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DESIGN AND PERFORMANCE EVALUATION OF CANOLA-SEED CLEANING MACHINE

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ABSTRACT

canola cleaning machine was designed depending upon the mechanical and aerodynamic separation theories. The designed machine was tested at three levels of cylindrical sieve angle (4, 7 and 10 degrees) and three levels of flat sieve speed (0.62, 0.88 and 1.08 m/sec).The maximum values of machine productivity and cleaning efficiency (680.14 kg/h and 99.85 %) and the minimum value of specific consumed energy (5.88 kW.h/ton) were achieved at cylindrical sieve slope angle of 7 degrees and flat sieve speed of 0.88 m/sec.

Keywords: Canola seed, cleaning machine, mechanical separation, aerodynamic.

INTRODUCTION

Canola is a variant ancient crop rapeseed, a word is derived from the Latin rapum meaning turnip. It is considered one of the most important oil production crops in the world. It comes after palms and soybean as a source of world oil production. Canola is grown for its seed, which is crushed for oil used in margarine, cooking, salad oils and edible oil blends. The properties of the oil, second only to olive oil in proportion of mono-unsaturated fatty acids. Canola oil is free from cholesterol and contains about 6% saturated fats and about 94% *(Statistical Year-Book 1999,* Arabic reference*).* After the oil is extracted, the by-product is a protein rich meal used as the intensive livestock industries. Egyptian government tries to increase canola-cultivated area in order to increase oil production, which compensate the shortage of oil production. Now there are about ten thousands feddan in the new lands are cultivated with canola using mechanical planting and harvesting methods *(Statistical Year-Book 1999,* Arabic reference*)*. Canola gives a good seeds yield in the new lands, but in fact, the harvested seeds yield contains some strange materials components such as sands, straw, ... etc, which decrease the quality of extracted oil. So, the objective of this study is to design and evaluate the performance of canola-seeds cleaning machine.

Dalgleish 1999 mentioned that in 1999 Australia exported canola oil to 16 countries, compared to just two countries at the beginning of the nineties. Germany and China were the biggest buyers followed by Bangladesh, Japan, Netherlands and United Kingdom as the top six destinations. He also mentioned that the total value of canola oil exports in 1999 was $130 million, compared with $32,000 in 1998.

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Jenks 2000 stated that the uncontrolled weeds could reduce canola yields by up to 77%. Contamination of harvested and processed canola with wild mustard causes serious price discounts or market rejection due to reduced quality. He added that the mechanical cultivation to remove weeds is not feasible, as canola is a shallow-seeded crop and tillage can injure canola seedling. ***El-Sayed et al. 2001*** stated that canola crop which sowed by seed drill with a suitable row width of 40 cm gave the highest yield (1450 kg/fed) and the lowest consumed energy (3.97 kW.h/fed) as compared with manual planting and planter. They added that the crop value minus planter expenses (CVPE) were 1239, 1064 and 1010 LE/ton for grain drill, planter and manual planting respectively. ***Chakraverty 1972*** evaluated of transportation and separation devices which based upon air needs to study the agricultural products aerodynamics properties. Also, the acquaintance of the terminal velocity of different crops is very important. Which determined the terminal velocity for some of grain crops and found that the terminal velocity values were 9: 11.5 and 19.3 m/sec for wheat and oats respectively. ***Klenin et al. 1985*** defined the terminal velocity as the air velocity required for seed suspense or balance. They mentioned that when seeds are exposing to air current through a certain path begin to move then remain constant at a certain velocity, at this velocity the net gravitational acceleration force equals the resistance upward drag force. At this velocity the seed is remaining constant and in this case this velocity called terminal velocity. ***Hawk et al. 1966*** cleared that both of aerodynamic drag and terminal velocity could be determined using two methods. The first method is the determination of time required for the free fall from different heights. The second method is putting the seed in a vertical air path then push air current at different air velocities, when the seed remains constant and don't move any vertical movement, at this moment the effecting forces become in balance state. So, the terminal velocity of seed become equivalent to air velocity. ***Mohsenin 1970*** mentioned that the drag coefficient could be determined using equation (1).

$$Dc = \frac{4gd_p(\rho_p - \rho_a)}{3\rho_a V_t^2} \qquad (1)$$

Where:

Dc	=	Drag coefficient	, - ;
d_p	=	Projected diameter	, m;
ρ_p	=	Particle density	, kg/m^3;
ρ_a	=	Air density	, kg/m^3;
V_t	=	Terminal velocity	, m/sec.

El-Raie et al.1996 (Arabic reference) determined both of terminal velocity and drag coefficient for wheat, rice and barley. The values were illustrated in table (1):

Table (1): Terminal velocity and drag coefficient of wheat, rice and barely seeds.

Crop	Terminal velocity, m/sec	Drag coefficient
Wheat	5.85: 9.705	0.32 : 0.51
Rice	7.888: 8.548	0.24: 0.27
Barely	7.049: 9.953	0.29: 0.64

MATERIALS AND METHODS

Cleaning operation is defined as the final operation for seeds separation from the other blemishes (empty pods, straw particles and sand). These different components are separated according to several separation theories.

