MODELING OF PROTOTYPE FOR GINNING SODOM APPLE PLANT

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ABSTRACT

Ginning process plays an important role in separating fibers from seeds, efficient ginning process provides farmers with viable and undestroyed seeds for plant type preservation and good fibers for textile processing. Due the great divergence in characteristics between sodom apple fibers and seeds and those of cotton, preliminary experiments showed that cotton ginning machines is incompatible with that able to gin sodom apple. Experiments were carried out with four drum speed, 1.05, 2.10, 3.15 and 4.20 m/s (100, 200, 300 and 400 r.p.m), concave clearances (0.005, 0.010, 0.015 and 0.020 m) and number of drums (one drum and two drums).Results showed that the two drums prototype at 0.005 m clearance and 4.20 m/s drum rotational speed was the optimal performing system as the productivity is 1.85 times that of one drum, seed damage, fiber losses percentage, energy requirements and criterion costs is decreased by 6.98, 13.32%, 48.69 % and 45% than that of one drum at the same operating conditions respectively. The dimensional analysis was reasonably accepted for predicting the separation time with coefficient of determination 0.96, that helps in producing large scale ginning machines.

1. INTRODUCTION

Sodom apple is a new wild agricultural plant specified as a member of the Asclepiadaceae, it is a woody, broadleaf evergreen coarse shrub 3-5 m tall. The plant is adapted to hot and dry climates, it can tolerate drought and prefers growth in semiarid and in saline soil. Sodom apple plant has many uses in medicine and all its parts have medical importance. This plant has high light creamy color fibers **(Grace, 2006)**.

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The fibers can be used in textiles field, natural plant fibers were collected; the fibers were separated from the seeds manually and stored in paper bags to reserve it. Fibers were tested and compared with other materials to know their specifications to help in using them in the textiles field. She concluded that sodom apple fibers could be spun alone or with other natural and man made fibers, and produce yarns which could be blended with cotton (65% sodom apple and 35% cotton), this blended yarn could be weaved **(Abbas, 2010)**. **Vogt (1995)** reported that their seeds the seeds contain about 34% protein and 17-30% oil.

Bhaskar (2000) reported that extracts of seeds of sodom apple plant found to have anti-microbial activity. The seed oil content of sodom apple seeds ranged from 19.7 to 24.0 %. Five main fatty acids were identified, with a predominance of unsaturated linoleic and oleic acids (approximately 70%). The oil profile of sodom apple plant presents interesting features that highlight its potential as a future alternative for the biodiesel market, especially in semi-arid regions **(Barbosa *et al*., 2014)**.

Badawy (2002) reported that the highest threshing efficiency was 97.17 % at the optimum performance of flax deseeding machine by increasing the drum speed from 9.28 to 15.33 m/s the capacity increased from 1800 to 2400 kg/h.

Sodom apple raw material (seeds and their fibers) is too light that it can fly in stagnant air or it has very low density. Although these characteristics are essential for plant spreading and type preservation, they form substantial problems in plant drying, ginning and other future processing. Due these great divergent characteristics between sodom apple fibers and seeds and those of cotton, preliminary experiments showed that cotton ginning machines is incompatible with that able to gin sodom apple. The main objective of the present work is to fabricate, test and model a suitable prototype for separation of sodom apple raw material fibers and seeds using dimensional analysis.

2. MATERIAL AND METHODS

A prototype of the separation machine is constructed at the Faculty of Agricultural Engineering workshop and the experimental part of the present study was carried out also in the laboratory of the Faculty of Agricultural Engineering Al-Azhar University, Nasr city, Cairo.

2.1. MATERIAL:

2.1.1. Raw material preparation: Experiments was carried out on a new raw material (wild sodom apple plant) which was collected from sporadic areas (Mokkatam, Misr-Ismailia Desert Road, Nasr city) in the summer months before the fruits bloom and the seeds spread in the air carried by fibers. The raw material (sodom apple) were collected and stored in paper bags to reserve it until the experimental work is started.

2.1.2. The separation prototype construction: A prototype, is manufactured for separating sodom apple plant fiber from its seeds, is consisted of a hopper, separation chamber, drum, source of power, outlet of seeds and outlet of fibers. The elevation and side view of the separation prototype are shown in Fig. (1). The separation prototype was consisted of:

- **Hopper:** The hopper was made of compressed wood of conical shape, the top rectangle of 200×180 mm and bottom rectangle of 120×180 mm with 191 mm high. One of the hopper side is made of inclined galvanized steel sheet for ease movement of the sodom apple batch.

