EFFECT OF ENGINEERING PARAMETERS OF RESIDUES CHOPPER ON CHOPPER QUALITY

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ABSTRACT

Crop residues are one of the most problems, which face the Egyptian farmer. The quantity of crop residues in Egypt reached about 18.7 to 25 million Mg per year. The performance of chopping machine was tested under the following parameters. A- Four cutter head speeds (22.1, 25.6, 29.2 and 35.3 m/s), B- Three number of knives were (2, 4, and 8 knives) and C- Three levels of corn stalks moisture contents were (35.0, 45.0, and 65.0 %).

The final results of this study could be summarized as follows:

Generally, increasing the cutter head speed from (22.1 to 35.3 m/s) tend to increase percentage of chopping length 0.5 to 2.0 cm from (50 to 60 %), degree of destruction from (28.7 to 38.2 %) , machine productivity from (1.32 to 2.81 Mg/h), useful power from (2.19 to 3.86 kW), and with decreasing the unit energy required from (1.87to 1.37 kW.h/Mg) and chopping machine cost from (16.33 to 7.22 L.E/ Mg) at number of knives 2 and corn stalk moisture content of 65.0 %.

INTRODUCTION

During the summer season, most of the Egyptian farmers feed their livestock on very poor quality roughage, such as rice and wheat straw. The decrease of forage crops during this period seems to be a serious problem in the nutritional requirements of animal. Beef, dairy cattle and other types of livestock will remain in better condition during the summer season if they receive a succulent feed. There are a little green pastures in the summer such as feed must be grown, harvested, processed and preserved in a silo so that it will be available when needed. In Egypt corn is the principal silage crop. Silage process was hoped to participate in solving the serious problems of feed shortage of livestock.

Hashish et al. (1994) studied some factors affecting the performance of chopping, crushing and grinding equipment for

field raw materials. They concluded that the optimum P.T.O. speed was found to be 700 rpm for the three different raw materials. The highest production rate and efficiency were obtained at low levels of moisture content of 2.50, 5.30 and 6.26 % for rice straw, cotton stalks and corn stalk, respectively.

Pasikatan et al. (1997) used chopper performance with three materials (napier grass, corn stalks and rice straw) was satisfactory. For corn stalks indicated the best setting was 1050 rpm at 2.0 mm clearance. This setting gave 1062 kg/h capacity and specific energy of 1.7 kW.h/Mg.

Khader (1997) studied the interaction effect between different speeds of cutter head and number of knives for cutting some field crop residues such as cotton stalks, been stalks and rice straw and its effect on power requirement and cutting length. He found that the cutting length decreased by increasing number of knives and cutter head drum speed. The recommended cut length for preparing animal fodder ranged from 1.5 to 3.0 cm, with obtaining silage may be produced by using cut length ranged from 3.0 to 6.0 cm.

Kholief et al. (1998) using a stationary chopper to show the effect of corn moisture content , cutter head speed and feed mechanism speeds on chopping lengths. unit energy and machine productivity. They found the maximum value of unit energy was 2.081kW.h/Mg at moisture content of 40.22%, cutter head and feed mechanism speed of 27.65m/s and 0.41 m/min, respectively. Meanwhile, the minimum value was 0.85 kW.h/Mg at moisture content of 62.82% , cutter head and feed mechanism speeds of 20.73m/s and 1.45m/min, respectively.

El-Khateeb (2001) indicated that the increasing the forward speed for chopper corn stalks by rotary mower from (2.51 to 4.51 km/h) tends to increase the stubble height from (8.20 to 12.0 cm), effective field capacity from (0.6 to 1.4 fed/h), and power requirement from (11.06 to 17.06kW), and decrease the cutting efficiency from (95.0 to 89.0%), degree of destruction from (35.0 to 21.0%) and cutting energy from (18.43 to 12.19kW.h/fed).

El-Ashhab et al. (2003) used four crop residues were in values of (corn stalks, corn Stover, rice straw and alfalfa) performance of the chopper before modification. Power

consumption was 1,740, 1,330, 1,580 and 1,350 kW for each of the four materials, respectively. Corresponding chopping energy were 0.775, 0.556, 0.310 and 0.880 kg/Wh for the four materials , respectively.

