SELECTION OF THE MAIN FACTORS AFFECTING CLEANING AND GRADING FENNEL SEEDS AT INCLINED SIEVE OSCILLATION

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ABSTRACT

Nowadays, the world considers the medicinal and aromatic plants as natural alternative to the chemical drugs because it has no side effects. Moreover, there is a difficulty for any country to achieve self- sufficient of chemical drugs. Fennel is considered one of the most important medicinal and aromatic plant in Egypt.

Commercial fennel varies greatly in quality, this being due to the lack of care during harvesting. Also, the presence of impurities in seeds decrease in the quality and standardization. So the use of grain cleaning and grading equipment is important for cereal producer as an aid to marketing his product.

An experimental cleaning machine was development. The slope of the sieve unit, air velocity, crank speed and stroke length could be adjusted easily as required. The cleaning unit was tested under the following main factors (the crank speed of the sieve unit, stroke length, and slope of the sieve unit).

Seeds were graded by the machine, into three categories, collected at three separate outlets. The maximum cleanliness obtained for grade one, two ,and three were 99.15,98.74 and 83.65 % respectively, and obtained at crank speed of 250 rpm, amplitude 20mm, sieve slope 8.5 degrees, and air velocity 2.7 m/s. The maximum effectiveness of the unit was 78.8%.

INTRODUCTION

Fennel is considered to be one of the most important medicinal and aromatic plants in Egypt, Seeds from 4 to 5 % volatile oils. Fennel can be used as antispasmodic, carminative and for the relief of epigastric pain, intestinal cramps and colics especially for infants. Its roots are also used as laxative and diuretic. Fennel oil is used in manufacturing of condiment,

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perfumes, soap and as a food flavor. Commercial fennel varies greatly in quality, this being either due to lack of care in harvesting or deliberate adulterate. It may contain dust, stem tissues, weed seeds and other materials.

Seed cleaning is an important operation in a number of processes connected with the handling of seed after harvest. It is impossible to grow and harvest seed crops without getting undesirable intermixtures despite proper care and tending of the crop. These intermixtures may comprise weed seeds, other crop seeds, and various inert matter as well as undeveloped seeds of species in question.

The purpose of the present investigation is to develop a cleaning unit, which designed by Hanna 2003, after making some adjustments, to be grade the cleaning seed into three grades according to its width. Adjustments were made to make the feed material near as possible to the air stream of the suction fan. This make it easier to separate directly most of the chaff and light foreign materials as it feed in. This work is a trial to use inclined oscillation of the sieve unit instead of vibratory oscillation to make the unit suitable for wide range of seeds.

REVIEW OF LITERATURE

Ministry of Economy and External Trade .1991, considered the following specifications to be fulfilled about degree of cleanliness of fennel seeds:

- Seeds must be cleaned from all normal odors and foreign seeds.
- Seeds must be homogeneous and the maximum allowed foreign matter is 5% by weight.

Elliott et al.1998., used a simulation analysis to determine the extent to which spatial competition limits the incentive for elevators to grade correctly and pay producers quality-adjusted prices. Results show that because of spatial monopsony early adopter of grading and quality-based pricing pass on to producers 70 % of price differentials received from NIL buyers and receive above-normal profits at the expense of their competitors. However ,if competing elevators adopt such practices, profits of all elevators return to near normal.

Ebaid.2005., said that the cell shape, sieve tilt angle, sieve oscillation and air speed were the main factors that affect purity and total losses in cleaning. The purity increased by increasing air speed, sieve tilt angle and sieve oscillation .Total losses increased by increasing air speed, sieve tilt angle and oscillation.

Awady et al. 2003., showed that cleaning efficiency and total losses were positively affected by air speed, and sieve tilt angle, but purity was negatively affected by moisture content, and feed rate.

Sahay and Singh .1994., reported that there are different regime motions that can take place for rigid particles placed on a moving trough depending upon the frequency of oscillation.

Ismail .1986., stated that increasing the stroke length improved significantly the separation efficiency in both vertical and lateral motion at all sieve slopes, while in frontal motion, the separating efficiency decreased with the increase of stroke length at sieve slopes more than 15 degrees. In compound motions, an increase in stroke length caused a corresponding increase in separating efficiency especially in small sieves.

