J. Agric. Sci. Mansoura Univ., 32 (9): 7307 - 7323, 2007

DEVELOPMENT AND REDESIGN OF CROP RESIDUE CHOPPING MACHINE

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ABSTRACT

Crop residues are considered among the most important materials in Egypt, e.g. especially cotton stalks, corn stalks and rice straw. There are many types and makes of the imported choppers to Egypt to assist in recycling the field crop residues. One of the chopper machines which are imported have many problems such as size of cut and throwing cut materials outside the machine. The present research work was conducted at Gimaza research station, Gharbia Governorate to test the machine performance before and after modification. The main objectives of this study were:

1- Testing and evaluating the chopper (original type).
2- Modifying and redesign the machine to improve the thrower operation, power transmission, the efficiency and increasing the productivity.
3- Producing and fabricating the machine after modification locally.
4- Testing and evaluating the chopper machine after fabrication.

The modified machine was fabricated from local materials at a private sector company (Tanta motors). The cutting drum was modified, 32 flail knives were mounted on the circumference of a pipe drum (18 cm diameter). The overall drum diameter was 56 cm. The thrower fan was also modified to have direct central suction (centrifugal fan). The main results of the machine capacity before modification were: 484.6 kg/h and 625 kg/h (max. machine capacity) for cotton stalks and corn stalks, respectively at 3500 rpm drum speed. The max. chopping power required was 15.5 kW (21 hp) and 13.4 kW (19 hp) for cotton and corn stalks, respectively. The air speed was not enough at all tests to throw the cutting material outside machine duct, so the rear plat (concave cover) was moved through tests. The modified locally manufactured machine was tested with cotton stalks, corn stalks and rice straw. The results were improved with cotton and corn stalks and the machine was successful with rice straw. The main capacities were as follows: 1200, 800, 1224 kg/hr (max. machine capacity) for cotton stalks, corn stalks and rice straw, respectively at 3500 r.p.m chopping drum speed. The maximum chopping power requirements were 25.98 kW (35.35 hp), 22.98 kW (31.27hp) and 24.29 kW (33.05 hp) for chopping cotton, corn stalks and rice straw respectively. The size of the cut materials varied between 1.4 mm to 300 mm before modification and between > 0.71 mm to 30 mm after modification.

INTRODUCTION

Field crop residues are available in abundance in Egypt. They are estimated to be about 30 million tons every year (Ministry of Agriculture 2004). Cotton stakes, corn stalks and rice straw are considered as the main problems facing agriculture in Egypt as well as polluting environment. Nowadays different types of shredding and chopping machines are imported. Some of those machines are not suitable for Egyptian conditions. For this reason the present study is concerned to measure and calculate the performance, productivity and power requirement of a French type chopping machine which was imported from France to test evaluate and to compare with a locally fabricated chopping machine which was redesigned and modified to be suitable for use under Egyptian condition to cut and shred different crop residues. Cotton–stalk removal is one of the most urgent field operations to mechanize, because of the timeliness importance of land clearance and labor has become so scarce and expensive. The suitable rotational speed for chopping cotton stalks was assumed to be 500 rpm. (Awady et al 1985).

Bainer *et al* (1975) reported that shear failure is almost invariably accompanied by some deformation in bending and compression, which increase the amount of wok required for the cutting operation. A common way of applying the cutting force is by means of two opposed shearing elements which meet and pass each other with little or no clearance between them. A single cutting element is sufficient if the nature of the operation permits a fixed surface such as the ground to act as one of the shearing elements.

McRandal and McNulty (1978) reported that impact cutting tests were conducted using two drums vertical spindle rotary mowers in 8 fields. Mowing tests at a blade velocity of 5.5 km/h revealed that power consumption increased linearly as crop density increased from 0.95 to 5.42 kg/m^2. A stepwise multiple correlation analysis confirmed that the mass of crop per unit area of ground was by far the most important factor affecting the power consumption. By comparison, the stem shearing strength, number of stems per unit area, dry matter content and crop height accounted for14,13,6 and 2% respectively. Also mentioned laboratory studies have revealed that power is consumed in impact cutting mainly in crop acceleration and in stem-blade friction during and after cutting takes place whereas the shearing resistance consumes only a friction of total energy.

El-Nakib (1985) used a rotary cutter shredder in cutting stalks. It worked as a unit with a tractor provided with hydraulic lifters. It provid to be satisfactorily in cotton stalk harvesting. A low speed of 1.65 km/h gave clean cut with short stubbles of 8.1 cm height. Whereas a high speed of 6.3 km/h gave a ruptured cut with longer stubble of 18.7 cm mean height.

Jekendra and Singh (1991) reported that the energy requirement of various fodder harvesting machines differ significantly from those of net cutting. Crop acceleration, compaction and conveyance normally consume more than 50 % of total energy while energy consumed in shearing stems is normally less than 3 %. A desired blade bevel angle ranging from 20° to 30° with a rake angle of 10° to 20° operating at speeds between 25 to 35 m/s gives an optimum cutting energy requirement for forage materials having 35 % moisture content.

El-Saadany (2003) concluded that the percentage of cutting efficiency increased with increasing the numbers of helical shaft revolution until it reached the maximum cutting efficiency. The cutting efficiency increased with increasing edge angle from 21° to 24°, while it decreased with increasing edge angle from 24° to 27° at the same helical shaft speed.