Lotfy (2003) develop and evaluate a machine for cut and throw agricultural residues. He found that the machine output was (1822, 2128 and 1976 kg/h), average cut length was (2.8, 2.5 and 2.6 cm), energy requirements was (12.14, 11.45 and 11.03kW.h/Mg) and operating cost was (8.13, 6.80 and 7.02 L.E/Mg) for cutting rice straw, cotton stalks and corn stalks, respectively, under cutting speed 43.35m/s, feeding speed 2 m/s and cutting clearance 2 mm.

Musa et al. (2004) developed of combination unit for cutting and chopping corn stalks. He found the maximum percentage of cutting efficiency (96.67%) and chopping efficiency of (86.91%) were obtained at forward speed of 0.9 km/h and knife revolving speed 920 rpm (72.25m/s).

Metwally et al.(2006) developed a chopper machine for agricultural residual. They found that the increase of cutter head speed from 0.75 to 1.88 m/s tends to increase the chopping length by 24.1 and 60.5 % for serrated and straight-edge shapes

MATERIALS AND METHODS

The experimental work was carried out at research farm of Rice Mechanization Center, Meet El Deba, Kafr El- Sheikh, Governorate. During summer season 2006.To evaluate the operating parameters affecting on power and energy requirements for chopping and to fulfill the objectives of this research work, the forage chopper was used for chopping corn stalks under the following variables:

A-Four cutter head speed of (22.1, 25.6, 29.2, and 35.3 m/s).
B-Three number of knives of (2,4, and 8 knives) and
C-Three levels of corn stalks moisture contents of (65.0, 45.0, and 35.0 %).

These factors were studied for the following determinations: machine productivity, chopping length, chopping power requirements, degree of destruction of stalk borer and chopping cost for the corn stalks variety one-cross 10.

Equipment:

The stationary forage chopper was mounted on the 65 hp NASR tractor (48.5 k.W) by three hatch points during chopping corn stalks in the present study. The main components of this chopping are sketched in Figure (1) and technical specifications of this chopper are summarized in Table 1.

Table 1: Machine Specifications:

Item	Detal
Model	ALTIC
Country	EGYPT
Power source	P.T.O. Shaft (65 H.P. 540 r.p.m.)
Feeding system	Manual (axel direction with cutter head)
Number of knives on cutter head	2 ,4, and 8 knives
Flywheel diameter	70 cm
Cutting r.p.m. and Feeding r.p.m.	1620 and 270
Upper feed drum	Scraper and diameter is 20 cm
Lower feed drum	Flat and diameter is 12 cm.
Maximum height	275 cm
Maximum length	155 cm
Maximum width	160 cm

Machine performance determination:

Machine Productivity:-

Was calculated by using the following formula by **Mady, 1999.**

$P = W \times 3600 / T$, Mg/h,.....1

where:

P = productivity in Mg/h; W = mass of the sample in Mg, and T = time in sec.

Degree of destruction of the stalk borer:-

Was calculated by using the following formula by **Hånna et al.1985.**

$$\text{Degree of Destruction, \%} = \frac{F - L}{F} \times 100, \quad \text{.....2}$$

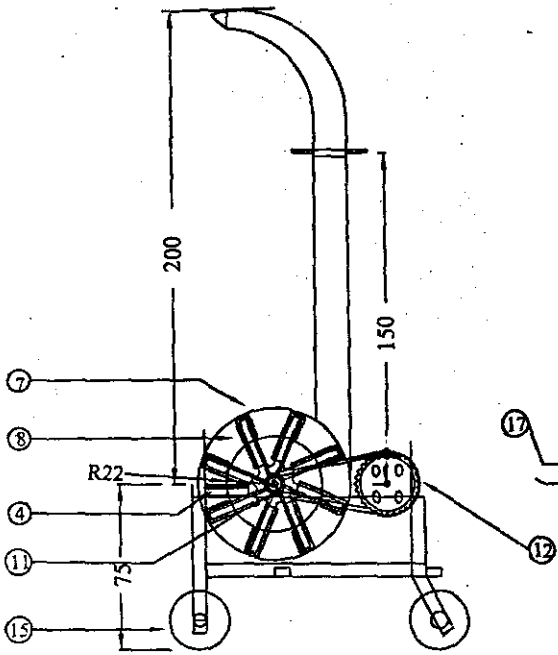
where:

