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ENERGY AND COST REQUIRMENTS OF A DEVELOPED SEPARATING MACHINE FOR FLAX FIBER

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ABSTRACT

The aim of this work is to estimate the energy and cost requirements for a developed machine of flax fibers separation. This machine was fabricated in a locally workshop at Meet - Ali - Dakahleia Governorate and testing in Tag EL- EZZ Agricultural Research Station, Dakahleia governorate The determined properties of performance machine were:- separating percentage of flax fibers, the energy and cost requirments.These parameters were investigated as affected by different machinery, and crop variables such as: separating drum speed (of 1.58, 3.52 and 8.21 m/s),straw feeding rate (of 2.0, 2.5 and 3.0 kg/ min).,and straw moisture content (of 8.42, 10.8 and 12.6 %,wb).

The results indicated that;

- The best performance of a developed machine for separating percentage of flax fiber 75.7% were obtained at drum speed of 8.21 m/s, feeding rate of 120 kg/hr and straw moisture content of 8.42%.
- The lowest values of energy requirements for separate one ton of fiber flax 13.94 kW.h/ton were obtained at drum speed of 1.58 m/s, feeding rate of 180 kg/hr and straw moisture content of 8.42%
- The lowest values of cost requirement for separate one ton of straw flax 54.33 L.E/ton were obtained at drum speed of 1.58 m/s, feeding rate of 180 kg/hr and straw moisture content of 8.42%.

INTRODUCTION

In the necessary for evaluate the performance of a technical system for separating flax fibers, estimate the performance and economical side for working cost and energy consumption. Van Sumere (1992) reported that in water-retting, flax stems are submerged in rivers and lakes, and anaerobic bacteria colonize the flax stems and degrade pectin's and other matrix compounds, thus freeing fibers from the core tissues. Pasila (1999) was used. The fiber fraction was obtained by a process consisting of taking samples from the field in autumn or sampling from the bale, cutting as a pretreatment, milling the cut straw with a hammer mill and separating the fiber and sheaves fractions with a drum separator. Akin, et.al. (2002) Mentioned that, progress is reported for three areas of research undertaken by ARS-USDA and collaborators including: 1) improved retting, i.e., separation of fiber in stems, 2) mechanical fiber cleaning integrated with retting, and 3) objective standards to judge fiber quality. An enzyme-retting method has been developed to pilot plant level but must be improved based on cost and fiber properties. A USDA Flax Fiber Pilot Plant has been established for the first stage of mechanical cleaning. The Flax and Linen subcommittee of ASTM International has developed three approved standards, has a document on trash for committee balloting, and continues

work on standards for other properties. Anthony, W.S. (2002) Mentioned that the seed flax stalk is usually considered a waste product but it can be separated into fiber and shive. The separation of fiber from fiber flax stalks is a rigorous and expensive process that requires the stalk to be biologically degraded (retted) before processing, and is not feasible for seed flax stalks. The initial straw in this article contained about 20% fiber. Results of three separate studies involving over 25,000 kg (55,000 lb) produced fiber contents ranging from 9.6 to 15.8%. The effectiveness of several combinations was about the same, but the most effective was three cylinder cleaners followed by one saw-type lint cleaner, which produced 13.7% fiber at 86.1% purity. The degree of retting is the single most important factor governing the mechanical separation of the fiber from the stalk.

So, the main objective of this work is to estimate the energy and the cost of a developed machine for separating flax fibers.

MATERIALS AND METHODS

The achieve aim of this work a simple machine for separation flax fibers, was fabricated at locally workshop at Meet - Ali - Dakahleia Governorate. The experiments for testing the developed machine were carried out through two successful season of 2007/2008 in Tag EL- EZZ Agricultural Research Station, Dakahleia Governorate. The results of a developed machine compared with manual and mechanical system in the factory.

1. Materials

1.1. The developed machine:

The sketch of developed machine and mechanical system in the factory. are shown in Fig. (1) and Fig. (2). the specifications of this machine are shown as the following:

1.2. Variety of flax:

In this testing fifty kg. of flax straw were used from flax variety of sakalana.

The specification of flax fiber separation machine:

Type	**Flax fiber separation machine**
Machine model	locally
Manufacturer	Locally workshop - at Meet - Ali – Dakahleia governorate.
Separating drums:	
Type	Cylindrical
Drum diameter	11.2 cm
Drum length	48 cm
Drum numbers	8
Feeding out let gate dimensions	at of 60, 52 and 20 cm length, width and high respect.
Fibers out let gate dimensions	at of 50, 52 and 20 cm length, width and high respect..
Wood pieces out let gate dimensions	at of 30, 20 and 10 cm length, width and high respect..
Source of power	Electric motor

2. Methods of measurements:

To carry out the experiment and to test the optimum performance of developed machine and estimate the energy and the cost requirements, the following measurement were determined;

2.1. Straw moisture content:

Straw moisture content of flax determined according to *ASAE(1992)* Standard *ASAE S358* by taken a five straw samples randomly at 10, 15 and 20 days after time retting and drying by oven at 70 C^0 for 24 hours. The mean moisture content was calculated as follows:

$$M = \frac{M_{ws} - M_{ds}}{M_{ws}} \times 100 \text{ ---------- (1)}$$

Where:

M = Straw moisture content, %

M_{ws} = Wet straw weight, g.