El-Iraqi and El-Khawaga (2003) found that the maximum percentages in cutting length less than 5cm were 87.80 and 92.00% obtained for rice straw and corn stalks residues, respectively, at cutting speed of 10.09m/s, feeding rate of 0.771ton/h and knife clearance of 1.5mm. The maximum values of power consumption of 4.90 and 4.76kW were obtained at the same feeding rate and cutting speed with 4.5mm knife clearance for cutting rice straw and corn stalks, respectively.

MATERIALS AND METHOD

Crop residues during storage will cause environmental pollution and many hazard fairs. The original machine and the local modified machine were tested with cotton, corn stalks and rice straw to evaluate their performance, productivity, power requirement and cost analysis.

1- Machine specification:

Specification.	Machine status	
	Before modification.	After modification.
Feeding width	40 cm.	40 cm.
Drum width	40 cm.	40 cm.
Drum diameter	52 cm.	56 cm.
Machine width	42 cm.	55 cm.
Machine length	120 cm.	180 cm.
Machine height	85 cm. total 145cm.	90 cm. total 210 cm.
Drum Speed.	max. 95.25 m/sec. min. 66.67 m/sec	Max.102.57 m/sec. Min 71.8 m/sec.
Fan speed.	3500 rpm (73.26 m/sec)	2333 rpm.(68.37 m/sec)

Figures (1 and 2) show the main assembly drawings for the machine before and after modification.

2- Machine components:

1- Main frame:

The machine main frame was fabricated from sheet metal 5 mm. thickness (steel 37). The main housing also was fabricated from 5 mm sheet metal and welded to the machine base as shown in Fig. (2).

2- Chopping drum:

It was modified, redesigned and fabricated locally to improve the cutting efficiency and increase the productivity.

-- **Chopping drum before modification** was consisted of as shown in fig (3):- 1- Main shaft 55 mm diameter 2- Knives bases consists of 12 blades (29cm length, 10cm width and 5 mm thickness). 3- 24 knives (flat iron 40 mm width, 150 mm length and 10 mm thickness). The knives haven't any over lubing.

-- **Chopping drum after modification** was consisted of as shown in Fig. (4):1-main shaft 2-steel pipe (18 cm diameter) 3-Knives: The knives were (flail type). The knives were heat treated (hardened and tempered). Static and dynamic balance was run on the chopping drum at 4500 rpm. The knives had over lubing.

3- Suction fan:

- **Before modification**: as shown in Fig. (5). The fan was mounted on the same main shaft of chopping drum. It was fly wheel, radial type and it was consisted of flange (40 cm diameter) and four blades are welded perpendicular on the flange.
- **After modification:** as shown in Fig. (6). Suction fan was centrifuge type. It was consisted of 1- horizontal shaft. 2- Four arms 3- Four fan blades were

mounted on the four arms. 4- Fan housing. 5- Three suction duct. Two duct are sucked the cutting materials to the fan housing and one duct to suck the cutting materials to outside machine.

4- Feeding system:

As shown in Fig. (2) The feeding system was fabricated from sheet metal 5 mm thickness) and modified by adding feeding drum to arrange the feeding materials to be homogeneous.

5- Power transmission:

Universal joint was used to transmit the power from tractor PTO. to the machine through gear box (1 to 7) which increased the speed from 500 to 3500 rpm on the main shaft (chopping and fan). Safety unit (coupling unit) was mounted between gear box and main shaft. After modification the power was transmitted from main shaft to the feeding drum and fan shaft by pulleys and belts.

Field experiments:

The machines were tested under four different rotational speeds 2450 – 2800 – 3150 – 3500 rpm, (66.67 – 76.2 – 85.72 – 95.25 m/sec) before modification and (71.8 - 82 – 92.3 – 102.57 m\sec) after modification, respectively. Crop residues were used in the experiments as cotton stalks, corn stalks and rice straw. The experiments were run at Gemmiza research station in the Gharbia government.

1- Physical properties.

Three samples from cotton stalks, corn stalks and rice straw were randomly collected and chosen to determine the stalk length, diameter, average weight, specific density and number of plants in one squire meter of the field. Each sample was 100 stalks.

2 - Power required for cutting materials.

The power required for operating machine was calculated by measuring the fuel consumption of tractor and machine with no load.

- The power required for cutting materials was calculated from measurements and determining the power consumption of tractor and machine with load.

The following formula was used for calculations (Hanna, 1985).

$$HPc = Fc \times \sigma_f \times C.V \times (4270/750) \times 0.735 \quad (1)$$

$$HPc = 4.18\ Fc \times \sigma f \times C.V \quad (2)$$

$$HPAc = Fc \times \sigma f \times C.V \times (4270/750) \times 0.814 \times 0.3 \quad (3)$$

Where:-

Fc = the fuel consumption, lit/sec.

σ_f = Density of the fuel, kg/lit; (0.85kg/lit).

C.V = Calorific value of fuel, k.cal/kg.(considered as 1000K cal/kg)

427 = Thermo-mechanical equivalent, kg. m/kcal.

HPAc = Actual required power HP.

0.3 = Thermal horsepower. (Artamonov,1967)

0.814 = Transmission efficiency. (Cales E. Sheets J. 1967)

HPt = HPc + HPd

HPc = The required power for cutting materials..

HPd = The required power for operating the machine.

3 - Cutting efficiency:
Cutting efficiency was calculated by measuring the stem length before cutting and the size or length of particles after cutting. That according to the following equation:

$$\zeta cutting = (Lb - Laf) / L \text{ ---------------------------------- } (4)$$

Where:-
ζcutting = cutting efficiency. (%).
Lb = Residual length before cutting.
Laf = Particles length after cutting.

