DEVELOPMENT AND EVALUATION OF AN CRACKING APRICOT STONE MACHINE

Tayle,S.A*, EL Nakib,A.A*, Zaalouk,A.K, Ahmed,A.N*****

ABSTRACT

The main objectives of this research are to study feasibility of cracking machine for apricot pit cracking and select the optimum conditions for operating it .Cracking machine performance was investigated as a function of change in cracking cylinder speeds of 120, 180, 240, 300and 360 rpm, space between the cylinders (clearance) 6, 7, 8, 9 and 10 mm and apricot pit moisture contents 8, 15 and 19 %. The results revealed that, optimum operations conditions were obtained at 240 rpm cracking cylinder speed, space between the cylinders (clearance) of 8 mm and average moisture content 8% . At this level the cracking efficiency of 90 %, the percentage uncracked of 5 % the mechanical damage of 5 %, consumed energy of 48 kW.h / ton and cost of cost 200 L.E/ton .

INTRODUCTION

Apricot (*Prunus armeniaca* L.) is classified under the prunus species of Prunaidea sub-family of the Rosaceae family of the Rosales group.

Apricot has an important role in human nutrition and apricot fruits can be used as fresh, dried or processed fruit. It can be made into juice, marmalade, jam, and jelly. **(Gezer et al., 2002)**

The stone of apricot are used in the production of oils, Benz al de Hyde, cosmetics, active carbon, aroma perfume, and food after remove glycoside amygdaline, **(Vursavus and Faruk 2004)**

In Egypt the annual production apricot about 78500 tons apricot stone from this production, Most of the apricots are produced in Al-Qulybia and Al-Fayome. (**FAO2007**).

Important applications of activated carbons are related to their use in water and industrial wastewater treatment for removal of flavor, color, odor and

*** Prof. Emeritus of Ag. Eng. Dep., Fac. of Ag. Al-Azhar Uni. –Cairo, Egypt.**
**** Assistant Prof. of Ag. Eng. Dep., Fac. of Ag. Al- Azhar Uni. –Cairo, Egypt.**
***** An Agric . Eng.**

other undesirable organic impurities. Activated carbon has found increasing application in the field of hydrometallurgy, especially in the recovery of gold and silver from cyanide solutions (**Dorbrowksi 2001**). Cracking apricot stones by hand is a time consuming and a difficult task.

Kittichai (1984) developed a power- operated groundnut (peanut) sheller. He found that, the best performance of the shller was achieved at 20 mm clearance and shelling bar speed of 180 r.p.m . At these parameters the capacity, shilling efficiency and percentage of breakage were 210.5 kg kernels /h, 98 % and 5.3 % respectively. The power consumption of the sheller was about 1.0 to 1.1 kW.

Duraisamy and Manian (1990) developed a hand and power operated castor bean sheller . The output and shelling efficiency of power and hand operated castor bean sheller were 163 kg and 52.65 kg, 97.29 % and 98.72 %with kernel breakage of 0.82 % and 0.88 % respectively .

Simmons (1995) invention that achieves these and other objects by providing a nutcracker that includes a pair of spaced-apart rollers having a gap there between which is slightly narrower than the diameter of the nuts to be cracked. Nuts, such as s pecans, are fed through the gap between the rollers and cracked as they are compressed between the rollers. Each roller has an outer gripping surface to engage the nuts and help feed the nuts into the gap. The outer surfaces of the two rollers rotate at different speeds, thereby rotating the nuts as they pass through the gap. This speed differential and resulting rotation of the nuts spreads be cracks around substantially the entirety of the shell. The nuts are then much more easily opened. In the preferred embodiment of the invention, the apparatus includes two counter-rotating rollers of approximately the same diameter. The rollers are rotated by a drive system so as to feed the nuts into die gap. However, one of the rollers is rotated at a greater angular velocity than the other roller. Alternately, two rollers of different diameters could be provided and rotated at the same angular velocity. The outer surface of the roller with the greater diameter would therefore move at a greater speed than the outer surface of the smaller roller. With either configuration, the difference between the outer surface speeds of the two rollers can be varied depending on the type of nuts being cracked .The outer surfaces of the rollers are preferably covered with a gripping material such as grit non-slip resin-bonded abrasive material forming a gripping layer..

Inan (2001) reported that the machine was motivated by a redactor and in the latter design, V-belt was used for the same purpose. The back and forth movement of the mobile jaw was provided with the cam system which in turn was motivated by the shaft. A bevel gear that was also connected to the same shaft was used to provide motion to another bevel gear. The shaft of the second bevel gear was connected to another cam which provided vibrating motion to apricot stone collection container. By this mechanism, the apricot stones were made to fall into the cylindrical container, which collects the stones before the stones fall between the jaws and sends the stones into the jaws after the cracking. The stones pressured from two sides between the jaws are cracked and by the backward motion of the mobile jaw, the cracked stones fall into the collection container and the cracking process is completed. An adjustment screw placed underneath the immobile jaw is used to adjust the clearance between the jaws and ideal clearance for optimal cracking efficiency is determined.

The main objective of the present research is to the study the following

- To design and manufacture apricot stone cracking machine.
- To evaluate the performance of the machine under different operation conditions.

MATERIALS AND METHODS

This study was carried out at the Agricultural Engineering Department, Faculty of Agriculture Al-Azhar University; during the years 2007 to 2010.

1- Material.

1.1 Variety Apricot stone:

The variety Alamar was used in this study.

1.2 Apricot stone cracking machine:

The cracking machine was made from local material.It was manufactured installed and tested at workshop of Agric. Eng. Department, Faculty of Agriculture, AL-Azhar University. Fig. (1) Show an elevation, and side view of apricot stone cracking machine dimensions and details, and Fig. (2) Show elevation, and side view (photograph):

-Frame:

The overall frame is constructed from steel angles (50x50x5) mm that welded together to format common frame. The frame dimensions (length, width and height) were (42, 41 and113 cm) respectively. All parts of the machine are mounted and assembled on the frame

-Hopper:

It was designed and manufactured to feed the apricot pits into cracking unit. It is made of cardboard sheet 5mm thick. The dimensions of the hopper top were (35x41) cm and the bottom was (10x41) cm with the height of 40 cm. The sides of the hopper have gradual slope depending on the coefficient friction of the cardboard sheet was (0.77) was used to construct the hopper sides. It was increased and considering to allow sliding of apricot pits. To operate the cracking machine, the hopper base gate opining is shut completely by means of the flow rate control device. The gate opening that delivers the desired feed rate which selected using the flow rate control device and apricot pit are allowed to flow into the cracking. The hopper fixed on main frame using four steel bolts. The capacity of the hopper was used is $0.1 m^3$ which was 50kg dipping on the bulk density of the apricot stone