F = Number of infested corn stalks borer before chopping and

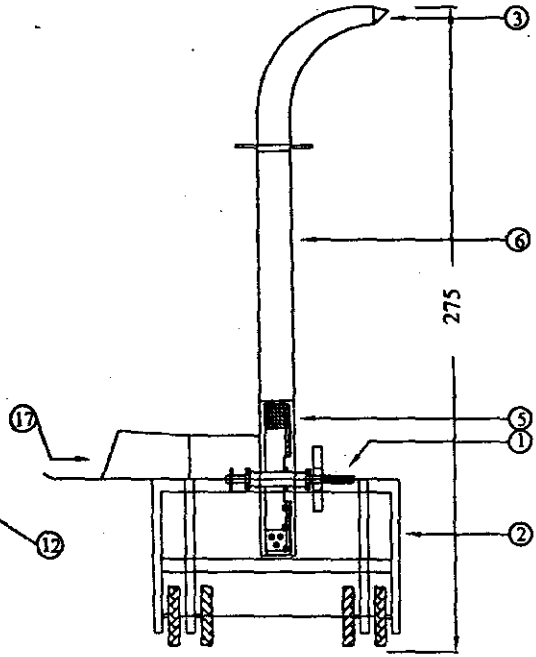
L = Number of infested corn stalks borer after chopping operation

Required power :

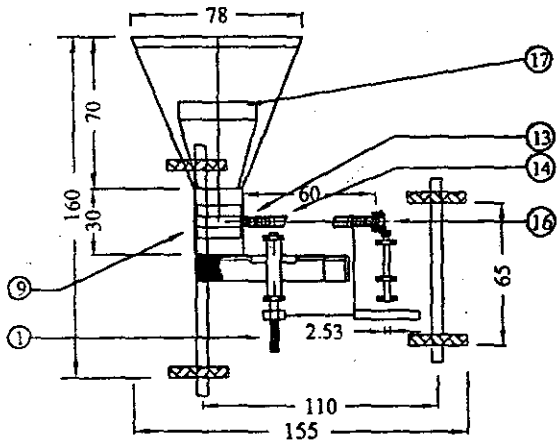
Chopping energy requirements estimated by using the following formula, **Embaby 1985.**



ELEVATION



SIDE VIEW



PLAN

No.	Part name
1	Driver (power) shaft.
2	Chassis.
3	Deflector cap.
4	Fixed blade (counter shear bar)
5	Impeller blade.
6	Delivery spout.
7	Flywheel (cutterhead).
8	Rotate blade (chopper).
9	Upper feed roller.
10	Down feed roller.
11	Driver sprocket.
12	Driven sprocket.
13	Universal joint.
14	Telscope shaft.
15	Transport wheels.
16	Bevel gear ratio (1/2).
17	Feed gate.

Dimenssions in cm.

Fig. (1) CHOPPER MACHINE (ALTIC-FLYWEEL)

$$E_P = (F_C \times \frac{1}{3600})\rho_F \times L.C.V. \times 427 \times \eta_{th} \times \eta_m \times \frac{1}{75} \times \frac{1}{1.36} \text{ kW}, \ldots\ldots\ldots\ldots 3$$

where;

E_P =power required ;

F_C =the fuel consumption, L/h;

ρ_F =the density of fuel, 0.85 kg/l;

$L.C.V$ =lower calorific value of fuel, 10000kcal/kg;

η_{th} = the thermal efficiency of engine, 35% for diesel engine;

427 = thermo- mechanical equivalent, kg.m/k.cal, and

η_m = the mechanical efficiency of engine, 80% for diesel engine.

Useful Power = (load –unload) power, kW,..... 4

$$\text{Power unit} = \frac{useful\ power, kW}{machine\ productivity, Mg/h}, \text{ kW.h/Mg}.....5$$

Estimation chopping cost:

The total hourly cost of chopping corn stalks using the forage chopper could be estimated by the following equation according to **EL-Awady, 1978** as follows:

$$C = \frac{p}{h}(\frac{1}{L} + \frac{i}{2} - + a + r) + (0.9w \times f \times u) + b, \ldots\ldots\ldots\ldots 6$$

where;

C = cost per hour of operation, L.E/h;

P = estimated price of the machine, 8000 L.E for chopper machine ;

h = estimated yearly hour operation ,1000 for chopper machine;

L = life expectancy of the machine, 10 years;

i = annual interest rate, 10 %;

a = annual taxes and overheads, 2 %;

r = annual repair and maintenance rate, 18 %;

0.9 = correction factor for rated load ratio and lubrication;

w = engine power, 65 hp;

f = specific fuel consumption, L/hp.h;

b = hourly labor wage, 3 L.E/h, and

u = fuel price, 0.75 L.E/L .