Selection of separation theory

As mentioned above there are several theories for seeds separation from the other blemishes. These theories are aerodynamic separation by using air from fan, mechanical separation by using sieves, aeromechanical separation and surface textures separation ***(Eid 1992).***

The separation of canola-seeds from other blemishes (empty pods, straw particles and sand) could be achieved using mechanical and aerodynamic separations.

1. Mechanical separation

In this theory, the separation of canola-seeds from other blemishes depends upon the differences of the components dimensions. Different scales sieves are used for separation operations. So, for this task, the mechanical cleaning unit was designed. It's consists of three sieves one of them is cylindrical shape, moving in rotational movement to separate empty pods. The others are flat sieves moving in reciprocating movement for separating straw and some other blemishes. The function of these sieves is to accelerate the materials (empty pods and straw particles) to the exit hole. During this operation canola-seeds and fine sand moving to the aerodynamic separation unit through seed receiver.

2. Aerodynamic separation

The principle of aerodynamic separation depends upon the differences of terminal velocity and differences of drag coefficient of the different components. In this theory the separation is proceeding by pushing air current using a fan to separate canola-seeds from fine sand and any remain blemishes. Determination of the terminal velocity and drag coefficient for canola-seeds are considered the most important factors for aerodynamic separation unit design.

Design of canola cleaning machine

The designed machine consists of the following main components, **fig. 1.**

1- Mechanical separation unit

The mechanical separation unit, **fig. 2,** consists of three sieves for the separation of canola-seeds from the other blemishes.

One of these sieves is cylindrical shape has a length of 136 cm, 50 cm diameter and 5 mm holes diameter used for the separation of empty pods. The hole diameters were selected after the experimental determination of empty pods lengths and diameters which were 17 and 8 mm respectively. The empty pods and the other blemishes separation based on centrifugal force that generated from the rotational movement of the sieve besides the slope angle on the longitudinal axis of sieve. The optimum peripheral speed of the cylindrical sieve is 23 m/sec equivalent to 878 rpm (***Kepner et al. 1992***). The cylindrical sieve is connected with ball bearings fixed on U-beam (10 cm x 4.5 cm x 6 mm) at its end. This beam can be adjusted up and down for controlling sieve slope angle.

The other two sieves (flat type) were placed below the cylindrical sieve. The higher one has a length of 150 cm, 70 cm width and 3 mm holes diameter. This sieve is used for completely separation of straw and empty pods. This sieve permits canola-seeds and fine sand to fall to the lower sieve. Receiver was fabricated to receive the empty pods and straw particles from the cylindrical and first flat sieve. This receiver has a reciprocating movement by crankshaft receiving movement from 10 cm diameter pulley fixed the end of the cylindrical sieve axis. This crankshaft was designed to give a stroke of 5 cm and rotating speed 820 rpm.

The lower sieve was designed with a total length of 200 cm and total width of 70 cm. This sieve was divided into two sections. The first section has a length of 150 cm and 0.5 mm holes diameter to keep canola-seeds above the sieve. The second section has a length of 50 cm and 5 mm holes diameter to permit for canola-seeds to go to the next cleaning unit. It has to be mentioned here that the two sieves are reciprocally moving by the reversible reciprocating arm. The flat sieves takes the harmonic reciprocating motion by transmission shaft and eccentric crank in order to facilitate the transmission of canola-seeds to the seeds receiver then to the second separation unit (aerodynamic separation unit). The rotating speed of the transmission shaft to flat sieve could be determined from equation (2) according to (***Kerber and Dugas 1996***).

$$\omega = \left(\frac{g}{r}\right)^{0.5} \times 60 \qquad (2)$$

Where:

ω	=	Transmission shaft rotating speed	, radian/min;
r	=	Eccentric crank radius	, m.

Three values of r (5, 10 and 15 cm) were selected in order to determine the suitable transmission shaft rotating speed.

The flat sieve has a reciprocating harmonic motion with eccentric crank radius (5, 10 and 15 cm). This harmonic motion is represented in **fig. (3)**. The flat sieve starts its reciprocating motion at point (a) the sieve forward velocity increased gradually to reach its maximum at the middle of the curve (point b), then its decreases gradually until it stops completely at point (c). This harmonic motion of