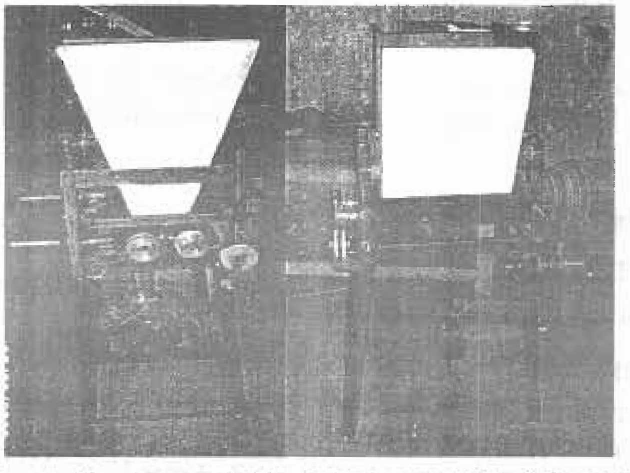

Fig. (1) Elevation and side view photographs of the apricot *stone cracking machine*

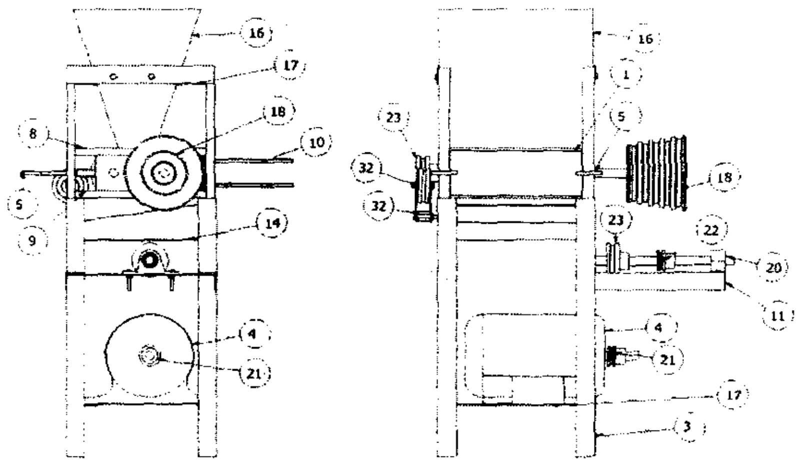

Fig. (2) Elevation and side view detail of the apricot stone cracking machine

1	roller	13	drive pulley
2	springs	14	collector
3	lower main frame	15	driven pulley
4	electric motor	16	feeding box
5	power screw	17	stand for electric motor
6	upper main frame	18	multi pulley(5 belt)
7	bearing house	19	axe 25 mm
8	upper bar	20	bearing
9	lower bar	21	Pulley diam.60 mm
10	screw springs	22	Pulley diam. 60 mm
11	stand for bearing & pulley	23	Pulley diam. 100 mm
12	adjustable pulley		

Source of power:

The power source utilized in this machine is an electrical motor of 1.22 kW, with rotating speed of 1400 rpm and a potential difference 220V. Depinding on the rapture force $\simeq$ 1400 N and the diameter of cracking cylinder was choose 11 cm . The suitable power for cracking cylinder was 960 W and the power of motor was used about 1.22 KW. The power is transmitted from the source to the machine by means of pulleys and V-belt. The pulley assembled on the driver shaft of the motor is 2.5 cm diameter with pulley of 4.5 cm diameter attached each other by single V-belt to produce the suitable of the cracking unit.

-cracking unit:

Cracking unit component constructed from:

a- Two cylinders (drive cylinder – driven cylinder).
b- Two bearing house for each cylinder.
c- Four springs mounted on driven cylinder.
d- Two power screws are used to adjust the clearance between the cylinders.

The cracking unit is set on two cylinders each one of thin are supported on two adjustable bearings, which are attached on the main frame which bolts. The cylinder is a cylindrical 11cm diameter fabricated from steel cylinder. Depending on the max thickness of apricot stone pit 13 mm and max thickness of apricot stone kernel 6.3 mm. The clearance between the cylinders was allowed to be adjustable from 6 to 10 mm.

2- Measuring instruments:

Evaluation of apricot stone cracker

-Cracking efficiency:

Cracking efficiency of the mechanical cracker was estimated according to the following formula:

The Un-Cracking efficiency:

The total count output of the un-cracking percentage (L_u) of each one was calculated. by the following formula:

The damaged efficiency:

The total count output of the damaged percentage (L_d) of each one was calculated. By the following formula:

$$L_d = \frac{W_d}{W} \times 100 \text{ -------------------------------- } (1)$$

Where:

E = Cracking efficiency percentage.
L_u = un-cracking percentage
L_d = damaged percentage
W_u = Total of count un-cracking apricot pits.
W_d = Total of count damaged apricot kernel.
W = Total of count sample.

-Estimation of power consumption and energy requirement:

Both ammeter and voltmeter were used for measuring current strength and potential difference respectively, before and during cracking.

The total costumed electric power under machine working load (P) was calculated according (Iockwood and Denstan, 1971) by the following equation.

Total consumed power (load power)

$$= I.V.\mu.\cos\theta / 1000 \quad KW \text{ --------------- } (2)$$

No. Load power

$$= I.V.\mu.\cos\theta / 1000 \quad KW \text{ --------------------- } (3)$$

Useful power = (load- no load)

Where:

I=line current strength in amperes

V= potential difference voltage being equal to 220 V

Cos Θ= power factor (being equal to 0.85)

η= efficiency (0.95)

Productivity

Machine production: time of cracking was measured by means of a stopwatch to determine the machine production in kg/h

$$\text{Productivity} = \frac{\text{wight of apricot stone}}{\text{time of chopping}} \text{ -------------------- } (4)$$

Specific energy requirements

The specific energy requirements in kW.h/kg were calculated by using the following equation:

$$\text{Specific energy requirements} = \frac{\text{Power (kw)}}{\text{Production}(\frac{kg}{hr})} \text{ ---------- } (5)$$

Cost analysis and statistics:

The mechanical cracked economical and financial analysis were carried out calculating the following parameters, The methodology of estimating spraying costs (LE/h) was as follow **(Hunt,1983)**.

