CONSTRUCTION AND PERFORMANCE EVALUATION OF A LOCAL UNIT FOR SEPARATING SUNFLOWER SEEDS AND ENVIRONMENTAL PRESERVATION

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Abstract

The present study aimed to develop a local unit for separating sunflower seeds by using both centrifugal and gravitational forces. The separation process was carried out without crushing sunflower heads subsequently decrease the power consumption. Also, to obtain the minimum rate of environmental pollution with little separating cost. The study was conducted by using different beaters types with (spike-tooth, angle-bar and knives) inner cone speeds (7.24, 9.11, 12.9 and 15.4 m/s) seed moisture content of (26.9, 21.2, 15.7 and 9.8 %), separating clearance was kept constant between 4 and 2 cm between the top and end of inner cone with outer cone. It is recommended to use spike-tooth as beaters, operating at seed moisture content ranging from 21.2 to 15.7 % w.b. at 12.9 m/s inner cone speed.

INTRODUCTION

In Egypt, the gap between oil consumption and production is very high. Therefore, the direction toward planting untraditional oil crops such as sunflower crop because it is an important oil crop in the world, it ranks the second after soybeans with respect to oil production, it could be cultivated in the newly reclaimed area and its adaptability to a wide variation of soils and climatic conditions (Keshta *et al.*, 1993). However, threshing and separation of sunflower seeds are still carried out manually. This method consume more time, with high losses. El-Said (1992) designed and fabricated a conical sheller to be used for shelling peanut. The performance of the sheller was investigated under different operating conditions. The minimum losses of shelling were obtained at revolving speed of 350 rpm. Hendawy (1995) designed and fabricated a conical prototype to be used for threshing different crops (berseem, wheat and beans). The design is a conical vertical drum rotating into another fixed outer drum. The obtained results showed that the total efficiency values were 95, 92 and 93% for berseem, wheat and beans crops respectively. Helmy *et al.* (2000) compared the performance of two types of threshing drums (triangular rasp-bar and triangular spike-teeth), four peripheral drum speed levels (6.59, 8.06, 9.53 and 10.99 m/s), four concave clearance ratios (1.4, 1.8, 2.2 and 2.6) and three grain moisture contents(15.4, 20.9 and 28%) were tested to evaluate the performance of a modified

Bamby 049 BBy thresher against the conventional Bamby 049 BBy and a local thresher (Misr CRS) in Turkey. The use of the spike-tooth drum and clearance ratio of 1.8-2.2 resulted in the lowest grain losses and grain damage. Likewise, a drum speed of 9.53 m/s and grain moisture content of 15.4-20.9% produced optimum results for the modified thresher. The modified thresher obtained the highest threshing efficiency (98.08%), with lowest total grain loss, grain damage and fuel consumption for various moisture content and drum speed levels. The local thresher recorded the lowest threshing unit power requirement and threshing cost per unit production. El-Saharigi *et al.* (2002) compared between the traditional method and combine harvester in threshing sunflower crop. The obtained results indicated that the optimum forward speed for harvesting sunflower crop was 3.5 km/h, which gave the least total losses and the maximum level of cleaning efficiency. Moisture content of 16% (wb) gave the lowest level of total losses and seed damage and achieve the highest level of cleaning and threshing efficiencies, while the optimum cylinder speed and concave clearance were 500 rpm and 2.2 cm, respectively. The study also indicated that increased length of stalks decreased the total losses. Moussa and Mohamed (2005) reported that two mechanical harvesting methods (mower then thresher) and combine harvester were compared with traditional method (manual then thresher). The mechanical harvesting methods were conducted at five different field speeds of 2.5, 3.1, 3.6, 4.0 and 4.5 km/h for mower and combine. Three different drum speeds of 450, 500 and 550 rpm were also affected grain losses and damaged grain for combine and thresher machines at three different moisture content 8.78, 10.68 and 13.37%. They found that increasing thresher drum speed from 450 to 550 rpm increase threshing losses by about 0.46% and damaged grain by about 1.35% at feed rate of 1.0 Mg/h. Garg *et al.* (1999) developed an axial flow sunflower thresher and tested it at different cylinder speeds to find out the best speed. The threshing efficiency was more than 99% and cleaning efficiency varied from 71.33 - 89.66%. Total grain losses were less than 1.0% in most cases except at higher speeds.

