MANUFACTURE AND PERFORMANCE EVALUATION OF A LOCAL MACHINE FOR SEPARATING FLAX FIBERS

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ABSTRACT

The experiments were designed to manufacture and performance evaluation of a local machine for separating flax fibers. The performance of the machine was tested under three sieve speeds of 1.6, 2.21 and 2.8 m/sec, three moisture content of 7.75, 10.32 and 12.75% and five feeding rate 100, 150, 200, 250 and 300 kg/h, respectively.

The results indicated that, the opitmum performance of a manufacture machine was the separating efficiency of flax fibers 74% with vibration movement at sieve speed 2.8 m/s, feeding rate 100 kg/hr and moisture content 7.75%. The length fibers was (89.5cm.) obtained at sieve speed 1.6m/s, feeding rate 100 kg/hr and moisture content 7.75%. The best degree of fiber fineness (182.6 mm/mg) was at sieve speed 2.8 m/s, feeding rate 100 kg/hr and moisture content 7.75%. While the best value of fiber strength (36.5 tex /gr) were obtained at sieve speed 2.8 m/s, feeding rate 100 kg/hr and moisture content 12.75 %. The lowest values of energy requirements for separating one ton of flax fibers 17.1 kw.h/ton were obtained at sieve speed 1.6 m/s, feeding rate 300 kg/hr and moisture content 12.75%. The lowest values of cost requirement for separating one ton of straw flax 48.2 L.E/ton were obtained at sieve speed 1.6 m/s, feeding rate 300 kg/hr and moisture content 7.75%.

INTRODUCUTION

Flax considers the most important economic oil and fiber crops in the world as well as in Egypt. The fiber separating processes (retting, drying, breeking and separating) needs a hard efforts and high cost. The several steps to complete separating of the fibers consist of many stepes , the first step is called retting. Retting is the process of rotting away the inner stalk, leaving the outer fibers intact.

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Easson and Molloy (2000), Reported that fiber percentage in the flax straw increases from flowering to maturity from around 17% to 25%, it remains constant at around 16% in linseed. Eichhorn (2001), found that the mechanical properties at flax, density 1.5 g/cm3 ,break 2.7-3.2 %, tensile strength 345-1035 MPa, young's modulus 27.6 GPa. While these two natural fibers are similar, the properties of the plant as well as the mandatory processing to obtain fibers vary greatly. Flax stalks contain approximately 30% fiber and 70% trash. Mohanty et al., (2001), The results showed that the flax density was 1.5 g/cm, tensile strength was 345-1100 (Mpa) young's modulus 27.6 (Gpa) and elongation at Break was 2.2- 3.2% .Anthony (2002), reported on three studies to determine the cleaning effectiveness of gin machinery in separating flax fiber from chopped seed flax straw. His three studies used various combinations of cylinder cleaners and lint cleaners and flax raw material chopped to about 5.1 cm in length, retrieval of pure fiber (corrected for shive content) ranged from a low of 7.1% to a high of 12.8%. Anthony (2005) report that evaluated the potential of several machines to remove flax fiber from chopped seed flax straw. Then, a new machine that incorporated the principles of several machines was built and tested. The initial version of the machine did not yield the desired 80% fiber purity, so more saw cylinders were added. The most effective version produced 13.8% yield out of a possible 20% fiber with a purity of 81.4%. The yield can be improved with additional modifications to the machine. Ismail et al. (2009) indicated that the degree of fibers fineness decreased by increase in straw moisture content, the highest value of fiber fineness 129.74(mm./mg) were obtained at straw moisture content of 8.42%,while the lowest value of fiber fineness 126.63 (mm./mg) were obtained at straw moisture content of 12.6%. Till present time, the Egyptian farmers do not have any small-scale machines to help him for separating flax fibers. To raising the income of the farmer, it can be achieved by a simple mechanical system using for separating flax fibers, thereby can be reduce all losses and save transporting costs. Consequently, we can be reducing the problems which face farmers Egyptian from selling their crops after harvesting with low prices, and also affected the main Physical and mechanical properties of flax fibers.The main objectives of this study were to manufacture a new local machine for separating flax fibers and evaluate the performance of the machine under different operating conditions (sieve speed, feeding rate and moisture

MATERIAL AND METHODS

The machine manufactured at a private locally workshop in Mansoura-Dakahleia governorate .the performance of the machine was evaluated at the experimental farm Research Station, Gmiza; Ghrbia governorate. Tests were carried out to evaluate the separating machine for flax fibers and determine the optimum parameters affecting the fibers separation process such as straw moisture content, drum speed and feeding rate. All treatments in this research were conducted in five replications by using three sieve speeds (1.6, 2.21and 2.8 m/s, 325, 450 and 570 r.p.m), five Feeding rates (100, 150, 200, 250 and 300 kg /h) and three moisture content values (7.75, 10.32 and 12.75%) at breaking straws.