Total cost (LE/h) = Fixed cost (LE/h) + Variable cost (LE/h) ......(6)

1 - Fixed costs:

Depreciation:

Declining Balance Method was used for estimating the depreciation (hunt, 1983). In this method the value of depreciation was different for each year of the machine's life.

$$D = V_n - V_{n+1} \text{ ---------------------------- } (7)$$

$$V_n = P(1 - \frac{X}{L})^n \text{ --------------------------- } (8)$$

$$V_{n+1} = P(1 - \frac{X}{L})^{n+1}$$

Where:

D = Value of depreciation charged for year (n + 1).

P = Purchase price in L.E.

L = Time between buying and purchasing, year.

n = Number representing age of the machine in years at beginning of year (A+1)

V= remaining value at any time .

X = Maximum rate depreciation =1.5

Interest on investment, Sheller, taxes and insurance:

Interest on investment, shelter, taxes and insurance (ISTI) was estimated to be 17.5% oil the remaining value (Hunt, 1983).

ISTI=V x 0.175 LE/Yr ---------------------------- (9)

2. Operating costs:

a- Repairs and maintenance (R+M)

For machinery is about 5.77% of purchase price

b-Electric cots:

Total power consumed (Iockwood and Denstan, 1971).

(W) = V.I.µ.cosΘ

Where:

V = Potential difference, volt I = Current strength, ampere

CosΘ = Coefficient of utilized power (0.85),

µ = Mechanical efficiency of motor, assumed (95%).

c -Lubricant cost:

d- Labour cost

$$Operation\ cost\ LE/kg\ = \frac{machine\ cost\ LE/h}{actual\ machine\ production\ Kg/h} \text{ ---- } (10)$$

3 -Experimental procedure

The experiments were carried out to optimize some operating parameters affecting the performance of apricot stone cracking machine, these parameters are the following:

1- Five drum rotation speed of 120,180,240,300 and 360 rpm
2- Three level of grain moisture content of 8,15 and19 %
3- Five drum clearances of (6,7,8,9 and10)mm

The levels were chosen after reviewing the trials of researches carried out either locally or in other countries

Reflects all technical aspects of performance of apricot stone cracks taking into account all purpose and usage of the produced stone.

The output of the apricot stone cracker was balanced and classified into:

1. Un-cracked stone : stones that are not split or broken.
2. Cracked stone : split, skin slippage and broken stone.
3. Damaged stone : broken and intact pit.

This criteria were used to determine and calculations the cracking and separation performance for all treatments.

RESULTS AND DISCUSSIONS

Un-cracked and damaged apricot stone:

The un-cracked apricot stone as well as damaged apricot stone are affected by many parameters such as Cracking cylinder speed, clearance and apricot stone moisture content.

1- Effect of cracking cylinder speed on un-cracked and damaged:

Relating to the effect cracking cylinder speed on the percentage of un-cracked stone, result's Fig. (3) and (4) show that increasing cracking cylinder speed from 120 to 240 rpm decreased the un-cracked stone and increased the damaged under all experimental conditions then start's to increase again with increased of cracking cylinder speed from 300 to 360 rpm for un-cracked and damaged .Increasing cracking cylinder speed from 120 to 240 rpm under constant clearance of 8 mm and various apricot stone moisture content 8, 15 and 19/% decreased the percentage of un-cracked from 42 to 5, 37 to 9 and 38 to 6% respectively. While the vice-versa noticed with the damaged kernel . Increasing cracking cylinder speed from 120 to 240 rpm under constant clearance of 8 mm and various apricot stone moisture content 8, 15 and 19/% increased the percentage of un-cracked from 3 to 5, 11 to 19 and 15 to 24% respectively.

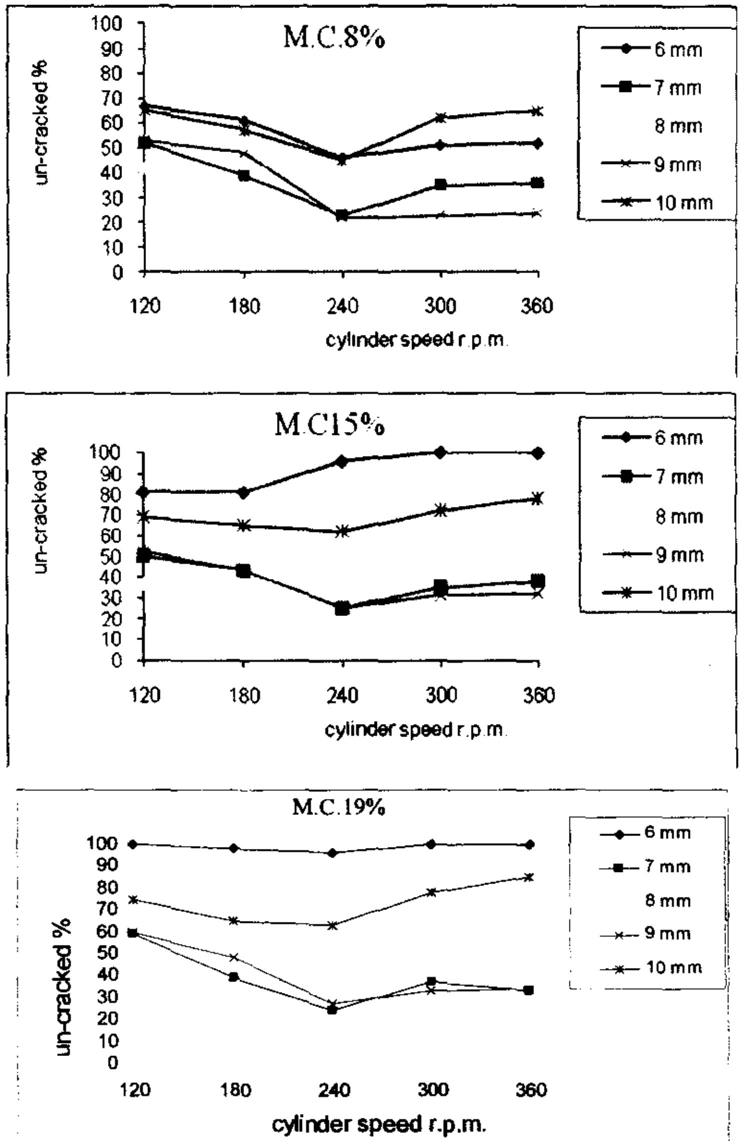

Fig. (3) Effect of cracking cylinder speed, clearance and moisture content on un-cracked