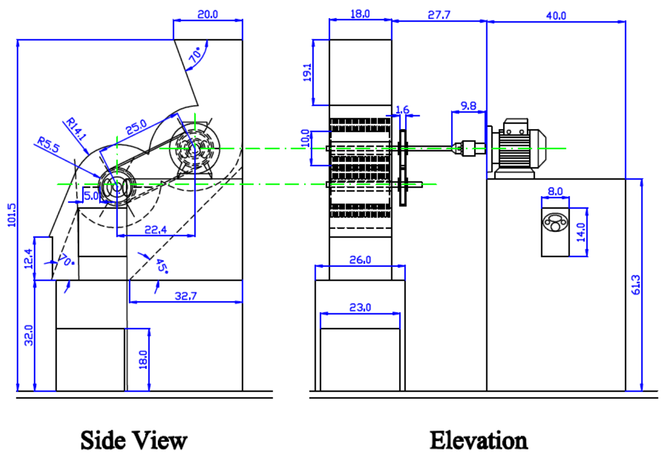

Fig. (1): Side view and elevation of separation prototype.

- **Separation chambers:** Separation chambers play substantial role in the ginning or separating sodom apple seeds from fibers in our designed prototype. Two champers circular-shape 100 mm radii from both left and right sides, each of them was enclosed by a concave made of 1.5 mm thick perforated steel sheet (screen), 7.0 mm hole diameter and 2.0 mm apart. The separation chambers side were constructed of compressed plywood 15 mm thick and covered with steel sheet cover.

One rotary drum for each chamber made of wood 170 mm length and 100 mm diameter. Six rows of 18 flexible steel fingers are installed on the peripheral of each drum Fig. (2).

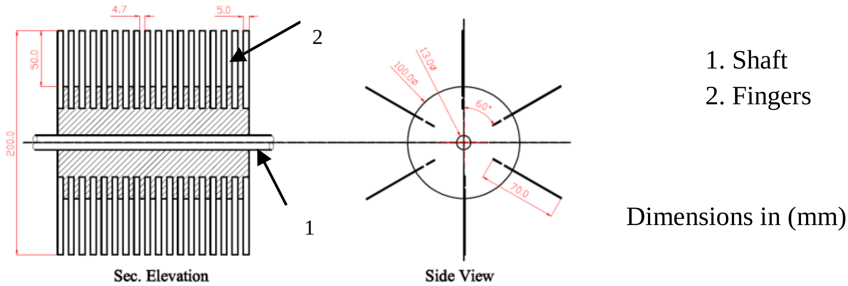

Fig. (2): Elevation and side view of the drum of separation prototype.

- **The source of power:** The power source used was an electrical motor directly joined to a pulley of 110 mm diameter, of 1400 r.p.m, and 0.5 hp (0.37 kW) power, Cos ϕ is 0.8, made in Italy. The electrical motor was connected with a speed control apparatus (Inverter) of model: No. SV004iC5-1, made in Korea, by which the rotational speed of the motor can be controlled from 0 - 1400 r.p.m.
- **Outlet of seeds:** The outlet of seeds is made of compressed plywood from left and right sides and the bottom of the outlets of seeds is made of galvanize steel sheet for ease movement of the seeds, it has dimensions of 180 × 460 mm, inclined by 45^{o} with the horizontal.
- **Outlet of fibers:** The outlet chute of fibers is made of galvanize steel sheet it has dimensions of 180×124 mm, with inclined angle exceeds 42^{o}.

2.1.3. Measuring instruments:

2.1.3.1. Digital caliper: A digital caliper (accuracy 0.01mm) made in china, was used for measuring the seed dimensions.

2.1.3.2. Electrical balance: Weight of samples were measured by a Sartorius electrical balance made in Japan, (HR- 200, max 210 g) having accuracy of (0.0001 g).

2.1.3.3. A digital AVO meter: A digital AVO meter was used to measure the consumption of electrical current "A", specification of device were as follows: accuracy of device 0.01, rang the measurement (0 - 40 A) and the device made in china.

2.1.3.4. Stop watch: Stop watch (accuracy 1 sec.) was used to record the separation time. Separation time is assumed to be terminated when seeds is approximately stopped falling out of the concave.

2.1.3.5. Digital photo tachometer: A digital photo tachometer was used to measure the rotational speed r.p.m of the drum. The specifications of tachometer are as follows: range of the measurement is 2.5 to 99999 r.p.m and its accuracy is 0.1 r.p.m through the speed 2.5 to 999.9 r.p.m and 1 r.p.m over 1000 r.p.m.