-Giza (10) variety of flax crop was used in this study. Table (1) shows some of flax physical properties. After harvesting the flax plants and separating seeds at the stalks thin connect the stalks and send it's to the retting. The retting process took about 7-15 days, and then plants were dried in the yard for a few days. After this process called breaking in order to crush by passing stalks into breaking machine which work of through fluted rollers. Its stay by cutting stalks into small pieces of bark called shives. Then they are transferred to broken stalks at the cleaning machine to extract the fibers from the shives with rotating sieve finally releasing the flax fibers from stalks.

Table(1): some physical properties of flax crop and flax fibers:

Physical properties	Main value
Plant height, mm	1140
Technical length, mm	989
Stalk diameter, mm	3.45
Seed yield, kg/fed	3300
Straw yield, ton/ fed	3.28
Length of flowering zone, cm	15.1
Length of root zone, cm	12-15
Average diameter of the root, mm	3.15
Fibers percent %	20%
Woody-shives %	80%

Description of machine:There are tow frames, the first one for the sieve and the other for the base of the machine. It was constructed by angle iron of 4*4 cm. shape at length of 150cm, width of 100cm and height of 50cm. The legs were connected together by links of iron angel and fixed on a concreting base. Fig (1) shows general view of the separating machine used in this study. The general specifications of the locale separating machine are listed in table (2).

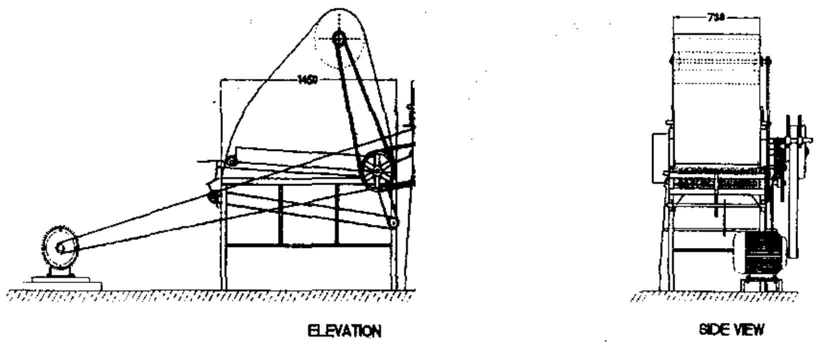

Fig.(1) Separating machine.

Table 2: The specifications of the locale separating machine used.

Item	Value or specification
Overall length, cm	150
Overall width, cm	100
Overall height, cm	140
Overall length of sieve, cm	130
Overall width of sieve, cm	90
Overall mass, kg	145
Feeding gate, cm2	75x22
Gate let- out, cm2	75x22
Feeding system	Automatic from breaking machine.
Separating unit	Sieve moving
Power source	Electric motor
Labor requirement, men	2

-Frame the sieve and drawing belt: It was constructed by steel angle of " 4*4" cm. The farming length of 130 cm, width of 90 cm

-Pulleys group: It was ride into two pulleys and fabricated aluminum metal, first diameters of 30cm. and other is 15cm.

-Feeding gate :it was constructed at a high of 60 cm. from surface earth at the front of machine and the area of feeding gate"75x22",(about 1650cm^2.)

-Gate let –out of the fibers separation: It was constructed at a high of 55cm. from machine at dimension of 75x22 , (about 1650cm^2.)

Sieve units: consists of a wire with openings square area of 4.0cm^2.It was moved by two drum rolls that take the movement of a wheel leader that is taking movement from leader reel of the breaking machine. The source power is an electric motor by belt connected with two drum rolls. The width of the belt is 15cm and the area of the sieve is (75x130) cm^2.The sieve was connected into sides by iron joints with belts and the drum roll was fixed with the frame by bearings. There are two gears was fixed with lower frame are moving by chain the arm for vibrations at sieve with speed the sieve as showed in fig.(2).

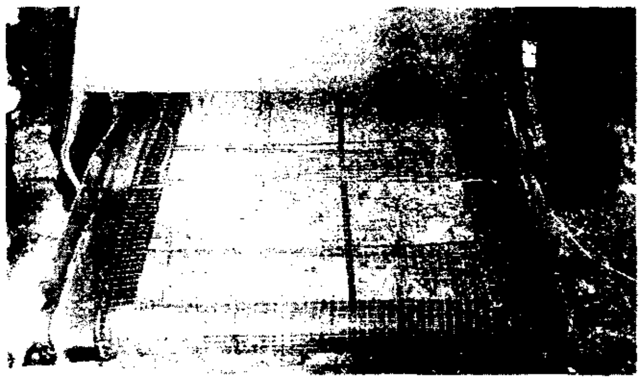

Fig.(2) photograph showing the sieve units.