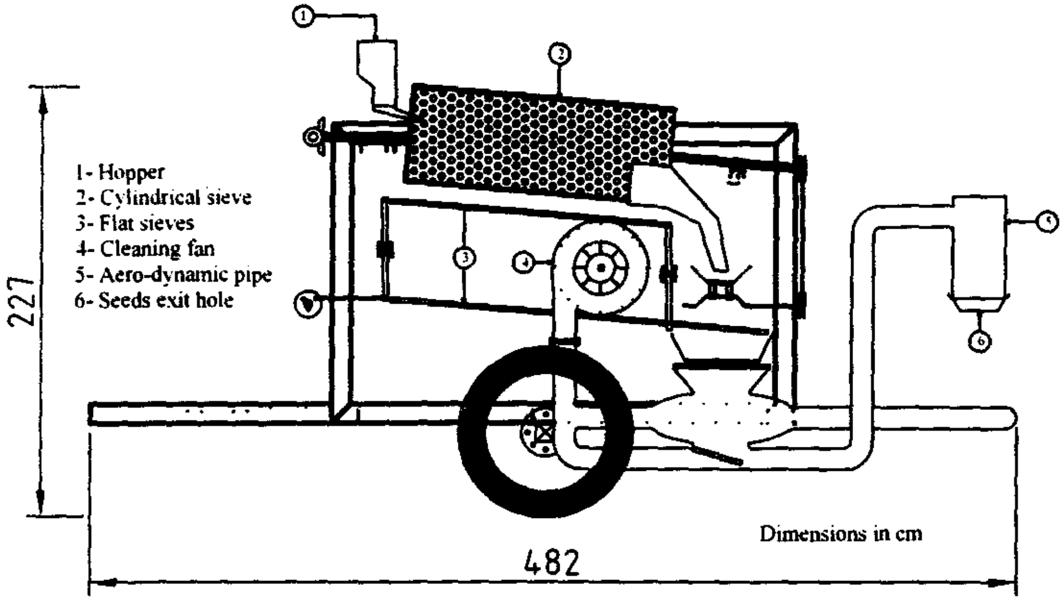

Fig. (1): Canola-seeds cleaning machine.

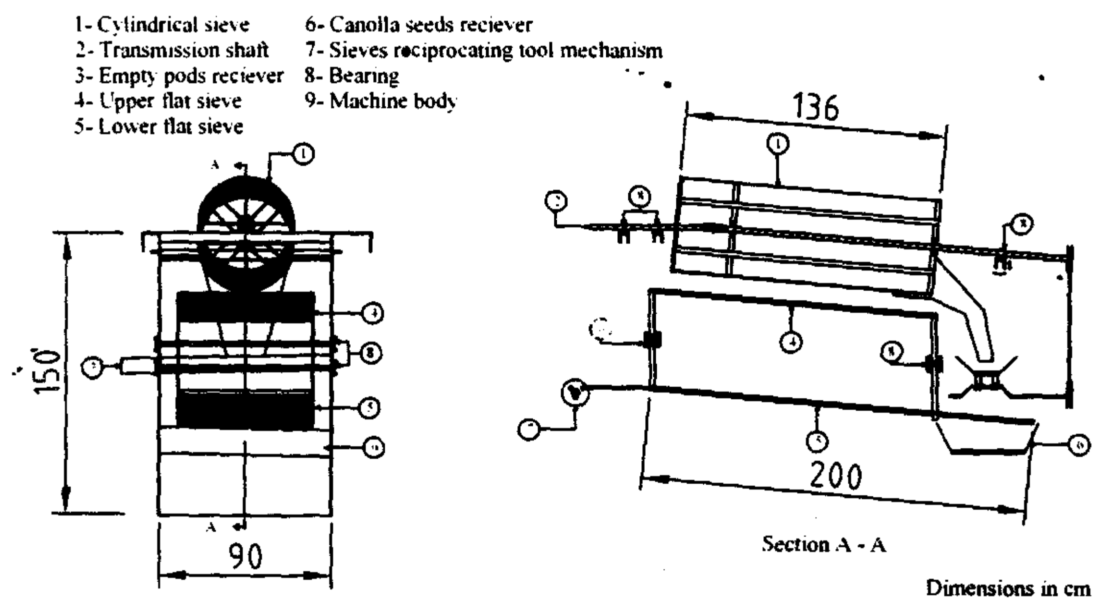

Fig. (2): Mechanical cleaning unit.

the sieve occurs during 180 degrees of eccentric crank. The average sieve speed was calculated from equation (3).

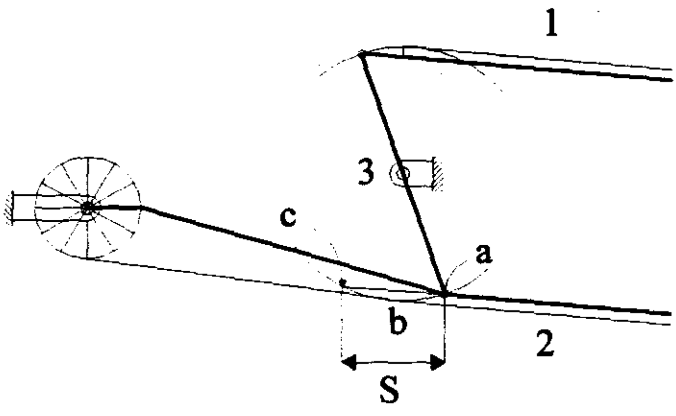

Fig. (3): Flat sieve harmonic motion.

$$F_{ss} = \frac{S}{T} \qquad (3)$$

Where:

F_{ss} = Average speed of flat sieve , m/sec;
S = Sieve reciprocating stoke , m;
T = Time required for sieve reciprocating stoke = $30 / \omega$, sec.

From equations 2 and 3 and fig 5, the values of F_{ss} were 0.62, 0.88 and 1.08 m/sec that equivalent for eccentric crank radius 5, 10 and 15 cm.