2.2. METHODS:

2.2.1. The experiments procedure:

Experiments were carried out on two prototypes using one and two drums respectively, the following items were studied of the two prototypes for selecting and optimizing the fabricated prototype with the aide of productivity in kg/h.

Experiments were carried out with four drum speed, 1.05, 2.10, 3.15 and 4.20 m/s (100, 200, 300 and 400 r.p.m) concave clearances (0.005, 0.010, 0.015 and 0.020 m) and number of drums (one drum and two drums).

Dimensional analysis has been done for the optimal selected system to predic suitable formula for large scal ginning machines.

As drum rotating with angular velocity (ω) rad/s, flexible fingers impact the raw sodom apples batch mass (M) Kg by a torque (τ) N.m, against friction force caused by the perforated concave repeatedly causing the ginning process.

2.3. Evaluation of the performance:

2.3.1. Productivity: Machine productivity was calculated as follows:

$$P_r = \frac{M}{t} \qquad \text{..........................} (1)$$

Where: ***M***: The total mass of raw material (kg); and ***t***: The time consumed in separation operation (h).

2.3.2. The percentage of seeds damage (%): The damaged seeds were determined by hand collecting and weighing, damaged seeds estimated according to (**Hassan *et al*., 1994)**.

$$F_L = \frac{MSD}{MT_S} \times 100 \qquad \text{……………………….. (2)}$$

Where: ***MSD***: Mass of damaged seeds; ***MT***

2.3.3. The percentage of fiber losses (%):

The fiber losses were determined by manual collecting and weighing from the output seeds, the percentages of fiber losses were determined by using the following equation **(Marey, 1997)**:

$$F_L = \frac{MFL}{MT_F} \times 100 \qquad \text{………………………… (3)}$$

Where: ***MFL***: Mass of fiber losses collected at seeds outlet, (kg);

and ***MT_F***: Mass of total fibers input, (kg).

2.3.4. Power requirements (W): Both of Ammeter and Voltmeter were used for measuring current strength and potential difference respectively, before and during separation process.

The consumed electric power under load (P) was calculated according to **(Lockwood and Dunstan, 1971)** by the following equation:

$$P = \frac{V.I.\mu.\cos\theta}{1000} \quad \text{kW} \qquad \text{...……………...……… (4)}$$

Where: ***I***: Line current strength in amperes; ***V***: Potential difference voltage being equal to, (220 V); ***cosɵ***: Power factor assumed to be, (0.8); and ***μ***: Mechanical efficiency of motor, assumed, (0.95).

2.3.5. Cost analysis (LE/h):

The total cost was determined by using the following equation **(Hunt, 1983)**.

Total cost (LE/h) = Fixed cost (LE/h) +Variable cost (LE/h).

A. Fixed costs:

- Depreciation of the machine:

The depreciation of the prototype was calculated from the following equation:

$$D = \frac{(P - S)}{L} \qquad \text{…………….…………….... (5)}$$

Where: ***D***: Machine depreciation, LE/Year; ***P***: Purchase price, LE; ***S***: Salvage or selling price, LE (Salvage = 10% of cost now); and ***L***: Time between buying and selling, Year. (10 Years).

- Interest rate:

The interest rate of the prototype was calculated from the following equation: $Interest = \left[\left(\frac{P+S}{2}\right) \times R\right]$ .... (6)

Where: ***R***: Interest rate (the interest rate of 9% was used in the present study).

- Taxes, insurance and shelter: The costs of taxes, insurance and shelter were considered 2% of the machine purchase price per year.

B. Variable costs:

- Repairs and maintenance: For machinery is about 5.77% of purchase price.

- Electric costs: Total power consumed **(Lock wood and Dunstan, 1971)** $P = V.I.\mu.\cos\theta$ Price kW of electric 0.3 LE/ kW.h.

- Lubricant cost: Lubrication cost was taken as (15%) of electric costs.

- Labour cost: Labour wage was considered 500 LE/month work so that the labour wage was 6000 LE/year. Yearly working hours is assumed in the present work to be: (300 days/year × 8 h/day = 2400 h/year).

C. Operating cost: $\cos t\, of\ (LE/kg) = \frac{prototype\ hourly \cos t(LE/h)}{productivity(kg/h)}$ …… (7)

Dollar exchange rate at the time was the equivalent of 7.6 LE.