-The fan: consists of four wings were made in japan. The fan diameter is 50 cm. every wing is (25) cm. in length and (15) cm. in width to generate air stream in the same direction toward feeding flax straw to carrying small pieces of wood stems after breaking operation and push it toward the holes sieve under machine. The fan and cone units were covered by galvanized sheet iron at a thickness of (2) mm. The cone area is 3600cm^2. in the top and 4400 cm2 in the bottom as in shown Fig. (4).

-Power source: Electric motor (3.728 kw or 5 hp), rotation frequency, r.p.m. of 1250, pulleys diameter of 40 cm length,22 cm diameter of cycle

Laboratory tests:

Straw moisture content: Straw moisture content of flax was determined after retting times at different three stages of drying by taking a five straw samples randomly after 10, 15 and 20 days from retting these samples were dried in the oven at 70 C0 for 24 hours.

-**The straw moisture content** was calculated as follows:

$$M = \frac{M_{WS} - M_{DS}}{M_{WS}} \times 100$$

Where: M = Straw moisture content, %

MWS = Wet straw weight, g. MDS = Dry straw weight, g.

-**The separating efficiency**: The separating efficiency was estimated by using the following equation.

$$S_p = \frac{W_B - W_A}{W_B} \times 100$$

Where :

Sp = Separating efficiency, % W_B =Total weight of wood pieces, kg

W_A = Total weight of wood pieces with fibers, kg

-**Long fiber percentage**: Long fiber percentage was estimated according to Radwan and Momtaz (1966), using the following equation.

$$L_F = \frac{W_F - S_F}{W_F} \times 100$$

Where: L_F = Long fiber percentage, %. W_F = Total weight of fibers.

S_F = Weight of short and small fibers.

-**Long fiber length** :Long fiber length was measured using a scale meter (model). And determined (very long, long, medium, short and very short) of flax fibers.

-**Fiber fineness**: Fiber fineness in metrical number (mm/mg), was determined according to Radwan and Momtaz (1966), using the following equation;

$$N_m = \frac{N \times L}{G} \times 100$$

Where:Nm= Metrical number, mm/mg N= No.fibers (20 fibers each 10 cm).
L = length of fibers in mm,(2000). G = Weight of fibers in mg.

-Long fiber strength: Long fiber strength was measured by Pressely implement was determined according to Radwan and Momtaz (1966), using the following formula;

$$F_S = \frac{N \times L \times C_F}{G}$$

Where: FS= Fiber strength, mm. N / mg. G = Weight of tested fibers in, mg.
N = Number of 20 fibers tested fibers (each 10 cm.)
L = Length of tested fibers in, mm (2000).
Cf = Mean of the tensile force for breaking an individual Fiber, N

-Energy requirements: Super clamp meter- 300 KR-National- Made in Japan was used estimated and calculate the current strength and potential difference before and during working. The consumed power (HP) was calculated from the knowledge of line current strength (I) and potential difference values (V) .using the following formula

$$\text{Total consumed power} = \frac{\sqrt{3} \times I \times V \times \eta \times \cos\theta}{746}$$

Useful power = (Load — No-Load). H.P

Where: I = Line current strength in Amperes.
V = Potential difference (Voltage) being equal to 380 V.
Cos θ = Power factor (being equal to 0.84).
√3 = Coefficient current three phase (being equal 1.73).
η = Mechanical efficiency assumed (95%).

-Cost requirements: Cost analysis was performed considering the conventional method of estimating both fixed and variable costs, according to price level (2009.)

Fixed costs: The fixed cost for the modified separating machine included reduction , interest on investment, taxes, shelter and insurance. It was calculated according to the straight- line .

$$F_C = \left[\left(\frac{P - 0.01(P)}{e} + \frac{P + 0.01(P)}{2}\right) \times (I + 0.02P)\right]$$

Where: FC = fixed cost, LE/hr P = purchase price, L.E i = interest rate (16%). e = expected life of the machine, year.

Variable costs:The variable costs included the following: (repair, maintenance, electricity cost, and labor cost).

They were calculated as the follows:

Repair and maintenance cost = 95% of depreciation

Energy (electricity) cost = (3.55 kW ×0.42) = 1.49 L.E /hr.

Labor cost 2×5.00 = 10.00 L.E /hr.

Grease and daily services = 1% of purchase price.

Purchase price = 5000 L.E.

Salvage value = 10% of purchase price. Interest rate=16%

Expected life of the machine = 8 years =11520 hour.

8 Hours in per day, 20 days per the month = 9 months in the year

One (kW) of commercial electricity = 0.42 L.E/hr.

Yearly operation hours = 1440 hr.

RESULTS AND DISCUTION

The performance of the fabricated machine at different parameters has been discussed.

-Effect of feeding rate on separating efficiency at vibration movement

The effect of feeding rate on the separating efficiency was shown that in Fig.(3). Decreased by increasing the feeding rate and an increasing the moisture content. It was when the sieve speed 2.8 m/sec. The separating efficiency was maximum values 74% at feeding rate 100kg/h and moisture content 7.75% , minimum values was 38.1% at feeding rate 300 kg/h. and moisture content 12.75%. This may by attributed to Fig.18. that effecting fan speed on the separating efficiency were increased by decreasing the feeding rate , decreasing the moisture content and increasing the fan speed, caused an increase of momentum the broken flax fibers when increasing the feeding rate and also increasing the moisture content percentage.

