DATE PALM LEAVES DISINTEGRATION USING DRUM CHIPPER MACHINE

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ABSTRACT

The drum chipper prototype investigated as a tray for chipping the date palm leaves and to solve the residues problem according to pruning palm tree. Because of there are about 1.5 thousand trees scattering in the green garden areas at Mansoura University. It mean that about 45±7.83Mg per year of leaves residues must be take advantage of them by converting to benefit material (such as pellet bedding, livestock bedding, composter, or etc....) and on the other hand, to get rid of pests and rodents that live in them. The outdoor experiments conducted on the available chipper machine under five PTO revolution convert to relative five feeding and chipping drum speeds. The results indicated that, if need a homogeneous samples with pieces lengths from 5.0 to 22mm it is attributed to moving the chipping drum at 1961.40rpm (2717.5m/s). And if want to get out samples with pieces width ranged from 1.0 to 7.0mm must regulate the machine to chipping at drum revolution of 2194.90rpm (3101.4m/s) Also, if require to get the pieces with thickness ranged from 2.0-3.0mm must adjust the chipping drum revolution at 877.96rpm (1240.6m/s). Following the previous instructions lead to reduction chipping drum speeds, which would lead to conservation energy.

Key word: *palm leaves - drum speed - chip length - chipper machine - chipper productivity* – feeding speed

INTRODUCTION

Based on particles fragmentation principle, commercial chippers come in three main types: disc chippers, drum chippers and cone screw chippers (**Pottie and Guimier 1985**). The first two types are most used, while cone-screw-chippers or are seldom used professionally when producing energy chips and are the object of further development (**Wegener and Wegener 2012**). **Goldstein and Diaz (2005)** regarded that mobile disc chippers are especially common for

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production of pulp chips, whereas drum chippers find a secondary use for brush disposal, often in gardening operations. In Europe, disc chippers and large drum chippers are used for chipping of logs, while the drum chippers dominate the chipping of logging residues and small trees on landings **(Kärhä 2011)**. Both chipper types have been in use for many years and much anecdotal evidence is avail-able about their relative merits. Operators state that disc chippers produce more uniform chips than drum chippers, especially if fed with good quality raw material **(Ismail and Ghazy-2016). Spinelli and Hartsough (2001)** indicated that the flexible small branches might pass through the disc resulting in low chip quality. For this reason, the drum chippers are the best when dealing tops and branches of trees.

The chipping process is one of the most critical stages because often requires a great deal of energy. Various processing machines are used in the handling and production chain of these materials. Furthermore, the efficiency of this machinery is generally low. Therefore, several parts affect the machine efficiency and some studies have been conducted to investigate different parameters involved in the residues chipping operation, such as operation time and performances **(Spinelli et al., 2011)** or the effect of machine configuration on final product quality **(Krajnc et al., 2014)**.

Alessio and Eugenio (2014) conducted studies on chipping machine and indicated that the cutting tool wear status has a strong effect on the overall performance and efficiency of the machine reducing the productivity and in-creasing the specific fuel consumption (up to +40%). Cut length setup and the presence of the piece-breaker affect chips size, and productivity and specific fuel consumption too. Chips size is one of the market requirements, thus the possible improvement in productivity and efficiency of machines acting on these parameters is reduced. The blade wear status usually is detected arbitrary according to the operator's experience. In this regard, **Ismail and Ghazy (2016)** evaluate the design of offset slider crank for drum wood chipper and evaluate the operating parameter of drum chipper on wood chip removal rate (WCRR, m^3/h), actual chip thickness (ACT), share plan angle (SPA), chip thickness ratio

(CTR), chip reduction coefficient (CRC), size classification of wood chips (SCC) and the machine productivity.

Nearly, in gardens of Monsura University about 1.5 thousand of palm trees and at considering each palm trees product about 20 leaf per one year (**Ismail and Abou Habaga-2008**). Roughly, if each leave have a weight of 1.65±0.261kg, then the all palm trees product about 45±7.83 ton per year of green residues. Many efforts were conducted to take benefit of this residue, but until now it a major problem. The entrance to solve that problem is cutting, chipping and break up chopping date palm leaves. Therefore, the aim of this work is to evaluate some of engineering parameter of mobile chipper machine on the disintegrate performance of date palm leaves.

