make seed more, subjected to the smashing forces.

4. Seed damage:

Table (3) and Fig. (4) illustrate the percentage of seed damage for different feed rates and drum speeds. The results indicated that the damage decreased rapidly at each speed as the feed rate was increased from 6 to 12 kg/min. increasing the feed rate from 6 to 12 kg/min tends to decrease the seed damage by 61.64% at drum speed of 450 r.p.m.

The damage also rapidly increased if the drum speed increased from 375 to 600 r.p.m for all feed rates. The seed damage increased from 0.38 to 3.50% when the drum speed increased from 375 to 600 r.p.m.

5. Cleaning efficiency:

Table (4) indicated the effect of feeding rate; shaker speed and sieve slop angle on cleaning efficiency of pea seed after separating operation was tested by varying the angle of the shaker and fixing the separating bar speed at 400 r.p.m.

The highest values of cleaning efficiency were recorded with feed rate of 6 kg/min at any shaker speed and angle. Increasing the feed rate from 6 to 12 kg/min the cleaning efficiency decreased by 3.53% at shaker speed 225

r.p.m and sieve slop angle 15 degree. The shaker speed of 225 r.p.m achieved the highest values of cleaning efficiency compared with the other speeds under all feed rates. This may be due to increase motion of seeds with strip on shaker surface therefore increasing the loss of seeds by increasing shaker speed than 225 r.p.m. Also, it was increased with the shaker slope angle. Whereas, reducing the shaker speed leads to increase the amount of seeds and strip above the shaker sieve specially with the reduction of the shaker slope angle.
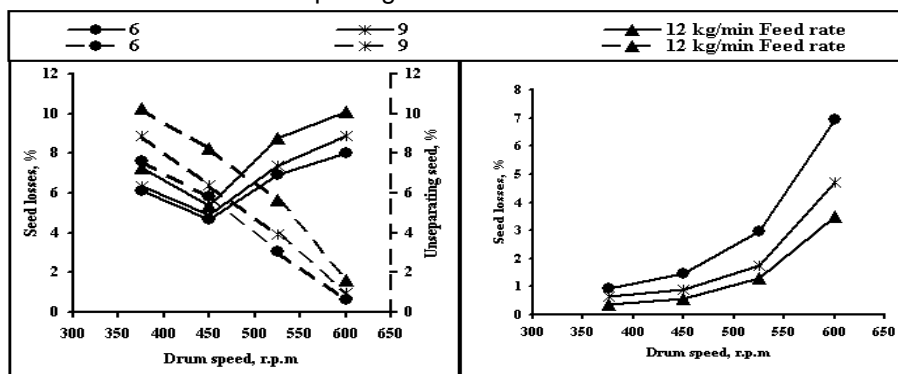

Fig. 3: Effect of drum speed and feed rate on seed losses and unseparating percentage.

Fig. 4: Effect of drum speed and feed rate on seed damage percentage.

Table 4: Effect of feed rate; shaker speed and sieve slop angle on cleaning efficiency at separating drum speed 400 r.p.m

Shaker speed, r.p.m	Sieve slop angle	Cleaning efficiency, %		
		Feed rate, kg/min		
		6	9	12
150	15	88.41	86.91	84.78
	20	90.24	89.04	87.00
	25	86.62	84.31	82.00
225	15	94.81	93.26	91.46
	20	96.00	95.10	92.92
	25	92.08	91.86	90.73
300	15	84.36	83.87	82.00
	20	87.64	86.80	85.74
	25	82.90	81.62	80.12

On the other hand, the cleaning efficiency decreased at 15 and 25 degree shaker angles and increased at 20 degree. At the higher sieve slop angle more impurities, which include pieces of crushed pods, roll down the shaker and pieces of pods pass through the wire mesh screen.

The cleaning efficiency was low at the 25 degree shaker angle. This may be due to a too high sieve slop angle caused both peas and pieces of pods to roll down and clog the wire mesh screen on the inclined shaker. Therefore the optimum sieve slop angle was considered to be 20 degrees.

1427

Specific energy, kW.h/Mg:

The influence of feeding rate and drum speeds on the specific energy has been shown in Table 5 and Fig. 5. It is clear from the data that there was a positive effect of feeding rate and drum speed on the specific energy during the separating processes of pea seed.

Table 5: Effect of feeding rate and drum speeds on the specific energy

Feeding rate, kg/niin	Specific energy, kW.h/Mg			
	Drum speed, r.p.m (m/s)			
	375 (8.83)	450 (10.60)	525 (12.36)	600 (14.13)
6	10.745	11.446	12.384	13.153
9	7.176	7.607	8.092	8.77
12	5.596	5.774	6.272	6.638

The specific energy decreased from 10.745 to 5.596 kW.h/Mg when the feeding rate was increased from 6 to 12 kg/min and drum speed was 375 r.p.m. However, the feeding rate of 12 kg/min achieved the lowest values of specific energy during the separating processes of pea seed for all drum speeds. The data also indicated that increasing the drum speed from 375 to 600 r.p.m caused an increase in the specific energy for all feeding rate. The specific energy increased by 22.41% when the drum speed was increased from 375 to 600 r.p.m at feed rate 6 kg/min. Generally, the drum speed of 375 r.p.m recorded the minimum values of specific energy for all feeding rate.
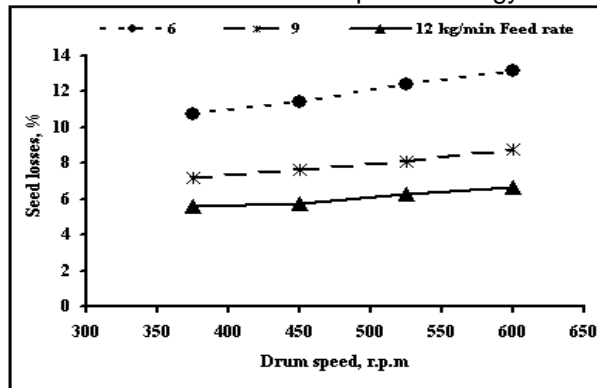

Fig. 5: Effect of drum speed and feed rate on the specific energy.