Feller .1980., reported that, to evaluate screen performance, both partial passage and clogging of the screen should be considered. A screen rate function, defined as the sum of the passage and clogging rate factor versus relative particle size, was developed to characterize screen performance. This function is independent of screen duration and can be used as a general expression that is not limited to a particular size distribution of the material or to one screen duration.

Perry and Chilton .1973., reported that the optimum slope of inclined vibrating screen is that which handle the greatest volume of oversize and still remove the available undersize required by the standards of the particular operation. To separate a material into coarse and fine fraction, the bed thickness must be limited so vibration can stratify the load and allow fines to work their way to screen surface and pass through the opening. Increased slope naturally increases the rate of travel, and given rate it reduces the bed thickness.

Abd El_ Tawwab et al .2007., reported that the slope of the sieve was the main factor that has a great effect on separation efficiency. The separation efficiency increased significantly with increase of sieve slope at small stroke length and decreased at high stroke lengths.

Wang et al. ,.1994.,and Negrini et al. .1994., evaluated a laboratory grain and separating equipment and found out the overall removal efficiency which is determined by calculating the material balance of impurities on an input-output basis:

$$\eta_{imp} = \frac{(IMP)_{out}}{(IMP)_{in}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where:

η_{imp} : is the overall removal efficiency ,% ;

$(IMP)_{in}$: total mass of impurities in test samples before separation, kg and

$(IMP)_{out}$: total mass of impurities removed from test sample, kg.

MATERIALS AND METHODS

A cleaning unit capable of treating more than one type of seeds was designed and constructed at the Tractor and Farm Machinery Testing Station at Alexandria, Agricultural Engineering Research Institute. The main parts of the cleaning machine as shown in Fig(1) are:

The frame:

The frame was constructed from steel squares and channels (40×40 and 100×50 mm respectively). The frame dimensions are 1000 *1000*1610 mm (width × length × height).

The feed hopper:

The feed hopper was designed to give continuous feeding of the admixture of seeds and impurities to the sieve unit.

The sieve unit:

The sieve unit consists of two sieves; the upper one is used for separating coarse material from the admixture. The lower sieve is divided in to three sections for grading seeds. The cleaning unit has five discharge chutes.

Centrifugal blower:

A suction air stream is supplied by a centrifugal blower operated by an electric motor of 0.75 kW. The blower has 6 straight blade impeller with a circular duct .The duct is placed over the intake of the blower. The air sucked by the blower moves through the duct and entrains the light particles (straw and chaff) from the seeds. The air velocity over the upper sieve was kept less than the terminal velocity of the principal seeds. The sucked light particles, as dust and chaff pass through to the cyclone.