Therefore the main objective of this study aims to develop a simple unit for separating the seeds from sunflower heads. It aims also to obtain higher efficiency of separation using this machine. The present study covers the following objectives:

1- Construction of a local unit for separating sunflower seeds suitable for small farms and decrease environmental pollution by leaving sunflower heads without crushing.
2- Evaluation of the developed unit performance under different operating parameters, and;
3- Evaluation of the cost in using the developed unit.

MATERIALS AND METHODS

A conical unit was designed and fabricated in El-Serw Agric. Res. Station, Dammietta Governorate for separating sunflower seeds in 2006 season as shown schematically in Figs 1,2 and 3. The new conical unit consists of main parts as follows:-

1-Separating unit (two cones inner and outer cones and guide of the heads),

2-Cleaning unit (two sieves and fan) and

3-Power source is a motor (0.75 kW).

Separating unit:

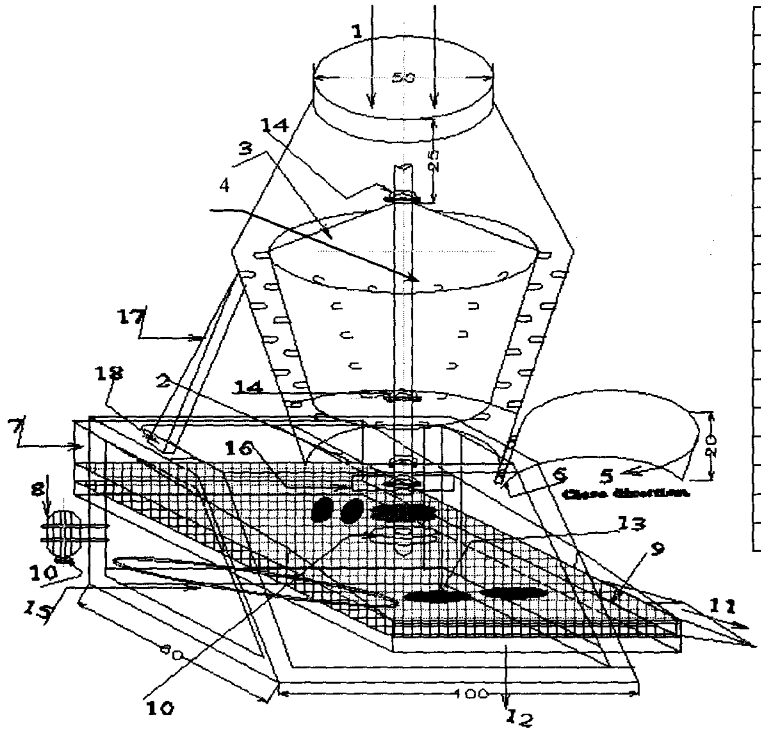
The inner cone, it has 50 and 25 cm for upper, lower diameters and 40 cm height respectively. The spike tooth or angle - bars or knives were arranged in ten rows and fixed on the outer surface in direction of longitudinal axis (8 spike tooth or 8 knife or one angle-bar in every row). In the middle of inner cone an axis shaft is rotating at different speeds through transmission pulleys and belts powered by an electric motor of 1 hp (0.75 kW).

The outer cone, was mounted on the frame around the inner cone to guide the heads. The spike tooth or angle- bars or knives were arranged in ten rows on the inner surface in longitudinal direction (8 spike tooth or 8 knife or one angle-bar in every row). It has a feed opening (25cm diameter). The clearance between inner and outer cones was fixed (4/2 cm for upper and lower clearance).