M_{ds} = Dry straw weight, g.

3.2. Drum speed:

Speedometer was used to measure the rotary speed of the electricity motor shaft and drums.

3.3. The samples weight:

A spring Balance was used to measure the weight of samples from dry flax straw after retting operation with accuricy of 0.01kg.

3.4. The operation time:

A digital stop watch (made in Japan) was used to estimate the time.

3.5. The separation percentage:

The separation percentage estimated by using the following equation.

$$S_p = \frac{W_B - W_A}{W_B} \times 100 \quad \text{..... (2)}$$

Where

Sp = Separation percentage, %

WB = Total weight of sample before separation process, kg

3.6. Cost requirements:

Cost analysis was performed considering the conventional method of estimating both fixed and variable costs, according to price level of 2007.

Fixed costs:

The fixed costs for the modified separating machine included depreciation, interest on investment, taxes, shelter and insurance. It was calculated according to the straight-line methods described in the ASAE (1980).

$$FC = \left[\frac{P - 0.1P}{e} + \frac{P + 0.1P}{2} \times i + 0.02P\right]$$

Where:

FC = fixed cost, ---------- LE/hr

P = purchase price, ----------L.E

i = interest rate (16%).

e = expected life of the machine, ------year.

WA = Total weight of sample after separation process, kg

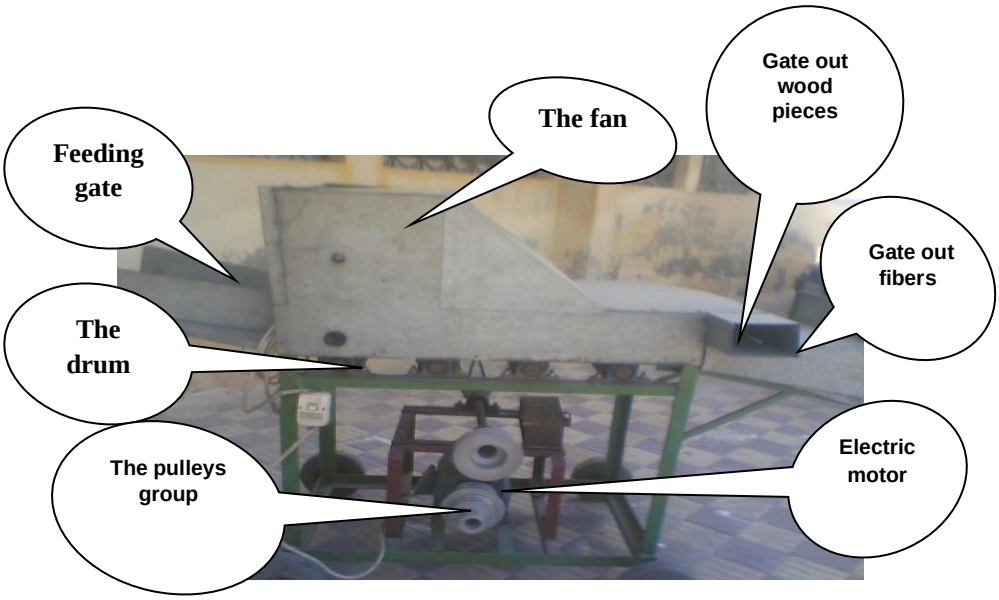


Fig. (1): The sketch of the developed machine for separation flax fiber

Fig. (2):The sketch of the factory system for separating flax fiber.

1. Variable costs:

The variable costs included repair, maintenance, electricity cost, and labor cost. They were calculated as the following assumption:

- Repair and maintenance cost = 100% of depreciation.
- Energy (electricity) cost 3.55 kW (0.39) = 1.38 L.E/hr.
- Labor cost = 5.00 L.E/hr.
- Grease and daily services = 1 % of purchase price.
- Purchase price = 9000 L.E.
- Salvage value = 10 % of purchase price.
- Interest rate = 16 %.
- Expected life of the machine = 6.00 years = 8640 hour.
- One (kW) of commercial electricity = 0.39 L.E/hr.
- Yearly operation hours = 1500 hr.

