THE SCREW WEAR INFLUENCE ON THE PERFORMANCE OF AN OILSEED EXPELLER

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ABSTRACT

The main objective of the present study is investigating the influence of the tapered screw hardening treatment and screw operating hours on the abrasive wear at three different zones of feeding (A), crushing (B) and pressing(C) on the screw as well as the expeller performance during the oil expression process for determining the optimum time for the screw replacement. This study was carried out to compare the performance of two types of the tapered screws, the hardened (HS) and Non-hardened (NHS) to press flax seeds during 400 h of working at the recommended operating conditions of 9% for seed moisture content, 30 rpm for screw speed and 0.4 mm for outlet clearance. The obtained results revealed that, the HS would decrease the wear after 400 h of oil expression by about 30.54, 26.22 and 35% at A, B and C zones, respectively compared to NHS. The using of HS would increase the feeding capacity, expressed oil and expression efficiency by about 6.7, 7.44 and 5.56%, respectively more than the NHS. Also, the using of HS would decrease the oil in cake, and consumed energy by about 11.75 and 6.7%, respectively compared to the NHS. Ultimately, it is suggested to make replacement to the tapered screw with a new one after 300 and 400 operating hours for the NHS and HS, respectively, this mean that, the HS may give 100 h of oil expression more than the NHS.

Keywords: *Flax seeds, expeller, tapered screw, abrasive wear, hardening, machine performance*

INTRODUCTION

Expression is the process of mechanically removing oil from contained in oilseed by using of equipment such as screw presses, hydraulic presses, roll presses and mills. The expression is less thorough but may yield both oil and meal products of high quality.

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Contrary to oil extracting systems that using chemical solvents, the residue after pressing can be used directly for human/animal food stuffs because there is no chemical contamination for the oil quality and this method ensures extraction of a non-contaminated, inexpensive protein-rich low fat cake **(Bamgboye and Adejumo, 2007)**.The mechanical extraction method is better especially for small scale production. For example, in mechanical extraction method, residual oil in the produced cake is high; so it may be considered an advantage in the rural regions because it can be used as animal feeds **(Sari, 2006).**Hence, the most widely method of extracting edible oil from oilseeds is mechanical pressing especially for small scale productions. **El-Sahrigi, *et al.* (2005)** concluded that the optimum operation conditions for the expeller machine using tapered or standard screw were found to be at 9% oil seed moisture content, 0.4 mm outlet clearance and 30 r.p.m. screw speed. They also added that the tapered screw was better than the standard screw, as it recorded expression efficiency of 84.26%, while the standard screw recorded 79.26% expression efficiency at the optimum conditions. The major part of the expression machine is the screw which is subjecting to high mechanical stress due to the oil expression is often performed at lower outlet clearance and consequently, this process could be led to high abrasive wear rates on the screw. Wear and tear on screw is usually rapid because the improper materials are used or materials are not hardened. **Neale (1995)** indicated that, the metal wear caused by hard particles like that occurs during grinding process and can be likened to a cutting or machining operation. Moreover, there is a relatively simple link between metal wear resistance and hardness. The wear phenomenon may cause severe surface damage, and this damage would be led to significant deterioration. The types of metal could be classified into the abrasive wear, erosive wear, surface fatigue, corrosive wear and fretting according to **Maleque and Salit (2013).** Treating metals with heat is an operation involving the heating and cooling of a metal or its alloys in the solid state for the purpose of enhancing its mechanical and physical properties without any change in chemical constitutes. There are several methods of heat treatments like hardening, tempering, annealing, normalizing, and spheriodising **(Khurmi and Gupta, 2005)**. The new anti-corrosive technique of polyaniline, which is an organic metal (conductive polymer) that used by (**Wessling *et al.*, 1996)** . It is based on an immense surface ennobling and the formation of a passivating metal oxide. Therefore, the main objective of this study is determining the influence of the abrasive wear of the screw and its hardening treatment on the mechanical performance of a simple oilseed expeller.