-Effect of feeding rate on separating efficiency without vibration

Fig.(4) shown with different sieve speed and different moisture content at without vibration movement. These factors effect of on the separating efficiency. So the results indicated that the separation efficiency of flax

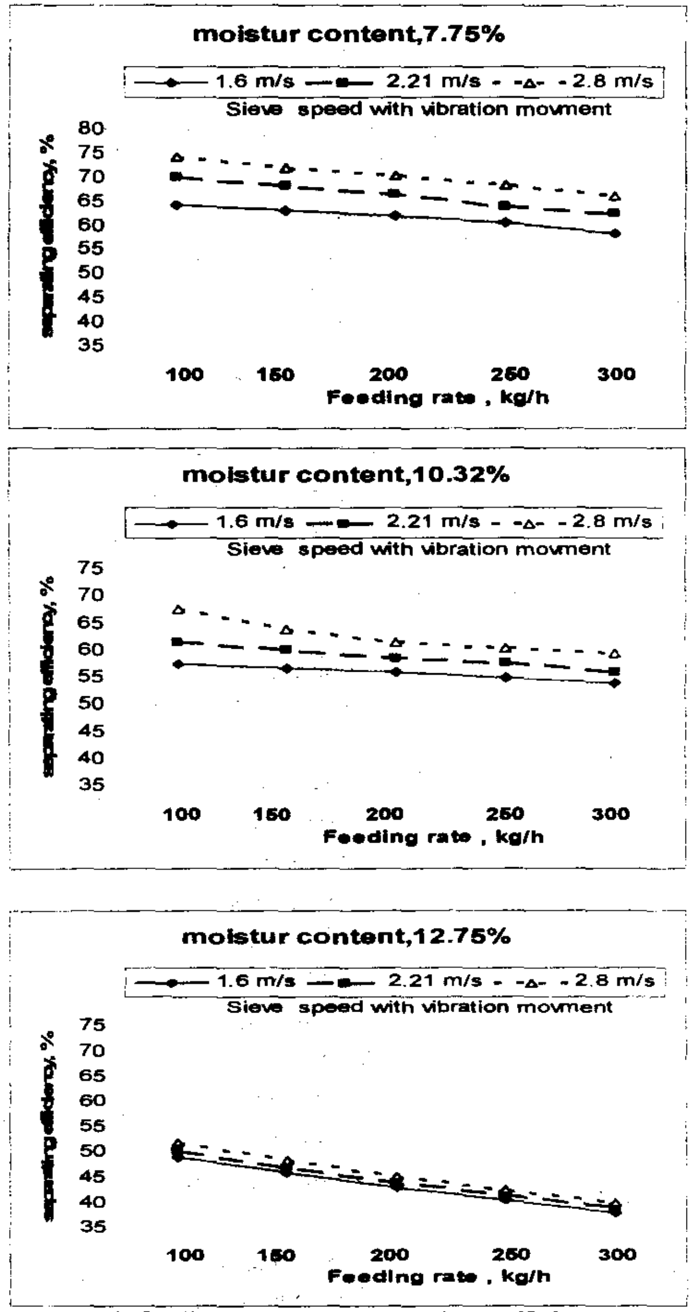

Fig (3) Effect of feeding rate on separating efficiency at vibration movement.

fibers decreasing by increasing from (61.6, 59.5, 57.4 and 53.5%),(51.8, 49.7, 47.6, 45.7 and 43.8%) and(41.7, 39.6, 37.5,35.6 and 33.7%) at increased the moisture content(7.75, 10.32 and 12.75%) and when each of increased the feeding rate from (100, 150, 200, 250 and 300 kg/h)of breaking straw at fan speed was 637 r.p.m and sieve speed 1.6 m/sec, respectively. Thereafter, increased the sieve speed from 1.6 m/sec and the same separating efficiency decreased with increasing the feeding rate and also with increasing the moisture content. The same trend with the sieve speed 2.8 m/sec and different feeding rate and so the different moisture content. This may be attributed to that increasing the moisture content more than 7.75%,caused an increasing of stick flax fibers by woodly and each other. So increased feeding rate was caused an increasing of momentum of fibers and then decreased the separation efficiency of flax fibers

-Effect of feeding rate on fibers fineness, mm/mg:

Fig.(5) shows the effect of feeding rate on fibers fineness of flax fibers are referring that there were regular diminution in the values of flax fineness decreased by (153.4, 151.5, 149.6, 147.7 and 145.8,) (166.7, 164.8, 162.7, 160.8 and 158.9) and (182.6, 180 , 178.8,176.9 and175) at increasing of feeding rate from 100 to150 ,200,250 and 300 kg/h, under sieve speed 1.6 m/sec, 2.21 and 2.8 m/sec and straw moisture content of 7.75%,respectively.