The length of the residual before and after cutting was measured as average from 100 random samples which were collected from residues before cutting and from particles after cutting.

4 – Productivity:

It was calculated with each of cotton stalks, corn stalks and rice straw according the following equation.

P = Feeding rate (inlet) kg/hr

$$P = Fr/t \text{ ---------------------------------- } (5)$$

Where:-
P = Productivity (kg/h). Fr = Feeding rat (kg.)
T = Time in hrs.

5 – Energy required for operating machine:

It was calculated by using the following equation:

$$E = P/ M \text{ ---------------------------------- } (6)$$

Where:-
E = Energy kW h/kg P = Total power kW M = productivity kg/h.

6 – Fan performance:

It was calculated by measuring the fan speed as rpm and linear speed as m/sec before and after modification with productivity, also measuring the air speed m/h by anemometer. The theoretical fan power requirement was calculated by using the following equation (El-Sahrigy, 1997):

$$P_{th} = V \rho h / \text{standard HP} \text{ ---------------------------------- } (7)$$

Where:-
P_{th} = theoretical fan power requirement
V = Air discharge, m^3/min.
V = S * A, m^3/min
S = Air speed, m/min
A = Section area, m^2
ρ= Air density, kg/m^3. (1.2 kg/m^3) add a pressure of 400 pa (N/m^2).
h = Fan dynamic head, m.
standard HP = 4500 (const)
Fan dynamic head = h = P/y
Y = ρ g where:-
g = Acceleration of gravity, m/ s^2

Fan efficiency:

$$\eta = P_{th} / P_{act} \text{ ---------------------------------- } (8)$$

Where:-

η = fan mechanical efficiency, %.

P_{act} = fan actual power, HP (kW).

7 –Estimated Cost of the machine operation:

The costs are calculated according to the following (Awady, 1982):

$$C = P/hr\ (1/a + 1/2 + t + r) + (1.2\ w.f.u) + m/144 \quad \text{-------- (9)}$$

Where:-

P = Price of the machine . (pound) Hr = Yearly working hours (h)

a = Life expected of the machine. I = intrest rate /year.

T = Taxes and over heads ratio. r = Repairs and maintains ratio.

w = Power of the machine. f = Specific fuel consumption.

1.2 = A factor accounting for lubrication.

m = Operator monthly salary. u = Price of the fuel/L E.L

144 = The monthly average working hours.

RESULTS AND DISCUSSIONS.

The chopping machine was tested before and after modification with cotton, corn stalks, and rice straw. Nasr tractor 65 Hp was used to operate the machine.

The results for the original machine before modification were recorded with cotton stalks and corn stalks but after modification the machine able to deal with cotton, corn stalks and rice straw at different speeds 2450, 2800, 3150 and 3500 rpm.

1 – Physical and mechanical properties of crop residues:

Physical properties were studied and recorded as shown in table (1)

Table (1) Physical properties of crop residues.

Crop residues	Average length, cm.	Average diameter, cm.	Average moisture content, %.
Cotton stalk.	115 to160 (137.5)	1 to 1.8 (1.4 cm.)	11
Corn stalk.	190 to 230 (210)	1.5to 2.5 (2 cm.)	13
Rice straw	70 to 90 (80)	0.4 to 0.7 (0.55 cm)	14

2 – Power required for operating machine and cutting materials:

It was calculating according to equation (1,2,3).

- **Machine before modification.** In this case the power was measured with cotton, corn stalks but it wasn't successful with rice straw because the knives distribution on the cutting drum hasn't over lubing and the main shaft diameter is too small (55 mm), so the cutting materials was longer and not pass through the concave holes and the straw rap around the shaft. The power required for operating machine and cutting materials was increased with increasing the rotation speed at same moisture content for each crop residuals as shown in table (2) and and Fig. (7). All the previous data and results were recorded without operating thrower fan because the fan caused the jamming of the materials inside the machine. The results of regression analysis show that the relationship of total power required and net power for cutting with rotational speed (before modification) as shown in Fig. (7).

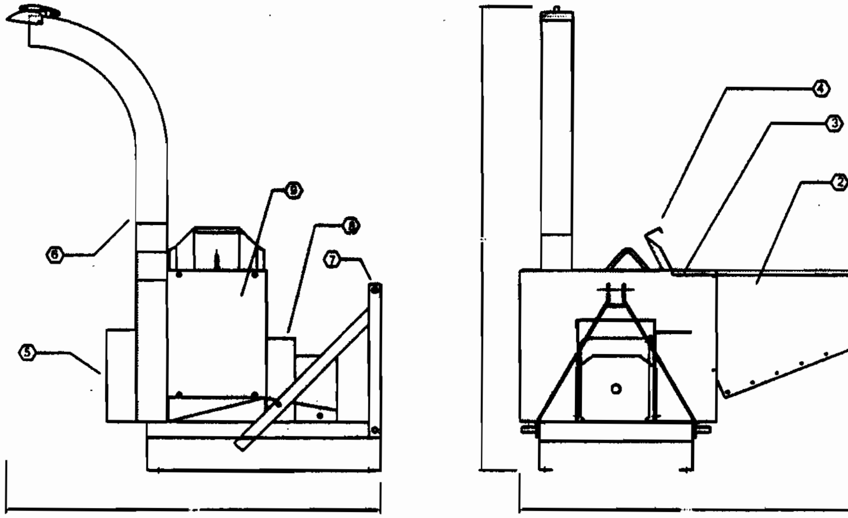
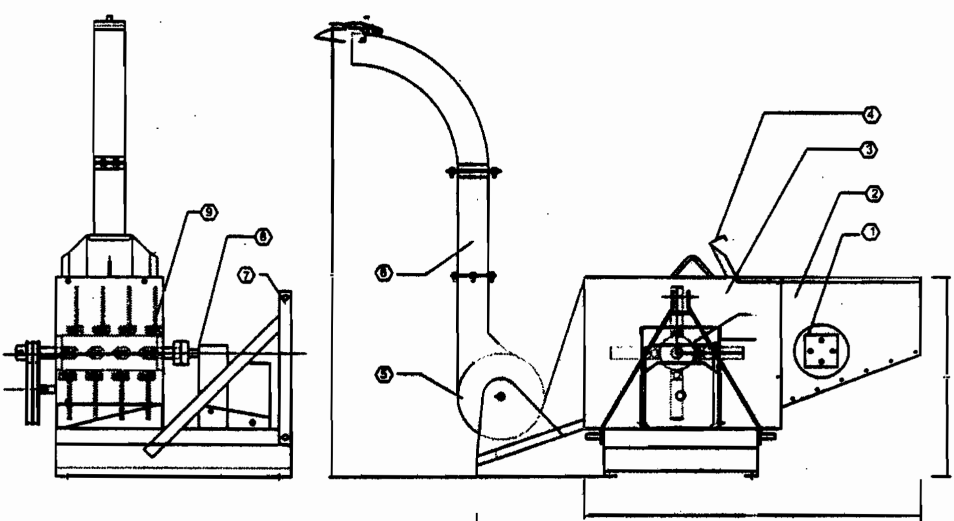