RESULTS AND DISCUSSION

1-- Chopping length (cm):-

Data and results of chopping length of stalks as affected by different variables are summarized in Table 2. The percentage of small chopping length increased as the cutter head was increased at constant number of knives and corn stalks moisture content.

Chopping machine at 65 % corn stalk moisture content and number of knives2, by increasing cutter head speed from 22.1 to 35.3 m/s it was found that percentage of chopping length changed to from (50 to 60 %, 30 to 26 % and 20 to 14 %) at cut stalk lengths of (0.5 to 2 cm, 2 to 4 cm and bigger than 4 cm), respectively.

Table 2 :- Effect number of knives and cutterhead speed on cutting stalk length at different corn stalks moisture content.

Moisture content, %	Cutter head speed, m/s.	Cut stalk of lengths, cm	Number of knives		
			2	4	8
65.0	22.1	0.5 – 2	50 %	69 %	80 %
		2 – 4	30	28	20
		> 4	20	3	--
	25.6	0.5 – 2	54	73	86
		2 – 4	29	27	14
		> 4	17	--	--
	29.2	0.5 – 2	57	77	92
		2 – 4	28	23	8
		> 4	15	--	--
	35.3	0.5 – 2	60	82	99
		2 – 4	26	18	1
		> 4	14	--	--
45.0	22.1	0.5 – 2	46 %	66 %	76 %
		2 – 4	34	24	24
		> 4	20	10	--
	25.6	0.5 – 2	48	69	82
		2 – 4	32	31	18
		> 4	20	--	--
	29.2	0.5 – 2	52	74	88
		2 – 4	30	26	12
		> 4	18	--	--
	35.3	0.5 – 2	56	76	95
		2 – 4	27	24	5
		> 4	17	--	--
35.0	22.1	0.5 – 2	42 %	64 %	71 %
		2 – 4	35	29	29
		> 4	23	7	--
	25.6	0.5 – 2	46	66	78
		2 – 4	33	34	22
		> 4	21	--	--
	29.2	0.5 – 2	49	71	84
		2 – 4	31	29	16
		> 4	20	--	--
	35.3	0.5 – 2	54	73	90
		2 – 4	28	27	10
		> 4	18	--	--

Chopping machine at 22.1 m/s cutter head speed and corn stalk moisture content of 65 %. when the number of knives increased from 2 to 8 knives, the percentage of chopping length

changed to from (50 to 80 %, 30 to 20 % and 20 to 3 %) at cutting stalk lengths of (0.5 to 2 cm, 2 to 4 cm and bigger than 4 cm), respectively. The cut stalk lengths of 4 to 5 cm did not appear at number of knives 8.

Chopping machine at cutter head speed of 25.6 m/s and number of knives of 2, when the corn stalks moisture content increased from 35 % to 65 %, the percentage of chopping length changed to from (46 to 54 %, 33 to 29 % and 21 to 17 %) at cutting stalk lengths of (0.5 to 2 cm, 2 to 4 cm and bigger than 4 cm), respectively, as summarized in Table 2.

2- Chopper productivity (Mg/h):-

The results of chopper productivity are shown in Figure 2. From these results it could be indicated that an increase in cutter head speed, number of knives and corn stalks moisture content results in an increment in the chopper productivity .Mg/h.

The average values of the chopper productivity of 1.56, 1.95, 2.63 and 3.53 Mg/h were obtained when using number of knives 8 on chopper cutter head under cutter head speed of 22.1, 25.6, 29.2 and 35.3 m/s at corn moisture content of 65 %.

3- Degree of destruction of stalk borer (%):-

The degree of destruction is affected by cutter head speed. number of knives and corn stalk moisture content as shown in Figure 3. It is noticed that the following cutter head speed of 22.1, 25.6, 29.2 and 35.3 m/s, gave the degree of destruction of 50.9. 55.8, 65.1 and 72.5 %, respectively, The other number of knives 2 and 4 gave the same above mentioned trend. Also, it can be concluded that increasing corn stalk moisture content from 35 to 65 % tends to decrease the degree of destruction from 72.5 to 42.3 %. These results agreed with that obtained by **El-Khateeb, 1991**.