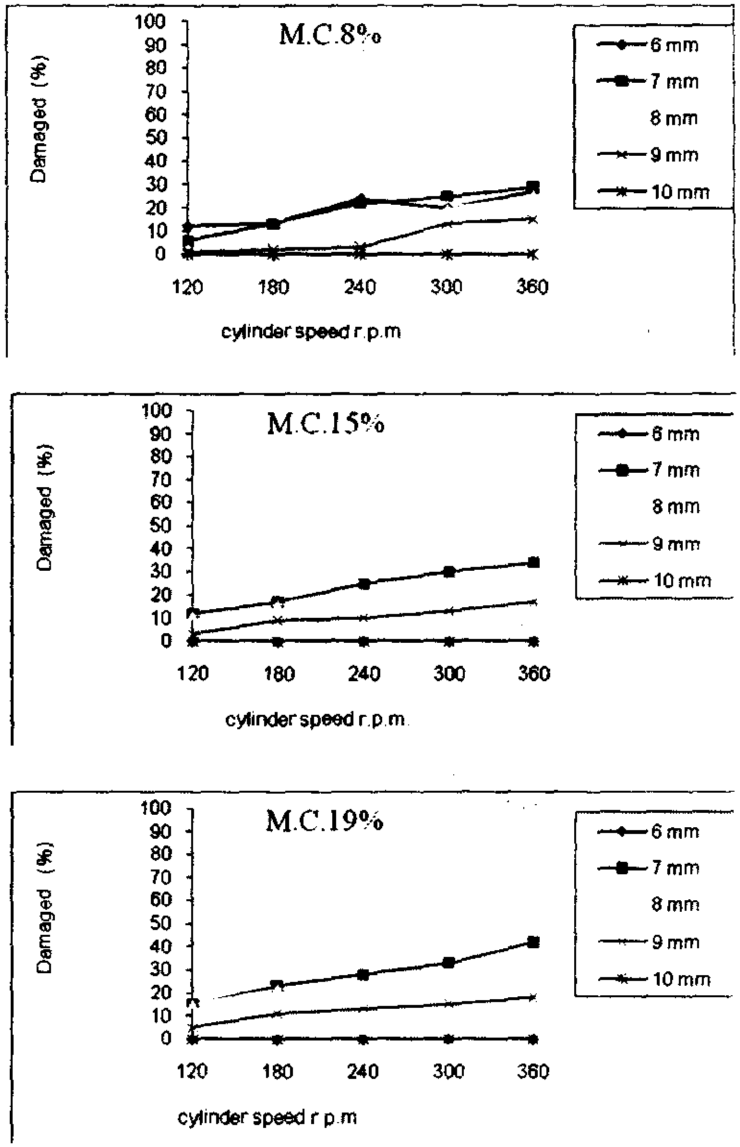

Fig. (4) Effect of cracking cylinder speed, clearance and moisture content on damaged

2-Effect of clearance on un-cracked and damaged stone :

The effect of clearance on the percentage of un-cracked stone, are shown Fig. (5) and (6). Increasing clearance from 6 to 8 mm decreased the percentage of un-cracked stone and damaged under all experimental conditions. However it increase again with increasing of clearance from 9 to 10 mm.

Increasing clearance from 6 to 8 mm at cracking cylinder speed of (120-180-240-300-360 rpm and various apricot stone moisture content of 8,15 and 19% decreased the percentage of un-cracked stone from (67 to 42), (61 to 35), (46 to 22) , (81 to 37) , (81 to 25) and (96 to 9) respectively.

While increasing clearance from 9 to 10 mm under at different cylinder speed and different moisture content increased the percentage of un-cracked stone.

While increasing clearances from 6 to 10 mm decreased the percentage of damaged stone at all cylinder speeds and different moisture content.

3-Effect of cracking cylinder speed on cracking efficiency:

The effect of cracking cylinder speed on the percentage of cracking efficiency, are shown in Fig. (7) and (8). Increasing cracking cylinder speed from 120 to 240 rpm increased the cracking efficiency under all experimental conditions, after that decreased again with increasing of cracking cylinder speed from 300 to 360 rpm. Increasing cracking cylinder speed from 120 to 240 rpm at constant clearance of 8 mm and various apricot stone moisture content 8, 15 and 19/% increased the percentage of cracking from 55 to 90, 52 to 72 and 47 to 70% respectively.

These results may be due to increasing the impact action of the cracking cylinder on the apricot stone.

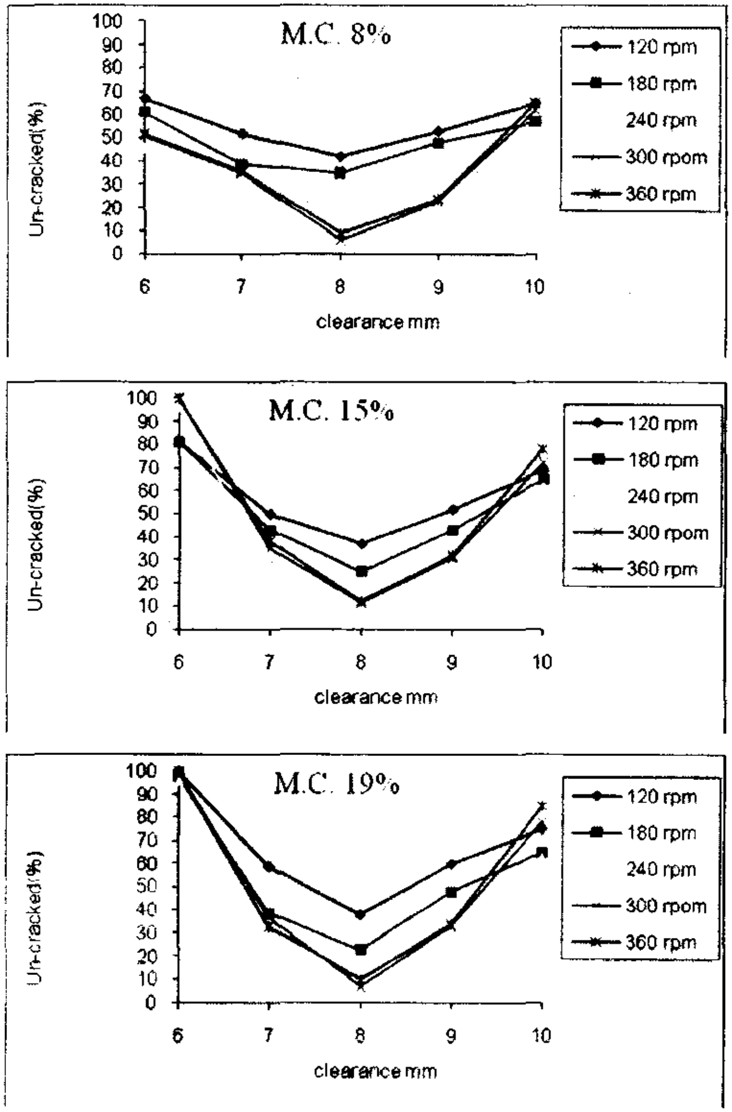

Fig. (5) Effect of cracking cylinder speed, clearance and moisture content on un-cracked