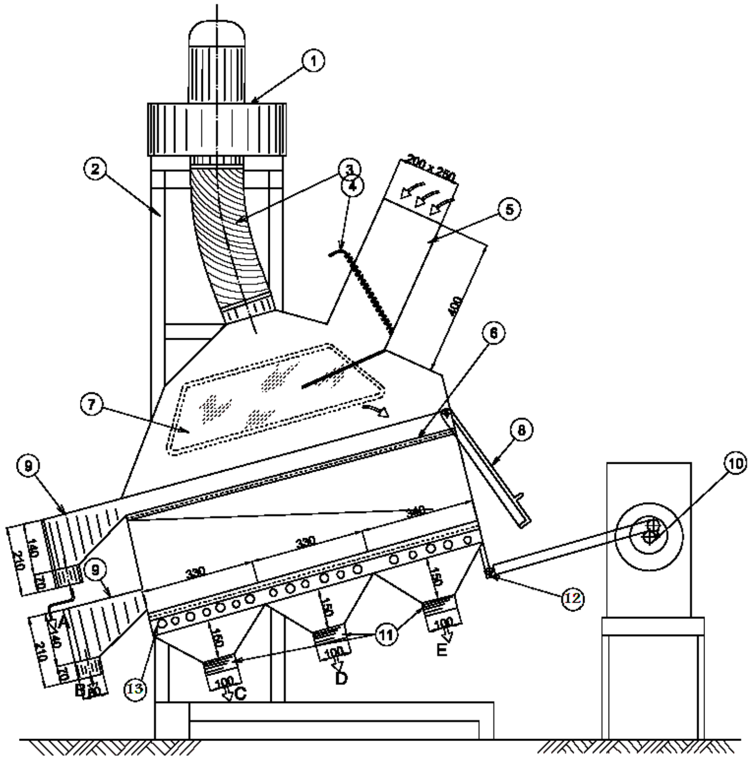


Fig.1: A front view showing the main components of the cleaning unit

1 - Suction blower	7 - Transparence window
2 - Frame	8 - Rear gate
3 - Flexible rubber tube	9 - Outlet chutes
4 - Feed rate adjusting gate	10 - Variable speed electric motor
5 - Seed box with delivery duct	11 - Outlet chutes
6 - Upper sieve	12 – Drive mechanism

13 - Lower sieve

(A) Discharge chute of large, heavy impurities and long pieces of straw

(B) Discharge chute of large principal seed, grade 1.

(C) Discharge chute of principal seed, grade 2.

(D) Discharge chute of small seeds, grade 3

(E) Discharge chute of immature seed, short pieces of chaff and fine other impurities

Power source:
An electric variable speed motor of 2.24 kW (3 hp) with maximum rotating speed of 3000 rpm was installed in the frame of the cleaning unit.

The drive mechanism:
A cleaning unit is oscillated by multiple linkage system. The sieveunit has a link mechanism which performs an horizontal oscillating motion.

Experimental design:
Tests were conducted to cover the full combinations of the considered variables under their different levels. This was to determine the performance of the cleaning unit, and also to get the best combinations among the variables that lead to maximum cleanliness in all out puts with minimum overlap, and maximum grain recovery (minimum losses).

The main variables tested in this evaluation were : the crank speed, the slope angle of the sieve unit, amplitude, and feed rate.

The air velocity through out the sieve unit was kept in all experiments at 2.7 m/s . This velocity was selected according to of the preliminary experiments carried out to determining the terminal velocity of the fennel seed, straw, and chaff, as shown in Fig.(1) which gave minimum losses .

Levls and its vaues of the tested variables

* Four levels of crank speed : 250, 275, 300, and 325 rpm.
* Four levels of stroke length: 15, 20, 25, and 30 mm.
* Three levels of the slope angle of the sieve unit : 5.6, 8.5, and 12 degree.
* Four levels of feed rate: 6, 12, 18, 4 Kg/hr per .cm width of sieves.

The total amount of the fennel seeds sample was analyzed to determine its main components. Based on the seed dimension measurements showed that the sample consists of 36 % (grade one), 36%(grade two), 12%(grade three) and 16 % impurities (chaff, straw, dust, small immature seeds).

Used fennel seeds:
Fennel seeds used in all experiments were graded on the basis of width.

Seeds grade one more than 2.1mm. Grade two ranged from 1.4 to 2.1 mm, while Grade 3 seeds less than 1.4 mm.

In order to evaluated the performance of then cleaning unit, parameter cleanliness, grain recovery, and effectiveness were used. These criteria could be determined from the following relationships. According (Kashayap and Pandya,1965).

$$\text{Cleanliness, \%} = \frac{a}{a+b} \times 100 \quad \ldots\ldots 3$$

$$\text{Grain recovery, \%} = \frac{a}{a+c} \times 100 \quad \ldots\ldots 4$$

$$\text{Chaff rejected, \%} = \frac{d}{b+d} \quad \ldots\ldots 5$$

$$\text{Effectivness, \%} = \left(\frac{a}{a+c}\right)\left(\frac{d}{b+d}\right) \times 100, \quad \ldots\ldots 6$$

where:

a : grain recovery in the product.

b : straw and immature in the product .

c : grain in the reject. and

d : straw and immature in the reject.

RESULTS AND DISCUSSION

The machine was designed on the basis of the physical and aerodynamic properties of the seeds, knowing the thickness and width of seeds can help in choosing the perforation size required for the upper and lower sieves to make grading to the seeds. The air velocity over the sieve unit was kept less than the terminal velocity of the principal seeds under investigation.