4- Useful power (kW):-

Results of useful power required to chopping corn stalks as affected by different variables are shown in Figure 4. At number of knives of 2 and corn stalk moisture content of 65 %. when the cutter head speed increased from 22.1 to 35.3 m/s, it was found that useful power increased from 2.19 to 3.86 kW. due to increase of fuel consumption. Chopping machine at cutter head speed of 22.1 m/s and 65 % moisture content, when the number of knives increased from 2 to 8 knives the useful power increased from 2.19

to 2.94 kW, due to increase of fuel consumption by increasing number of knives.

Chopping machine at cutter head speed of 22.1 m/s and number of knives 2, when the corn stalks moisture content increased from 35 to 65 %, the useful power decreased from 5.81 to 2.19 kW.

5- Unit energy (kW.h/Mg):-

The unit energy (kW.h/Mg) is the best indicator to show the effect of these parameters. Figure 5 and Table 3 shown the unit energy increased as the number of knives was increased at constant cutter head speed and corn stalks moisture content. By increasing the number of knives from 2 to 8 tends to increase the unit energy from 1.87 to 2.65 kW.h/Mg. at corn stalk moisture content of 65 % and cutter head speed of 22.1m/s. Chopping machine at number of knives 2 and moisture content 35 %, when the cutter head speed increased from 22.1 to 35.3 m/s tends to decreased the unit energy from 5.19 to 2.91 kW.h/Mg. Chopping machine at cutter head speed of 35.3 m/s and number of knives of 8. when the corn stalk moisture content increased from 35 to 65 % tends to decrease the unit energy from 3.10 to 1.65 kW.h/Mg. These results agreed with that obtained by **Mohamed et al.,1999.**

Table 3: Effect number of knives and cutter head speed on unit energy at different moisture contents.

Corn stalk moisture content, %	Cutter head speed, m/s	Unit energy, kW. h/Mg.		
		Number of knives		
		2	4	8
35	22.1	5.19	5.25	5.40
	25.6	4.60	4.59	4.96
	29.2	3.67	3.76	3.83
	35.3	2.91	3.03	3.10
45	22.1	2.41	2.66	2.72
	25.6	2.33	2.40	2.46
	29.2	2.25	2.32	2.40
	35.3	1.96	2.00	2.10
65	22.1	1.87	2.59	2.65
	25.6	1.66	1.74	1.89
	29.2	1.60	1.66	1.75
	35.3	1.37	1.46	1.65

6- Chopping machine cost (L.E/Mg) :-

The chopping machine cost of stalk residues was estimated. It could be cleared that the chopping machine cost was found to be 25.48 L.E/h. The chopping machine cost was 16.33, 13.07, 9.63,

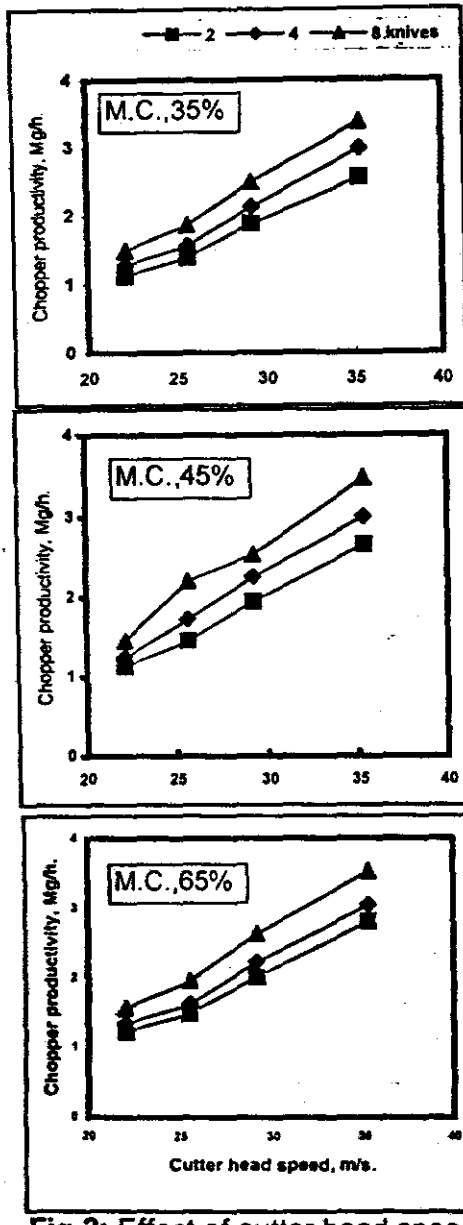


Fig.2: Effect of cutter head speed and knives number on chopper productivity at different moisture content.