RESULTS AND DISCUSSION

1. Effect of drum speed on separating degree percentage of fiber flax:

Data in Fig. (3) Illustrate the separating percentages as affected by different drum speed. Analyses, these data revealed that, **separating degree** percentage of fiber flax have a liner relation between drum speeds and other parameters under studies. The corresponding regression equations and correlation coefficients for each individual curve are also included in Fig.(3). These results indicated that as increasing of drum speed from 1.58 to 8.21 m/s increased the separating percentage of fiber flax by (13.83, 13.78 and 14.83 %),(12.92, 14.64 and 13.85%) and (12.53, 20.77 and 25.81%) at feeding rate of 120,150 and 180 kg /hr and straw moisture content of 8.42%, 10.8% and 12.6% respectively. That result trend may due to augmentation in air stream produce from the fan and enough breaking straw especially at low straw moisture content. However the highest values of separating percentage of fiber flax 75.7% were obtained at drum speed of 8.21 m/s, while the lowest values of separating percentage of fiber flax 24.8% were obtained at drum speed of 1.58 m/s.

2. Effect of straw feeding rates on separating degree percentage of fiber flax.

Data in Fig.(4) Clarify the combined effects of feeding rates on separating degree percentage of fiber flax, and as affected by different drum speed and straw moisture contents.The regression analyses of data revealed that, separating degree percentages have a liner relation between straw feeding rates and other parameters under studies. Also, the regression equations and correlation coefficient of mentioned data are included in Fig.(4). The results indicated that, at increasing of feeding rate from 120 to 180 kg/hr, the separating percentage of fiber flax decreased by (13.83, 12.64 and 13.08%), (20.22, 19.05 and 19.57%) and (40.24, 36.79 and 33.19%) under drum speeds of 1.58, 3.52 and 8.21 m/s and straw moisture content of 8.42%,10.8% and 12.6% respectively. That result trend may due to flax straw accumulation and don't have opportunity to break straw wood. However, the highest value of separating percentage of fiber flax 75.7% were obtained at feeding rate of 120 kg/hr, while the lowest values of separating percentage of fiber flax 24.8% were obtained at feeding rate of 180 kg/hr.