MATERIAL AND METHODS

The mobile drum cutting machine

The general view of mobile drum chipper machine, as shown in Fig. (1), consists of two main units (the feeding place and cutting chamber). The feeding unit is used to control the amount of feeding date palm leaves by changing the clearance between them, which it adapted by up-down forces of two helical springs distributed in each side of drum. The transmission motion of feeding drum derived by two gears take the rotation from tractor PTO (Fig. 2).

1- Open of in-let material 2- Out let gate 3- PTO connecting

Fig. (1): Photo of mobile drum machine

The second unit of cutting machine is cutting part. It is including four wide blade (300mm length and 150mm width) with sharping edge of 40 degree up the horizontal position. The blades were located in cross position on drum of 150mm diameter with inclination angle of 10 degree relative to the vertical axis (Fig. 3). The motion was conveyed to cutting unit through the two pulleys conducted with three V-belts (Fig. 2). And the PTO from Romanian tractor (65HP) is considered the main of power source.

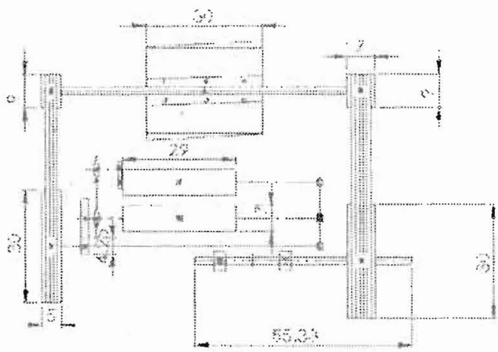
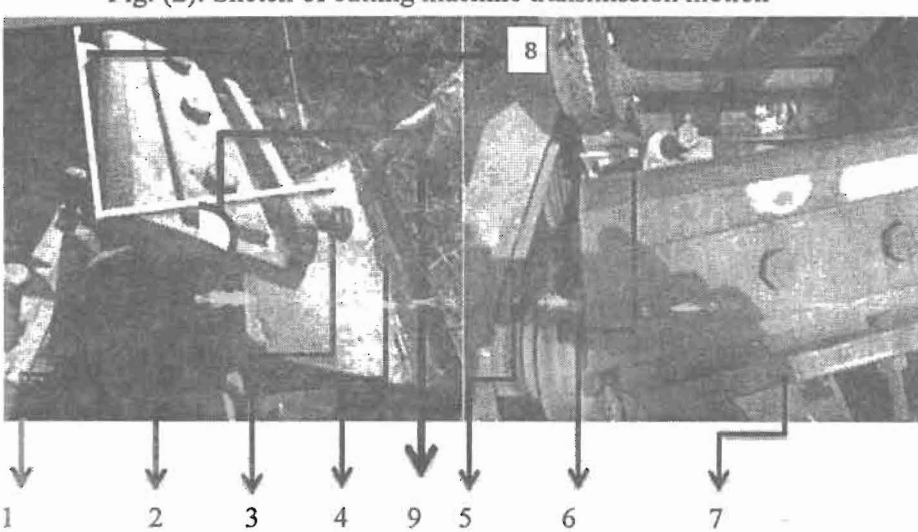


Fig. (2): Sketch of cutting machine transmission motion



1- blade gap control 2- drum 3-controll stud 4-plate surface
5- V-belts 6- blade angle 7-concave edge 8- rake angle 9- blade angle

Fig. (3): The cutting unit performances

Experimental considerations

Many attempted were confirmed to success this work such as:

- The outdoor experiments were run-out by feeding the cutting machine with the average dry date palm leaves of 17±2% M.C. The amount of palm leaves were accumulated in open field to essay tuned-over and natural dried as shown in Fig. 1.
- Pre-feeding the material, the machine with tractor were flattened at one plan and the connection between the shaft of PTO and the machine spindle regulated at zero level (Fig.1)
- The feed rate was controlled by changing the gears ratio between two feeding drums and the chipping drum. But the clearance between two feeding drum keeping in constant area under all experiment with an average of 55mm (80mm with big palm leaves bulk and 30mm with smallest one).
- The machine was operated firstly under no-lode until arrived to stat motion, after then it was feed. The above system conformed under all five operation speeds.
- The cutting blades were deformed at two angles blade rake angle (8) and cutting angles (9) as shown in Fig. 3. They were regulated and kept constant under all experiments at 15 degree and 40 degree respectively.
- Each samples were weight around 15kg and the operator was feed it to machine with equivalent feeding.
- The out-door experiments were carried out under five PTO revolution of 188; 220; 370; 420 and 470rpm respectively. These revolutions can be conformed to chipper drum with peripheral speeds of 1242.6; 1451.7; 2441.5; 2771.5 and 3101.4 m/s.
- The chipping rate under all variables were evaluated by weighing all pieces produced within each repetition per unit time.
- According to European Standard CEN/TS 15149-1 four sieves were used to separate particle size distribution: >20 mm, 20–50 mm, 50–100 mm. Each fraction was then weighed with a precision scale.
- Data were analyzed with the Excel statistics software. Analysis of variance was conducted to determine the most parameters

affecting the chipping performance of date palm leaves. In addition, the relationship between productivity, piece size and tree part was estimated using multiple linear regression technique.

RESULTS AND DISCUSSION

Chipping drum revolution via date palm pieces performances

The amount of pieces above sieves were weighed as a function of chipper drum revolution (figure 4). Generally, from figure (4-A), it is clear that by increment chipping drum revolution from 877.96 to 2194.90 rpm the chipping length of date palm leaves tended to decrement under all above the sieves hole diameters. The decrement rate(τ) of chipping length for sieves hole diameter of 20-50mm is more great than that for others ($\tau_{20\text{-}50}$ = 2.033 > $\tau_{0\text{-}10}$ =1.34 > $\tau_{10\text{-}20}$= 0.6). But, for the chipping width of date palm pieces (4-B), the dimension of width decrement with increment the chipping drum revolution for the pieces above the sieves of 0-10mm and 10-20mm and vice versa for 20-50 sieves hole diameters. This explains that the increase in the speed of chipping drum tended to increase the thickness of the pieces at the expense of the length of broken pieces. It meaning increased speed leads to increase the percentage of small lengths of pieces from 56.9 to 74.2% opposite decreasing date palm pieces from 20 to 18% and from 6 to 5% for width and thickness respectively.

On the other hand, the chipping thickness of date palm pieces (4-C), decrement with increment the drum PTO revolutions from 877.96 rpm until 1961.40rpm. But at increased the revolution up that the thickness of pieces decreased for the pieces above the sieves of 0-10mm and vice versa for the 10-20mm and for 20-50 hole diameters. This because of increasing the chipper drum revolution tended to smallest in length at the expense of thickness of pieces.

The frequency curves for pieces of date palm leaves

The frequency curves for pieces of date palm leaves relative to chipping drum revolution were illustrated in figure (5). The chipping drum revolution that recognized the normal distribution curve for length pieces of date palm were found at 1961.40 rpm but it at 2194.9 and 877.9 rpm for width and thickness respectively.