Heads guide, it is located above the inner cone on the same axis shaft from its middle for regulating the motion of sunflower heads towards the clearance between inner and outer cone. It has 50, zero cm for lower, upper diameter and 15 cm height to give upper clearance more than the radius of sun flower heads to allow it to fall down by both centrifugal and gravitational forces in separating clearance. The clearance between heads guide and outer cone narrowing towards the separation chamber until the lower clearance of the guide is the same as upper clearance of inner and outer cone.

Cleaning unit, it consists of three main parts:

- **A- fan:-** It has 4 blades (8 × 4 cm), fixed on the axis end rotating at the same rotating speed;
- **B- The upper sieve:-** It has 50 × 75 cm for width , length and made from a wire mesh, 1.5 cm holes diameter and used to prevent any volume which is bigger than the seeds size .



No.	Objects
1	Feed opening
2	Bearing
3	Heads guide
4	Rotating shaft
5	Door
6	Hinges
7	Standing frame
8	Electric motor
9	Slaves (upper&lower)
10	Pulleys
11	Grains output
12	Trashes outlet
13	Sunflower heads
14	Contact point
15	V belt
16	Fan
17	Carrier
18	Fixed point

Fig. 1. Schematic diagram of the designed unit.

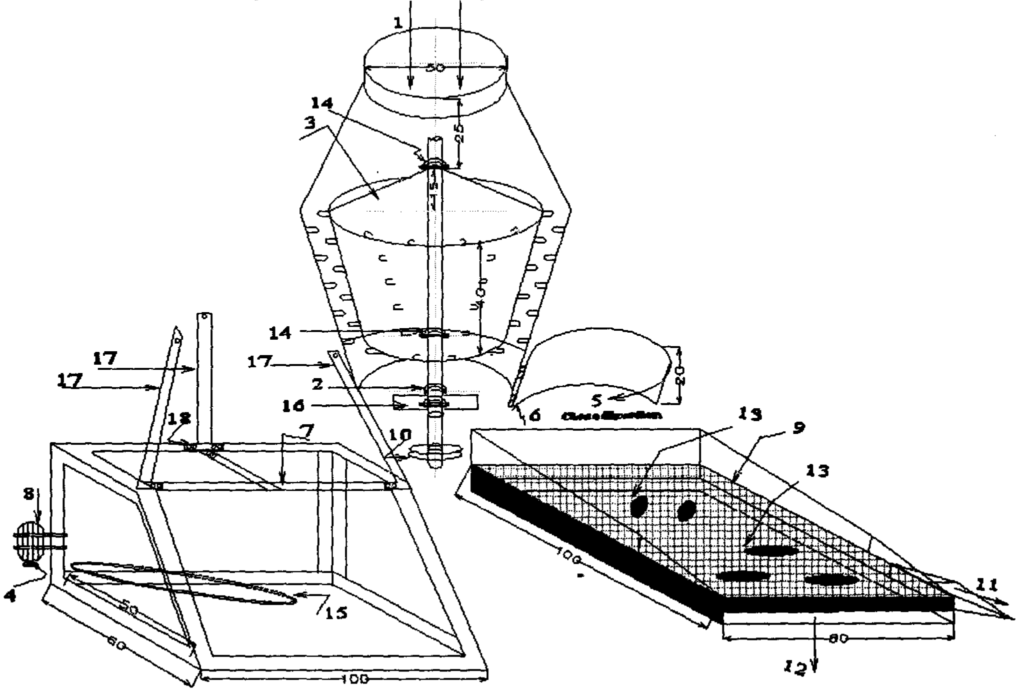


Fig. 2. Explode view of the unit.