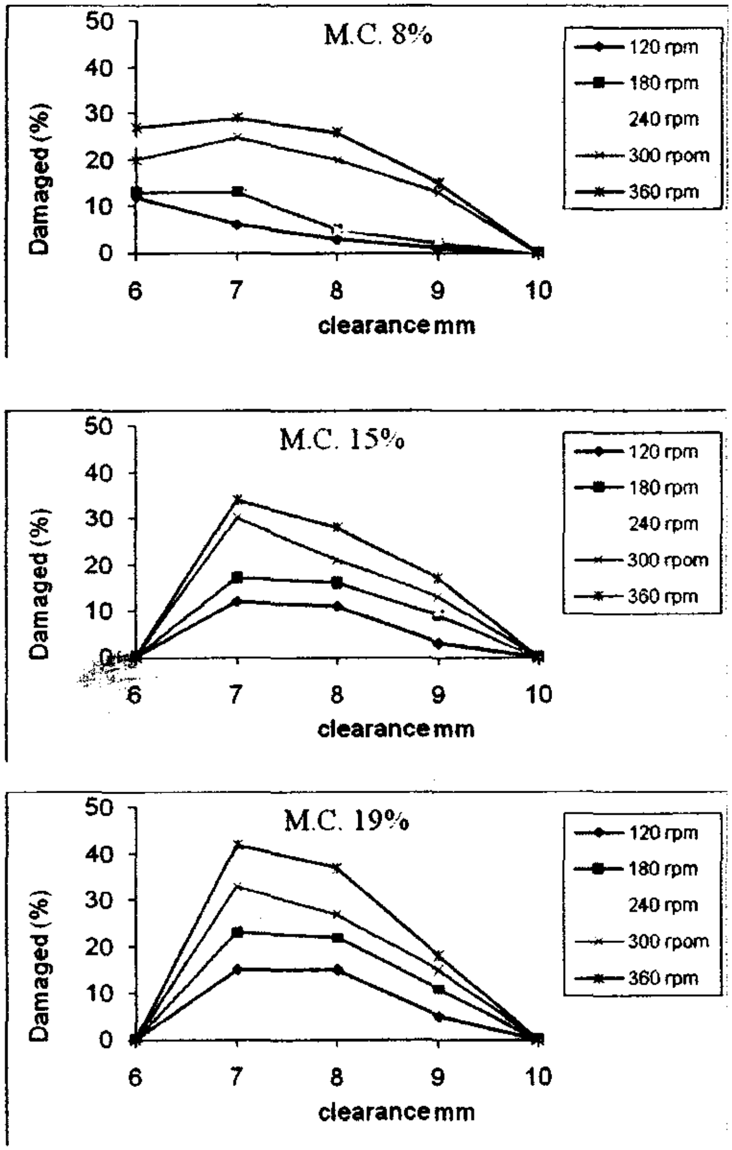

Fig. (6) Effect of cracking cylinder speed, clearance and moisture content on damaged

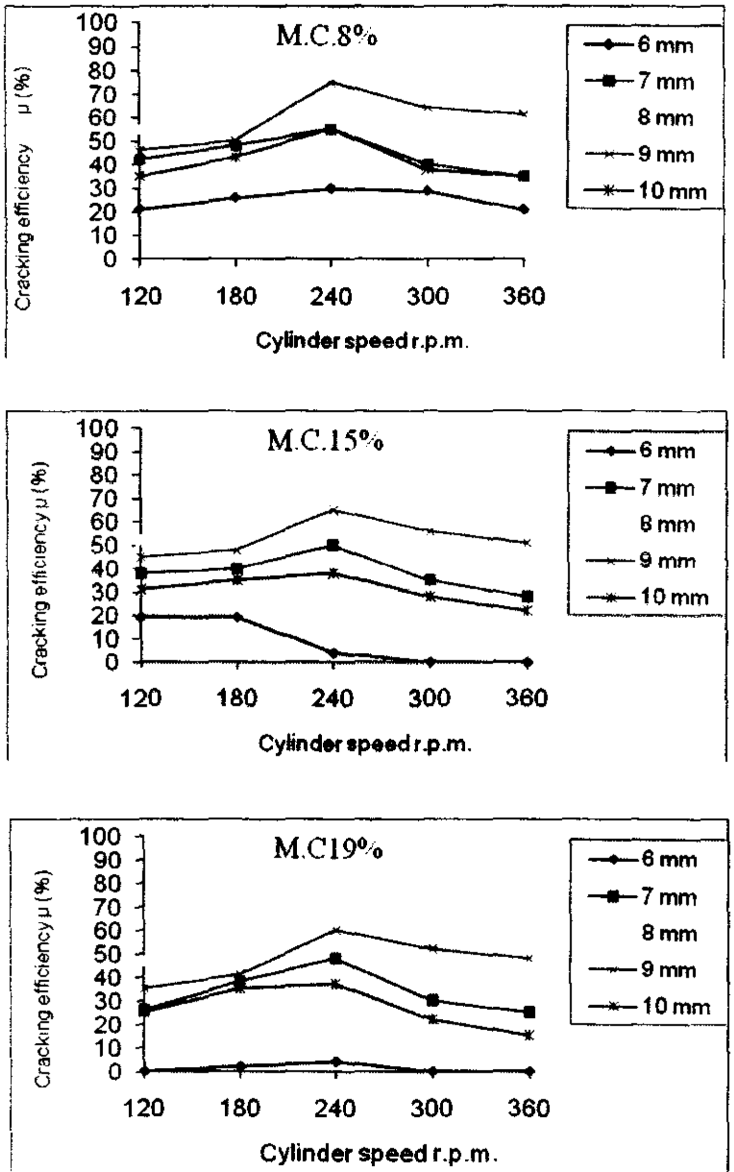

Fig. (7) Effect of cracking cylinder speed, clearance and moisture content on cracking efficiency.