2- Aerodynamic separation unit

Aerodynamic separation unit, **fig. 4**, receiving canola-seeds and fine sand from the mechanical separation unit through a conical hopper made from iron-sheet 3 mm thickness having 30 cm diameter at bottom and 50 cm diameter at the top. The design of aerodynamic separation unit based upon the determination of terminal velocity of canola-seeds. Where, the average value of terminal velocity was 7.23 m/sec for canola-seeds. In this unit a fan with 50 cm diameter, 0.55 m^3/sec discharge and 950 rpm was used. This fan was connected with 125 mm diameter iron pipe. **Fig. 5** shows the separation zone between canola-seeds and fine sand. The air path diameter at the section (A) was determined using equation (4) where, the forward air velocity is equal to 4.3 m/sec and it should be less than canola-seeds terminal velocity. The air velocity at section (B) is equal to 22 m/sec and it should be more than seeds terminal velocity to cause a dragging force for canola-seeds toward exit hole. The manually adjustable door is used for controlling air velocity at the section (B).

$$d = \left(\frac{4q}{\pi V_t} \right)^{0.5} \qquad (4)$$

Where:

d	=	Air path diameter	, m;
q	=	Air flow rate	, m^3/sec;
V_t	=	Terminal velocity	, m/sec.

3- Feeding hopper

Feeding hopper was fabricated with a total capacity of 50 kg of canola-seeds. The feeding hopper was designed with a slope to allow easy movement of canola-seeds to cylindrical sieve.

4- Transmission system

Transmission system of canola cleaning machine was graphically presented in **fig. 6**. It consists of electrical motor (4 kW at 1330 rpm) as a source of power. This motor was connected with two pulleys 15 and 10 cm diameters. The transmission system consists of four units. The first unit transmits the motion from electrical motor (using the 15 cm diameter pulley) to separation fan (950 rpm and 21 cm diameter pulley). The second unit transmits the motion from the electrical motor(using the 10 cm diameter pulley) to the cylindrical sieve using 27 cm diameter pulley fixed with shaft ending with two bevel gears 26 and 15 teeth respectively. The recommended rotating speed of the cylindrical sieve was 878 rpm according to ***Kepner et al. 1992.*** Hence the final used bevel gear was 15 teeth, the rotating speed of the cylindrical sieve became 853 rpm. The third unit transmits the motion from the shaft No. 6 (transmission shaft to cylindrical sieve), **fig. 6**, to the flat sieves using 10 cm diameter pulley to 26 or 37 or 45 cm diameters pulleys that

fixed with shaft No. 5 (transmission shaft to flat sieve) which rotates at 189 or 133 or 109 rpm respectively. The fourth unit transmits the motion from the end of cylindrical sieve shaft using 10 cm diameter pulley to straw and empty pods receiver using 10 cm diameter pulley.

The diameter of driving and driven pulleys for each transmitting stage were determined according to the rotating speed of the driving and driven pulleys. Open V-belts are used to transmit the motion between driving and driven pulleys. The length of V-belts are standardized by ANSI in U. S. customary units and SI units and was calculated according to ***Hall et al. 1980***.

5- Machine frame

The frame of canola cleaning machine, **fig. 7**, was manufactured from U-beam (10 cm x 4.5 cm x 6 mm). Machine sides were fabricated from iron-sheet 3 mm thickness. The total width for the canola cleaning machine was 90 cm, the total length was 482 cm including the trailed arm and total height was 227 cm including the higher part of cylindrical sieve.

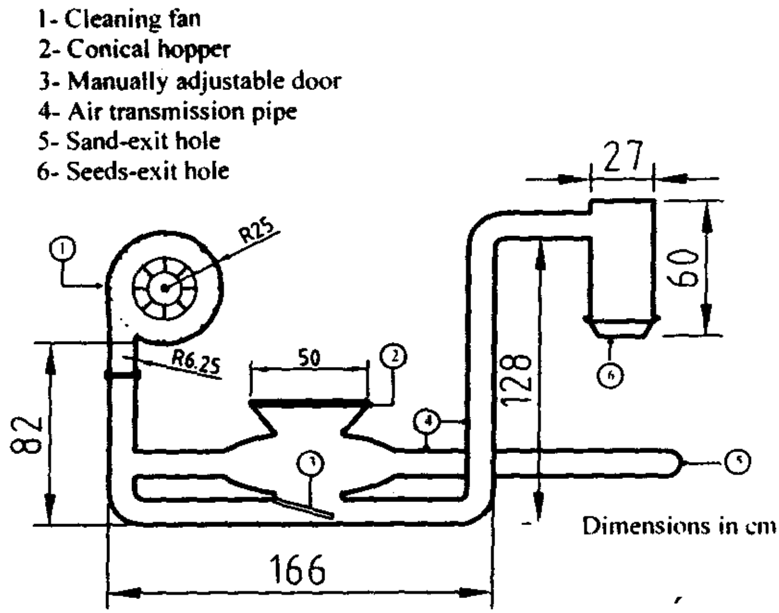

Fig. (4): Aerodynamic cleaning unit.

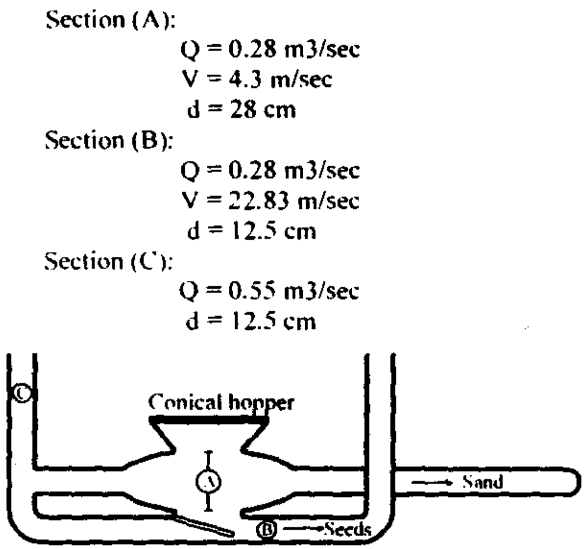

Fig. (5): Separation zone between canola-seeds and fine sand.