2.4. Analytical study:

Dimensional analysis technique was used to develop a prediction model for the optimal slected sodom apple ginnig system based on the Buckingham π theorem **(Langhaar1951)**. The number of dimensionless and independent quantities (namely π terms) required to express a relationship among the variable in any physical system can be determined as follows: $N = n - b$ ….…………..... (8)

Where: ***N***: Number of π terms; ***n***: The total number of variable; and ***b***: The number of basic dimensions.

Six variables are pertinent for the ginning machine prototype and they are presented in Table (1). Basic dimensions are mass (M), length (L) and time (θ). The separation time required can be expressed as a function of the other five variables. $t = f(v, c, \tau, d, m)$

A determinant of three variables not equal to zero *t*, *v* and τ is considered achieving rule as shown below:

$$\begin{array}{c} \\ M \\ L \\ \theta \end{array} \begin{array}{c} \begin{array}{ccc} t & v & \tau \end{array} \\ \begin{vmatrix} 0 & 0 & 1 \\ 0 & 1 & 2 \\ 1 & -1 & -2 \end{vmatrix} \end{array} = -1$$

Solving the above determinate for *t*, *v* and *τ*. Since the determinant does not equal to zero, the resulting equations are independent and the selection is valid. The following dimensionless groups are obtained: $\pi_1 = \frac{vt}{d}$, $\pi_2 = \frac{mv^2}{\tau}$, $\pi_3 = \frac{c}{d}$

Table (1): Variables used in the dimensional analysis.

No.	Symbol	Description	Dimension	Units
1	*v*	Drum speeds	$L\theta^{-1}$	m/s
2	*c*	Clearance between drum fingers and concave screen (Concave clearance).	L	m
3	*t*	Separating time	θ	s
4	*τ*	Separation torque	$ML^2\theta^{-2}$	N.m
5	*d*	Drum width	L	m
6	*m*	Feeding batch mass	M	Kg

Accordingly, the prediction equation can be reduced to the form:

$$t = \frac{d}{v} f\left(\frac{mv^2}{\tau}, \frac{c}{d}\right) \qquad \text{........................} (9)$$

Experiments were conducted to determine the proportional constant.

3. RESULTS AND DISCUSSION

3.1. Effect of the drum speed, concave clearance and number of drums on the separation prototype productivity "P_r"(Kg/h):

Fig. (3) shows the relationship between separation prototype productivity "P_r" and drum speeds "V_d" (1.05, 2.10, 3.15 and 4.20 m/s) at different concave clearances "C_c" (0.05, 0.010, 0.015 and 0.020 m) for one and two drums of separation prototype.

It is clear that the productivity is affected linearly by increasing drum speed from 1.05 to 4.20 m/s when the concave clearance is constant for the one and two drums tested in the separation prototype.

These data showed that productivity affected inversely by increasing the concave clearance at constant drum rotational speed for both prototypes tested. These results agreed with that reported by **Badawy (2002)**. It is clear from Fig. (3) that the highest values of productivity were 1.75 and 3.23 Kg/h for one and two drums used respectively for concave clearance of 0.005 m and drum speed of 4.20 m/s.

The productivity, when two drums used is 1.85 times that of one drum at the same operating conditions. So, using two drums in the separation process is considered for the optimum productivity of the separation prototype.

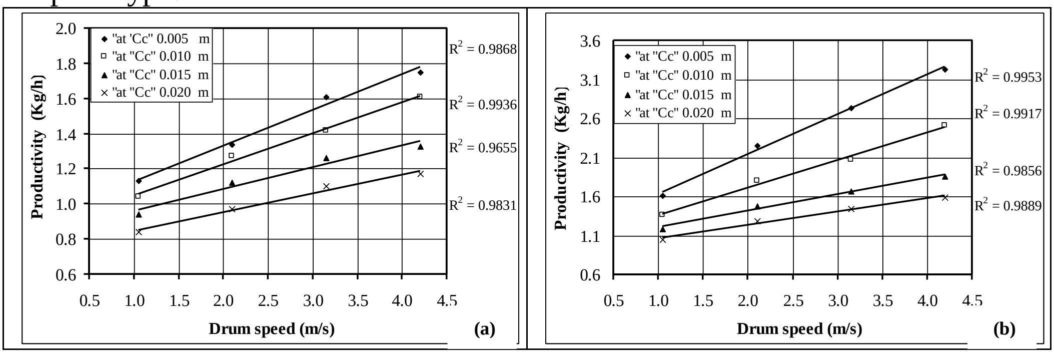

Fig. (3): The relationship between productivity "P_r" as affected drum speed at different concave clearances when one drum (a) and two drums (b) are used for separation prototype.