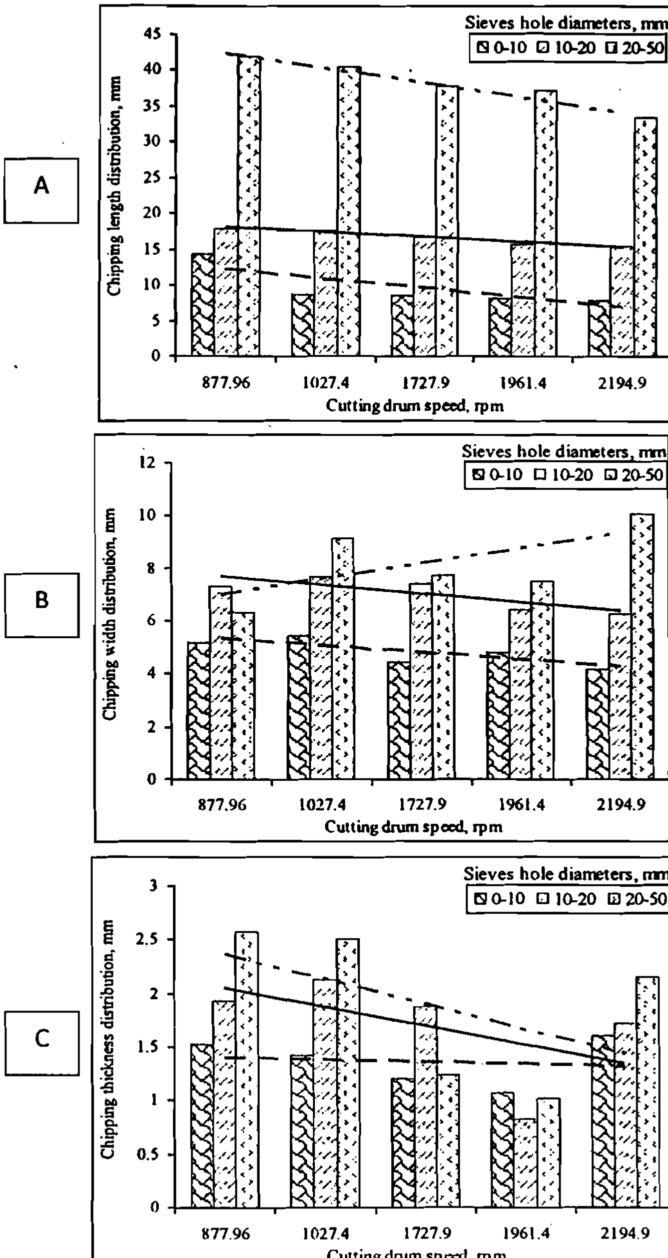


Fig (4): Effecting of chipping drum revolution on date palm leaves performances

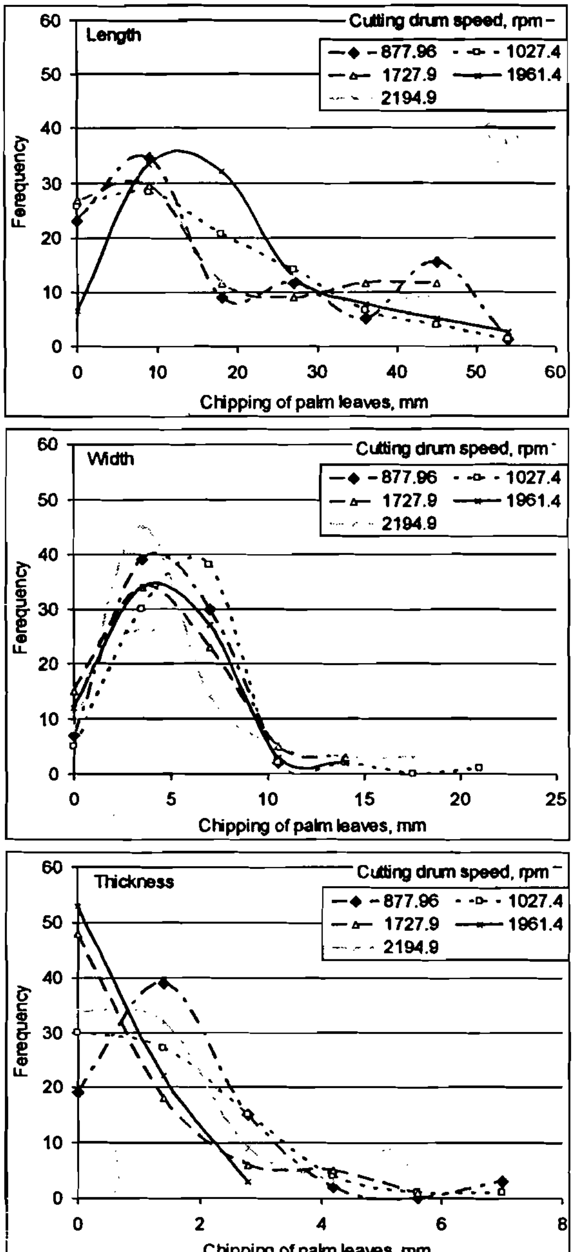


Fig. (5): The frequency curves for pieces of date palm leaves

Previous result means that if required to obtain a homogeneous samples with pieces lengths from 5.0 to 22.0mm. It is attributed to moving the chipping drum at 1961.40 rpm and if wanted to get out samples with pieces width ranged from 1.0 to 7.0mm must regulate the machine to cutting at drum revolution of 2194.9 rpm. Also, if needed to gut the pieces with thickness ranged from 2.0-3.0mm must adjust the chipping drum revolution at 877.96rpm. Following the previous instructions lead to reduction chipping drum speeds which would lead to the rationalization of energy.

The average and the stander deviation of palm leaves dimensions

Table (1) is showed the average and the stander deviation of palm leaves dimensions under different chipping drum revolution. From table, there are no clear trend connected the SD of data with drum revolution. Generally, the SD of pieces of date palm leaves above the sieves increased with increasing the sieves hole diameter. For example, at 877.96 rpm the SD increased relative sieves hole diameters from 2.39; 3.48 and 9.548 for 0-10; 10-20 and 20-50 sieves diameter respectively. Also, the same trend was found for 1027.40rpm; 1727.9rpm and 2194.90rpm of chipping drum revolution. But at 1818rpm, the SD decreased from 6.03 to 3.69 and the increased to 9.61.

Factors affecting machine productivity

The rate of feeding material and drum peripheral speed are the two main factors affecting machine productivity. Figures (6 & 7) demonstrate the relationship between each of drum peripheral speed and feeding rate on machine productivity. Generally, there are a direct relationship between machine productivity and each of drum peripherals speed