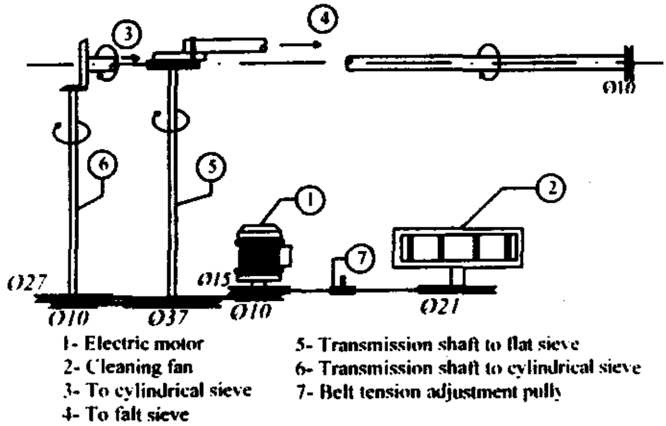

Fig. (6): Transmission system.

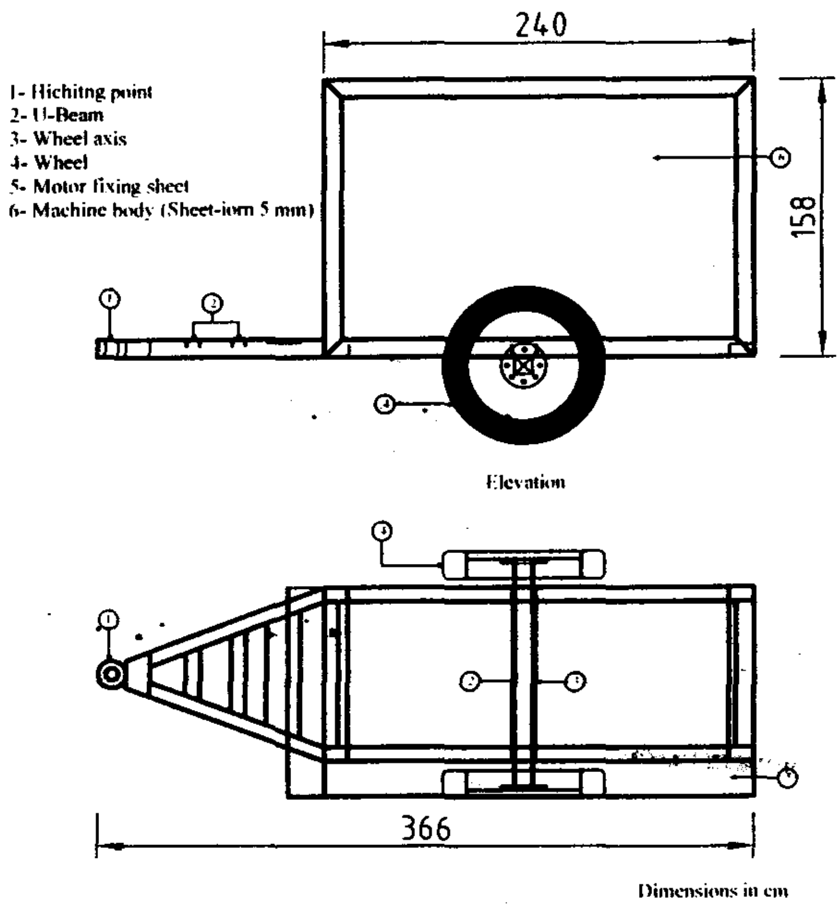

Fig. (7): Machine frame.

6- The design of the rotating shafts

All rotating shafts for the canola cleaning machine were designed according to the stability of the shaft during rotation and not according to transmitted torque. The design of cylindrical sieve shaft were 240 cm length and 4.5 cm diameter. The dimensions of the transmission shaft to cylindrical sieve were 75 cm length and 2.5 cm diameter while that for the transmission shaft to flat sieve were78 cm length and 2.5 cm in diameter. The diameter of each rotating shaft was calculated according to ASME code (***Hall et al. 1980***). Each rotating shaft was fixed to the machine frame through two ball-bearings.

Treatments

1- Cylindrical sieve slope angle(C_{ssa})

The tested values of cylindrical sieve slope angle were 4, 7 and 10 degrees according to ***Kepner et al. 1992.***

2- Flat sieve speed (F_{ss})

The tested values of flat sieve speed were 0.62 , 0.88 and 1.08 m/sec according to ***Kepner et al. 1992.***

Measurements and calculations

1. Canola seed diameter

Canola seed diameter was determined using a digital camera and AutoCAD program. In this experiment, a group of seeds were fixed on a paper and 1 cm x1 cm group of squares

2. Terminal velocity of canola-seeds

The terminal velocity of canola-seeds was measured according to the method described by ***Matouk 2002.***

3.Air velocity

The air velocity was measured using air velocity meter (range, from 0.1 to 25.41 m/sec and accuracy of 0.1 m/sec).