C- The lower sieve:- It has 50 × 75 cm for width and length and made from wire mesh, 0.5 cm holes diameter, used to prevent any volume which is small than the seeds size. The sieve is attached with the outer cone at angle of 300 on the horizontal. The separating material flow on sieve by action of gravitational force, sieve angle and vibrating motion resulting in rotating inner cone.

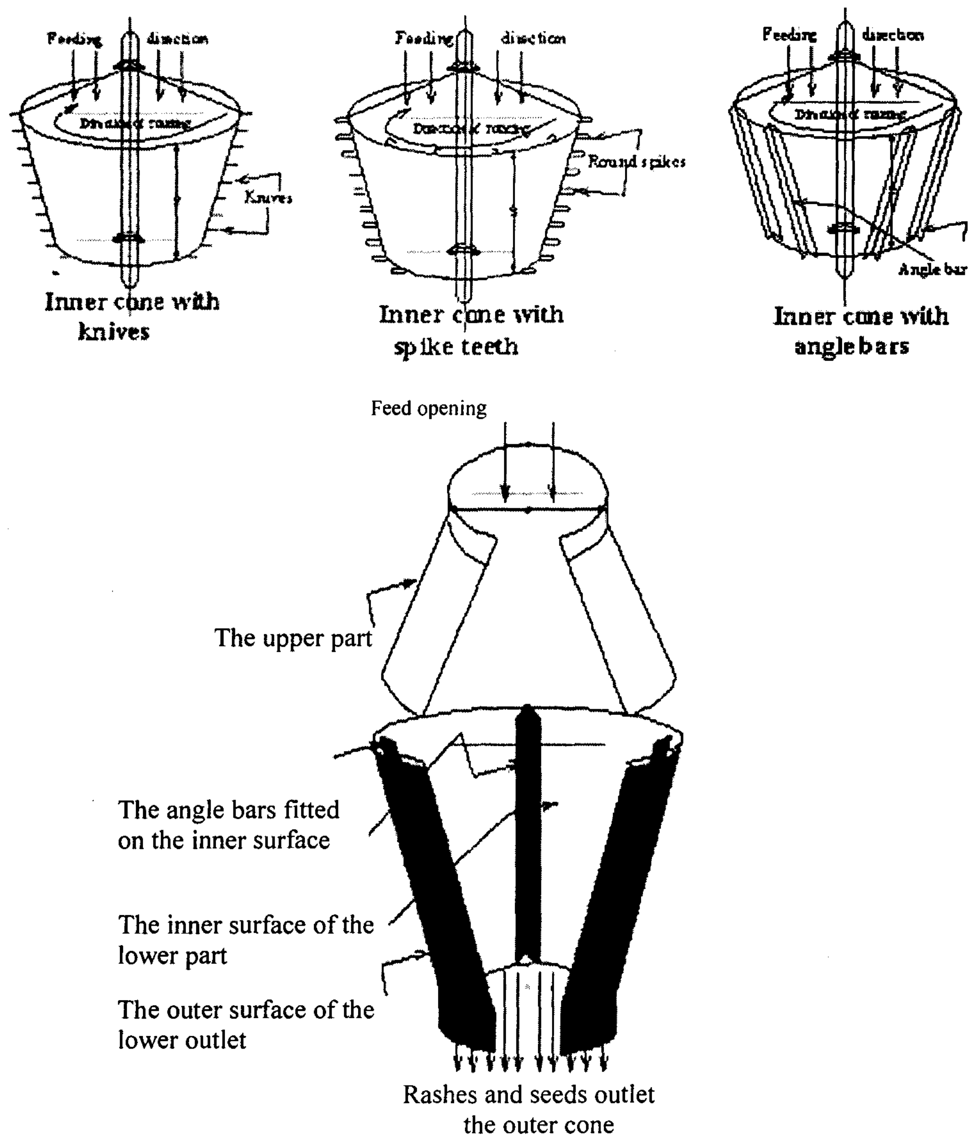


Fig.3. Different types of the inner and outer cones.