and rate of feeding (m/s). For example, if required production of 10 kg/h, the chipper machine must be controlled at drum peripheral speeds of 218orpm with feeding material rate at 0.68 m/s. On the other hand, at 0.77 and 0.86 feeding material speeds were achieve the same machine production (10 kg/h) but at using 0.77m/s, the cutting pieces included a large amount of pieces with a big width. While, at using the o.86 m/s, the large amount of sample having pieces with great thickness. Previous information interprets the values of data in the Fig. (4).

Table (1): Average, Max., Min and Stander deviation for the shedding pieces

S.h.d	0-10mm			10-20mm			20-50mm		
P.D	L	W	T	L	W	T	L	W	T
Drum revolution, 877.96rpm									
Average	8.68	5.14	1.52	15.72	7.29	1.93	41.94	6.32	2.56
Max	16.95	7.97	3.17	22.22	12.14	4.56	58.65	9.82	7.37
Min	4.9	1.63	0.75	9.36	4.16	0.71	27.21	3.99	0.27
SD	2.39	2.16	0.56	3.48	1.86	0.87	9.548	1.58	1.97
Drum revolution, 1027.40rpm									
Average	8.42	5.43	1.42	17.93	7.65	2.12	33.44	9.12	2.49
Max	16.9	8.74	3.74	31.68	10.25	5.24	55.26	21.38	8.49
Min	6.24	1.93	0.36	11.88	5.76	0.33	20.98	2.62	0.28
SD	2.51	1.82	0.80	4.72	1.26	1.26	9.615	4.012	1.99
Drum revolution, 1727.90rpm									
Average	8.07	4.43	1.19	16.61	7.39	1.88	40.47	7.71	1.23
Max	11.26	8.9	4.7	31.5	14.27	6.97	53.97	14.87	5.17
Min	5.33	2.09	0.29	10.14	3.08	0.3	21.41	1.83	0.24
SD	1.48	1.71	1.12	4.62	2.42	1.58	8.75	3.69	1.28
Drum revolution, 1961.40rpm									
Average	14.30	4.79	1.06	17.75	6.43	0.82	37.13	7.51	1.01 8
Max	24.92	8.97	3.19	25.96	12.42	1.78	55.3	15.24	3.5
Min	0.9	1.81	0.22	11.64	1.59	0.23	21.32	1.45	0.23
SD	6.03	2.31	0.71	3.69	2.65	0.47	9.61	3.62	0.88
Drum revolution, 2194.90rpm									
Average	7.90	4.17	1.60	15.58	6.24	1.71	37.75	10.05	2.15
Max	12.09	6.65	4.82	25.02	10.61	3.66	50.65	18.65	5.43
Min	5.82	1.58	0.43	10.45	3.06	0.71	25.62	3.8	0.37
SD	1.54	1.57	0.90	3.91	1.64	0.66	8.07	4.50	1.39