4. Drag coefficient (*DC*)

The drag coefficient of canola-seeds was calculated from equation (1) according to ***Mohsenin 1970.***

5. Drag force (*Df*)

The drag force of canola-seeds was calculated from equation (5) according to ***Mohsenin 1970.***

$$Df = \frac{DC \times a \times \rho_a \times V_t}{2} \qquad (5)$$

Where:

Df = Drag force , kg_f;

a = Seed projected area , m^2;

ρ_a = Air density ,kg/m^3;

V_t = Canola-seeds terminal velocity , m/sec.

6.Machine productivity (*MP*)

The machine productivity was calculated from equation (6)

$$MP = \frac{S}{T} \quad (6)$$

Where:

MP = Machine productivity , kg/h;
S = The total weight at seeds outlet , kg;
T = Consumed time ,h.

7. Cleaning efficiency (*CE*)

The cleaning efficiency (*CE*) was calculated from equation (7) (***RNAM 1995***).

$$CE = \frac{S_1}{MP} \times 100 \quad (7)$$

Where:

CE = Cleaning efficiency , %;
S_1 = Seeds weight at seeds outlet per unit time , kg/h;
MP = Machine productivity , kg/h.

8.Percentage of seed losses (P_{sl})

The percentage of seed losses (P_{sl}) was calculated from equation (8) according to ***RNAM 1995***.

$$P_{sl} = \frac{S_2}{FR} \times 100 \quad (8)$$

Where:

P_{sl} = Percentage of seed losses ,%;
S_2 = Weight of seed per unit time collected at all outlets except for seed outlet , kg/h;
FR = Feed rate , kg/h.

9. Specific consumed energy (E_c)

The specific consumed energy (E_c) was calculated from equation (9)

$$E_c = \frac{P}{MP} \quad (9)$$

Where:

E_c = specific consumed energy , kW.h/ton;
P = Motor power , kW.

10.Germination percentage (*Gp*)

The germination percentage (*Gp*) was experimented to test the effect of mechanical cleaning on the germination ratio, as this ratio is affected by invisible damage caused by mechanical cleaning.

RESULTS AND DISCUSSION

1- Canola-seeds characteristics

The values of canola-seeds diameter, density, terminal velocity and drag coefficient are shown in table (2). From table (2) its clear that the average values of canola-seeds diameter and density were 0.28 cm and 0.65 gr/cm^3 respectively. The average value of terminal velocity was 7.23 m/sec. Also, the drag coefficient value of canola-seeds was 0.39. While, the drag force of canola-seeds was1.01x10^{-5} N.

Table (2): Some characteristics of canola-seeds.

Characteristics	value
Diameter, cm	0.28
Density, gr/cm^3	0.65
Terminal velocity, m/sec	7.23
Drag coefficient,	0.39
Drag force, N	1.01*10^{-5}

2-Designed machine productivity (*MP*) and specific consumed energy (*E$_c$*)

The performance of the designed machine depends upon the cylindrical sieve slope angle (C_{ssa}) and flat sieve speed (F_{ss}). **Fig. (8)** shows the effect of C_{ssa} and F_{ss} on the *MP* and E_c. From fig. (8) its clear that the maximum value of machine productivity (680.14 kg/h) and the minimum value of specific consumed energy (5.88 kW.h/ton) were achieved at cylindrical sieve slope angle of 7 degrees and flat sieve speed of 0.88 m/sec. While, the minimum value of machine productivity (590.64 kg/h) and the maximum value of specific consumed energy (6.77 kW.h/ton) were performed at cylindrical sieve slope angle of 4 degrees and flat sieve speed of 0.62 m/sec.

From figure (8) its also clear that the productivity values of the designed machine increased by increasing of the cylindrical sieve slope value up to 7 degrees and by increasing the flat sieve speed up to 0.88 m/sec.

Through the above mentioned conditioned the *MP* and *Ec* values were in decreasing trend with the increasing of slope angle up to 7 degrees. After that, the machine productivity decreased and the consumed energy increased abnormally.

3- Cleaning efficiency (*CE*)

The average value of cleaning efficiency (*CE)* of the designed machine are shown in **fig. (9).** From fig. (9) its clear that the *CE* decreased by increasing of cylindrical sieve slope angle (C_{ssa}) and flat sieve speed (F_{ss}).

At 4 degrees of C_{ssa} , the *CE* decreased by 0.02 and 2.7 % when the F_{ss} was increased from 0.62 m/sec to 0.88 and 1.08 m/sec respectively. The same trend was found at 7 degrees and 10 degrees of F_{ss}.

At 0.62 m/sec of F_{ss}, the *CE* decreased by 0.13 and 1.22 % when the C_{ssa} was increased from 4 degrees to 7 and 10 degrees respectively. The same trend was noticed at 0.88 m/sec and 1.08 m/sec of F_{ss}.