Experimental procedures:-

Vidok variety of sunflower was used in this study. The average of physical properties of Vidoc variety are summarized as follows in table 1.

Table 1. Some physical properties of sunflower seeds "Vidoc variety".

Head Dia, cm	Head Thichness,cm	1000 seed mass, g	Seed yield, g/head	Seed length, cm	Seed width, m
18.9	3.2	59	162.1	0.9	0.5

The developed unit was evaluated under different main parameters as follows:-

1- Inner and outer cone with ten row of spike teeth (3 cm length , 1 cm diameter. and 8 spike-tooth on every row), ten angle - bars (3 cm height, 0.2 cm thickness and 40 cm length) and ten rows of knives (3.0 cm length, 1.0 cm width , 0.2 cm thickness and 8 knives on every row) in direction of longitudinal axis and fixed on every one. This positions named B1, B2 and B3.

2- Peripheral inner cone speed levels were (7.24, 9.11, 12.9 and 15.4 m/s) let them be S_1, S_2, S_3 and S_4, respectively.

3-Seed moisture content levels were (26.9 21.2, 15.7 and 9.8%) let them be M_1, M_2, M_3 and M_4, respectively

4-Separating clearance was constant (4/2cm at the top and end of inner cone according to many researches.

Evaluation of the unit performance:

Efficiency investigated according to **El-Saharigi *et al.*(2002**).

1-Seed damage (Sd%) was determined by taking 50 g sample and separating the damaged seeds (Wd%) and relating its mass to the total mass of the seed (Ws).

$$Sd = \frac{Wd}{Ws} \times 100, \quad \% \qquad \text{...(1)}$$

2- Seed quality ,% = (100 – visible damage) × 100 ....(2)

3- Separating efficiency (Sth) was evaluated by collecting the seed attached to the unthreshed parts of heads, separated by hand and weighed (Wunth) then related to the total seed mass

$$Sth = \frac{Ws - Wunth}{Ws} \times 100 \ , \ \% \qquad \text{...............................(3)}$$

Problems faced during developing the separating unit:

1- In primary tests, it was noticed that some discs (heads) move in a cycle motion on the top of inner cone without inserting in the separating zone between inner and outer cones. This problem was solved by fixing the heads guide above the inner cone. This idea gave good results by increasing separating capacity.

2- Inserting two discs (heads) together in the same time inside the clearance between the heads guide and outer cone subsequently preventing falling the discs (heads) in separating zone. This problem was solved by fixing ten spike teeth (3 cm length and 1 cm dia.) on the perimeter top of heads guide.

3- The first tests show high amounts of husks mixed with the seeds, and it was necessary fixing a fan to push separating material and cleaning the seeds from foreign materials (husks and head parts). This problem was solved by fixing a fan (4 blades) on the axis end below inner cone rotating at the same rotating speed. The best results were noticed at 8 cm blades length and 5 cm blades height.

4- It is noticed that the heads after separating action jam at the end of inner cone resulting in increasing top diameter more than bottom diameter. This problem was solved by opening a door at the end of outer cone. This idea was successful causing an increase in separating the seeds.

RESULTS AND DISCUSSION

Separating seeds is accomplished by action of the rotating inner cone which creates centrifugal force on sunflower heads and separating seeds which moves downwards by action of gravitational force without crushing the heads to minimize the amount of smooth dust subsequently decreasing polluting the environment.

Effect of different parameters; beaters type, inner cone speeds and seed moisture content on unit performance:

A- Separation capacity:

Data illustrated in Figs 4a, 4b, and 4c show that the effect of beaters type on separating capacity at different beaters types and separating speeds. The separating capacity increased with the decrease of seed moisture content. This is due to, at the minimum moisture content the seeds have little elasticity and lower resistance to separation action in opposite, the capacity increased with the increase of inner cone speed under all type of beaters and different levels of seeds moisture content. This is due to the fact that, at higher speeds the seeds oppose less separation action. The maximum separating capacity was (16.6 kg/min) for beater knives followed by spike-tooth (15.4 kg/min) and angle-bar (10.3kg/min).