3.2. Effect of the drum speed, concave clearance and number of drums on seed damage percentage:

Fig. (4) shows the relationship between seed damage percentage "S_d" and drum speeds "V_d" (1.05, 2.10, 3.15 and 4.20 m/s) at different concave clearances "C_c" (0.005, 0.010, 0.015 and 0.020 m) when one and two drums are used for separation prototype respectively.

Generally it can be observed that the seed damage percentage increases linearly with increasing drum speed, while the seed damage percentage decreases with increasing concave clearance. It is also clear that values of seed damage percentage with one drum were more than two drums of separation prototype.

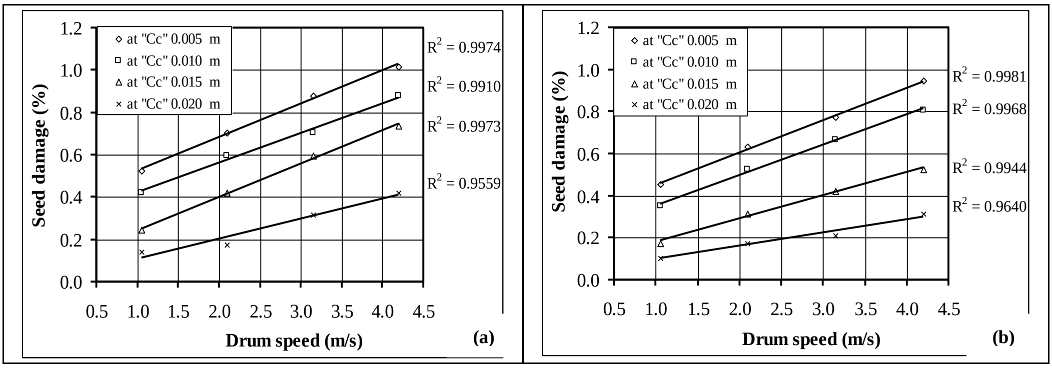

Fig. (4): The relationship between seed damage percentage and drum speed at different concave clearances when one drum (a) and two drums (b) are used for separation prototype.

As previous results of productivity, concave clearance of 0.005 m and drum speed of 4.20 m/s was the optimal for the separation prototype productivity. Comparing seed damage percentage for the same operational conditions clears that the two drums seed damage percentage was 0.947 % compared to 1.018 % for the one drum seed damage, or we can concluded that the two drums seed damage percentage is lower by 6.98% than that of one drum.

3.3. Effect of the drum speed, concave clearance and number of drums on fiber losses percentage:

Results showed that the fiber losses percentage "F_L" increases proportionally with increasing drum speed "V_d" and decreases with increasing concave clearance "C_c". It is also clear that values of fiber losses percentage with one drum were more than that of two drums for separation prototype as illustrated in Fig. (5).

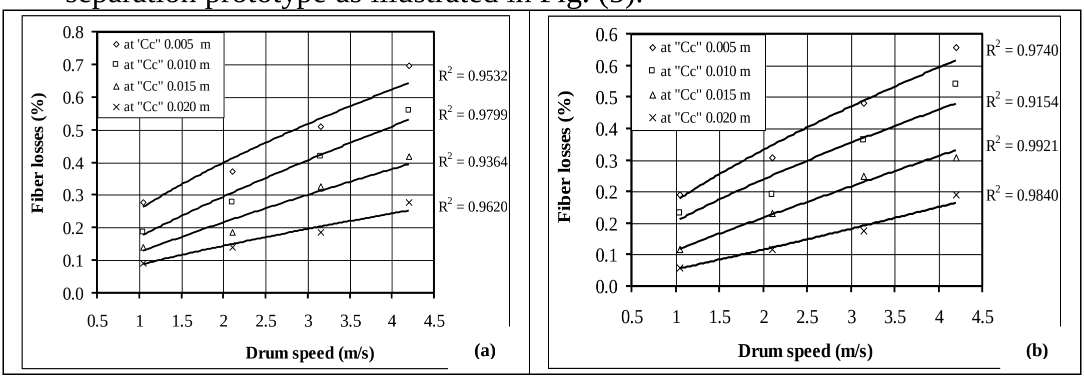

Fig. (5): The relationship between fiber losses percentage and drum speed at different concave clearances when one drum (a) and two drums (b) are used for separation prototype.