MATERIALS AND METHODS

A-Materials

The oilseed expression machine that used in this study was modified and fabricated at the workshop of Agricultural Engineering Research Institute,(AEnRI), Dokki, Giza, Egypt by **(El-Ashry, 1999),** as shown in Figs.(1,2)**.** All the practical experiments for studying the screw wear were carried out at Shobrameles village, El-Gharbia Governorate, Egypt after new press screw was installed. The most important technical specifications of the modified expression machine are shown in Table (1).

Table (1): The Specifications of the oilseed expression machine

Item	Feature
1- Screw:	Tapered
Length, cm	56
Diameter, cm	10
Pitch, cm	5
Trough depth, cm	1-1.5
Number of flights	10
Speed, rpm	30
Electric motor:	
Power, kW	7.5
Volt, V	380
Ampere, A	17
Speed, rpm	970

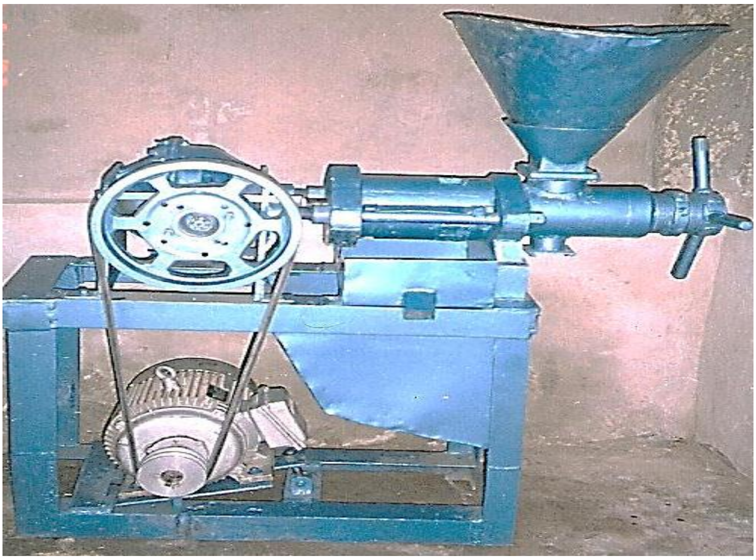
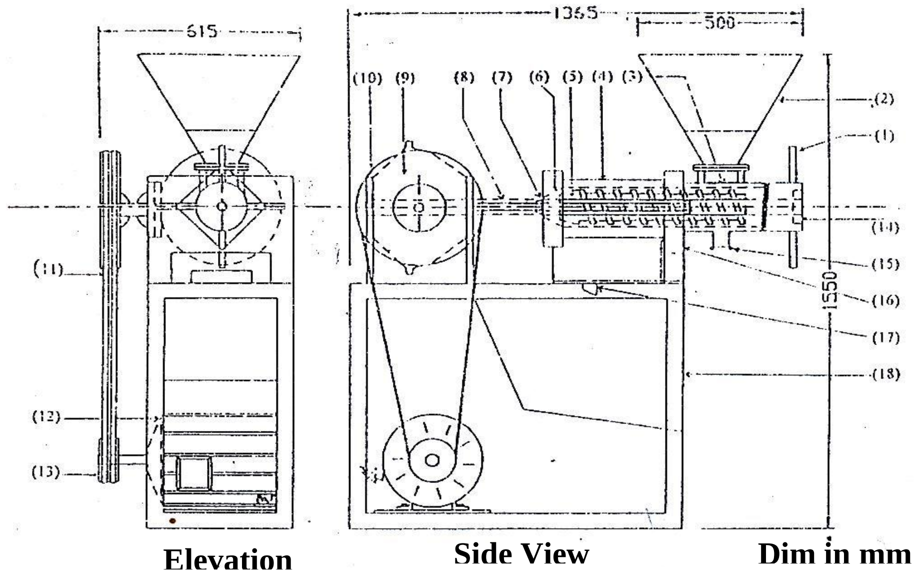


Fig.(1): The oilseed expression machine (*El-Ashry,1999*).