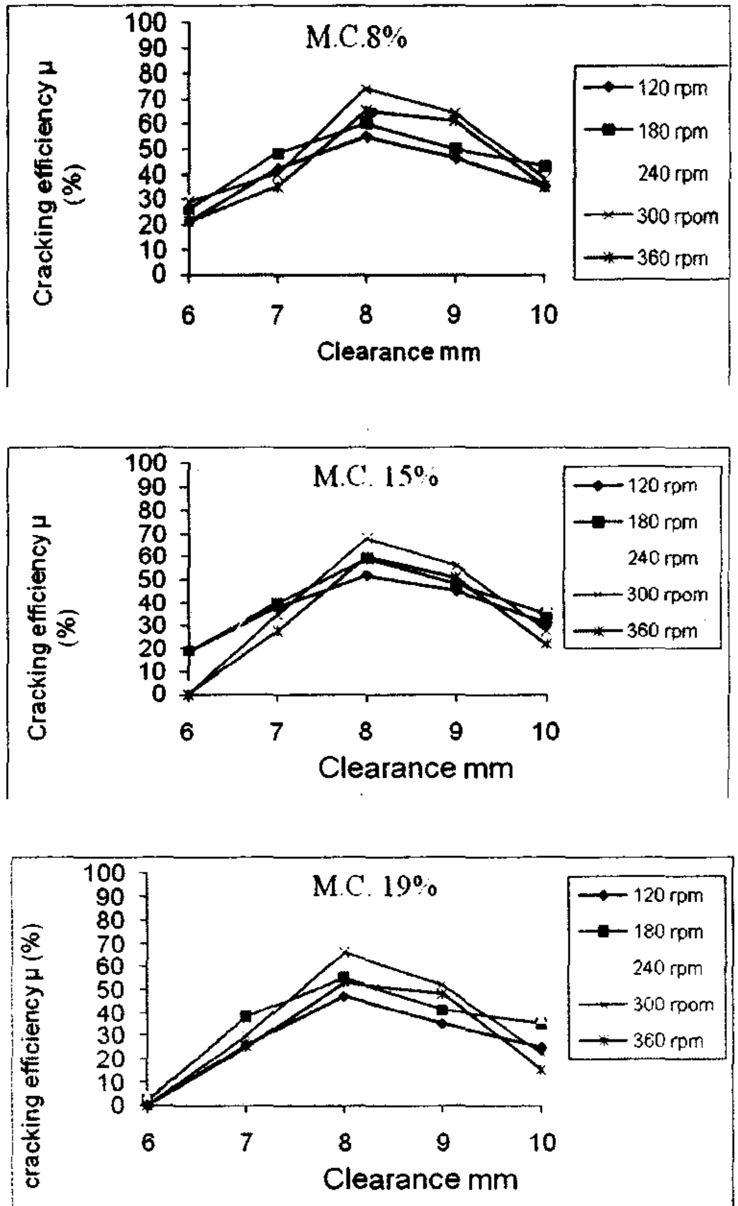

Fig. (8) Effect of cracking cylinder speed, clearance and moisture content on cracking efficiency.

Power requirement:

The effect of different cracking cylinder speed, different clearance and different moisture content on the power requirements of the machine and useful power needed for cracked operation:

1- Effect of cracking cylinder speed on the power requirements:

Increasing the cracking cylinder speed tended to increase both the power requirement and useful power for cracked operation, as shown in Fig. (9).

The results indicated that the power required to operate the cracking machine without load did not increase as the cracking cylinder speed increased.

The results indicated that when the cracking cylinder speed increased from 120 to 360 rpm tended to increase, the power requirement from (0.654 to 0.774), (0.645 to 0.750) ,(0.627 to 0.727) , (0.613 to 0.709) and (0.599 to 0.672) KW at clearance of 6,7,8,9 and 10 mm, respectively.

2-Effect of clearance on the power requirements:

Increasing the clearance tended to decrease both the power requirement and useful power needed for cracked operation, as shown in Fig. (10).

The results indicated that the power required to operate the cracking machine without load did not increase as the clearance increased.

The results indicated that, increase of clearance from 6 to 8 mm tended to increase, the power requirement from (0.654 to 0.599), (0.685 to 0.622), (0.705 to 0.636), (0.741 to 0.633) and(0.773 to 0.672) kW at cracking cylinder speed of 120, 180, 240, 300 and 360 rpm respectively.