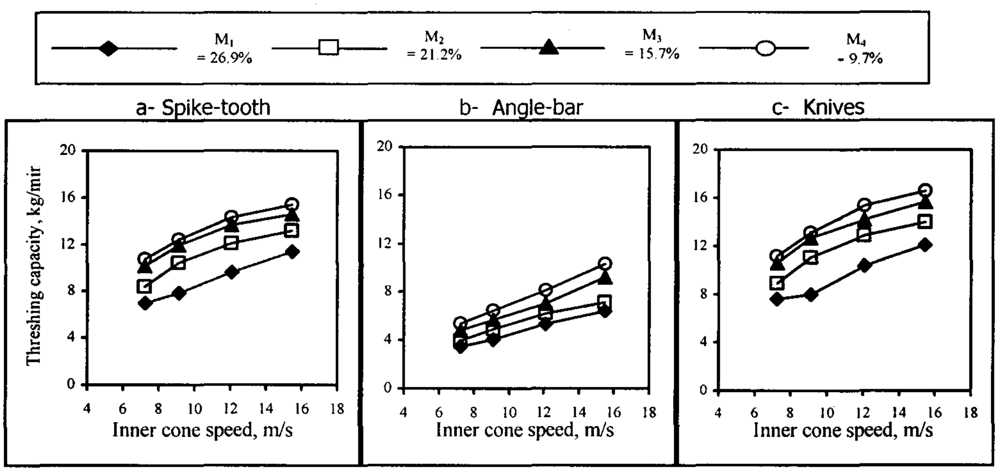


Fig. 4. Effect of inner cone speed, beater types and seed moisture content on threshing capacity, kg/min.

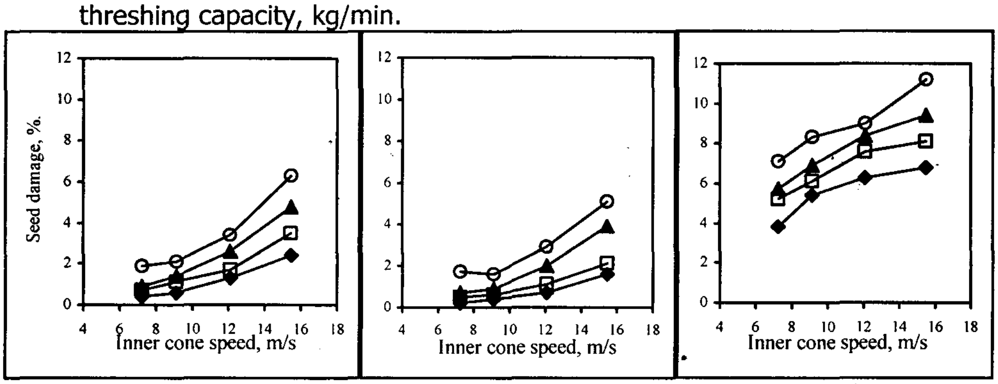


Fig. 5. Effect of inner cone speed, beater types and seed moisture content on seed damage percentage.