-Effect of feeding rate on fibers fineness, mm/mg:

Fig.(5) shows the effect of feeding rate on fibers fineness of flax fibers are referring that there were regular diminution in the values of flax fineness decreased by (153.4,151.5,149.6,147.7 and145.8, (166.7,164.8,162.7,160.8 and 158.9) and (182.6,180 7,178.8,176.9 and 175) at increasing of feeding rate from 100 to150 ,200,250 and 300 kg/h, under sieve speed 1.6 m/sec, 2.21 and 2.8 m/sec and straw moisture content of 7.75 %,respectively.

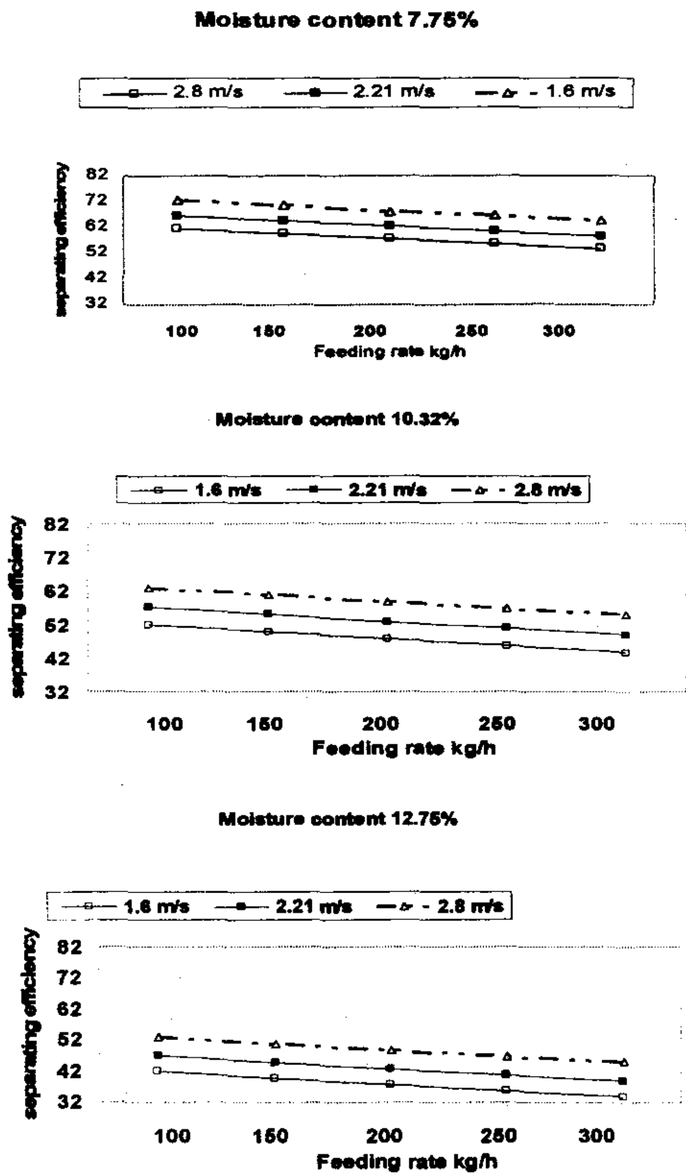

Fig (4) Effect of feeding rate without vibration on separating efficiency.

