# SOME ENGINEERING FACTORS AFFECTING DATE PITS CRUSHING

**Khairy, M. F. A. *; S. H. Desoky**; R. A. Werby**; K. A. M. Ali*****

## ABSTRACT

*The main objective of the present work was to study and evaluate some engineering factors affecting date pits crushing for small locally made crushing unit at moisture content of 7.75 % db. The performance of date pits crushing unit was evaluated at different cylinders speeds (150, 250, 350 and 450 rpm), clearances between cylinders (zero, 1 and 2 mm) and opening feed areas (30, 37.5 and 45 cm²). The results showed that the highest productivity was 822 kg/h obtained at 150 rpm cylinder speed, 2 mm clearance between cylinders and 45cm² opening feed area. The best result for crushed date pits particle size was obtained at 350 rpm, 0 mm clearance between cylinders and 37.5 cm² opening feed area. While the minimum specific energy 1.11kW.h/Mg was obtained at 150 rpm, 45 cm² opening feed area and 2 mm clearance between cylinders.*

## INTRODUCTION

Date palm trees are grown all-over Egyptian lands. In addition, date palm trees considered as the most successful fruit tree that cultivated in the new reclaimed lands in Toshki, El-Ewinates, and Sinai areas (**Bekheet, 2013**). Egypt is considered as one of the most important producers of date in the whole world. It produce about 1.47 Tg on 2012 (**FAO, 2012**). There are many by-products from palm trees some of them, date pits (that represents 10 - 15 % of the date fruit), palm tree leaves, and non-edible dates could be used in animal feeds. The date pits is composed of both organic and inorganic substances such as carbohydrates 62.51 %, fats 8.49 %, proteins 5.22 %, fibers 16.20 %, and ash 1.12% (**El-Agamy et al, 2003**).

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**Almana and Mahmaud (1994)** evaluated date pits as an alternative source of dietary fiber in comparison with wheat bran, and suggested that they may provide a valuable contribution to dietary fiber intakes. Therefore, date pits were examined because they may have an extractable high value-added component for including in functional foods. **Allam et al. (1997)** mentioned that Date pits (date stone) by-product meals have been examined in livestock (poultry, and ruminants), and fish (for aquaculture) diets as a nonconventional source to substitute or supplements for expensive conventional feed, and to cut-down on the feed gap between production and consumption. Date stone by-product meal provides a good potential as concentrated feed source for poultry, ruminants and fish feeding instead of maize or other grains that are used for human foods.

**Khairy and Attalla (1995)** studied physical and mechanical properties of twelve date palm cultivars commonly growing in Gassim region. 50 date fruit were examined for each cultivar. The shapes of these cultivars were studied in terms of fruit length "L", maximum width "A", minimum width "B", pulp thickness "T", pit length "L1", maximum width "A1", minimum width "B1", the angle of friction between date fruit and both of wood "Φw" and galvanized mild steel "Φs" surfaces were measured by inclination-plate method. Pit separation force "PF" (N) and pulp rigidity "RG" (MPa) were measured by an apparatus developed, constructed and calibrated by first author.

**Maynard and Heid (1964) and Kozmin (1988)** classified the types of milling equipment according to the principles of action of their working organs upon the treated product as follow:

1. Cutting (chipping off) machines.
2. Pressing (crushing) machines.
3. Machine acting by free impact.

Milling equipment may depend upon a single one of these actions or upon a combination of two or more. Miller also can be designed and frequently are to produce attrition and impact grinding. **Simmons (1963) and Kozemin (1988)** showed that grinders may be placed in two categories:

1. Stone grinders or mill stone:

a. Horizontal grinders. (the top – runner type and the under – runner type)

b. Vertical grinders.

2. Roller mills which can be designed to produce both compression and attrition grinding.

The main objective of the present work is to develop a small locally made crushing unit and study some engineering factors affecting date pits crushing and evaluating the performance of crushing unit.

## MATERIALS AND METHODS

The experiments were carried out at Faculty of Agricultural Engineering, Al-Azhar University, Nasr City during the years of 2013 – 2015 for small crushing machine locally manufactured.