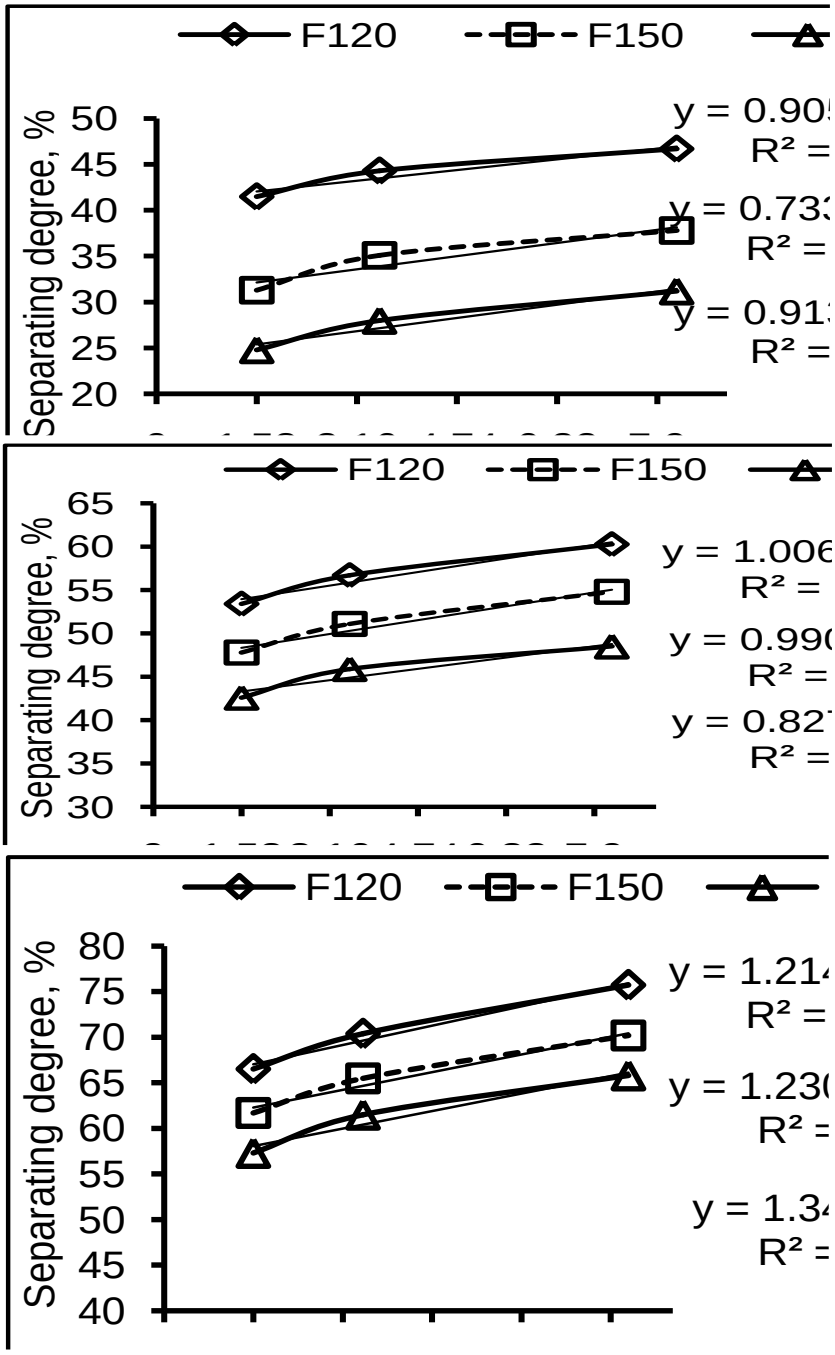


Fig. (3): The separating degree (%) of flax fibers as affected by drum speed.

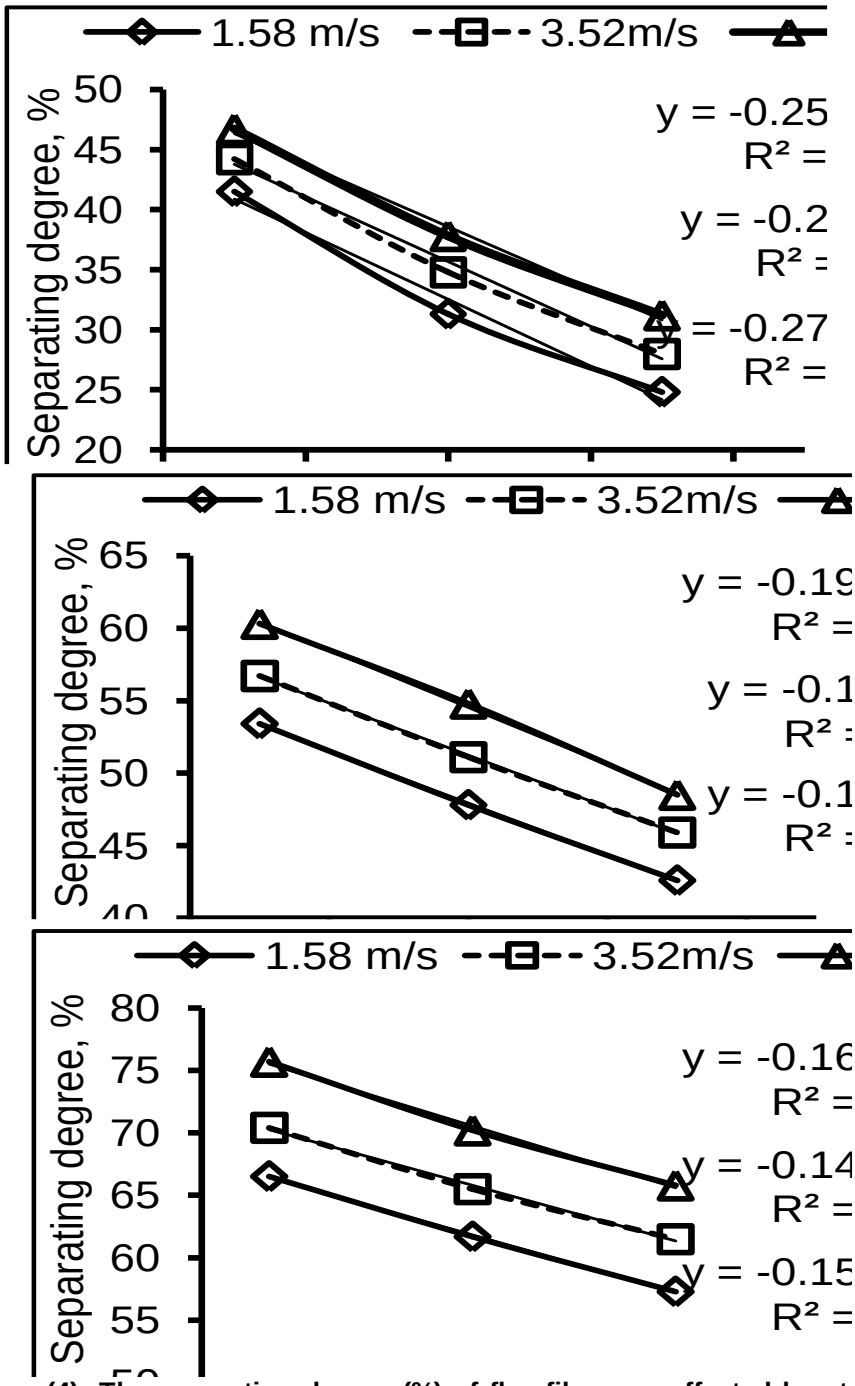


Fig. (4): The separating degree (%) of flax fibers as affected by straw feeding rate.