Physical, mechanical and aerodynamic properties of fennel seeds and chopped straw:

Results listed in Table (1) and frequency curves given in Fig. (2) show the terminal velocity of fennel seeds and associated foreign matter (immature seeds, straw pieces, and chaff) .

Fig.(2) shows the limits of terminal velocity and its frequency for the fennel sample, straw pieces and chaff. The minimum terminal velocity required to air borne fennel seed was 2.1 m/s. while the maximum terminal velocity was 4.8 m/s. The frequency distribution of the seed sample between the minimum and maximum terminal velocities depends on the physical properties of the seeds. The graphical drawing shows that using an air velocity of 2.7 m/s is suitable for cleaning operation.

Table(1):Physical and mechanical properties of fennel seeds.

characteristics	Av. Value
Length, mm	5.9
Width, mm	1.85
Thickness ,mm	1.5
Bulk density, Kg/ m^3	480
Moisture content, %	12
Coefficient of friction	0.38
Angle of repose θ, degrees	40
Terminal velocity of the seed ,m/s	3.45
Terminal velocity of straw ,m/s	2.3

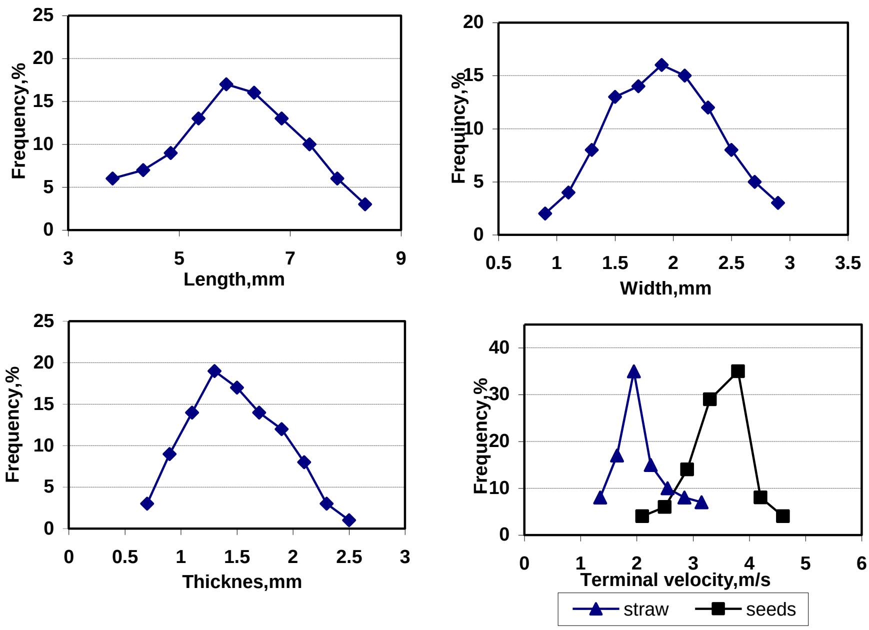


Fig. 2: Frequency distribution curves for fennel seeds

Effect of feed rate on the machine performance of the cleaning unit: To select the best proper feed rate of the machine, ,four levels of feed rates were used 6, 12, 18, and 24 Kg/h per cm width., Experiments were carried out at crank speed 250 rpm, sieve angle 8.5 degrees ,and amplitude 20 mm . As shown in Fig. (3) increasing the feed rate from 6 to

24 Kg/h per cm ,the seed cleanliness decreased by 4.93% These results were taken from the average output in grade one and two. High feed rate creates a thick layer of material on sieves, which causes a considerable deterioration of conditions required to penetrate seeds through the sieve perforations. The maximum seed cleanliness for average of grade one and two was about 99%. So all experiment should be carried out at feed rate of 6 Kg/h. per cm width of sieve.