**1. Date pits Variety.**

Experiments were carried out on date pits variety *sewi*. Some physical and mechanical properties of 100 date pits are studied according to **(Khairy and Attalla 1995)** and listed in table (1).

**Table (1): Some physical and mechanical properties of date pits.**

| Parameters | mean | CV (%) |
|---|---|---|
| Moisture content db (%) | 7.75 | 1.18 |
| Length "L" (mm) | 21.50 | 8.52 |
| Width "W" (mm) | 10.02 | 4.89 |
| Thickness "T" (mm) | 8.53 | 4.90 |
| Mass "m"(g) | 1.33 | 14.94 |
| Real density "$\rho_r$" (g/cm$^3$) | 1.27 | 4.67 |
| Bulk density "$\rho_b$"(g/cm$^3$) | 0.83 | 1.15 |
| Friction angle "$\alpha^o$" ( degree) | 27.47 | 3.00 |
| Angle of repose " $\theta^o$ " ( degree) | 15.96 | 14.99 |
| Compression force (kN) | 2.55 | 4.8 |
| Shear force (kN) | 1.37 | 8.3 |

**2. Crushing unit:**

The crushing unit installation used in this study is shown in Fig (1).

The frame was constructed of steel plate (60×60×3) mm to carry the

engine and fixed it by means of four sets screw bolts and nuts. The frame also carried the crushing unit and the power transmission system.
The feeding hopper was installed to feed the date pits into the crushing unit. The gate of this hopper sloped gradually by $30^0$ to keep a free flow of date pits. The gate was drilled on the side of hopper to control on the feeding rate of date pits from hopper to crushing unit.
The crushing unit was necessary for crush the date pits to facilitate the crushing process. Cracking process is done by a pair of herringbone cylinders of 80 mm diameter and 290 mm length. The clearance between cylinders was adjusted by tow screws.
An electrical motor (1400 rpm, 1.5 kW) was used to drive the crushing unit the power from the source was transmitted to crushing unit by means of pulley and V belt and sprocket wheels and chain.

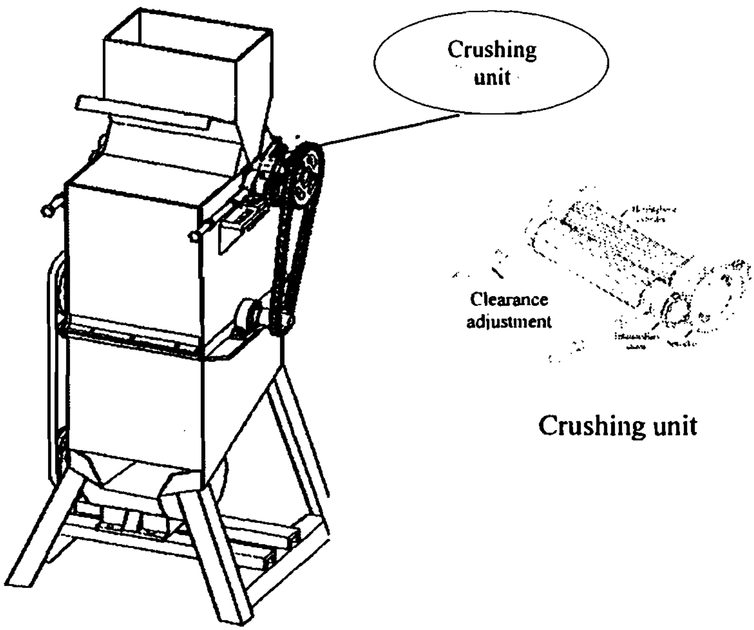


Fig. (1): Isometric of the developed crushing unit.

The effect of the following variables on the date pits particle size, crushing unit productivity and specific energy requirement for date pits were studied:

1. Four cylinders speed of 150, 250, 350 and 450 rpm.
2. Three clearances between cylinders of zero, l and 2 mm.
3. Three opening feed areas of 30, 37.5 and 45 cm2.