Fig. (1) Chopper before modification.



1- Feeding drum 2- Feeding tray 3- Main frame 4- Feeding gate 5- Fan
6- Thrower duct 7- Three hitch points 8- Gear box 9- Chopping drum
Fig. (2) Chop, ər after modification.

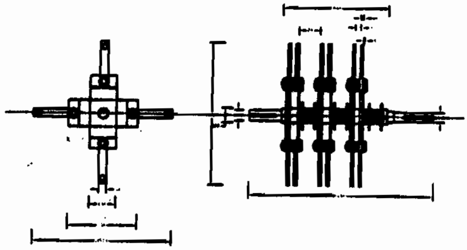


Fig. (3) Cutting Drum Before Modificationm

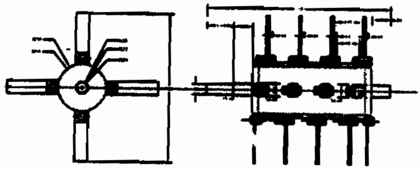
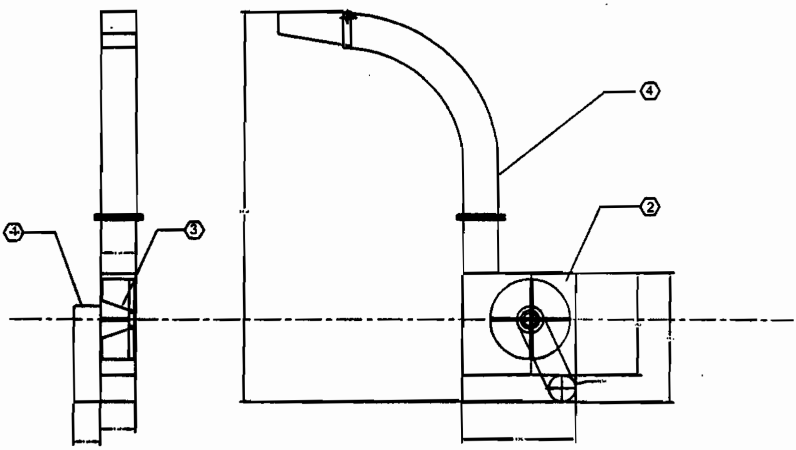
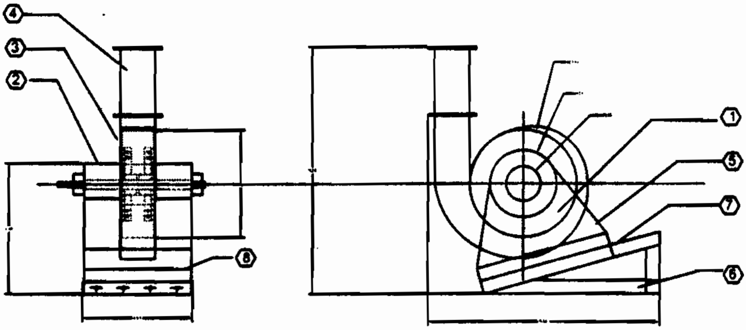


Fig. (4) Cutting Drum after Modificationm



1- Main fram 2- Housing 3- Fan 4- Thrower fuct
Fig. (5): Fan before modification.



1- Main duct 2- Housing 3- Fan 4- Thrower duct 5- Suction duct (right and left) 6- Support 7- Front cover 8- rear cover.

Fig. (6): Fan after modification.