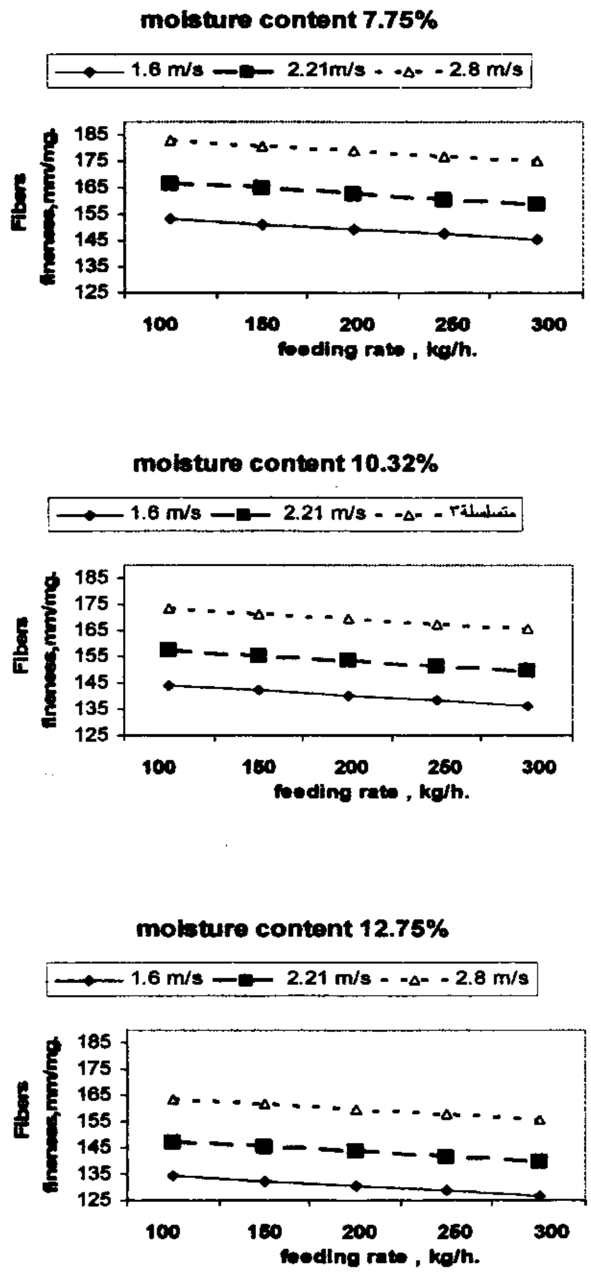

Fig.(5) Effect of feeding rate on fibers fineness of flax fibers, mm/mg.

-Effect of the feeding rate on length of fibers (cm) of flax fibers:

Figure (6) shows that, the long fibers(cm) increased by decreasing the feeding rate and decreasing with increasing the moisture content of straw flax fibers and increased by decreasing the fan speed, r.p.m and decreasing the sieve speed, m/sec . The results indicated that, the maximum values for long fibers(cm) was 89.5 with sieve speed 1.6 m/sec, feeding rate 100 kg/h and fan speed 637 r.p.m% and minimum values was 73.5(cm) when feeding rate 300 kg/h and sieve speed 2.8 m/sec and moisture content 12.75% of flax fibers.

-Specific energy requirement (kw.h/ton) :

Fig.(7) shoes the specific energy requirement (kw.h//ton) at different parameters studies. The results indicated that, the specific energy requirement for separating one ton fibers of flax straws increased by (25, 30.1 and 35.2), (21.5, 23.6 and 27), (19.8, 22.4 and 24.9), (17.6, 19.6 and 21.6) and (17.1, 18.8 and 20.5) kw.h/ton at increasing of sieve speed from 1.6 to 2.21 and 2.8 m/sec and increasing the feeding speed by (100, 150, 200, 250 and 300 kg/h) at moisture content 7.75%, respectively.

The same trend was noticed at the moisture content 10.32% and 12.75% with different sieve speed. However, the highest value of specific energy 41.2 kw.h/ton were obtained at sieve speed 2.8 m/sec ,feeding rate of 100 kg/h and moisture content of12.75% while the lowest value of specific energy 17.1 kw.h/ton were obtained at sieve speed 1.6 m/sec, feeding rate of 300 kg/h and moisture content of 7.75%. The data analysis show that , the specific energy requirement increased by increasing the sieve speed , feeding rate and moisture content.

-Cost requirement for separating flax fibers at different parameters studies:

The hourly cost of separating machine was estimated by calculate a fixed and variable cost by using standard method described in the ASAE (1980) and recorded in table(3).The results indicated that, the highest value of cost requirement for separating one ton of flax straw 80.4 L.E/ton were obtained at sieve speed of 2.8 m/sec, moisture content of 12.75% and feeding rate of 100 kg/hr, while the lowest value of cost requirement 48.2 L.E/ton were obtained at sieve speed of 1.6 m/sec, feeding rate of 300 kg/hr and moisture content of 7.75%.