**1. Particle size distribution:**

The date pits mean particle size (mm) was measured by using different sizes sieves "Ci" (mm) and weighting the weight over each sieves "Wi" (gm) where i is the sieve number and the following equation were used **(Finch. 2009)**.

$$L = \frac{(C1 * W1 + C2 * W2 + C3 * W3 + ..... + Cn * Wn)}{W1 + W2 + W3 + ..... + Wn}$$

**2. Productivity:**

Crushing time of 1 kg of date pits was measured by means of a stopwatch to determine the machine productivity in kg /h.

$$Productivity = \frac{mass\ of\ crushed\ date\ pits\ (kg)}{Time\ of\ crushing\ (h)}$$

**3. Crushing power requirements:**

A digital AVO meter was used for measuring the current Amber before and during experiments the total consumed electric power under machine working load (kW) was calculated according **(Lockwood and Denstan, 1971)** by the following equation.

$$power\ (kW) = \frac{(I.V.\eta.\cos\theta)}{1000}$$

Where:

I : Current strength in Amperes.

V: Voltage strength (equal to220 V),

Cosθ: Power factor (equal to 0.85) and

ή: Mechanical efficiency assumed to be (90%)

**4. Specific energy requirement**

The specific energy requirement (kW.h/Mg) was calculated by using the following equation:

$$CE = \frac{Power\ (kW)}{produtivity\ (Mg/h)}$$

## RESULTS AND DISCUSSION

There are no results for the following operational conditions:
At zero mm clearance between cylinders and 450 rpm for cylinders speed at all opening feed area (30, 37.5 and 45 $cm^2$) and at the same clearance where the speed was 350 rpm for 45 $cm^2$ opening feed area. That is because of the high loud on the electric motor led to stop the crushing operation.

- **Effect of cylinders speeds on date pits particle size:**

Fig (2) illustrated the relationship between the cylinder speed "Cs" (rpm) and date pits mean particle size (mm) at different opening feed areas and clearances between cylinders.

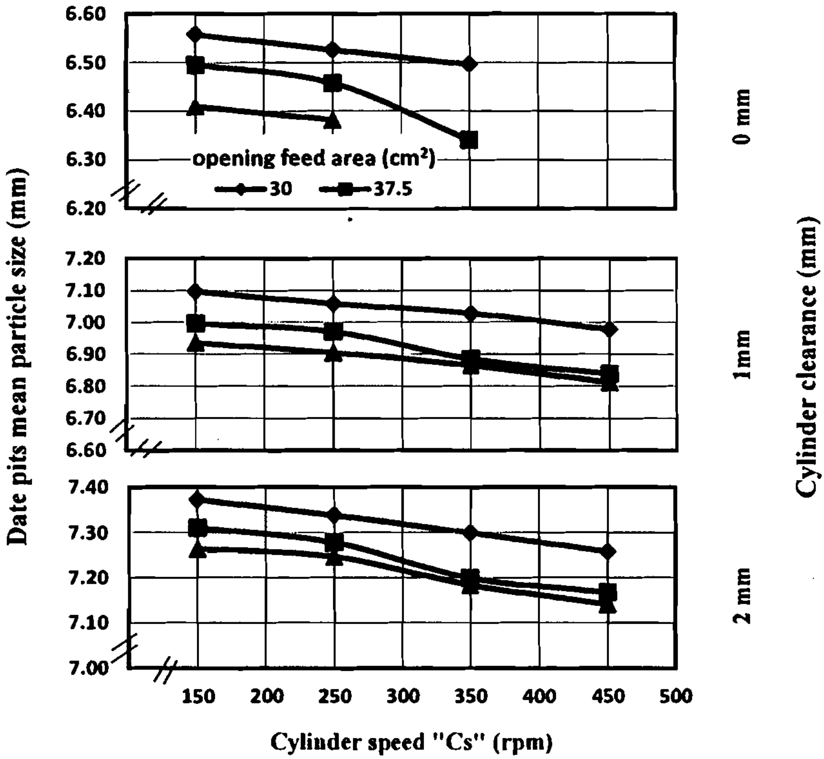


**Fig (2): Date pits mean particle size (mm) Vs Cylinder speed "Cs" (rpm) at different opening feed areas and clearances between cylinders.**

The obtained data showed that the crushing unit productivity increased with the increase of both opening feed area and clearance between cylinders and decreased with the increase of the cylinder speed.