1.Handle lever	7.Cake discharge	13.Motor pulley
2.Feed hopper	8.Horizontal shaft	14.Bearing
3.Feed end	9.Gear box	15.Sliding plate
4.Vessel	10.Driving pulley	16.Vessel bracket
5.Pressing screw	11.V-Belt	17.Oil outlet
6.Chunk	12.Electrical motor	18.Main frame

Fig.(2): Elevation and side view of the oilseed expeller (*El-Ashry,1999*).

- Pressing screw and the hardening process:

Actually, two tapered screws were used in this investigation, one steel screw without heat treatment (Non-Hardened Screw or NHS) and the other a steel screw with heat treatment (Hardened Screw or HS), whereas the screw was heated up to 950° C then it had been quickly cooled (quenching) in a medium of brine with salt concentration of 15%.Fig. (3) illustrate the used tapered pressing screw.

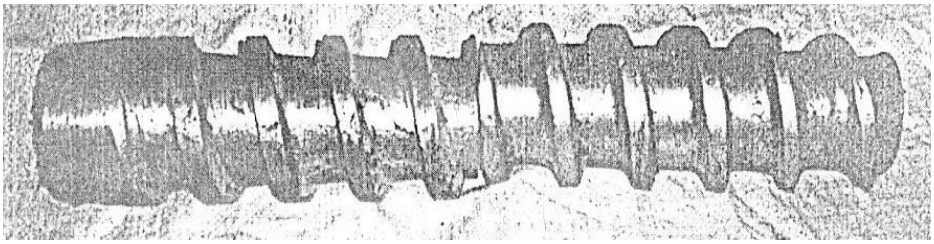


Fig.(3): The tapered screw.

- Experimental oilseeds:

Flax seeds (Variety Giza 8) was proposed to be pressed during the experimental hours (400 h) using the modified oilseed expeller at the recommended operating conditions of 30 rpm for screw speed, 0.4 mm for outlet clearance and about 9% for seed moisture content, as given by **El-Sahrigi *et al.* (2005)**.

B- Methods

The effect of the following variables on the mechanical performance and efficiency of the expeller using flax seeds as the following procedures:

1-Two types of tapered screw were used:

a) Hardened Screw (HS).
b) Non-Hardened Screw (NHS).

2- Screw operating hours (100, 200, 300 and 400 h)

3- The longitudinal wear was determined at three different zones on the outer diameter of the tapered screw of A, B and C, starting from the feed end as shown in Fig.(4) where:

A) Feeding zone
B) Crushing zone
C) Pressing zone

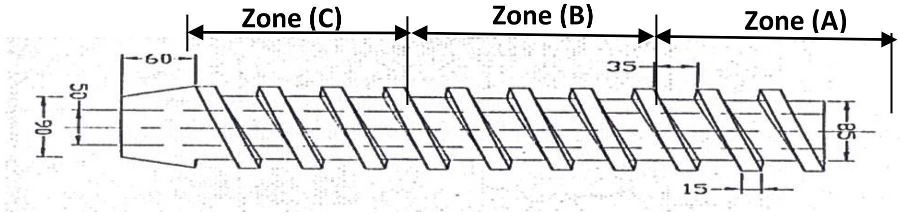


Fig.(4): The feeding, crushing and pressing zones along the tapered screw.

An average of the three replicates of this procedures was taken, then the screw wear (mm), machine productivity (kg_{oil}/h), expression efficiency (%) and energy requirement (kW.h/Mg) were estimated for each test.

-Machine feeding rate:

The machine feeding rate (kg_{seed}/h) in this study was started with 60.35 kg_{seed}/h of Flax seeds as it is considered to be the maximum capacity of the expeller to receive the seeds.

-Screw wear:

A vernier caliper with accuracy of 1/20mm was used to measure the diameter of screw after specified working hours in mm.