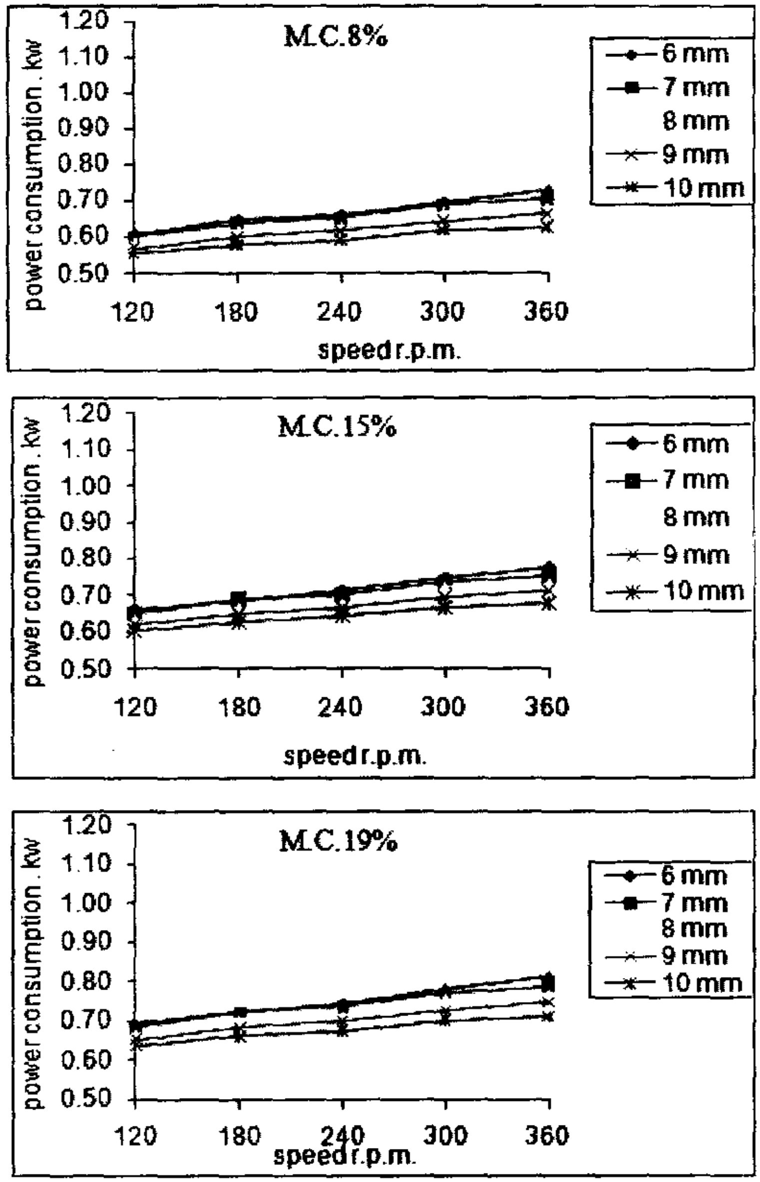

Fig. (9) Effect of the cracking cylinder speed, at different clearance and apricot stone moisture content on the power requirements.

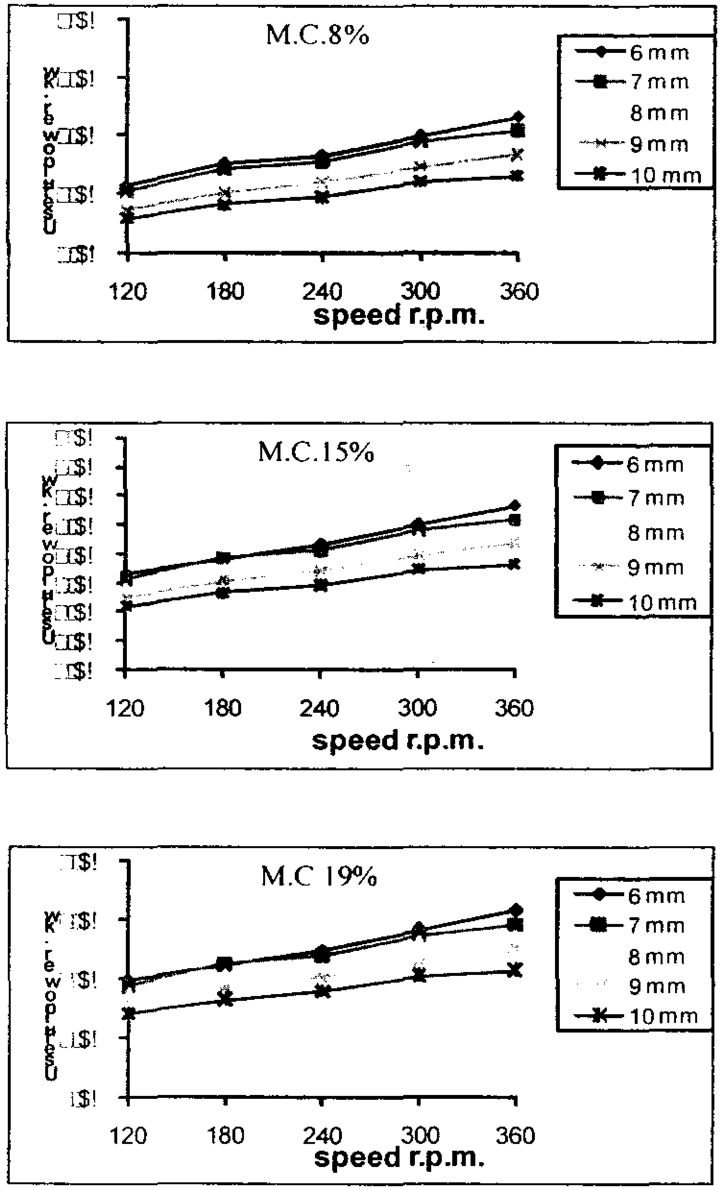

Fig. (10) Effect of the cracking cylinder speed, at different clearance and apricot stone moisture content on the useful power cracked.

Energy requirement:

The effect of different cracking cylinder speed, different clearance and different moisture content on the energy requirement (kW.h/ton) for cracked operation:

1-Effect of cracking cylinder speed on the energy requirements:

Increasing the cracking cylinder speed tended to increase the energy requirement for cracked operation, as shown in Fig. (11). The results indicated that when the cracking cylinder speed increased from 120 to 360 rpm tended to increase, the energy requirement from (50.33 to 59.67), (49.67 to 57.67), (48.33 to 56.33), (47.33 to to 54.67) and (46.33 to 51.67)kW.h/ton at clearance of 6,7,8,9 and 10 mm respectively.

2-Effect of clearance on the energy requirements:

Increasing the clearance tended to decrease the energy requirement for cracked operation, The results indicated that when the clearance increased from 6-10 mm tended to decrease the energy requirement from (50.33 to 46.33), (52.67 to 47.67),(54.33 to 44.67), (57.33 to 50.67) and (59.67, 51.67) kW.h/ton. at cracking cylinder speed of 120, 180, 240, 300 and 360 r.p.m respectively.

It was noticed that lowest value of energy requirement was obtained at cracking cylinder speed of 120 rpm, clearance 10mm and moisture content of 8%

- Productivity

Machine productivity was 13 kg /h.

Specific energy requirements :

The specific energy requirements 0.048 kw h/kg .

The cost of the cracking operation:-

The craking operation cost inclndes fixed and variable costsfor the machine. It was found to be 2.66 L.E/h. and the operation cost was 0.20LE/kg (200 L.E /ton) .