The maximum value of the crusher unit productivity was 822 kg/h at opening feed area of 45 $cm^2$, 150 rpm cylinders speed and 2 mm clearance between cylinders; while the minimum value of the crusher unit productivity was 152 kg/h at opening feed area 30 $cm^2$, 350 rpm cylinders speed and 0 mm clearance between cylinders.

- **Effect of cylinders speed on specific energy requirement for crushing unit:**

Fig (3) illustrated the relationship between cylinders rotational speed "Cs" (rpm) and specific energy "CE" (kW.h/Mg) at different opening feed areas and clearances between cylinders.

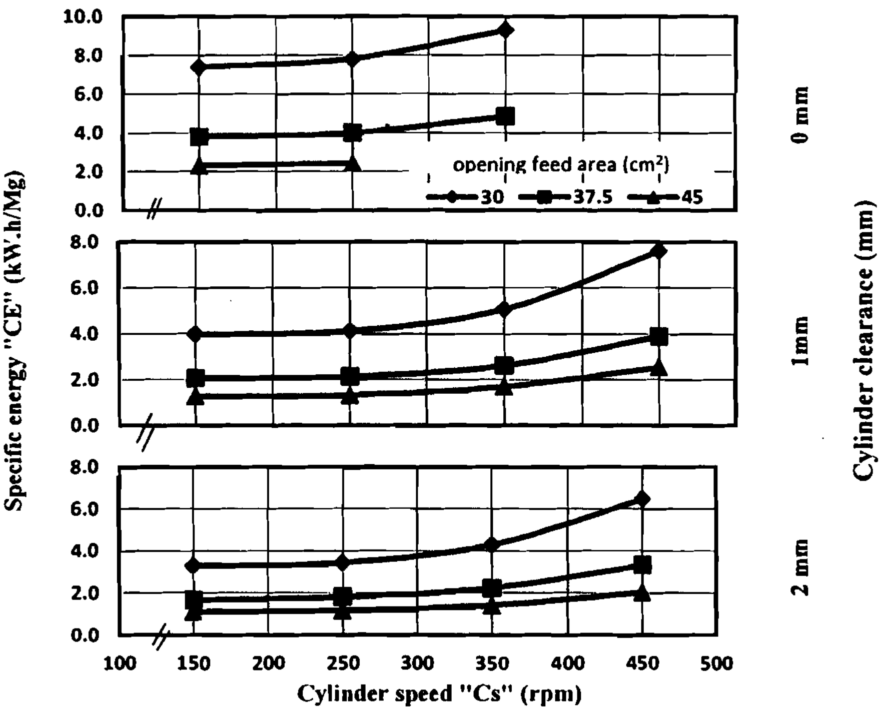


**Fig (4): Crushing unit Specific energy "CE" (kW.h/Mg) Vs Cylinder speed "Cs" (rpm) at different opening feed areas and clearances between cylinders.**

The obtained data showed that the date pits mean particle size decreased with the increase of both opening feed area and cylinders speed and it increased with the increase of clearance between cylinders.
The minimum value of date pits mean particle size was 6.34 mm at opening feed area of 37.5cm$^2$, 350 rpm cylinders speed and 0 mm clearance between cylinders while the maximum value of date pits mean particle size was 7.37 mm at opening feed area of 30cm$^2$, 150 rpm cylinders speed and 2 mm clearance between cylinders.

- **Effect of cylinders speeds on crushing unit productivity:**

Fig (3) illustrated the relationship between crushing unit productivity "CPr" (kg/h) and cylinder speed "Cs" (rpm) at different opening feed areas and clearances between cylinders.