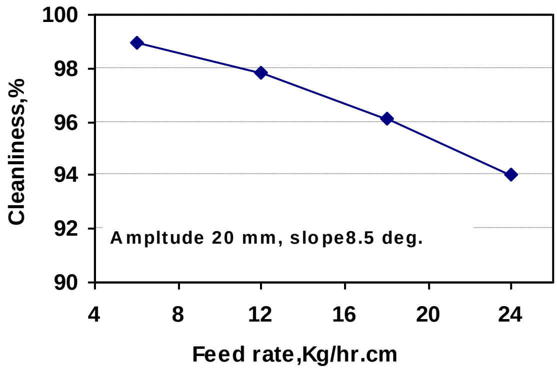


Fig .3:Effect of feed rate on cleanliness

Effect of crank speed on the machine performance:

The effect of crank speed on the machine performance was concentrated on grade one and two only which represented more than 85.7% from the total grain output. As shown in Fig. (4) increasing the crank speed from 250 rpm to 325 rpm the seed cleanliness decreased in all experiments except that for slope 5.6 degrees at amplitudes of 15,and 20 mm . For slope 5.6 deg., it was observed that, increasing the crank speed from 250 rpm to 275 rpm the cleanliness slightly increased . At low levels of crank speeds and lower sieve slopes and smaller amplitudes resulted in plugging the sieve perforation and permitting some immature seeds and straw to get out with the main seeds without going through the sieve perforations.

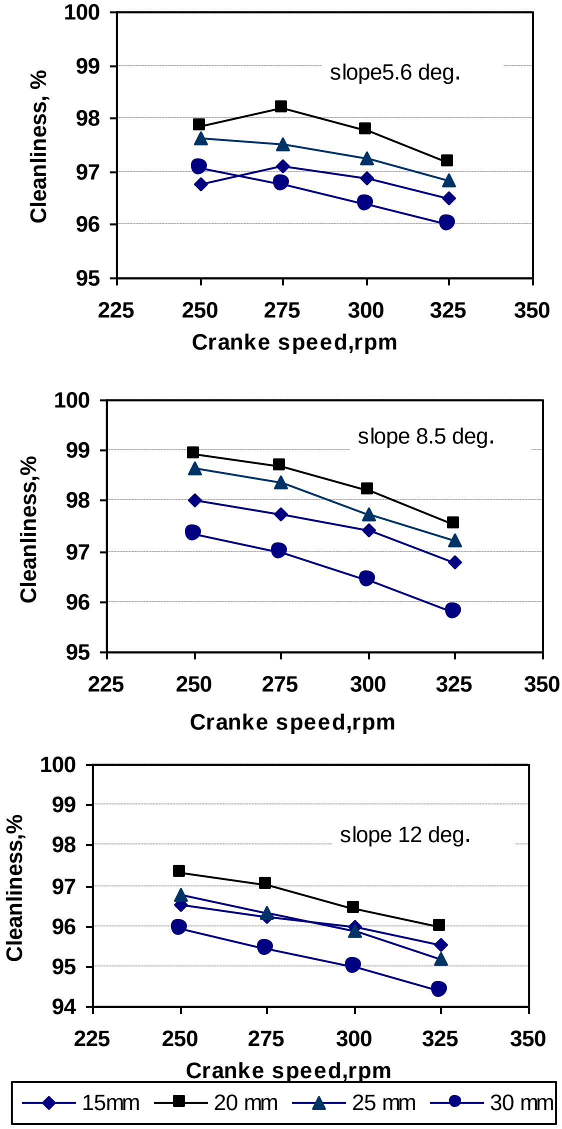


Fig.4 Effect of crank speed on seed cleanliness at different amplitudes (for seed grade1&2)

At higher crank speeds, tends to make seeds and straw to bounce without falling through it.

Fig.5,shows that the maximum cleanliness was obtained at grade "1" and "2" with an average of 98% ,under all crank speed ,amplitude, and sieve angles used. It was observed that the lower values of cleanliness of grade

"3" (about 75% as an average), was due to the convergence of seed dimensions and impurities in this product.