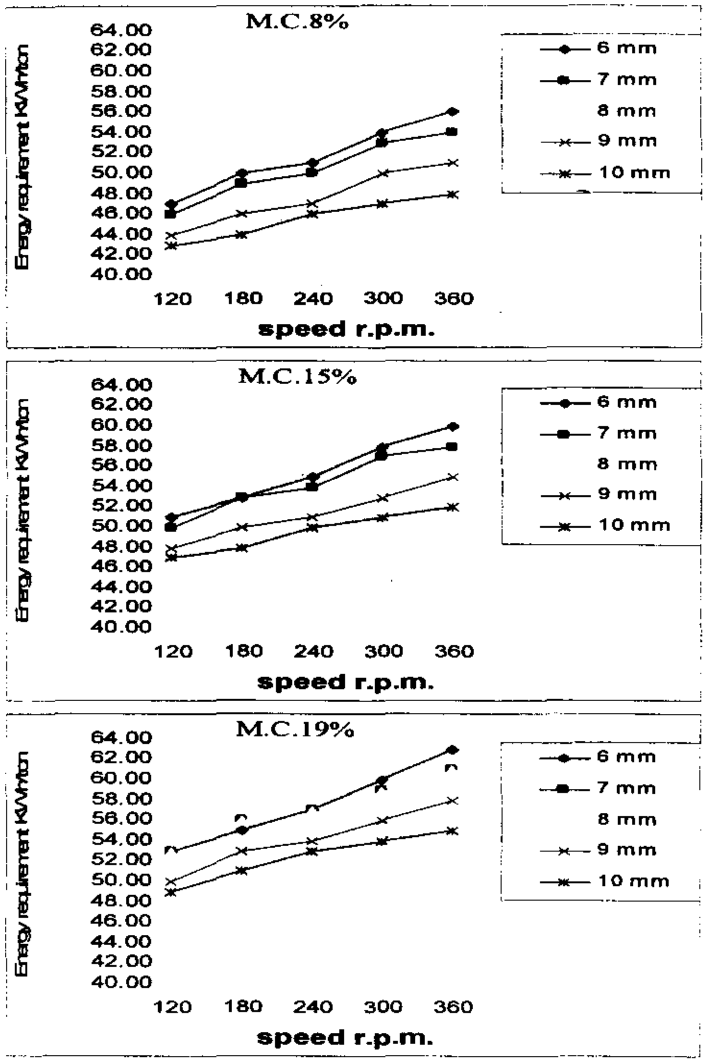

Fig. (11) Effect of the cracking cylinder speed, at different clearance and apricot stone moisture content on the energy requirement cracked.

CONCLUSION

- This research aimed to study the feasibility of using cracking. The machine was performed by using a range of cracking cylinder speeds, space between the cylinders (clearance) at different apricot pit moisture content.

- The optimum operating condition of cracker was found at Cracking cylinder speed of 240 rpm , space between the cylinders (clearance) of 8 mm and average apricot pit moisture content of 8 % where gave the best result of cracking efficiency of 90 %, percentage un-cracked of 5 %, the mechanical damage of 5 %, energy consumption 48 kW.h /ton and cost of 200 L.E/ton .

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الملخص العربي

تطوير وتقييم آلة تكسير نوي المشمش

أ.د سمير أحمد طايل * — أ.د عبد القادر علي النقيب*

د. أشرف كامل زعلوك** — م. أحمد نبيل احمد ***

تعتبر عملية تكسير نوى المشمش من اهم عمليات اعادة تدوير مخلفات التصنيع الغذائى لما يعرف عنه من امكانية تحضير كربون نشط عالي الكفاءة من نوى المشمش يستطيع أن يزيل الملوثات الناتجة عن العمليات الصناعية والغذائية ومياه الشرب ، وتستورد مصر حاليا كل احتياجاتها منه من الخارج للاستعمالات الصناعية وتنقية مياه الشرب ؛ كما يمكن انتاج التقاوى واستخراج زيت اللوز المر ويدخل فى صناعة الحلوى وتركيب بعض الادوية.

ولذلك تم التفكير فى تنشيط تلك الصناعات بتسهيل عملية تكسير نوى المشمش بواسطة تصميم اله تصلح لهذا الغرض .ولاجراء عملية التكسير لنوى المشمش يدويا فأنة يحتاج إلي وقت طويل ويتلف جزء كبير من النوى نتيجة تهشم اللب الداخلى للنوى اما التكسير الالى فهو غير مستخدم على نطاق واسع فى مصر .

وقد صممت وصنعت الة تكسير نوى المشمش للحيازات الصغيرة معتمدة على الدراسة المسبقة للخواص الطبيعية والميكانيكية للنوى المشمش حيث لا تتجاوز ارتفاعها١٣٠ سم وطولها ٤٢ سم وعرضها ٤١ سم داخل ورشة قسم الهندسة الزراعية جامعة الازهر بالقاهرة الهدف من الدراسة محاولة خفض نسبة المهشم والغير مكسور من نوى المشمش مع رفع نسبة النوى المكسور ولتحقيق ذلك الهدف تم دراسة مجموعة من المتغيرات الاتية :

أ- **نسبة الرطوبة للنوى** : ثلاث نسب رطوبة عند (٨ – ١٥- ١٩)%

ب- **سرعة الاسطوانات**: خمسة سرعات وهى (١٢٠- ١٨٠- ٢٤٠– ٣٠٠- ٣٦٠) لفة / دقيقة

ج- **المسافة بين الاسطوانات** : خمسة مسافات وهى (٦-٧-٨-٩-١٠) مم .

مع اجراء تقييم فنى واقتصادى للالة حيث تم الوصول إلي أعلي أداء عند ظروف التشغيل الأتية:

١- نسبة رطوبة للقشرة الخارجية ٨%.

٢- سرعة دوران للاسطوانات ٢٤٠ لفة / دقيقة.

٣- خلوص بين اسطوانات ٨ مليمتر.

واتضح ان اداء الالة بأستعمال المتغيرات السابقة كان:

- نسبة اللب المهشم = ٥% (بمعنى تكسير الغلاف الخارجى و تفتت اللب الداخلى)
- نسبة النوى الغير مكسور = ٥% (بمعنى بقاء الغلاف الخارجى بدون كسر)
- نسة النوى المكسور = ٩٠% (بمعنى تكسير الغلاف الخارجى مع بقاء اللب سليم)
- وقد تم حساب القدرة المطلوبة للتشغيل للالة : 0.627 كيلو وات/ساعة

وقد تم اجراء تقييم اقتصادى حيث وجد تكاليف تشغيل الالة ٢.٣٦ جنيه/ ساعة أى ٠.١٨ جنيه/كجم عند ظروف التشغيل المثلى.

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* استاذ الهندسة الزراعية المتفرغ – كلية الزراعة – جامعة الأزهر- القاهرة.

** أستاذ مساعد الهندسة الزراعية – كلية الزراعة – جامعة الأزهر- القاهرة.

*** مهندس زراعي.