-Machine productivity:

Machine productivity was calculated using the following relationship:

$$Machine\ productivity\ = \frac{Me}{t} \qquad (kg_{\ oil}/h)$$

Where: Me = expelled oil mass, kg , t = time of expression process ,h

-Expression efficiency:

The oil content of Flax seeds used in this study was found to be 34%. The residual oil contents in cakes were close to the values expected from the subtraction of expressed oil from the total oil in seeds. Oil expression efficiency is defined as the ratio of the filtered expressed oil to the total oil content in the oilseeds and can be calculated as:

$$Expression\ efficiency\ (\%) = \frac{Me}{Mo} \times 100$$

Where: M_o = oil mass in oilseeds, g

- Power and Energy requirement:

Ammeter and voltmeter were used for measuring current and potential difference, respectively with an accuracy of ± 1%. The actual power of the machine (p) was calculated according to the following equation:

$$p\ (W) = \sqrt{3}\ .I\ .V.Ɖ.\ cos\,\theta$$

Where: *I*= line current strength in Amperes.

V= potential difference (Voltage), equal to 380 V

Ɖ= Mechanical efficiency (Assumed 95%)

Cos Ɵ= Power factor (was taken as 85%)

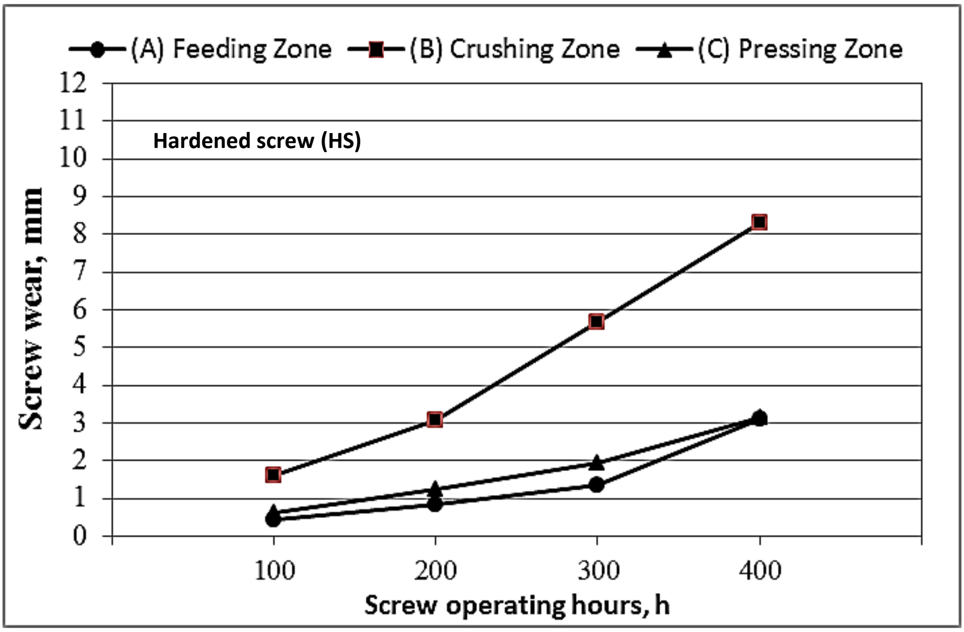
$$Energy\ requirement\ (kW.h/Mg) = \ = \frac{Consumed\ Power\ (kW)}{Machine\ \ productivity\ (Mg\ /\ h)}$$

RESULT AND DISCUSSION

The obtained results will be discussed under the following topics:

1- Screw wear:

The longitudinal wear along the screw was determined as described in the study procedures at three zones on the outer diameter of the screw namely: the feeding (A), crushing (B) and pressing (C) zones .Fig.(5) illustrate the average values of the screw wear occurred in the HS and NHS during about 400 of working hours for expelling the flax seed oil using modified oilseed expeller. The obtained results indicated that, the wear increased by increasing the operating hours of expeller, where the middle zone of B was subjected to the maximum wear while the A zone was subjected to the minimum wear . By increasing the operating hours from 100 to 400 h, the wear at zone of B increased from 3.05 to 11.25 mm and from 1.60 to 8.3 mm for NHS and HS, respectively. This may be expected because the oilseeds are conveyed in the A zone but in the middle zone of B, the seeds are flaked, so it subjected to an abrasive wear higher than another zones. After 100 h of working hours, the results show that, using the hardened tapered screw was reduced the wear by about 52.6, 47.54 and 57.14 % than using the Non-hardened tapered screw. Additionally, using the hardened screw led to decreasing the wear by about 30.54, 26.22 and 35% at A, B and C zones, respectively than the Non-hardened tapered screw after 400 h. Also, the results show that the wearing rate was increased rapidly after 300 h of working. It is obvious that, the HS gave a lower wear compared with NHS at all zones.



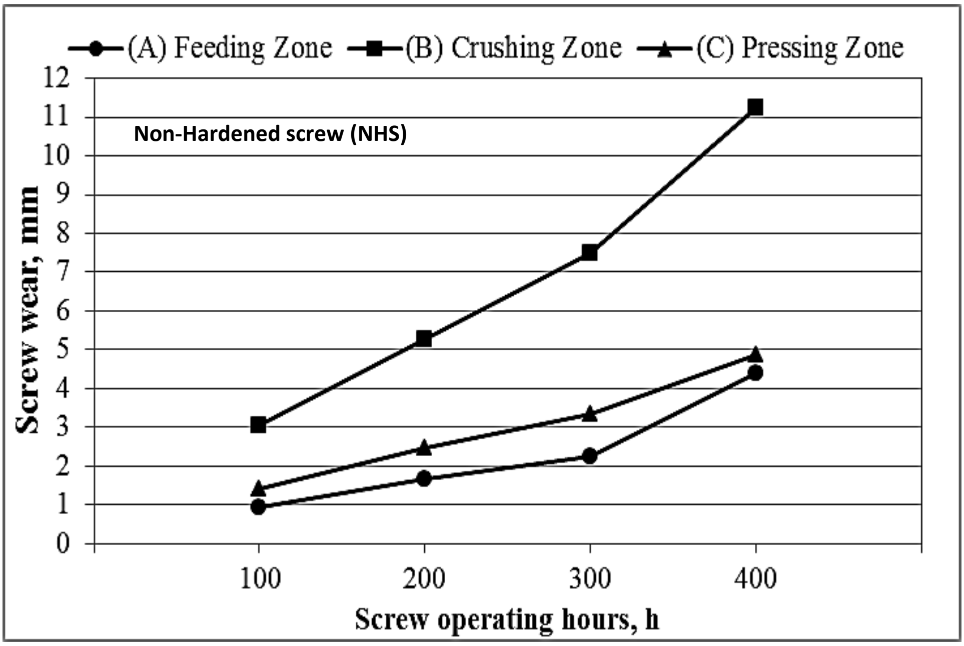


Fig.(5) : Effect of screw operating hours on the screw wear using the hardened and Non-hardened screws.

2- Machine productivity and feeding capacity:

It is no doubt that the feeding capacity affects the machine productivity which playing an important role in determining the energy requirement and consequently the total cost of the expression process. Fig.(6) illustrate the effect of the screw operating hours on the machine productivity and feeding capacity. It is obvious that, the increase of the screw operating hours will decrease both the feeding capacity and the productivity of the expeller during expression operation using the HS and NHS. The obtained results indicated that, the increase of screw operating hours from the new installation of the tapered screw to 400 h tended to decrease the feeding capacity from 60.35 to 48.45 kg_{seed}/h and from 60 to 45.2 kg_{seed}/h for HS and NHS, respectively.