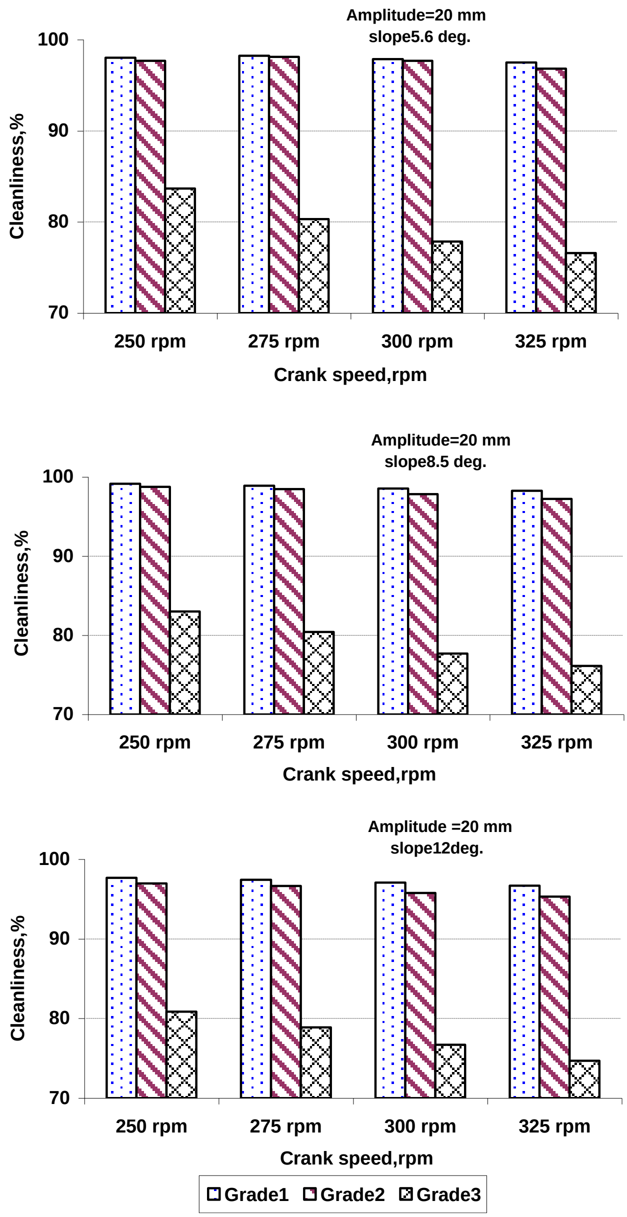


Fig. 5: Effect of crank speed on cleanliness at different sieve angles.

As shown in Fig. (6 and 7) the maximum cleanliness and effectiveness of the cleaning unit were 93.6 and 78.8% respectively.

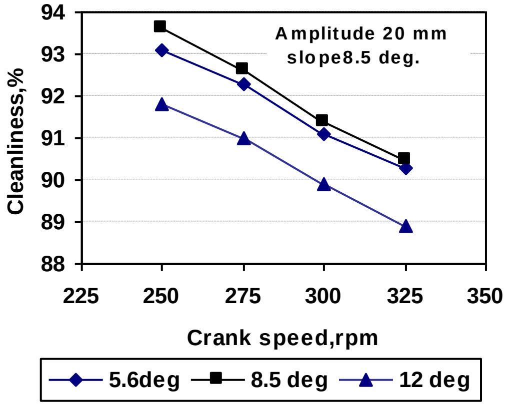


Fig. 6: Effect of crank speed on Cleanliness

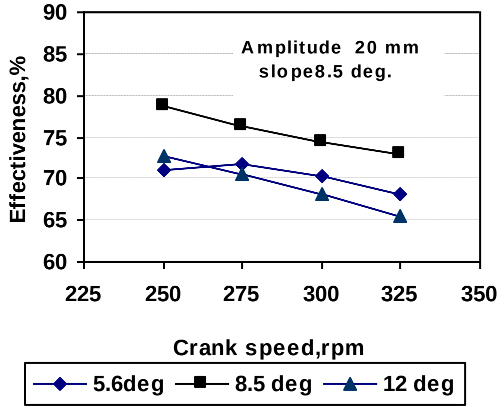


Fig. 7: Effect of crank speed on effectiveness

As shown in Fig. (8) a high percentage for grain recovery with minimum losses or overlap were 41.61%, 42.43 %, and 13.41 % with cleanliness 99.15, 98.74 and 83.03 % for the grade one, two, and three respectively .It was obtained at crank speed of 250 rpm, slope 8.5 degrees, and amplitude 20 mm.