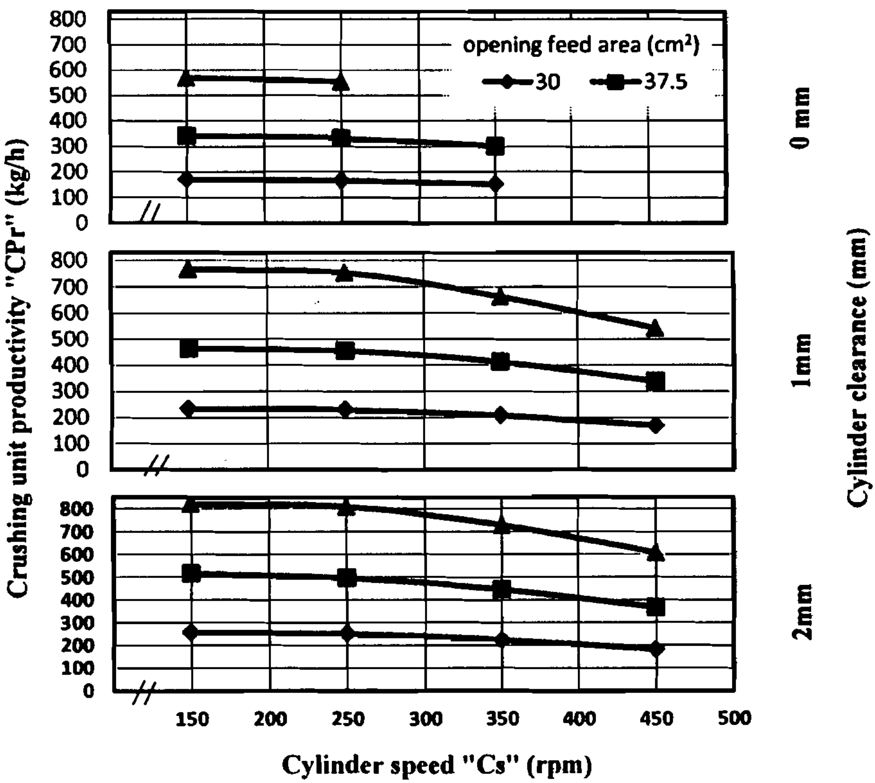


**Fig (3): Crushing unit productivity "CPr" (kg/h) Vs Cylinder speed "Cs" rpm at different opening feed areas and clearances between cylinders.**

The obtained data showed that the specific energy requirement decreased with the increase of both opening feed area and the clearance between cylinders and increased with the increase of cylinders speed. this results were agreement with **werby et,al (2012)**.

The maximum value of Specific energy requirement was 9.30kW.h/Mg at opening feed area of 30 $cm^2$, 350 rpm cylinders speed and 0 mm clearance between cylinders; while the minimum value of specific energy requirement was 1.11 kW.h/Mg at opening feed area of 45 $cm^2$, 150 rpm cylinders speed and 2 mm clearance between cylinders.

## CONCLUSION

The minimum value of date pits particle size was 6.34 mm at opening feed area of 37.5 $cm^2$, 350 rpm rotational speed and 0 mm clearance between cylinders while the maximum value of date pits particle size was 7.37 mm at opening feed area of 30 $cm^2$, 150rpm cylinders speed and 2 mm clearance between cylinders.

The maximum value of the crusher unit productivity was 822 kg/h at opening feed area of 45 $cm^2$, 150 rpm cylinders speed and 2 mm clearance between cylinders; while the minimum value of the crusher unit productivity was 152 kg/h at opening feed area 30 $cm^2$, 350 rpm cylinders speed and 0 mm clearance between cylinders.

The maximum value of Specific energy requirement was 9.30 kW.h/Mg at opening feed area of 30 $cm^2$, 350 rpm cylinders speed and 0 mm clearance between cylinders; while the minimum value of specific energy requirement was 1.11 kW.h/Mg at opening feed area of 45 $cm^2$, 150 rpm cylinders speed and 2 mm clearance between cylinders.