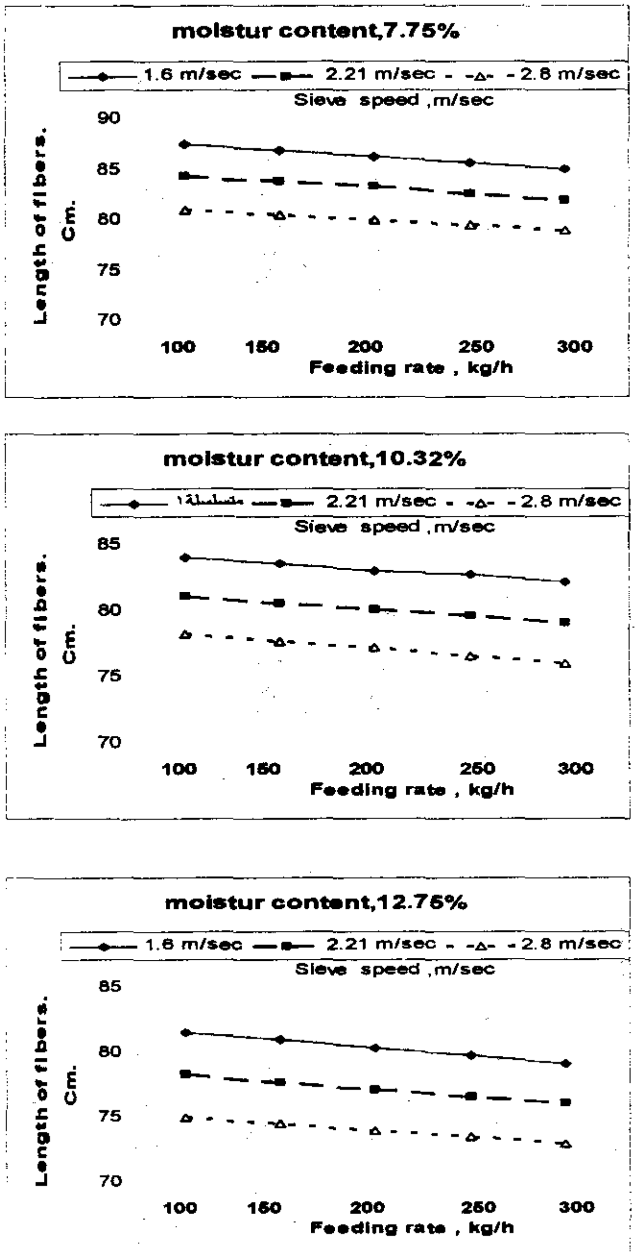

Fig (6) Effect of feeding rate on length of fibers, cm of flax.

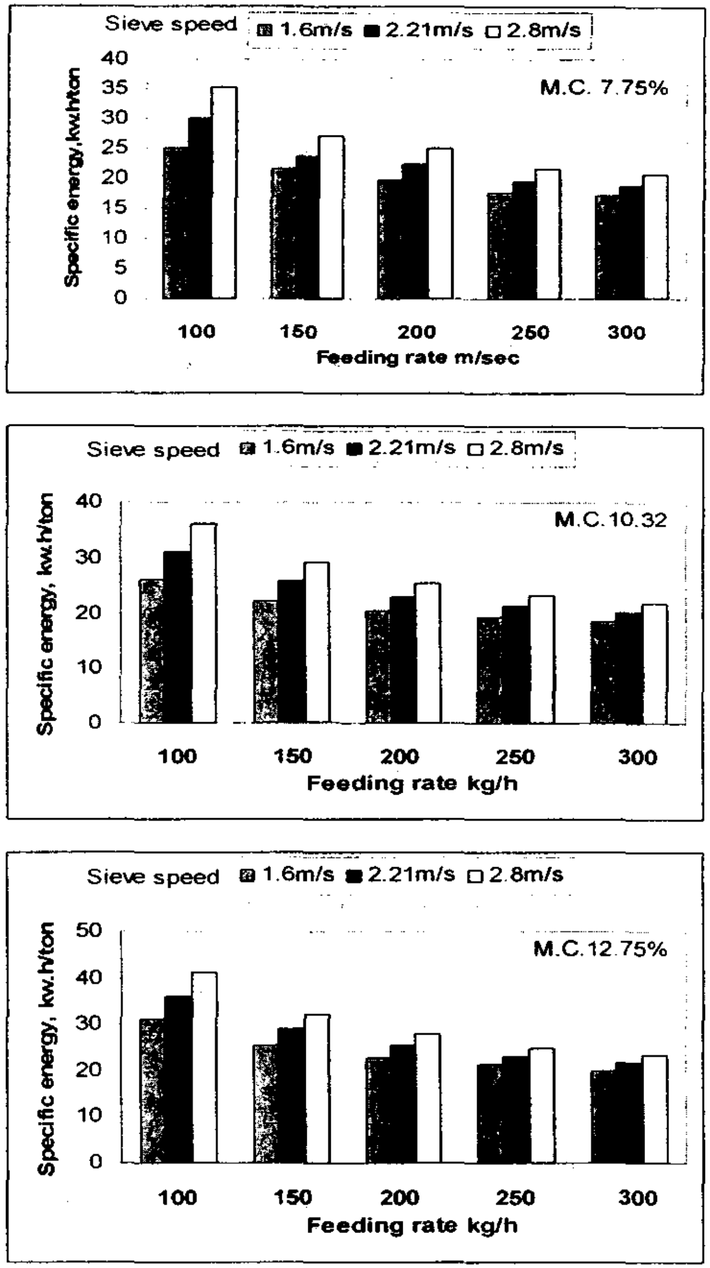

Fig.(7)Effect of feeding rate on specific energy requirement (kW. h/ton).