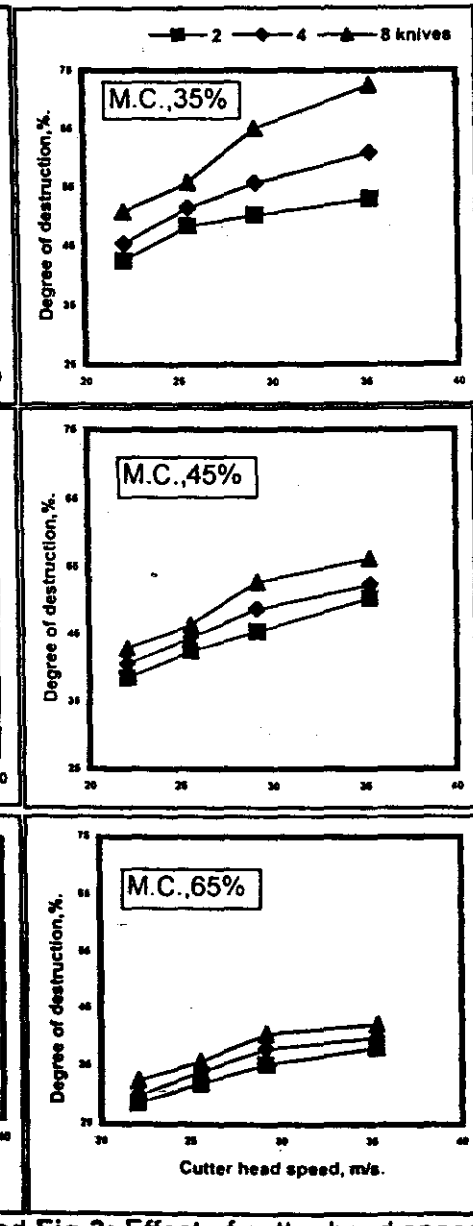


Fig.3: Effect of cutter head speed and knives number on degree of distruction at different moisture content.

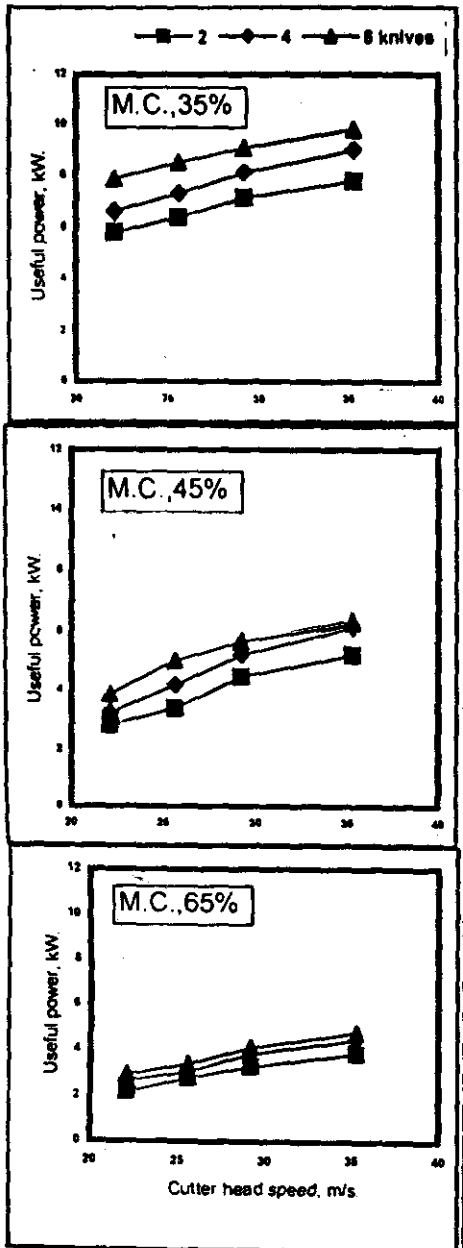


Fig.4: Effect of cutter head speed and knives number on useful power at different moisture content.