4. Effect of straw moisture content on separating degree percentage of fiber flax.

Data in Fig. (5) Showed the effect of different straw moisture content on separation percentage of fiber flax under different drum speed and feeding rates. The results indicated that, increasing in straw moisture content from 8.42 to 12.6%, the separation percentage of fiber flax decreased by (37.59, 37.07 and 38.31%), (49.27, 46.41 and 46.15%) and (56.72, 54.47 and 52.58%) under drum speeds of 1.58, 3.52 and feeding rate of 120, 150 and 180 kg/hr respectively. The results referred to, increasing in straw moisture content decreased the separation percentage that is due to increasing in flax straw elastic and adhesion degree between bundling of fiber and straw wood. However the highest values of separation degree percentage of fiber flax 75.7% were obtained at straw moisture content of 8.42%, while the lowest values of separation degree percentage of fiber flax 24.8% were obtained at straw moisture content of 12.6%.

4. Energy requirement (kW.h/ton):

Data in Fig. (6) showed the Power requirement (kW.h/ton) under different parameters studies. The results indicated that, at increasing of drum speeds from 1.58, 3.52 and 8.21 m/s, the energy requirement for separate one ton of fiber flax increased by (40.91, 34.47 and 29.64%), (40.38, 33.85 and 29.15%) and (39.41, 33.13 and 28.36%) under feeding rates of 120, 150 and 180 kg/hr and straw moisture content of 8.42%, 10.8% and 12.6% respectively. However, the highest values of energy requirements for separate one ton of flax fiber 106.67 kW.h/ton were obtained by manual separation at straw moisture content of 12.6%, while the lowest values of energy requirements for separate one ton of fiber flax 13.94 kW.h/ton were obtained by developed machine at drum speed of 1.58 m/s, feeding rate of 180 kg/hr and straw moisture content of 8.42 %.

5. Cost requirement (L.E/ton):

The hourly cost of separating machine was estimated by calculate a fixed and variable cost by using standard method described in the ASAE (1980).

Data in Fig. (7) Showed the cost requirement for separate one ton of flax straw (L.E/ton) under different parameters studies. The results indicated that, increasing in feeding rate from 120, 150 and 180 kg/hr decrease the cost requirement for separate one ton of straw flax by 30.40, 30.43and 30.48% under drum speeds of 1.58, 3.52 and 8.21m/s and straw moisture content of 12.6 % respectively. While at straw moisture content of 10.8% the cost requirement for separate one ton of straw flax decreased by 30.43, 30.44 and 30.50% under the same previous conditions, too at straw moisture content of 8.42 % the cost requirement for separate one ton of straw flax decreased by 30.44, 30.46 and 30.48 % under the same previous conditions. In the other side, the results indicated that, increasing in drum speed from 1.58 to 8.21 m/s increase the cost requirement for separate one ton of straw flax by 4.29, 4.24 and 4.14% under feeding rate of 120, 150 and 180kg/hr and straw moisture content of 12.6 % respectively.