Finally, it can be concluded from the previous results that the feeding rate of 6 kg/min and drum speed of 375 recorded the minimum values of specific energy.

CONCLUSION

The conclusions of this study are summarized as follow:
1. The drum speed of 450 r.p.m (10.60 m/s) gave the highest values of machine productivity and the lowest values of seed losses.

2. Increasing the feed rate from 6 to 12 kg/min tends to increase the machine productivity and seed losses whereas the seed damage was decreased.
3. The highest values of cleaning efficiency were obtained with shaker speed of 225 r.p.m and sieve slop angle of 20°.
4. The minimum specific energy were obtained with feed rate of 12 kg/min and drum speed of 375 r.p.m (8.83 m/s).

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تصميم وتقييم ماكينة لتفريط قرون البسلة الخضراء

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استمرارا لحل مشكلة تفريط وتنظيف البسلة الخضراء واستكمال للبحث المنشور في المؤتمر الخامس عشر للجمعية المصرية للهندسة الزراعية ٢٠٠٨، تم تفعيل النتائج المتحصل عليها لوضع تصميم نهائي نفذ في إحدى ورش القطاع الخاص بمحافظة كفرالشيخ. والجدير بالذكر أنه فى هذا البحث تم استخدام نظرية الدراس (صدر + درفيل) مع تصميم درفيل ذو مواصفات خاصة يقلل من تعرض حبوب البسلة للصدامات مع تعرض القرون لحركة التواء واتخاذ المسار الحلزوني لتوزيع الأسنان على سطح الأسطوانة لتساعد فى عمليتي الفصل والطرد السريع لمحتويات غرفة الدراس من غالبية القرون الفارغة من خلال فتحة فى نهاية الغرفة. بعد ذلك يسقط المخلوط من الحبوب وبقايا القرون الفارغة والقشور على غربال ترددي يعمل على فصل الحبوب ديناميكياً عن القرون الفارغة والبقايا الخضرية .

وتم تقيم أداء الآلة على محصول البسلة الخضراء صنف (Master B) مع عوامل التشغيل المختلفة: أربعة سرعات لاسطوانة الدراس ٣٧٥ ، ٤٥٠ ، ٥٢٥ ، ٦٠٠ لفة/دقيقة (٨,٨٣ ، ١٠,٦٠ ، ١٢,٣٦ ، ١٤,١٣ م/ث) مع ثلاث معدلات تغذية (٦ ، ٩ ، ١٢ كجم/دقيقة) وثلاثة سرعات لغربال التنظيف (١٥٠ ، ٢٢٥ ، ٣٠٠ لفة/دقيقة) مع ثلاثة ميول لغربال التنظيف (١٥ ، ٢٠ ، ٢٥ درجة) ومحتوى رطوبى ٧٦,٥٪ على أساس رطب على كفاءة الأداء للآلة وجودة المنتج.

وكانت أهم النتائج المتحصل عليها كالآتي:

١. أعطت سرعة الدرفيل ١٠,٦٠ م/ث (٤٥٠ لفة/دقيقة) أعلى قيمة لإنتاجية الآلة من البذور السليمة وأقل قيمة فى نسبة كسر البذور. بينما أعطت سرعة درفيل ١٤,١٣ م/ث (٦٠٠ لفة/دقيقة) أقل قيمة لإنتاجية الآلة من الحبوب السليمة مع أقل نسبة للقرون غير المفصولة وأعلى قيمة فى نسبة فقد وكسر البـذور مع معدلات التلقيم المختلفة. فى حين أعطت سرعة درفيل ٣٧٥ لفة/دقيقة (٨,٨٣ م/ث) أعلى نسبة قرون غير مفصولة مع اقل نسبة كسر للبذور.

٢. بزيادة معدل التلقيم من ٦ إلى ١٢ كجم/دقيقة أدى ذلك إلى زيادة كل من إنتاجية الآلة من البذور السليمة ونسبة القرون غير مفصولة ونسبة فقد البذور.

٣. كانت أعلى قيمة متحصل عليها لكفاءة التنظيف عند سرعة غربال التنظيف ٢٢٥ لفة/دقيقة مع زاوية ميل الغربال ٢٠ درجة. بينما كانت أقل قيمة تم الحصول عليها لكفاءة التنظيف عند سرعة غربال ٣٠٠ لفة/دقيقة وزاوية ميل ٢٥ درجة.

٤. بزيادة معدل التلقيم من ٦ إلى ١٢ كجم/دقيقة أدى إلى نقصان الطاقة النوعية المستهلكة لوحدة الإنتاجية بمقدار ٤٩,١٣٪. فى حين أدى زيادة سرعة درفيل الفصل من ٣٧٥ إلى ٦٠٠ لفة/دقيقة إلى زيادة الطاقة النوعية المستهلكة لوحدة الإنتاجية بمقدار ٢١,٤٥٪.

من خلال النتائج السابقة الذكر نستطيع أن نوصى باستخدام الماكينة عند سرعة درفيل الفصل ١٠,٦٠ م/ ث (٤٥٠ لفة/دقيقة) ومعدل تغذية ٦ كجم/دقيقة وسرعة غربال التنظيف (٢٢٥ لفة/دقيقة) مع ميل لغربال التنظيف (٢٠ درجة) وذلك للحصول على كفاءة تشغيل عالية مع أقل نسبة كسر وفقد للبذور مع كفاءة عالية للتنظيف.