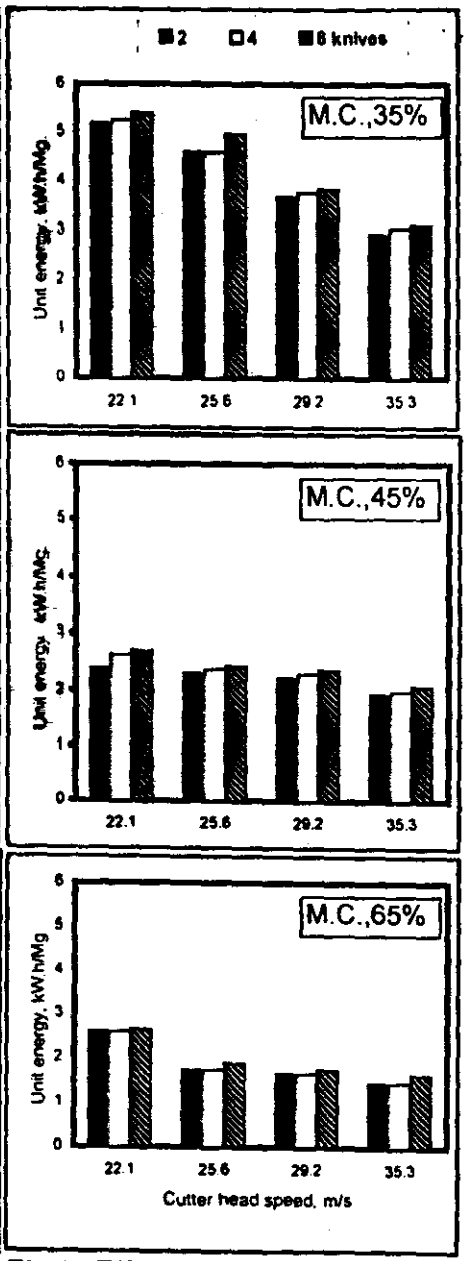


Fig.5: Effect of cutter head speed and knives number on unit energy at different moisture content.

and 7.22 L.E/Mg, when the cutter head speed increased from 22.1 to 35.3 m/s at corn stalks moisture content of 65 %and number of knives 8.

CONCLUSION

1- The chopper productivity values of 1.56, 1.95, 2.63 and 3.53 Mg/h were obtained when using 8 knives on chopper cutter head under cutter head speed of 22.1, 25.6, 29.2 and 35.3 m/s at corn stalks moisture content of 65.0 %.

2- By increasing cutter head speed from 22.1, 25.6, 29.2 and 35.3 m/s tends to increase the degree of destruction from 50.9, 55.8. 65.1 and 72.5 %,respectively. At moisture content 35% and number of knives 8.

3- When the cutter head speed increased from 22.1 to 35.3 m/s and number of knives from 2 to 8 knives tends to increase useful power from 2.19 to 3.86 kW. 2.19 to 2.94 kW and decreased useful power from 5.81 to 2.19 kW by increasing corn stalks moisture content from 35 to 65 %, at number of knives 2. and cutter head speed of 22.1 m/s.

4- The unit energy in kW.h/Mg decreased from 5.19 to 2.91 kW.h/Mg and 1.87 to 1.37 kW.h/Mg when the cutter speed increased from 22.1 to 35.3 m/s and corn stalk moisture content increased from 35 to 65%. Also, by increasing number of knives from 2 to 8, tends to increase the unit energy from 1.87to 2.65 kW.h/Mg, at moisture content of 65 % and cutter head speed of 22.1 m/s.

5- Total chopping machine cost was found to be 16.33, 13.07, 9.63 and 7.22 L.E/Mg, when the cutter head speed increased from 22.1. 25.6. 29.2 and 35.3 m/s. at corn stalks moisture content of 65 % and number of knives 8.

RECOMMENDATIONS

Results of this study may be recommended, that silage production can be produced by chopping corn stalk at 65.0% moisture content with using 2 knives on cutter head and cutter head speed of 35.3 m/s. Meanwhile, at the same corn stalk moisture content and cutter head speed chopping corn stalk for direct feeding

may be obtained by using 8 knives on cutter head to obtain an minimum energy consumption.