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## الملخص العربي

# بعض العوامل الهندسية المؤثرة علي جرش نوى التمر

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تعتبر جمهورية مصر العربية من أكثر الدول إنتاجا للبلح في العالم حيث بلغت إنتاجيتها من التمر حوالي ١,٤٧ ميجا جرام لعام ٢٠١٢م (FAO 2012) وينتج عن هذة الكمية نوى بمعدل ١٠ - ١٥ % من الإنتاج. وعدم توافر نوى التمر في صورة مجروشة أو مطحونة أدى الي عدم استخدامه في العديد من الصناعات القائمة على هذا المنتج الثانوي وذلك بسبب صعوبة طحنه لاحتوائه علي نسبة عالية من السيليلوز بالإضافة إلي عدم توافر آلات متخصصة في جرش نوى التمر بالأسواق المحلية. ويساهم البحث في سد العجز في المواد العلفية للمواشي والدواجن والأسماك وتوفير جزء من الحبوب التي يستهلكها الإنتاج الحيواني مثل الذرة والشعير والتي تصلح للاستخدام الآدمي. تم إجراء هذا البحث خلال عام ٢٠١٤ – ٢٠١٥ م في كلية الهندسة الزراعية جامعة الأزهر

ويهدف هذا البحث إلي الاستفادة من نوى التمر عن طريق جرشه حيث تم دراسة بعض العوامل الهندسية المؤثرة علي جرش نوى التمر وتصنيع آلة محلية الصنع رخيصة الثمن يمكن للمزارع المصري اقتنائها.

وللوصول إلي هذا الهدف تم دراسة الأتي:

١ . دراسة بعض الخواص الطبيعية والميكانيكية لنوى التمر والتي تساعد في تحديد أنسب تصميم للآلة.

٢ . تصنيع آلة محلية لجرش نوى التمر تناسب الكميات الصغيرة وذات تكاليف اقتصادية بسيطة وسهلة الصيانة.

٣ . دراسة أهم العوامل الهندسية التي تؤثر علي أداء وكفاءة آلة الجرش وهي

- سرعة اسطوانات الجرش وتم اختيار أربع سرعات ( ١٥٠ – ٢٥٠ – ٣٥٠ – ٤٥٠ لفة / د)
- الخلوص بين اسطوانات الجرش وتم استخدام ثلاث متغيرات ( صفر - ١ – ٢ مم )
- مساحة فتحة التغذية وتم استخدام ثلاث متغيرات ( ٣٠ –٣٧,٥ – ٤٥ سم٢ )

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وكانت أهم النتائج:

١ . إنتاجية الجرش تنخفض بزيادة سرعة اسطوانات الجرش لكل الخلوصات بين الأسطوانات وتزداد مع زيادة الخلوص بين الأسطوانات كما تزاد بزيادة فتحات التغذية وكانت اكبر إنتاجية جرش (٨٢٢ كجم / س) مع استخدام سرعة دوران للاسطوانات ١٥٠ لفة / د وخلوص بين الاسطوانات ٢ مم ومساحة فتحة تغذية ٤٥ سم$^{٢}$.

٢ . متوسط حجم الجزيئات لنوى التمر المجروش تنخفض بزيادة سرعة اسطوانات الجرش لكل الخلوصات بين الأسطوانات، وتزداد مع زيادة الخلوص بين الأسطوانات مع كل سرعات الدوران وفتحات التغذية المختلفة وكان اقل متوسط لحجم النوى المجروش (٦,٣٤مم) مع استخدام سرعة دوران للإسطوانات ٣٥٠ لفة / د وخلوص بين الإسطوانات صفر مم ومساحة فتحة تغذية ٣٧,٥ سم$^{٢}$.

٣. الطاقة النوعية المطلوبة للجرش تزداد بزيادة سرعة اسطوانات الجرش لكل الخلوصات بين الأسطوانات وتنخفض مع زيادة الخلوص بين الأسطوانات مع كل سرعات الدوران وفتحات التغذية المختلفة وكانت اقل طاقة نوعية مطلوبة (١,١١ كيلو وات . س / كجم) مع استخدام سرعة دوران للقرص ١٥٠ لفة / د وخلوص بين الإسطوانات ٢ مم ومساحة فتحة تغذية ٤٥ سم$^{٢}$.