As previous results for productivity and seed damage percentage of the two drums prototype is considered as an optimal performing system for separation prototype. Comparing fiber losses percentage for the same operational conditions clears that the two drums fiber losses percentage was 0.605 % compared to 0.698 % for the one drum tested, or, it can be concluded that the two drums fiber losses percentage is lower by 13.32% than that of the one drum.

3.4. Effect of the drum speed, concave clearance and number of drums on the energy requirements:

Comparing data for the energy requirements in the same operational conditions previously characterized in Fig. (6) for the optimal productivity, seed damage percentage and fiber losses percentage, it can be revealed that the energy requirements for the two drums prototype were lower than that of one drum and they were 18.63 and 36.31 kW.h/Mg respectively. It can also be concluded that the energy requirements for the two drums prototype is lower by 48.69% than that of one drum.

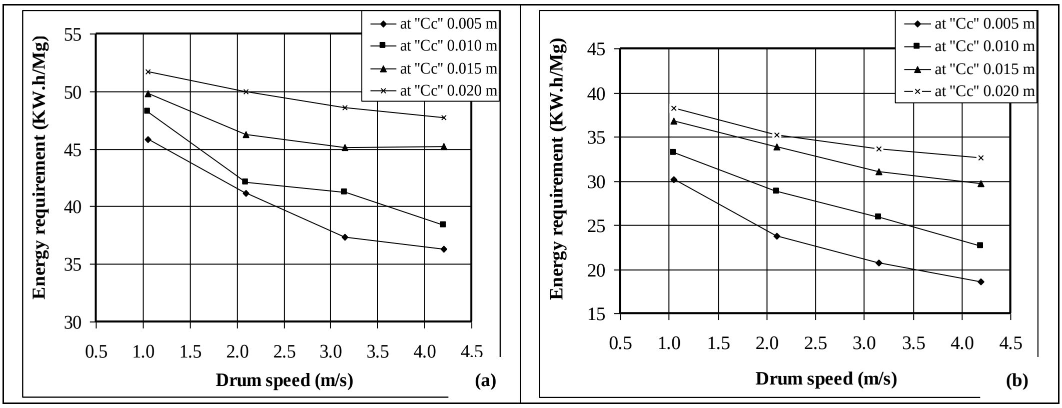

Fig. (6): Effect of the drum speeds and concave clearances on energy requirements at one drum (a) and two drums (b).

3.5. Effect of the drum speed, concave clearance and number of drums on the criterion cost (LE /kg):

Table (2) show the relationship between criterion cost and drum speed at different concave clearances when one and two drums are used in the separation prototype. Generally, the criterion cost increases with increasing concave clearance, while the criterion cost decreases with increasing drum speed. Also it is clear that values of criterion cost with one drum were more than two drums of separation prototype. Table (2) also showed that for the same optimal operational conditions characterized for productivity, seed damage percentage, fiber losses percentage and energy requirements, the criterion cost was 1.49 LE/kg for one drum prototype compared to 0.82 LE/kg for the two drums is decreased by 45% than that of one drum.

Table (2): Criterion cost at different drum speeds and different concave clearances for one and two drums of separation prototype.

Drum speed (m/s)	Criterion cost (LE /kg)							
	One drum				Two drums			
	Concave clearance (m)				Concave clearance (m)			
	0.005	**0.010**	**0.015**	**0.020**	**0.005**	**0.010**	**0.015**	**0.020**
1.05	2.35	2.51	2.79	3.16	1.62	1.92	2.21	2.43
2.10	1.97	2.08	2.35	2.69	1.16	1.46	1.78	2.02
3.15	1.62	1.87	2.08	2.35	0.96	1.26	1.59	1.82
4.20	1.49	1.62	1.97	2.20	0.82	1.06	1.40	1.66

4.6. Optimal selected system:

Results showed that the two drums prototype at 0.005 m clearance and 4.20 m/s drum rotational speed was the optimal performing system as the productivity is 1.85 times that of one drum, seed damage, fiber losses percentage, energy requirements and criterion costs is decreased by 6.98, 13.32%, 48.69 % and 45% than that of one drum at the same operating conditions respectively. The dimensional analysis was reasonably accepted for predicting the separation time with coefficient of determination 0.96, that helps in producing large scale ginning machines.