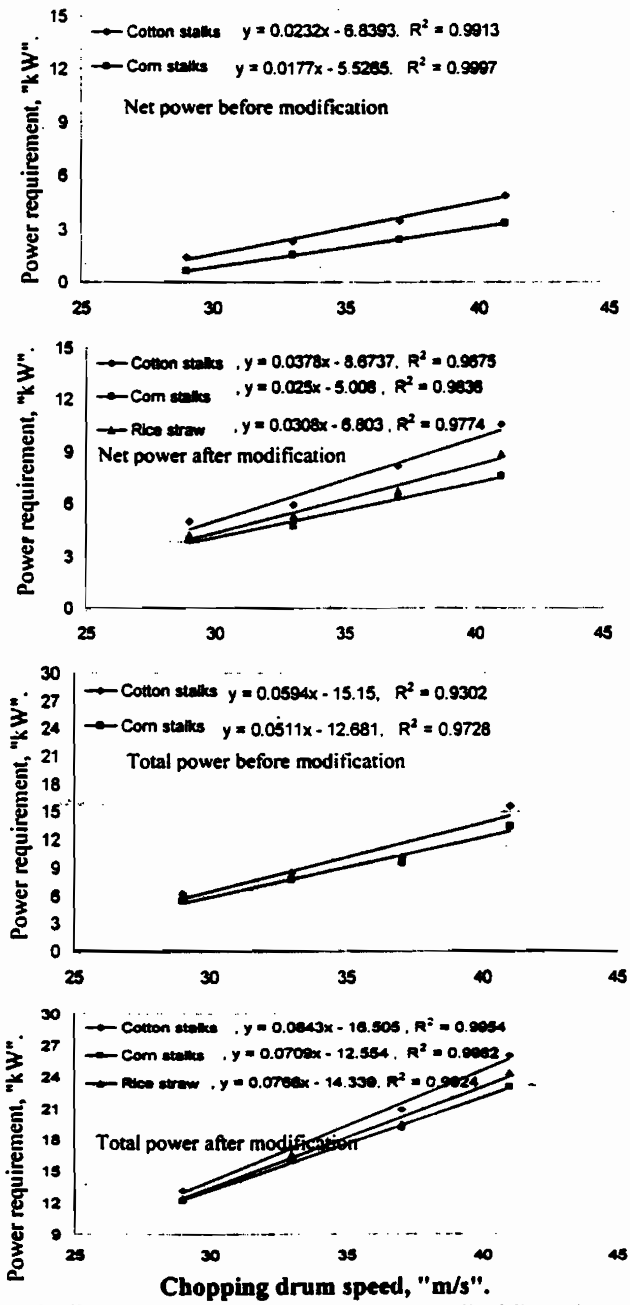


Fig. (7): The effect of chopping drum speed, "m/s" on the power requirements, "kW" before and after machine modification.

- **Machine after modification.** In this case the power was measured and recorded with cotton stalk, corn stalk and rice straw. At the same conditions before modification. As shown in table (3) and Fig. (7). The maximum and minimum power required to run the machine without any load were 21 Hp (15.44 KW) and 11.27 Hp (8.283 KW) at 3500 rpm (102.57 m/sec) and 2450 rpm (71.8 m/sec) respectively. In case of cotton stalk: The maximum total power required with load was 35.35 Hp (25.98 KW) for operating machine, feeding, cutting and throwing materials. The net power was 14.35 Hp (10.54 KW) for feeding, cutting and throwing material at 3500 drum rpm. The minimum total power required was 17.9 Hp (13.156 kW) and the net power was 6.77 Hp (4.976 KW) at 2450 drum rpm. In case of corn stalks: the maximum total power required with load was 31.27 Hp (22.98 KW) and the net power was 10.27 Hp (7.548 KW) at 3500 drum rpm. The minimum total power required was 16.6.Hp (12.2 kW) but the net power was 5.336 Hp (3.922 KW) at 2450 drum rpm. In case of rice straw: the maximum power required was 33.05 Hp (24.29 KW) and the net power was 10.05 Hp (7.387 kW) at 3500 drum rpm (102.57 m/sec). the minimum power required was 17.Hp (12.50 kW) and the net power was 5.73 Hp (4.21 KW) at 2450 drum rpm (71.8 m/sec). The results of regression analysis show that the relationship of total power required and net power for cutting with rotation speed (after modification) as shown in Fig. (7).

Table (2): The relationship between cutting speed and required power (Before modification)

drum speed rpm (m/sec)	Cotton stalks			Corn stalks			Units of Power
	No load	Load	Net power	No load	Load	Net power	
2450	6.560	8.453	1.893	6.560	7.453	0.893	Hp
(71.8m/sec)	4.822	6.213	1.391	4.822	5.478	0.656	kW
2800	8.394	11.49	3.096	8.394	10.49	2.096	Hp
(82 m/sec)	6.169	8.445	2.331	6.169	7.710	1.540	kW
3150	10.25	14.95	4.704	10.25	13.50	3.250	Hp
(92.3 m/sec)	7.534	10.172	3.457	7.534	9.555	2.388	kW
3500	14.49	21.138	6.648	14.49	19.00	4.510	Hp
(102.57m/sec)	10.65	15.536	4.88	10.65	13.377	3.315	kW

Table (3): The relationship between cutting speed and required power. (After modification)

drum speed	Cotton stalks			Corn stalks			Rice straw			Power units
	No load	Load	Net power	No load	Load	Net power	No load	Load	Net power	
2450 rpm	11.270	17.900	6.770	11.270	16.60	5.336	11.27	17.00	5.73	Hp
(71.8 m/s)	8.283	13.156	4.976	8.283	12.20	3.922	8.28	12.50	4.21	kW
2400 rpm	15.400	23.450	8.050	15.400	21.78	6.386	15.40	22.59	7.18	Hp
(82 m/s)	11.319	17.235	5.917	11.319	16.00	4.694	11.32	16.60	5.28	kW
3150 rpm	17.400	28.450	11.050	17.400	25.99	8.600	17.40	26.57	9.17	Hp
(92.3 m/s)	12.789	20.910	8.122	12.789	19.10	6.321	12.79	19.53	6.74	kW
3500 rpm	21.000	35.350	14.350	21.000	31.27	10.27	21.00	33.05	10.05	Hp
(102.57m/s)	15.440	25.980	10.540	15.440	22.98	7.548	15.44	24.29	7.387	kW

3 – Machine performance

It was evaluated at three directions: a- The size of materials after chopping, b- Cutting efficiency, c- Efficiency of the suction fan.

a– Size of the chopping materials.