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الملخص العربي

تأثير بعض العوامل الهندسية لآلة فرم المخلفات الحقلية على جودة الفرم

د / حمادة على الخطيب

باحث أول بمعهد بحوث الهندسة الزراعية

مركز البحوث الزراعية-الدقي الجيزة

تعتبر المخلفات الزراعية احد المشاكل الحيوية التي تواجه المزارع المصري في الوقت الراهن في كيفية الاستفادة المباشرة منها أو اعادة تدويرها حيث يصل أجمالي المخلفات الزراعية إلى ٧و١٨- ٢٥ مليون طن سنويا والتي يمكن أن تعتبر احد الموارد الطبيعية لزيادة الدخل القومي بما يقرب من ٦و١ مليار جنية مصري سنويا.

ولتحقيق هذا الهدف أجريت تجارب على آلة فرم المخلفات الحقلية محلية الصنع آلتيك لفرم حطب الاذرة في مركز ميكنة الأرز بميت الديبة موسم ٢٠٠٦ تحت تأثير المتغيرات الآتية:-

١- أربعة سرعات دورانية لسكاكين الفرم (١و٢٢ - ٦و٢٥ - ٢و٢٩ - ٣و٣٥ م/ث).

٢- ثلاث أعداد لسكاكين الفرم (٢ - ٤ - ٨).

٣- ثلاث محتويات لرطوبة عيدان الاذرة (٣٥ - ٤٥ - ٦٥ %).

وقد كانت النتائج المتحصل عليها كما يلي :-

١- أدى زيادة المحتوى الرطوبى لعيدان الاذرة من ٣٥ إلى ٦٥ % إلى نقص درجة تدمير ديدان ثاقبات الساق من ٥و٧٢ % إلى ٣و٤٢ %.

٢- عندما زادت سرعة سكاكين القطع من ١و٢٢ إلى ٣و٣٥ م/ث وعدد السكاكين من ٢ - ٨ أدت إلى زيادة القدرة المستفادة من ١٩و٢ إلى ٨٦و٣ كيلووات و ١٩و٢ إلى ٩٤و٢ كيلووات ونقصت القدرة المستفادة من ٨١و٥ إلى ٩١و٢ كيلووات بزيادة المحتوى الرطوبى لعيدان الاذرة من ٣٥ إلى ٦٥ % عند ثبات عدد السكاكين ٢ والسرعة الدورانية لسكاكين الفرم ١و٢٢ م/ث.

٣- عندما زادت سرعة سكاكين الفرم من ١و٢٢ إلى ٣و٣٥ م/ث المحتوى الرطوبى من ٣٥ إلى ٦٥ % أدى إلى نقص وحدة الطاقة من ١٩و٥ إلى ٩١و٢ كيلووات.ساعة / ميجا جرام ومن ٨٧و١ إلى ٣٧و١ كيلووات.ساعة/ ميجا جرام على التوالى.وبزيادة عدد السكاكين من ٢ -٨ سكينة أدى إلى زيادة وحدة الطاقة من ٨٧و١ إلى ٦٥و٢ كيلووات.ساعة /ميجا جرام عند محتوى رطوبى ٦٥% وسرعة سكاكين القطع ١و٢٢ م/ث.

٤- التكاليف الكلية لآلة فرم حطب الاذرة كانت ٣٣و١٦ - ٠٧و١٣ - ٦٣و٩ - ٢٢و٧ جنية / طن عندما زادت سرعة سكاكين الفرم من ١و٢٢- ٦و٢٥ - ٢و٢٩ -٣و٣٥ م/ث عند المحتوى الرطوبى ٦٥ % وعدد سكاكين الفرم ٨ .

التوصيات

توصى الدراسة عند عمل السيلاج يراعى تشغيل الإلة عندما يصل المحتوى الرطوبى ٦٥ % باستخدام ٢ سكينة على درفيل القطع وسرعة سكاكين القطع ٣و٣٥ م/ث. بينما يفضل تشغيل الإلة باستخدام ٨ سكينة على درفيل القطع عند فرم الاذرة بغرض التغذية المباشرة عند نفس المحتوى الرطوبى وسرعة سكاكين القطع وذلك لتقليل الطاقة المستهلكة في عملية الفرم.