S.h.d: Sieves hole **P.D**: pieces dimensions L: pieces length W: width **T**: thickness

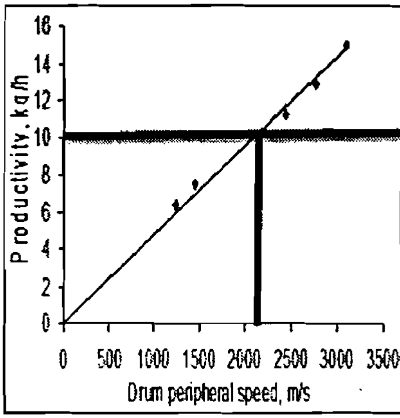


Fig. (6): cutting machine productivity relative to drum peripheral speed

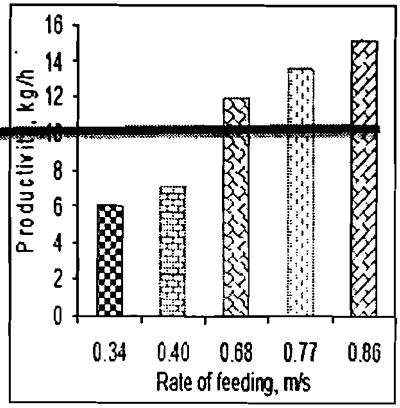


Fig. (7): cutting machine productivity relative to rate of feeding

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الملخص العربي

تفتيت أوراق النخيل باستخدام آلة التقطيع الأسطوانية

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تم دراسة سلوك إسطوانة نموذج تقطيع فى تقطيع أوراق أشجار النخيل الجافة كحل بديل لحرق مثل هذه المخلفات. وذلك لوجود ما يعادل ١.٥ ألف نخلة فى حدائق جامعة المنصورة. وهذا ما يعنى وجود حوالي ٤٥ ميجاجرام سنوياً من مخلفات أوراق الأشجار والتي يمكن تحويلها لتستخدم كفرشة لمزارع الدواجن او علف او سماد. وعليه يتم التخلص من الحشرات والقوارض التي تتغذى على هذه المخلفات. تم إجراء التجارب بإستخدام ماكينة التقطيع المتاحة عند خمس سرعات لدرفيل التغذية. وأوضحت النتائج انه اذا كان المطلوب الحصول علي عينات ذات اطوال متجانسه من ٥ الي ٢٢ مم يجب ان تكون سرعة درفيل القطع عند ١٩٦١.٤٠ لفه/الدقيقة واذا اراد عينات ذات عرض منجانس من ١.٠ إلى ٧.٠ مم يجب ضبط سرعة الدرفيل عند ٢١٩٤.٩٠ لفة/دقيقة ويتم ضبط سرعة درفيل التقطيع عند ٨٧٧.٩٦ لفة/دقيقة عند الرغبة فى الحصول على قطع بسمك ٢ إلى ٣ مم. مما سبق دراسته نجد أنه للمحافظة على إستهلاك الطاقة يجب خفض سرعات درفيل التقطيع.

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