3.7. Dimensional analysis:

In the present study a mathematical model is developed for the separation prototype used for separation of sodom apple fibers from seeds, which can be helpful in design and operation criterion and for increasing the efficiency of research accomplishment. As previously reported in item (3.3) the two drums design was the optimal design, so, the following analysis is derived.

Chapter (2) shows that the following prediction π groups or terms are valid for separation of sodom apple:

$$t = \frac{d}{v} f\left(\frac{mv^2}{\tau}, \frac{c}{d}\right)$$

Fig. (7) show the relationship between π_1 (vt/d) is affected by π_2 (mv^2/τ) at different values of π_3 (c/d) when two drums are used for the separation process. It is clear that the relation between π_1 and π_2 when π_3 varied satisfied a power function of the form:

$$\frac{vt}{d}=a\left(\frac{mv^2}{\tau}\right)^b$$

The parameter "a" as affected by values of π_3 are depicted in Fig. (8) with two drums. Power relationship was satisfied for two drums of separation process. The following equation is valid for two drums of separation process: $A=c\left(\pi_3\right)^D$

It is clear that the parameter "b" approximately doesn't change and takes the values (0.180, 0.205, 0.237 and 0.248) with an average value of 0.2172 for two drums of separation prototype.

The complete prediction equation for separation of sodom apple was of the form: $t=\left(\frac{d}{v}\right)\times\left[\left(8820.6\left(\frac{c}{d}\right)^{0.5025}\right).\left(\frac{mv^2}{\tau}\right)^{0.2172}\right]$ **R^2= 0.9627** … (10)

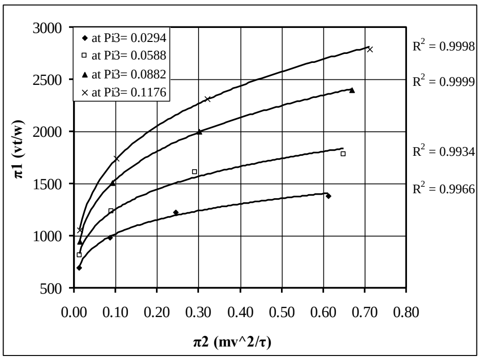

Fig. (7): The relationship between π_1 and π_2 at different π_3 for two drums used in the separation process.

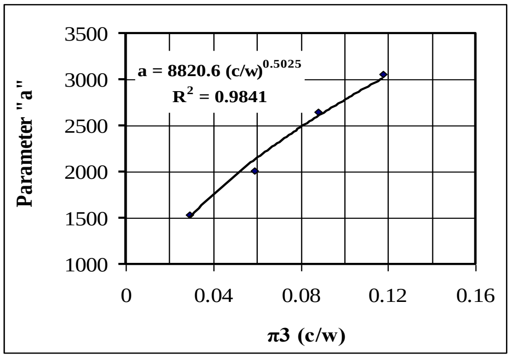

Fig. (8): The relationship between parameter "A" and "π_3" when two drums are used.

Fig. (9) show the relationship of the predicted and observed separation time for two drums of separation prototype.

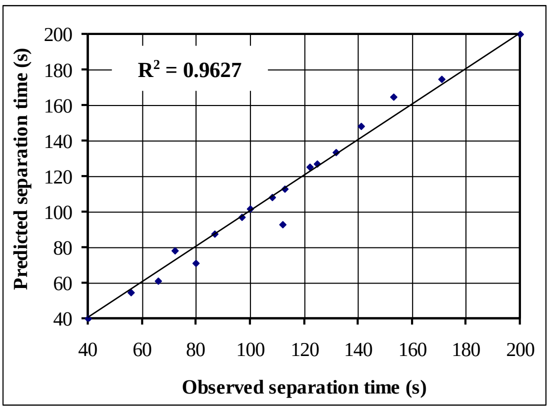

Fig. (9): Predicted and observed separation time "t" (s) when two drums of the separation prototype are used.

4. CONCLUSION

Ginning process plays an important role in separating fibers from seeds, efficient ginning process provides farmers with viable and undestroyed seeds for plant type preservation and good fibers for textile processing. Sodom apple raw material (seeds and their fibers) is too light that it can fly in stagnant air or it has very low density. Although these characteristics are essential for plant spreading and type preservation, they form substantial problems in plant drying, ginning and other future processing. Due these great divergent characteristics between sodom apple fibers and seeds and those of cotton, preliminary experiments showed that cotton ginning machines is incompatible with that able to gin sodom apple.