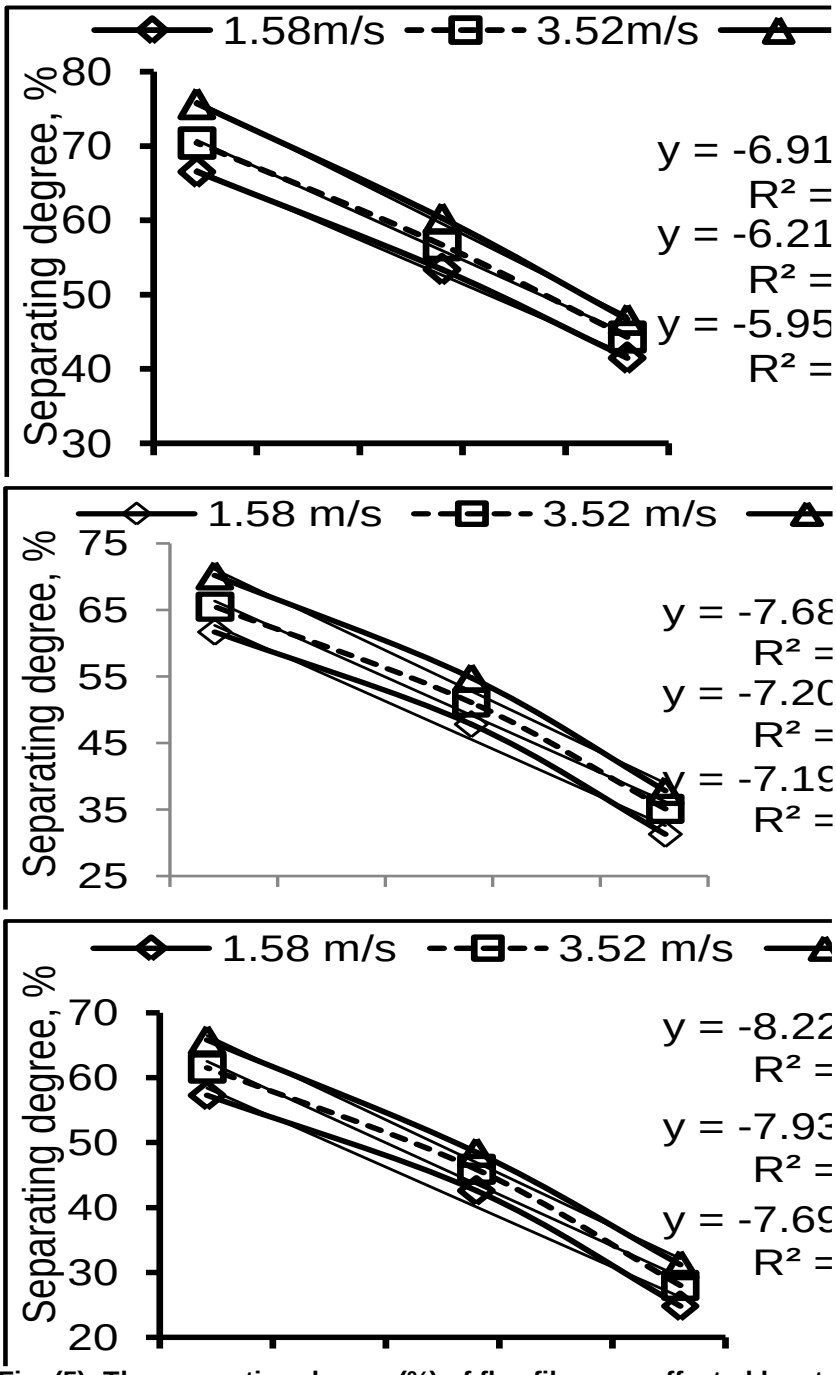
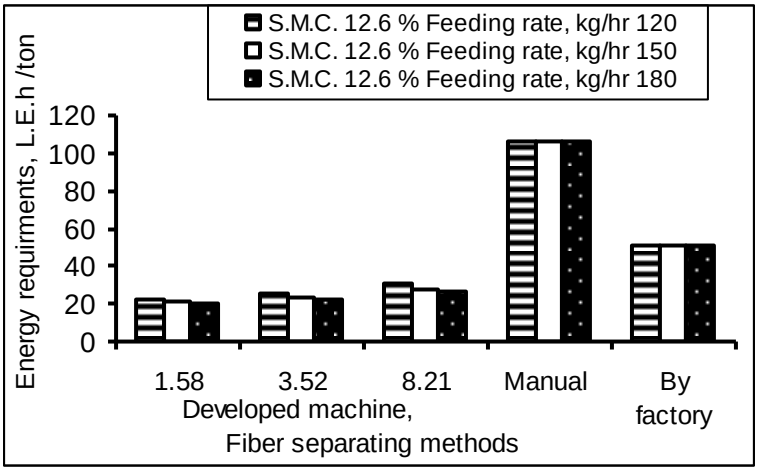
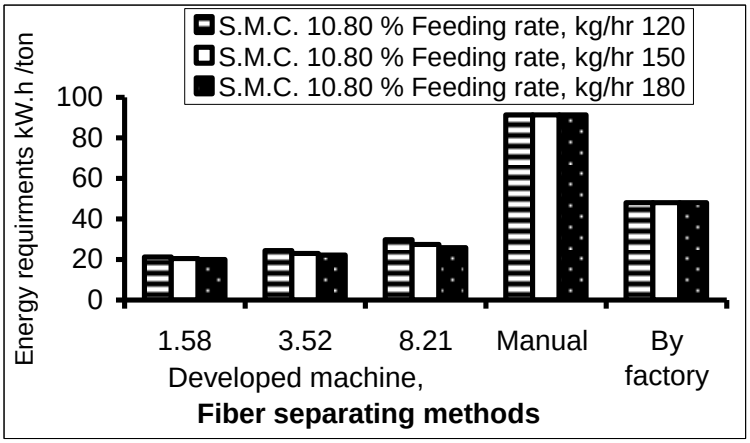


Fig. (5): The separating degree (%) of flax fibers as affected by straw moisture content