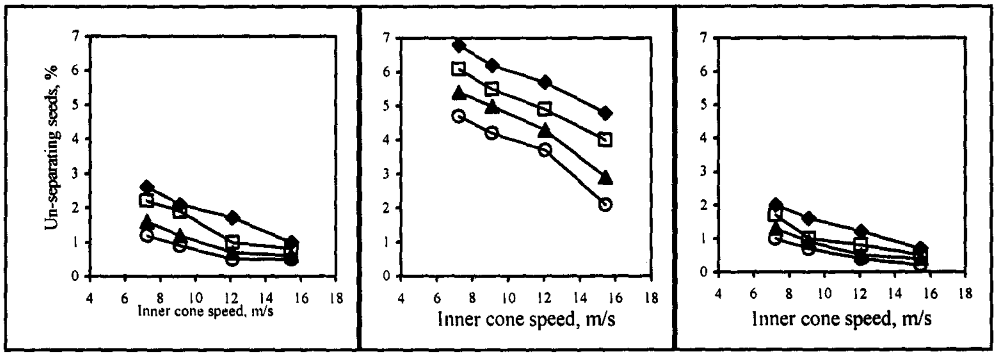


Fig. 6. Effect of inner cone speed, beater types and seed moisture content on un-separated seed percentage.

The equations representing the machine separating capacity were:-

C = 9.9550 + 0.5580 S -0.2529 M.C (${R^2}$ =0.975 with spike-tooth)

C = 3.8880 + 0.4786 S -0.1650 M.C (${R^2}$ =0.983 with Angle-bar)

C = 10.478 + 0.6042 S -0.2688 M.C (${R^2}$ =0.977 with knives)

Where:

C = Separating capacity, kg/min

S = Inner cone speed, m/s

M.C = Seeds moisture content, %w.b.

B- Seed damage and quality:

The results of seed quality are summarized in Figs. 5a, 5b and 5c. Data indicated that, the seed damage increased and seed quality decreased with the decrease of seeds moisture content and the increase of inner cone speed with all types of beaters. This is due to the lower seeds moisture causes seeds to be hard shell. While, increase of separation speed lead to increase of impact forces imparted to seeds in the heads subsequently increase the percentage of seed damage. Also it was noticed that, the percentage of seed damage with angle –bar was little than spike –tooth and knives respectively. On the other hand the seed quality with angle-bar was higher than spike-tooth and knives beaters respectively at different levels of seed moisture content .The higher percent of seed quality was 99.8 % as noticed with small inner cone speed 7.24 m/s and higher seed moisture content 26.9 % by using angle-bar as beaters. While the little percent of seed quality was 88.8 % remarked using knives as beaters with higher inner cone speed 15.4 m/sand minimum moisture content of 9.8%

The equations of seed quality were:-

Q = 99.785 – 0.3997 s + 0.1309 M.C (${R^2}$ =0.951 with spike –tooth);

Q = 99.521 -0.3058 s + 0.1211 M.C (${R^2}$ =0.931 with Angle-bar);

Q = 93.783 -0.4083 s + 0.1894 M.C (${R^2}$ =0.981 with knives).

Where:

Q = Seed quality, %

s = Inner cone speed, m/s

M.C = Seeds moisture content, %w.b.

C-Separation efficiency

Figs. 6a, 6b and 6c show that, the un-separated seed decrease and separating efficiency increased with increase of inner cone speed and the decrease of seed moisture content under all types of beaters. While it was noticed that beaters of knives gave higher efficiency more than spike-tooth and angle –bar, respectively at different levels of seed moisture content and inner cone speed .The maximum separating efficiency was 99.8 % remarked by using knives as beaters at higher speed of inner cone 15.4 m/s and minimum level of seed moisture content of 9.8 % While minimum separating efficiency of 93.2 % was noticed using angle-bar as beaters with lowest speed of inner cone of 7.24 m/s and higher percent of seed moisture content of 26.9 %.

The equations representing the separating efficiency were:-

E = 98.322 + 0.144 S – 0.064 M. C. (R^2 = 0.956 with spike-tooth);

E = 94.615 + 0.2723 S – 0.1289 M.C (R^2 = 0.989 with Angle-bar);

E = 98.579 + 0.1220 S – 0.0462 M.C (R^2 = 0.961 with knives).

Where:

E = Separating efficiency, %

S = Inner cone speed, m/s

M.C = Seeds moisture content, %w.b.