The size of chopping materials was decreasing with increasing the speed as shown in Fig. (8 and9)

–Before modification: The average sizes of materials were 1.4 mm to300 mm because the knives distribution on the cutting drum hasn't over lubing and the cutting materials were longer and can pass through the concave holes. The cutting wasn't clean and the sizes weren't homogenous.

- After modification: The high percentage from small size materials. The sizes of materials were homogenous from > 0.71 mm to 15 mm. and the cutting were clean.

b- Cutting efficiency.

It was affected by rotation speed. It increases with increasing the rotation speed at the same moisture content.

--Before modification the cutting efficiency was low because the average length of materials was 3.25 mm to 300 mm and the average of cutting efficiency was 83% to 85% with cotton and corn stalks

-- After modification the cutting efficiency was very high because the average length of materials after cutting was > 0.71 mm to 15 mm because the new design of cutting drum was having over lubing between the knives and the distribution knives were covering the surface area of cutting drum and the average cutting efficiency was 98.5 % to 99.5%

c- Suction fan efficiency.

Table (7) shows the difference between fan speed and air speed before and after modification. The theory of design fan after modification is a centrifugal suction fan which is different with radial design fan before modification.

The fan after modification operated better than the fan before modification and the fan speed before modification was higher than the fan speed after modification but the air speed after modification was higher than the air speed before modification. The main reasons for all previous: 1- the particles of materials after modification are smaller than before. That's resulted from modifying the chopping drum. 2- Fan design is centrifuge type and it had two ducts to suck the cutting materials directly.

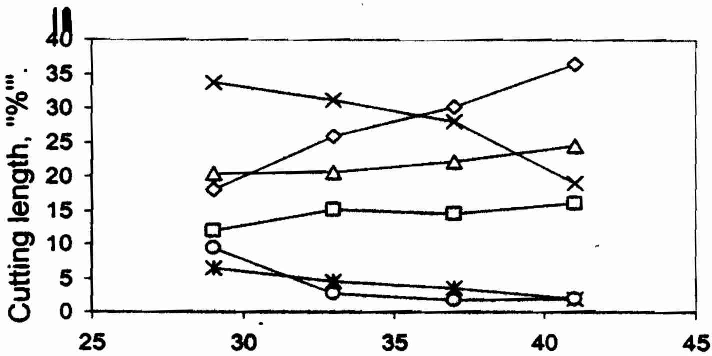
The efficiency of the thrower fan was calculating from equation (7) and (8). It was very high after modification and no jamming occurred because the particles of materials were small and homogenous.

From equation (7) the theoretical power was calculating by assuming: the open fan area (A) 0.15 * 0.15 (= 0.0225 m^2) and air speed of fan = S (peripheral fan speed m/min),

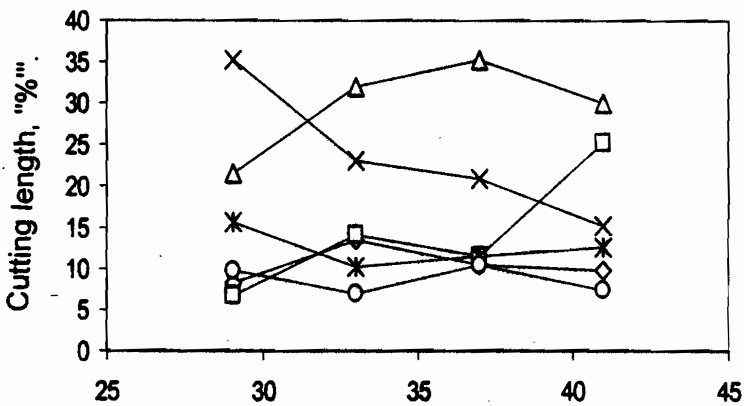
$$V = S * A, \quad m^3/min$$

and fan dynamic head $h = P/\rho g = 400\ N/m^2/(1.02\ kg/m^3)(9.81)$

theoretical power requirement $P_{th} = V\rho h/4500$



—◇— >1.4<2 y = 1.49x - 24.34, R2 = 0.99
—□— >2<3.35 y = 0.30x + 4.34, R2 = 0.73
—△— >3.35<9.5 y = 0.35x + 9.72, R2 = 0.88
—×— >9.5<12.5 y = -1.16x + 69.33, R2 = 0.91
—✱— >12.5<19 y = -0.36x + 16.63, R2 = 0.99
—○— 19 y = -0.58x + 24.33, R2 = 0.68



—◇— >1.4<2 $y = 3.73x^{0.29}$, R2=0.044
—□— >2<3.35 y = -1.56x + 78.27, R2 = 0.91
—△— >3.35<9.5 $y = 0.82x^{1}$, R2=0.49
—×— >9.5<12.5 y = 1.3x - 32, R2 = 0.76
—✱— >12.5<19 y = -7.75Ln(x) + 39.99, R2=0.25
—○— 19 $v = 12.8e^{-0.01x}$. R2=0.096

Chopping drum speed, "m/s"

Fig. (8): The effect of chopping drum speed, "m/s" on cutting lengths, "%", before machine modification.