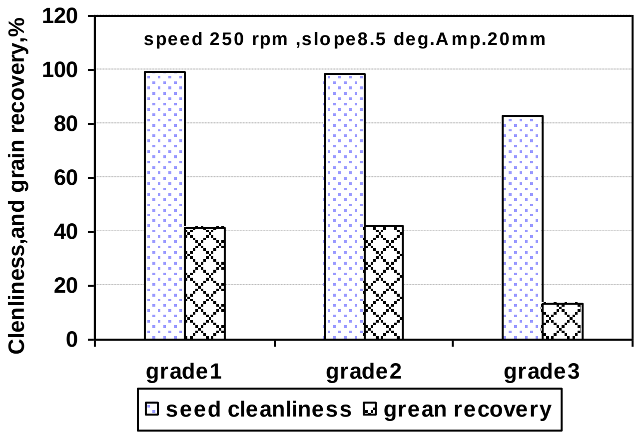


Fig 8: Grain recovery and cleanliness for different graded seeds.

Effect of the sieve angle on the machine performance:

As shown in Figs.(9 and 10) ,increasing the sieve angle from 5.6 to 8.5 degree increases cleanliness. But increasing this angle to 12 degree resulted in decreasing cleanliness. This results were obtained for all crank speeds and different amplitudes used. This was due to the plugging effect of the sieve perforations especially at low slopes, which resulted in permitting some of straw and immature seeds to move out with main seeds .

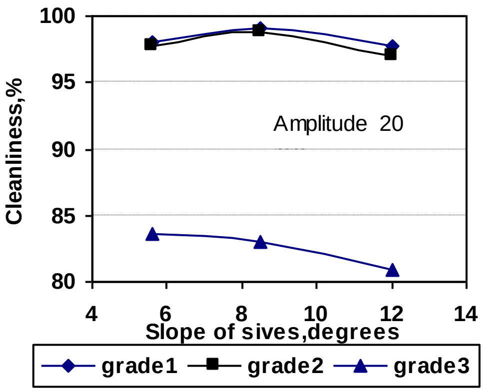


Fig.9:Effect of slope on cleanliness for different grades

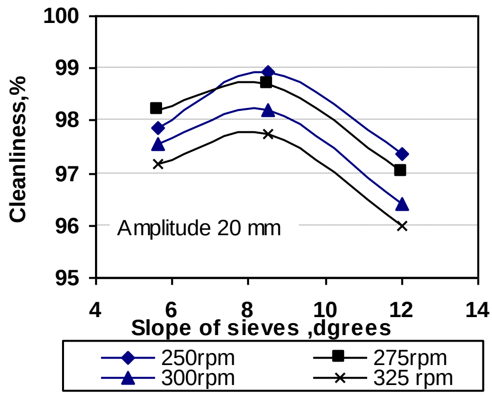
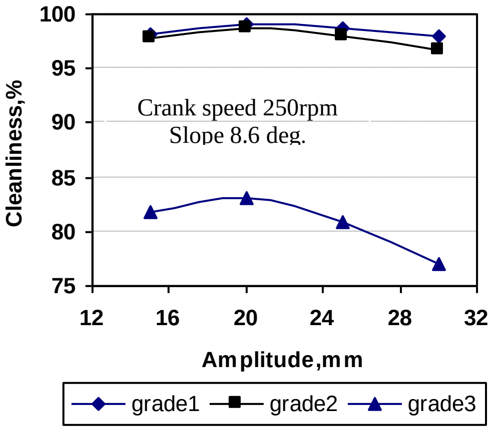


Fig. 10: Effect of slope on cleanliness for different speed(av. grade1&2)

Effect of the amplitude on the machine performance:

As shown in Figs(11and12) increasing the amplitude from 15 to 20 mm the seed cleanliness increased for all experiments while increasing the amplitude from 20 mm to 30 mm the cleanliness decreased 1.62%.

High amplitudes and high crank speeds permitting some immature seeds and straw to travel out with the main seeds without going through the sieve perforations. The maximum seed cleanliness in the grading seeds were obtained at amplitude 20 mm, crank speed 250 rpm, and slope angle 8.5degree.