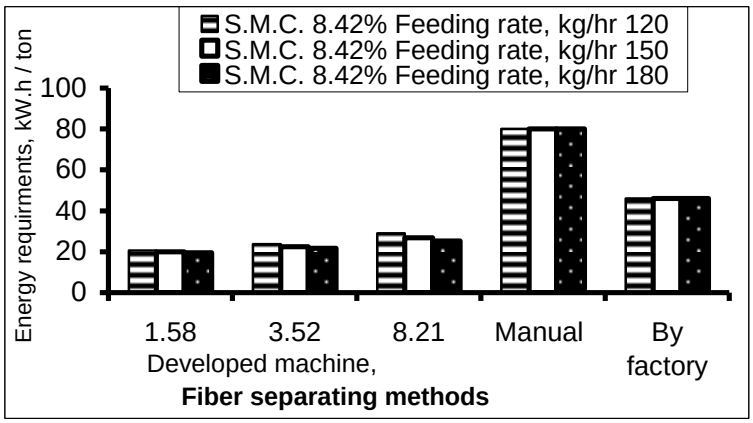


Fig. (6): Energy requirement (kW.h/ton) for separating methods under different drum speed, feeding rate and straw moisture content.

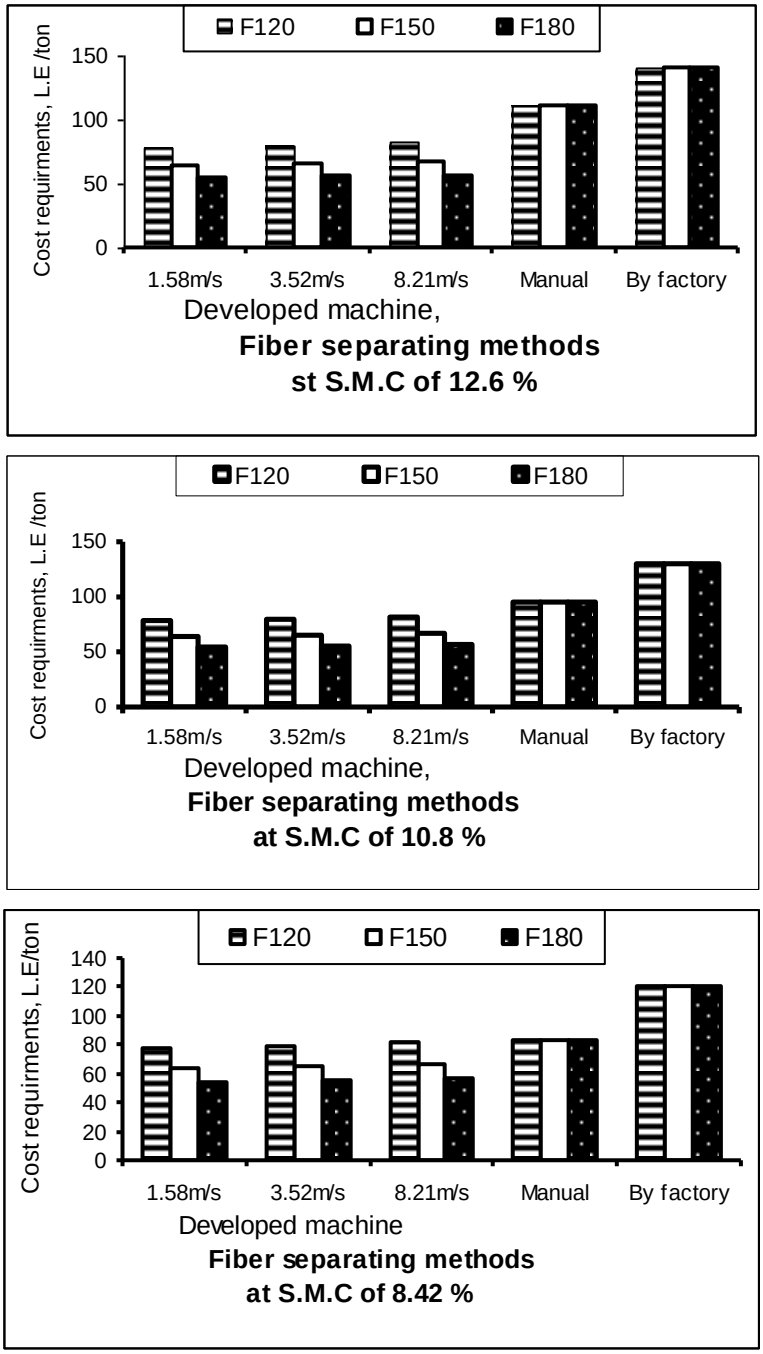


Fig. (7): Cost requirement (L.E/ton) for separating fiber flax under different parameters studies.