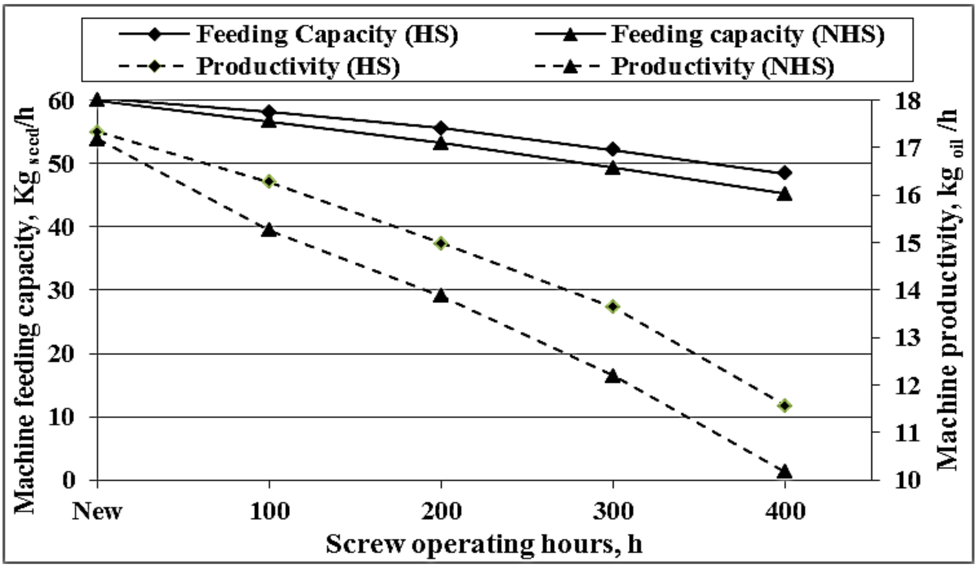


Fig.(6): Effect of screw operating hours on the machine feeding capacity and productivity using HS and NHS.

The decreasing of feeding capacity can be due to the rapid screw wearing that occurred by increasing the operating hours which may lead to decrease the ability of the machine to expel the oil causing a high accumulation of seed within the machine vessel and prevent the machine to receive more seeds. On the other hand, the increase of screw operating hours from new installation of the tapered screw to 400 h was followed with a clear decrease in the machine productivity from 17.33 to 11.56 kg_{oil}/h and from 17.88 to 10.7 kg_{oil}/h for HS and NHS, respectively. This may be expected because the decreasing of the expelling capability will reduce the mass of the expressed oil. From previous discussion, the HS gave best values for the machine feeding capacity and productivity compared to the NHS. Ultimately, it was found that the expeller has the ability to expel the oil from about 18 Mega gram of seeds during 300 h of working.

3-Oil in cake and expression efficiency:

Fig.(7) display the effect of screw operating hours and hardening treatment of screw on the oil in cake and expression efficiency. The obtained results revealed that, increasing the screw operating hours tends to increase the oil in cake and decrease the oil expression efficiency during expression operation using the HS and NHS. The data revealed that, increasing screw operating hours from the new installation of screw to 400 h causes a clear increase for the oil in cake from 15.53 to 29.79 kg_{oil}/h and from 15.76 to 33.76 kg_{oil}/h for the HS and NHS, respectively. This was followed with an apparent decrease in the expression efficiency from 84.47 to 70.21% and from 84.24 to 66.24% for the HS and NHS , respectively. This can be attributed to the screw wear which leads to decrease the discharge pressure and increase the slippage amount occurred inside the machine vessel that consequently tends to increase the retention time of oilseeds within the expeller in addition to the decrease of the expelled oil mass. It is clear that, the using of HS gave the lower amount of oil in cake and the higher percentage of the expression efficiency compared to the NHS, where the expression efficiency using the HS after 400 h of operating (70.21%) was very close to expression efficiency using the NHS after 300 h of operating (70.44%). These results can be attributed to capable it of the tapered HS to generate a much higher pressure than the tapered NHS resulting in increasing the expression efficiency. Generally, the hardened screw may give 100 h of oil expression more than the Non-hardened one.