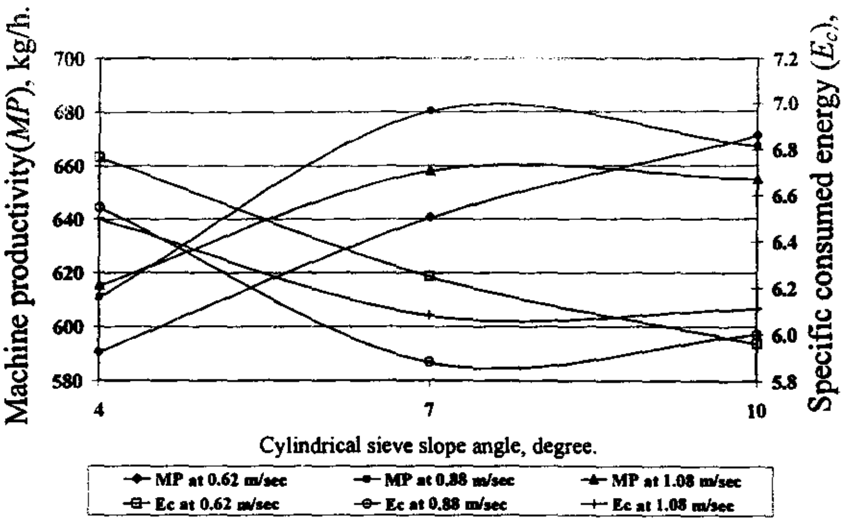

Fig.(8): The effect of cylindrical sieve slope angle and flat sieve speed (F_{ss}) on the machine productivity and specific consumed energy.

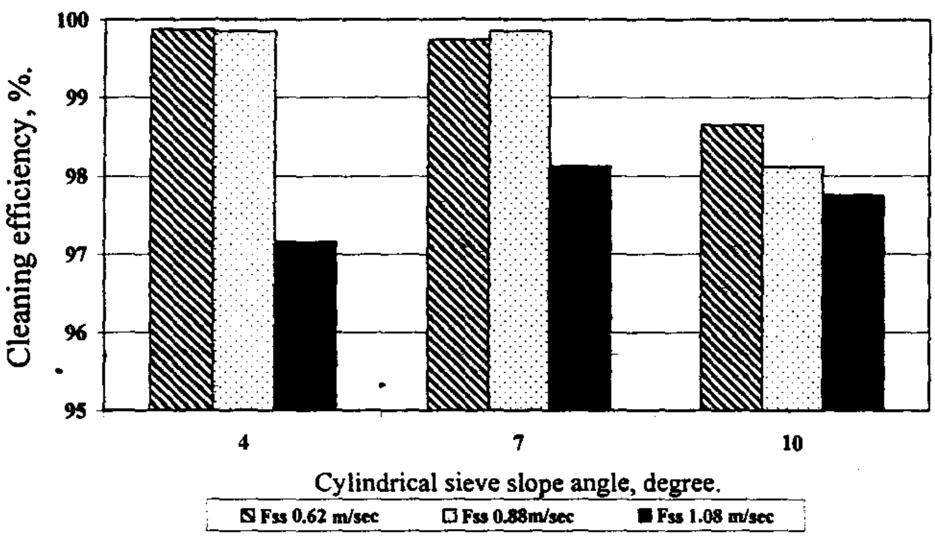

Fig.(9): The effect of cylindrical sieve slope angle and flat sieve speed (F_{ss}) on the cleaning efficiency.

4- **Percentage of seed losses (P_{sl})**

The average values of P_{sl} are shown in **fig (10)**. From fig. (10) its clear that the P_{sl} increased by increasing of cylindrical sieve slope angle (C_{ssa}) and flat sieve speed (F_{ss}). The minimum value of P_{sl}, 3.71%, was found at 4 degrees of C_{ssa} and 0.62 m/sec of F_{ss}. While, the maximum value of P_{sl}, 6.33%, was found at 10 degrees of C_{ssa} and 1.08 m/sec of F_{ss}.

At 4 degrees of cylindrical sieve slope angle (C_{ssa}), the percentage of seed losses (P_{sl}) increased by 0.17 and 2.15 % when the flat sieve speed increased from 0.62 m/sec to 0.88 and 1.08 m/sec respectively. The same trend was found at 7 and 10 degrees of C_{ssa}. This increase might be due to the increase of canola-seeds acquainting kinetic energy resulted from the increasing of sieve speed. This acquainting kinetic energy caused the increasing of lost seeds percentage.

At 0.62 m/sec of flat sieve speed, the percentage of seed losses (P_{sl})increased by 0.31 and 2.22 % when the cylindrical sieve slope angle increased from 4 degrees to 7 and 10 degrees respectively. The same trend was found at 0.88 and 1.08 m/sec of F_{ss}. This increase might be referred to the increase of cylindrical sieve slope angle that increases the acquainting kinetic energy of the seeds with centrifugal force that caused increasing of seeds pushing towards blemishes receiver. Therefore, the percentage of seeds losses was increased.