The main objective of the present work is to fabricate, test and model a suitable prototype for separation of sodom apple raw material fibers and seeds using dimensional analysis for the optimal selected ginning machine with the aid of productivity, seed damage and fiber losses percentage, energy requirements and criterion cost.

Experiments were carried out with four drum speed, 1.05, 2.10, 3.15 and 4.20 m/s (100, 200, 300 and 400 r.p.m) concave clearances (0.005, 0.010, 0.015 and 0.020 m) and number of drums (one drum and two drums).

The results can be summarized as follow:

1. It can be concluded that the two drums prototype at 0.005 m clearance and 4.20 m/s drum rotational speed was the optimal performing system in terms of productivity, seed damage and fiber losses percentage, energy requirements and criterion cost. The productivity of the two drums prototype is 1.85 times that of one drum, seed damage, fiber losses percentage, energy requirements and criterion costs is decreased by 6.98, 13.32%, 48.69 % and 45% than that of one drum at the same operating conditions respectively.

2. The dimensional analysis was reasonably accepted for predicting the separation time with coefficient of determination 0.96 that helps in producing large scale ginning machines.

A complete prediction equation for two drums was of the form:

$$t = \left(\frac{d}{v}\right) \times \left[\left(8820.6 \left(\frac{c}{d}\right)^{0.5025} \right) . \left(\frac{mv^2}{\tau}\right)^{0.2172} \right] \qquad \mathbf{R^2 = 0.9627}$$

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الملخص العربى

نمذجة نموذج أولى لحلج نبات العشار

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تلعب عملية الحلج دور هام فى فصل الألياف عن البذور. فعملية الحلج ذات الكفاءة العاليه تزود الفلاحين ببذور صالحة غير مهشمه للحفاظ على نوع النبات وكذلك لإنتاج ألياف جيدة تدخل فى عمليات النسيج. تعتبر المادة الخام لنبات العشار (ألياف وبذور) خفيفة جدا ذات كثافة منخفضة حيث أنها تتطاير فى الهواء الساكن. وبرغم أن هذه الخصائص ضرورية لإنتشار النبات والمحافظة على نوعه ولكنها تعتبر كمعوقات فى عمليات التجفيف والحلج وكذا أى عمليات أخرى مستقبلية. وبسبب الاختلاف الواسع بين خواص الياف وبذور كلا من العشاروالقطن فإن التجارب الأولية أوضحت أن الات حلج القطن غير ملائمة لحلج العشار.

تهدف هذه الدراسة الى إمكانية تصنيع نموذج أولى لحلج نبات العشار بفصل الألياف عن البذور وإختيار نموذج الفصل الأمثل بناءا على الانتاجية ونسبة البذور المهشمه ونسبة الالياف المفقودة ومتطلبات الطاقة وكذلك معامل التكلفة وإستخدام التحليل البعدى للتنبوء بزمن الفصل عند ظروف التشغيل المختلفة للإسهام فى تصميم ماكينات حلج تناسب الإنتاج المتزايد.

متغيرات الدراسة تتمثل فى الاتى:

١- سرعة الدرفيل ١,٠٥، ٢,١٠، ٣,١٥، ٤,٢٠ م/ث (١٠٠،٢٠٠،٣٠٠،٤٠٠ لفه/ دقيقة).

٢- الخلوص بين الصدر والدرفيل ٠,٠٠٥ ، ٠,٠١٠ ، ٠,٠١٥ ، ٠,٠٢٠ م .

٣- عدد الدرافيل تم استخدام نموذج ذو درفيل واحد و نموذج ذو درفيلين.

وقد تم تلخيص نتائج هذه الدراسة كالأتى:

١. أوضحت النتائج ان النموذج ذو درفيلين عند سرعة الدرفيل ٤,٢٠م/ث وخلوص بين الصدر والدرفيل ٠,٠٠٥م كان الافضل فى الاداء من حيث الانتاجية ونسبة البذور المهشمه ونسبة الالياف المفقودة ومتطلبات الطاقة وكذلك معامل التكلفة.

٢. تم التوصل الى نموذج رياضى بإستخدام التحليل البعدى للتنبوء بزمن الفصل عند ظروف التشغيل المختلفة للنموذج ذو الدرفيلين حيث حقق الصوره الأتية:

$$t = \left(\frac{d}{v}\right) \times \left[\left(8820.6\left(\frac{c}{d}\right)^{0.5025}\right) \cdot \left(\frac{mv^2}{\tau}\right)^{0.2172}\right] \longrightarrow \quad \mathbf{R^2 = 0.9627}$$

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