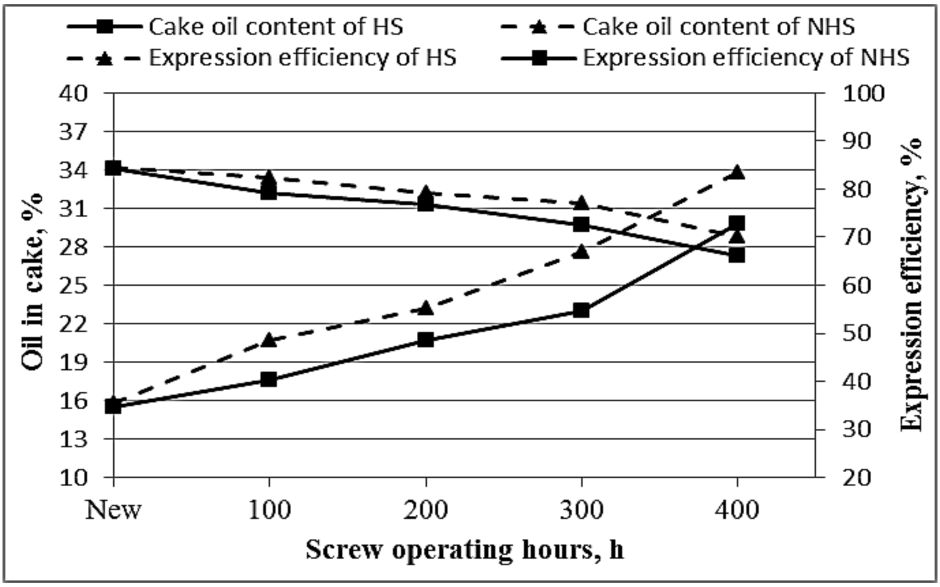


Fig.(7): Effect of screw operating hours on the oil in cake content and expression efficiency using HS and NHS.

4-Energy requirement:

The energy requirements depend upon the consumed power as well as the machine productivity. As shown in Fig.(8), increasing the screw operating hours tends to increase the energy requirement for expression operation using the HS and NHS. The obtained results indicated that, when the screw operating hours increased from the new installation of screw to 400 h would be led to increase the energy requirement from 68.77 to 85.66 kW.h/Mg and from 69.17 to 91.81 kW.h/Mg for HS and NHS, respectively. This increase in the energy requirement could be due to the increase in the stuffed oilseed within the expeller because of the rapid wearing in pressing screw resulting in increasing the power consumed and decreasing the machine productivity. Generally, the energy requirement values using of HS gave lower values than the NHS. It was noticed that, the lowest value for the energy requirement of 68.77 kW.h/Mg, while the highest value for the energy requirement of 91.81 kW.h/Mg was recorded after 400 hours of working using the NHS. Hence, it is necessary to replace the tapered screw with a new one after about 300 h of working to prevent the deterioration which may occur in the mechanical performance and the economical aspects of the expeller.