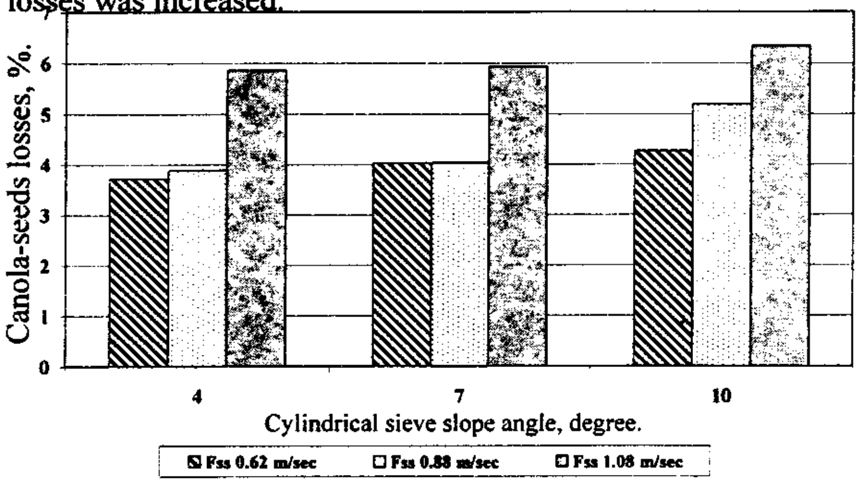

Fig.(10): The effect of cylindrical sieve slope angle and flat sieve speed (F_{ss}) on percentage of canola-seeds losses.

5-Canola-seeds germination percentage (G_P)

Germination percentages of canola-seeds from seeds exit were determined and are illustrated in table (3).

Table (3): Germination percentage of canola-seeds at different C_{ssa} and F_{ss}

C_{ssa}	F_{ss}	Germination percentage, %
4	0.62	97.0
4	0.88	99.5
4	1.08	98.3
7	0.62	99.2
7	0.88	98.3
7	1.08	98.6
10	0.62	98.0
10	0.88	99.1
10	1.08	98.2

C_{ssa} = Cylindrical sieve slope angle
F_{ss} = Flat sieve speed

From this table its clear that the germination percentage of canola-seeds at seeds exit ranged from 97 : 99.5 %.

From figures (9) and (10) its clear that the optimum value of machine productivity (*MP*), specific consumed energy (E_c) and cleaning efficiency (*CE*) could be realized when cylindrical sieve slope angle was 7 degrees and flat sieve speed was 0.88 m/sec. Under these working conditions the values of *MP*, E_c and *CE* were 680.14 kg/h, 5.88 kW.h/ton and 99.85 % respectively.

CONCLUSION

From this investigation the following conclusions can be done:

1. The terminal velocity of canola-seeds was 7.23 m/sec.
2. The productivity of the designed machine increased by increasing of cylindrical sieve slope angle up to 7 degrees and increasing of flat sieve speed up to 0.88 m/sec.
3. The minimum value of specific energy consumed, 5.88 kW.h/ton, deduced at cylindrical sieve slope angle of 7 degrees and flat sieve speed of 0.88 m/sec.
4. The maximum value of cleaning efficiency, 99.85 %, was found at cylindrical sieve slope angle of 7 degrees and flat sieve speed of 0.88 m/sec.
5. The percentage of canola seed losses increased by increasing of cylindrical sieve slope angle and flat sieve speed.
6. The germination percentage of canola-seeds ranged from 97 : 99.5 %.

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الملخص العربي

" تصميم وتقييم أداء ماكينة لتنظيف بذور الكانولا "

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تم تصميم ماكينة لتنظيف بذور الكانولا اعتمادا علي نظريتي الفصل المكانيكي والفصل الهوائي. واشتملت مكونات الماكينة المصممة علي وحدة فصل ميكانيكي عبارة عن ثلاثة غرابيل (غربال أسطواني ، ٢ غربال مسطح) للتخلص من القرون الضامرة وبقايا القش المقطع، وحدة فصل هوائية للتخلص من الرمال الناعمة اعتمادا علي السرعة الحرجة للحبوب، قادوس بسعة خمسون كيلو جرام، نظام لنقل الحركة عبارة عن مجموعة من السيور والطارات، مجموعة من الأعمدة الدوارة لنقل الحركة الي الأجزاء الوظيفية، اطار لتجميع مكونات الآلة.

وتم اختبار أداء الماكينة المصممة عند ثلاثة قيم لميل الغربال الاسطواني في الاتجاه الطولي (٤، ٧، ١٠ درجة) وثلاثة قيم للسرعة الخطية للغربال المسطح (٠,٦٢، ٠,٨٨، ١,٠٨ م/ث) وتم تقدير انتاجية الآلة، الطاقة المستهلكة، كفاءة التنظيف، نسبة البذور المفقودة و نسبة انبات البذور.

وقد بينت الدراسة مايلي :

١- متوسط قيمة السرعة الحرجة لبذور الكانولا ٧,٢٣ م/ث.
٢- متوسط قيمة معامل الجرف لبذور الكانولا ٠,٣٩ .
٣- تزداد انتاجية الماكينة المصممة وتقل الطاقة المستهلكة بزيادة زاوية ميل الغربال الاسطواني حتي ٧ درجة وسرعة الغربال المسطح حتي ٠,٨٨م/ث.
٤- حققت الماكينة أقل نسبة للحبوب المفقودة وهي ٣,٧١ % عند زاوية ميل الغربال الاسطواني ٤ درجة وعند سرعة الغربال المسطح ٠,٦٢ م/ث.
٥- أظهرت النتائج أن أفضل القيم لانتاجية الماكينة المصممة (٦٨٠,٤١ كجم/ساعة)، والطاقة المستهلكة (٥,٨٨ كيلووات. ساعة /طن) ، كفاءة التنظيف (٩٩,٨٥ %) عند تشغيل الماكينة المصممة عند زاوية ميل الغربال الاسطواني ٧ درجة وعند سرعة الغربال المسطح ٠,٨٨ م/ث.

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