Data showed that the percentage of smooth dust increased by increasing separation speed and decreasing the levels of seed moisture content under different beater types. The higher percentage of smooth dust of 4.9% was noticed at 15.4m/s higher separation speed and 9.7% lowest seed moisture content under knives beater type. While, the minimum percentage of smooth dust 0.7% was remarked with 7.24 m/s lower separation speed and 26.9% higher percentage of seed moisture content under angle-bar beater type. Also it can be arranged the beater types according to the lowest rate of smooth dust as follow:- angle-bar < spike tooth < knives . Finally all rates of smooth dust were little than 5% subsequently using the developed unit lead to reduce the environment pollution .

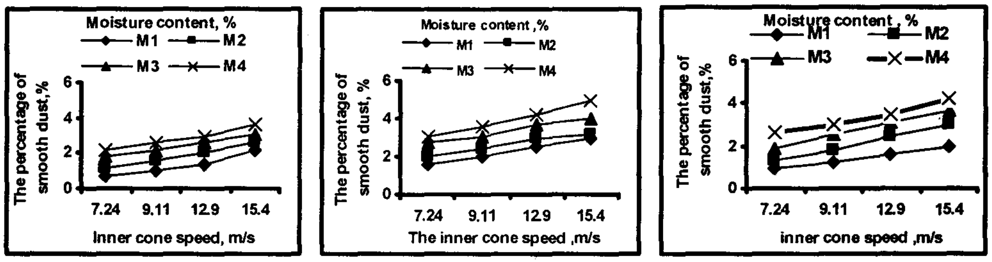


Fig 7. Effect of inner cone speed , beater types and seed moisture content on the percentage of smooth dust.

A- Separation costs :

The cost of separation calculated according the declining–balance depreciation method (Metweli,1984) at the best results by using spike-tooth and 12.9 m/s inner cone speed at 21.2 to 15.7 % seed moisture content .It is found that, the unit and labor costs = 8.6 L.E/h

Hence cost of separation of one ton= 10.46 L.E/t

One Feddan produce about 4 ton of sunflower heads

Mechanical cost of separation one Fadden = 41.84 L.E /fed.

Manual cost

One Feddan needs about 12 man × 10 = 120 L.E / fed.

∴ Mechanical cost equal 34 % from manual cost

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تصنيع وتقييم جهاز محلي لفصل بذور زهرة الشمس يقلل تلوث البيئة

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يهدف هذا البحث إلي تطوير وحدة محلية لفصل بذور أقراص زهرة الشمس باستخدام القوة الطاردة المركزية والجاذبية الأرضية، وروعي أن تتم عملية الفصل دون تكسير الأقراص وبالتالي خفض القدرة المستهلكة والتلوث البيئي وتكاليف الفصل. وتم تقييم أداء الوحدة المطورة باستخدام ثلاث أنواع من مضارب الدراس (ذو الأصابع – ذو العوارض المائلة – ذو السكاكين) مع سرعات للمخروط الداخلي (٧,٢٤، ٩,١١ ، ١٢,٩، ١٥,٤ م/ث)، ومحتوى رطوبي للبذور (٢٦,٩– ٢١,٢– ١٥,٧– ٩,٨%) مع ثبات خلوص الفصل عند ٢/٤ عند القمة العليا والسفلى للمخروط الداخلي على التوالي.

وقد أظهرت النتائج أن:

١- درفيل الفصل مع knives كان الأعلى في كلا من سعة الفصل والكسر.

٢- درفيل الفصل مع angle-bar كان الأعلى في البذور الغير مفصولة.

٣- درفيل الفصل spike-tooth كان وسطا بين angle-bar، knives.

٤- أفضل النتائج كانت باستخدام spike-tooth مع سرعة فصل ١٢,٩ م/ث مع محتوي رطوبي ١٥,٧ -٢١,٢ %.

٥- قدرت تكاليف فصل بذور زهرة الشمس بالجهاز حوالي ٣٤% من تكاليف الفصل اليدوي .