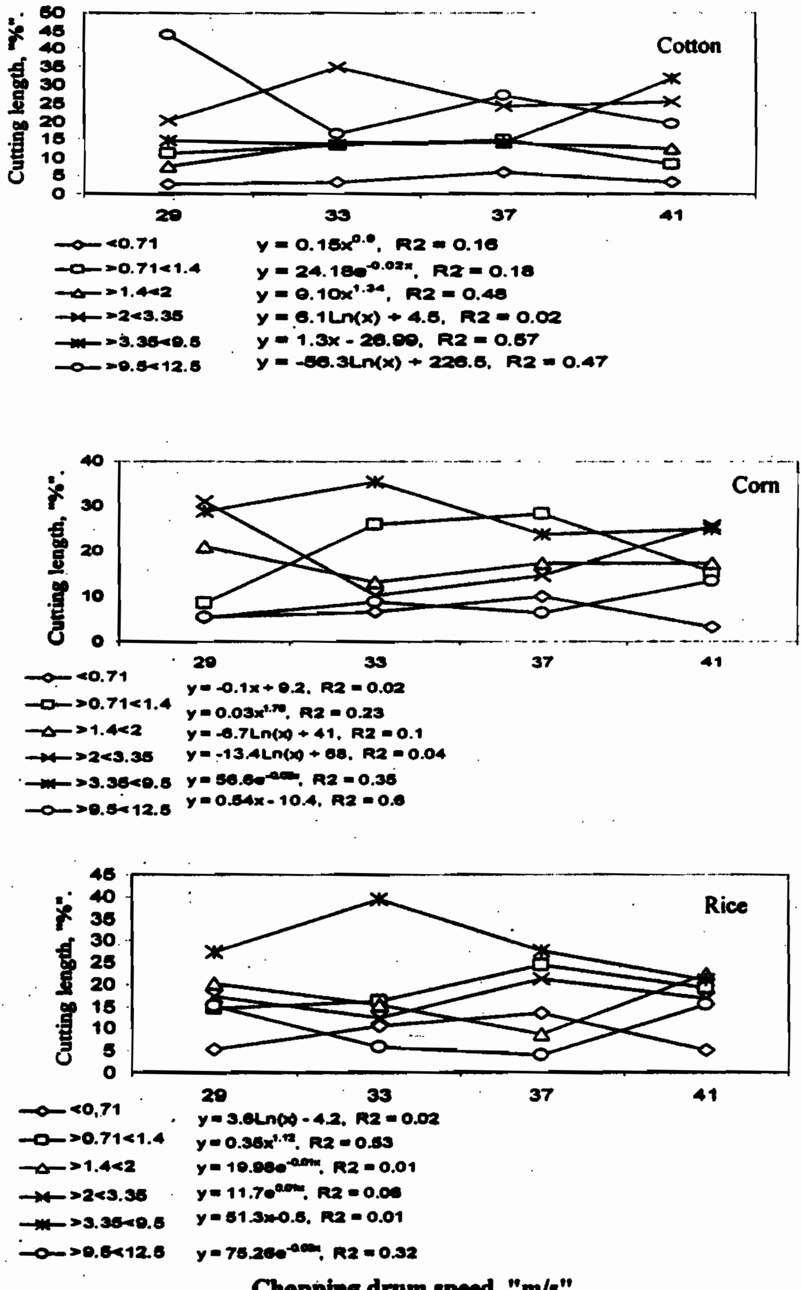


Fig. (9): The effect of chopping drum speed, "m/s" on cutting lengths, "%", after machine modification.

4- Fan efficiency:

$$\eta = P_{th} / P_{act}$$

where:

η = fan mechanical efficiency, %.

P_{act} = fan actual power, HP (kW).

Fan efficiency was calculated from equation (8) considering the maximum horsepower after calculating the fan power require. From last calculation fan efficiency reached 75% by using the new designed fan.

d-The productivity of chopping machine:

The productivity of chopper machine was affected by drum speed and fan efficiency. It was increasing with increasing the drum speed as shown in table (6)

-- Productivity before modification:- The maximum productivity was 484.633 kg/hr, 625 kg/hr at(3500 rpm) with cotton stalk and corn stalk respectively. The minimum productivity was 397.5 kg/hr and 250 kg/hr. at 71.8 m/sec (2150 rpm) with cotton stalks and corn stalks respectively.

-- Productivity after modification:- The maximum productivity was 1200 kg. 800 kg and 1220 kg. at 102.57 m/sec (3500 rpm) with cotton stalks, corn stalks and rice straw respectively. The minimum productivity was 750 kg/hr, 450 kg/hr and 489kg/hr. at 71.8 m/sec (2150 rpm) with cotton stalks, corn stalks and rice straw respectively.

Table (6) relationship between drum speed with fan speed, air speed and productivity.

Cutting speeds		Fan speed rpm	Air speed m/sec	Productivity (kg / h)		
				Cotton stalks	Corn stalks	Rice straw
2450 rpm. (71.8m/s)	B	2450	8.0	397.5	250	——
	A	1633	14.0	750.0	450	489.6
2800 rpm. (82 m/s)	B	2800	12.5	422..8	295	——
	A	1866.6	32.0	900.0	560	839
3150 rpm. (92.3 m/s)	B	3150	18.0	451.58	500	——
	A	2099.9	30.0	1058.0	720	1020
3500 rpm. (102.5m/s)	B	3500	20.0	484.6	625	——
	A	2333.3	35.0	1200.0	800	1220

5- Energy requirement:-

It was calculated according equation (7). As shown in table (7), the machine productivity increased after modification by 2.3 times than before modification, meanwhile the energy increased by 0.16 times than before modification.