Table (3): Cost estimation for a local machine to separating flax fibers

Equipment	A local machine
Purchase price, (L.E)	5000
Year, service life	8
Hr/year, annually use	1440 hr/years
Interest rate,(%)	16%
Taxes and overhead,(%)	2.0
Repair and maintenance from depreciation,(%)	95%
Depreciation , (%)	10
Lobar cost, LE/hr	10 L.E/hr
Electric cost, L.E/kw	0.42 L.E/hr
Grease and daily services, (%)	1.0
Hourly cost, L.E/hr	12.79

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الملخص العربي

تصنيع وتقيم أداء آلة محلية الصنع لفصل ألياف الكتان

طارق فوده*, سامىبدر**, أسعد دريالة***,عادل عبد العزيز العشرى****

يعد محصول الكتان من أقدم محاصيل الألياف ومن أهمها والتي استعملها الإنسان في صناعة ملابسه وقماش الخيام كما يصنع من الساس الخشب الحبيبي ومن الزيت يستخرج زيت الطعام والبويات وهو يزرع في مصر بغرض الحصول على الألياف والبذور وتبلغ المساحات المزروعة منه حوالي ٢٤٨٢٠ فدان حسب (إحصائيات وزارة الزراعة ٢٠٠٩) وتكثر زراعة الكتان في مصر في محافظات الغربية والدقهلية والبحيرة وبني سويف وتحتل محافظة الغربية المركز الأول في مصر وحتى الآن يقتصر دور المزارع المصري علي زراعته وحصاده, وبعد ذلك يقوم بنقله إلي مركز التجميع وإجراء كافة العمليات من فصل البذور وفصل الألياف وتصنيعها. ونظرا للصعوبات والمخاطر التي تواجه المحصول من فواقد في البذور والقش وانخفاض العائد الربحي للمزارع المصري و أيضا زيادة تكاليف النقل ونظرا لعدم توافر وسيلة آلية تساعد الفلاح في فصل الألياف وزيادة ربحه من المحصول لذلك يتطلب توافر وسيلة آلية بسيطة وميسرة تكون فى متناول المزارع تساعده فى عملية فصل الألياف مع الحفاظ بالخصائص الفيزيائية والميكانيكية لألياف الكتان. لذلك كان الهدف من هذه الدراسة هي تصنيع وتقييم أداء آلة محلية الصنع لفصل ألياف الكتان تم تصنيعها وضبطها فنيا بإحدى الورش الفنية الخاصة بالمنصورة- مركز الدقهلية- وأجريت التجارب خلال موسمين زراعيين ٢٠٠٩-٢٠١٠م بمحطة البحوث الزراعية بالجميزة (مركز السنطة – محافظة الغربية).

وتمثلت الخصائص الفيزيائية والميكانيكية لألياف الكتان وتقييم أداء الالة فى (كفاءة الالة - نسبة طول الألياف - طول الألياف (سم)- درجة النعومة للألياف – درجة المتانة للألياف) **تحت العوامل الدراسية التالية :**

سرعات الغربال (١.٦- ٢.٢١- ٢.٨ متر/ثانية)٠

معدلات التلقيم لعيدان الكتان(١٠٠- ١٥٠- ٢٠٠ – ٢٥٠ – ٣٠٠ كجم/ساعة)٠

المحتوى الرطوبى للعيدان (٧.٧٥- ١٠.٣٢- ١٢.٧٥ %)٠

وأوضحت النتائج ما يلى:

أفضل أداء للآلة من حيث كفاءة الفصل للألياف ٧٤% أثناء وجود الحركة الاهتزازية للغربال وفى حالة عدم وجودها كانت كفاءة الفصل٧٢.٥% تحقق ذلك عند سرعة الغربال ٢.٨ م/ث ومعدل تلقيم ١٠٠كجم/ساعة ونسبة رطوبة للعيدان ٧.٧٥%٠

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****مركز البحوث الزراعية.

ونسبة الألياف الطويلة ٣٥.٦٥% وطول الألياف الطويلة ٨٩.٥ سم أثناء الحركة الاهتزازية للغربال تحققت عند سرعة غربال ١.٦ م/ث ومعدل تلقيم ١٠٠ كجم/ساعة ونسبة رطوبة للعيدان ٧.٧٥%٠

أفضل أداء للآلة من حيث درجة نعومة الألياف ١٨٢.٦ مم/مللجم تحققت عند سرعة غربال ٢.٨ م/ث ومعدل تلقيم١٠٠ كجم/ساعة ونسبة رطوبة للعيدان ٧.٧٥% ٠

أفضل أداء للآلة من حيث متانة الألياف ٣٦.٥ تكس/جم تحقق مع معدل تلقيم ١٠٠ كجم/ساعة وسرعة غربال ٢.٨ ونسبة رطوبة ٧.٧٥%٠

أفضل قيمة لاستهلاك الطاقة ١٧.١ كيلوات ساعة/طن تحقق باستخدام الآلة عند سرعة غربال ١.٦م/ث ومعدل تغذية ٣٠٠كجم/ساعة ونسبة رطوبة للعيدان ١٢.٧٥%٠

أقل قيمة لتكاليف فصل الألياف ١ طن من قش الكتان ٤٨.٢ جنية مصرى/طن تحققت باستخدام الآلة عند سرعة غربال ١.٦م/ث ومعدل تغذية ٣٠٠ كجم/ساعة ونسبة رطوبة للعيدان ٧.٧٥%٠