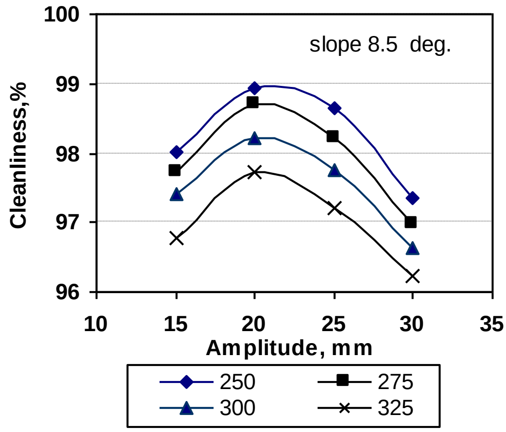


Fig 11:Effect of amplitude on cleanliness for different grades

Fig.12:Effect of amplitude on cleanliness for different speed(av. grade1&2)

CONCLUSION

The proposed cleaning unit was found to be very efficient in the separation process of cleaning fennel seeds from the associated foreign matter. This is due to the ease of adjustment of the working parts of the cleaning unit efficiently according to the crop conditions and percentage of cleanliness required of the product.

Seeds were graded by the machine, into three categories, obtained at three separate outlets. The maximum seed cleanliness for grade one, two ,and three were 99.15,98.74 and 83.65 % respectively and obtained at crank speed of 250 rpm, amplitude 20mm, sieve angle 8.5 degrees, and air velocity 2.7 m/s. The maximum effectiveness of the cleaning unit was 78.8%.

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المراجع العربية

وزارة ألاقتصاد والتجارة الخارجية.١٩٩١. النشرة الاقتصادي

الملخص العربى

اختيار العوامل الرئيسية المؤثرة علي عمليتي التنظيف والتدريج لبذور الشمر باستخدام الغرابيل ذات التردد المائل

د./ سلوي شفيق حنا ١ د./ شعبان محمود احمد١ د./ ناصر مصطفي العشماوي١

يعتبر محصول الشمر من أهم محاصيل النباتات الطبية والعطرية في جمهورية مصر العربية وتقدر المساحة المنزرعة بهذا المحصول بحوالي ١٩٧٣ فدان، وتعتمد معظم هذه المساحات علي العمالة اليدوية بالإضافة إلي انخفاض درجة نظافة الحبوب الناتجة والتي لا تتعدي ٨٥ % ونظرا لأهمية بذور هذه المحاصيل من الناحية التصديرية فان الهدف من هذه الدراسة هو تطوير وحدة آلية لتقوم بتنظيف وتدريج ليمكن استخدامها في عدة مجالات مختلفة أهمها التقاوي, الصناعات الدوائية وكذلك استخدامها في مجال الصناعات الغذائية والعطرية بأقل عمليات ضبط ممكنة,

وقد أمكن تطوير وحدة التنظيف والتدريج بحيث يمكن تغيير سرعة حركة وحدة الغرابيل وميولها ، ومعدلات التلقيم حتى يمكن الحصول علي أعلي درجة نظافة ممكنة للحبوب الناتجة مع تدريجها إلي عدة فئات حسب حجم البذور بأقل نسبة من الفاقد .وكانت أفضل النتائج التي تم الحصول عليها عند سرعة دورا نية ٢٥٠ لفه / دقيقة، ميل وحدة الغرابيل ٨,٥ درجة ، مشوار تردد الغرابيل ٢٠ مم ، معدل التلقيم ٦ كجم/ ساعة لكل سم من عرض الغربال، سرعة الهواء ٢,٧ م/ث. تقدر درجة نظافة الحبوب الناتجة ٩٩,١٥% ، ٩٨,٧٤% ، ٨٣,٦٥ % للدرجة الأولي والثانية والثالثة علي التوالي . وقد أمكن الحصول علي درجة فاعلية فصل للوحدة بأكملها ٧٨,٨ % .

١ـ باحث بمعهد بحوث الهندسة الزراعية- مركز البحوث الزراعية- الدقي - الجيزة