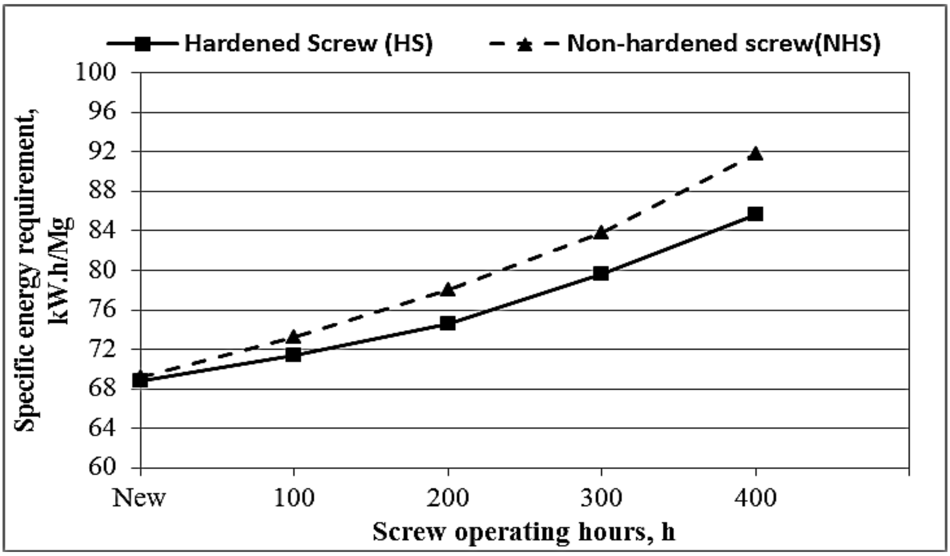


Fig.(8): Effect of screw operating hours on the energy requirement using the HS and NHS.

CONCLUSION

The obtained results revealed that, the tapered hardened screw (HS) would decrease the wear after 400 h of oil expression by about 30.54, 26.22 and 35% at feeding, crushing and pressing zones, respectively compared to the tapered Non-Hardened screw(NHS).The using of HS would increase the feeding capacity, expressed oil and expression efficiency by about 6.7, 7.44 and 5.56%, respectively more than the NHS. Also, the using of HS would decrease the oil in cake, and consumed energy by about 11.75 and 6.7%, respectively compared to the NHS. Ultimately, it is suggested to make replacement to the tapered screw with a new one after 300 and 400 operating hours for the NHS and HS, respectively, this mean that, the hardened screw may give 100 h of oil expression more than the Non-hardened one.

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الملخص العربي

تأثير التآكل في البريمة علي أداء معصرة البذور الزيتية

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الهدف الرئيسي لهذة الدراسة هو تقدير تأثير التقسية الحرارية وعدد ساعات التشغيل علي كل من تآكل بريمة معصرة الزيت الحلزونية المدببة في ثلاثة مناطق متساوية بطول البريمة وهي التغذية، السحق، الضغط والآداء الميكانيكي للمعصرة لتحديد موعد الإحلال الزمنى الذى يجب عندة عمل الإحلال للبريمة

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وذلك من خلال مقارنة أداء بريمتين من النوع المدبب أحدهما مقسي حرارياً و الآخر غير مقساه أثناء عصر بذور الكتان في فترة زمنية مقدارها ٤٠٠ ساعة تشغيل عند ظروف تشغيلية موصي بها وهي ٩% لرطوبة البذور، سرعة بريمة ٣٠ لفة/د و ٠,٤ مم لخلوص رأس المعصرة. و قد أوضحت النتائج أن بعد ٤٠٠ ساعة تشغيل فإن البريمة المقساه قد خفضت التآكل بنسب تقدر بحوالي ٣٠,٥٤ ، ٢٦,٢٢ ،٣٥% لمناطق التغذية، السحق، الضغط علي الترتيب مقارنة بالبريمة الغير مقساه. كذلك أشارت النتائج إلي أن إستخدام البريمة المدببة المقساه قد أدي إلي زيادة كل من سعة التغذية والزيت المستخلص و كفاءة العصر بنسب تصل إلي ٦,٧٠ ، ٧,٤٤ و ٥,٥٦ % علي الترتيب، و أيضاً خفض كل من زيت الكسب والطاقة المستهلكة في عملية العصر بنسب تصل إلي ١١,٧٥ و ٦,٧٠ % علي الترتيب، مقارنة بإستخدام البريمة المدببة الغير مقساه. أخيراً توصى الدراسة بإحلال البريمة المدببة المقساه بأخري جديدة بعد ٤٠٠ ساعة تشغيل و البريمة المدببة الغير مقساه بعد ٣٠٠ ساعة تشغيل ، و هذا يعني أنه يمكن استخدام البريمة المدببة المقساه لمدة ١٠٠ ساعة تشغيل أكثر من البريمة المدببة الغير مقساه.