While at straw moisture content of 10.8% the cost requirement for separate one ton of straw flax increased by 4.26, 4.21and 4.16% under the same previous conditions, too at straw moisture content of 8.42 % the cost requirement for separate one ton of straw flax increased by 4.2, 4.19 and 4.14 % under the same previous conditions. However the highest values of cost requirement for separate one ton of straw flax 140.00 L.E/ton were obtained by factory at straw moisture content of 12.6%, while the lowest values of cost requirement for separate one ton of straw flax 54.33 L.E/ton were obtained by developed machine at drum speed of 1.58 m/s, feeding rate of 180 kg/hr and straw moisture content of 8.42%.

Conclusions

- The best performance of separating percentage of fiber flax 75.7% were obtained at drum speed of 8.21 m/s feeding rate of 120 kg/hr and straw moisture content of 8.42%.
- The lowest values of energy requirements for separate one ton of fiber flax 13.94 kW.h/ton were obtained at drum speed of 1.58 m/s, feeding rate of 180 kg/hr and straw moisture content of 8.42%
- The lowest values of cost requirement for separate one ton of straw flax 54.33 L.E/ton were obtained at drum speed of 1.58 m/s, feeding rate of 180 kg/hr and straw moisture content of 8.42%.
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REFERENCES

ASAE Yearbook Sandard (1992) Agricultural engineers year-book. ASAE. St. Joseph, Ml., S303.1, S269,S358.

ASAE (1980). Agricultural machinery management data. Agricultural Engineers year-book. ASAE, St. Joesph, MI, 49085.

Akin, D., J. Foulk, and R. Dodd. (2002) Influence on flax fiber of components in enzyme-retting formulations. Textile Res. J. 72:510–514.

Anthony,-W-S.(2002) Separation of fiber from seed flax straw. Applied-Engineering-in-Agriculture. 2002; 18(2): 227-233.

Pasila, A. (1999) The effect of frost on fibre plants and their processing. Mol. Cryst. And Liq. Cryst. 353: 11- 22. Sisäilmaohje. Sosiaali- ja terveysministeriön oppaita 1997:1. Helsinki.

Van Sumere, C. (1992) Retting of flax with special reference to enzyme-retting. p. 157–198. In: H. Sharma and C. Van Sumere (eds.), The biology and processing of flax. M Publications, Belfast, Northern Ireland.

متطلبات الطاقة والتكاليف لآلة مطورة لفصل ألياف الكتان

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تعد عملية فصل الياف الكتان من العمليات الشاقة لدى المزارع المصرى حيث تتطلب جهد وتكاليف عالية ، وبتوفرآلة مطورة لفصل ألياف الكتان تم تشكيلها وضبطها فنياً بالورشة الفنية الخاصة ، بميت على ، مركز المنصورة ، محافظة الدقهلية. وتمت الدراسة خلال موسمين زراعيين ٢٠٠٧ و ٢٠٠٨ م بمحطة البحوث الزراعية بتاج العز – مركز تمى الأمديد – محافظة الدقهلية. لتحديد متطلبات الطاقة والتكاليف تحت الظروف المثلى لتشغيل الآلة المطورة لتقدير إقتصاديات الآلة والإحتياج إليها ومدى مساهمتها فى دعم العائد الإقتصادى للمزارع المصرى. ومن هنا تمثل الهدف لهذا البحث فى تقدير متطلبات الطاقة والتكاليف لآلة مطورة لفصل ألياف الكتان تحت الظروف المثلى لعمليات الفصل والتى تم تقديرها تحت عوامل الدراسة التالية:

- ثلاث سرعات لدرافيل الفصل (١,٥٨ و ٣,٥٢ و٨,٢١ متر/ ثانية).
- ثلاث نسب رطوبة لسيقان الكتان (١٢,٦ و ١٠,٨ و ٨,٤٢ %).
- ثلاث معدلات للتلقيم (٢,٠ و ٢,٥ و ٣,٠ كجم / دقيقة).

ومقارنتها بالطريقة اليدوية وبخط فصل الالياف بالمصنع.

وأوضحت النتائج مايلى:

- أفضل درجات الفصل للألياف ٧٥,٧ % تحققت بإستخدام الآلة المطورة وعند سرعة درفيل ٨,٢١ م / ث ومعدل تغذية ٢,٠ كجم / د وعند نسبة رطوبة للسيقان ٨,٤٢ %.
- أقل قيمة لإستهلاك الطاقة ١٣,٩٤ كيلووات.ساعة/ طن تحقق بإستخدام الآلة المطورة وعند سرعة درفيل ١,٥٨ م / ث ومعدل تغذية ٣,٠ كجم / د وعند نسبة رطوبة للسيقان ٨,٤٢ %.
- أقل قيمة لتكاليف فصل ألياف ١ طن من قش الكتان ٥٤,٣٣ جنيه / طن تحقق بإستخدام الآلة المطورة وعند سرعة درفيل ١,٥٨ م / ث ومعدل تغذية ١٨٠ كجم / ساعة وعند نسبة رطوبة للسيقان ٨,٤٢ %.