Table (7): Relationship between productivity, drum speeds, power required and energy required.

Cutting speeds		Power required (kW)			Productivity (kg/h)			Energy required (kW. h/kg)		
		cotton	corn	rice	cotton	corn	rice	Cotton	corn	rice
2450 rpm. (71.8m/s)	B	6.213	5.48	——	397.50	250	——	0.0160	0.22	——
	A	13.17	12.20	12.50	750.00	450	489.6	0.0170	0.27	0.026
2800 rpm. (82 m/s)	B	8.445	7.71	——	422..80	295	——	0.0200	0.26	——
	A	17.24	16.00	16.60	900.00	560	839	0.0190	0.029	0.02
3150 rpm. (92.3 m/s)	B	10.25	9.56	——	451.58	500	——	0.0230	0.019	——
	A	20.91	19.10	19.53	1058.00	720	1020	0.0197	0.027	0.019
3500 rpm. (102.5m/s)	B	15.54	13.38	——	484.60	625	——	0.0320	0.021	——
	A	25.98	22.98	24.29	1200.00	800	1220	0.0220	0.029	0.02

6- Estimated cost of the machine operation:-

The machine cost was calculated from equation (9). It was 5.82 L.E./hr and the cost of Nasr tractor was calculated from the same equation. It was 14 L.E/hr. The total cost was 20 L.E/hr approximately at maximum operation.

CONCLUSIONS AND RECOMMENDATIONS.

The main results were as follow:-

1- Distribution knives must be covering the surface area of cutting drum and the knives must be having over lubing between it at different level.

2- The locally machine after redesigning and fabricating was successful to chop different crop residues such as cotton, corn stalks and rice straw.

3- The maximum power of the machine before modification was 15.536, 13.37 kW and the net power for cutting was 4.88, 3.315 kW at 3500 drum rpm (95.25 m/sec) for cotton and corn stalks respectively.

4- The maximum power of the machine after modification was 25.98, 22.98and 24.29 kW and the net power was 10.54, 7.548 and 7.387 KW for feeding, cutting and throwing material at 3500 drum rpm for cotton stalks, corn stalks and rice straw respectively. The results of regression analysis show that the relationship between total power required and net power for cutting with rotation speeds was linear type.

5- Before modification: The average of cutting efficiency was 83% to 85% with cotton and corn stalks, respectively. Meanwhile, after modification the average of cutting efficiency was 98.5 % to 99.5% and 99% with cotton, corn stalks and rice straw respectively.

6- Lengths of the chopping materials. The lengths of cutting materials were decreased with increasing the chopping drum speed. Before modification the average lengths of materials were 3.35 mm to 30 cm. The cutting wasn't clean and the lengths weren't homogenous. Meanwhile, after modification the lengths of materials were homogenous from >1.4 mm to 15 mm. and the cutting were similar clean.

7- The centrifuge fan type was better than flay wheel (radial type) in this study because the fan after modification was operated better than fan before modification to suck cutting materials and the rotation speed before modification was higher than rotation speed of fan after modification, meanwhile, the air speed after modification was higher than the air speed before modification.

8-The productivity of chopping machine: After modifying the cutting drum. The productivity was increased from 484.633, 625 kg/hr at 95.25 m/sec to1200, 800 kg/h at 102.57 m/sec. Meanwhile, productivity was 1220 kg/hr. for rice straw.

9- the machine productivity increased after modification by 2.3 times than before modification, meanwhile the energy increased by 0.16 times than before modification.

10- Estimated cost of the machine operation was 5.82 L.E./hr and the cost of Nasr tractor was 14 L.E/hr. The total cost approximately was 20 L.E/hr at maximum operation.

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تطوير وإعادة تصميم لماكينة تقطيع مخلفات محاصيل حقلية

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في الآونة الأخيرة كان الاتجاه إلي استيراد وتصنيع الألا ت الخاصة بفرم النواتج الثانوية وتجهيزها حسب غرض الاستفادة منها. ونظرا لأهمية الاستفادة من النواتج الثانوية للمحاصيل الحقلية (المخلفات الزراعية) كأعلاف أو كأسمدة عضوية أو كعنصر من عناصر بعض الصناعات كالأوراق والأخشاب...... الخ. يتناول هذا البحث آلة تقطيع المخلفات المستوردة التي تم تشغيلها وتجربتها مع أهم النواتج الثانوية كحطب القطن والذرة وقش الأرز للوقوف على أداء الإلة وكفاءة التقطيع وكانت الخطوات كالتالي:-

١- أجراء التجارب الحقلية على الإلة من حيث معدلات الاداء والإنتاجية - خحم المواد المقطعة .

٢- قياس استهلاك الوقود للإلة أثناء التشغيل وحساب القدرات والطاقة الأزمة للتشغيل والتقطيع.

وجد من النتائج الأتي:-

١- الإنتاجية القصوي ٤٨٤,٦٨ , ٦٢٠ كجم/ساعة لكل من خطب القطن وحطب الذرة علي التوالي ولم تنجح الإلة مع قش الأرز وذلك عند سرعة ٣٥٠٠ لفة / د (٩٥,٢٥ م ث).

٢- تطاير أجزاء من الأحطاب اثناء التغذية.

٣- تصل أطوال التقطيع ما بين ٣,٥ الي ٣٠٠ مم ولا يوجد تجانس بين الاطوال والقطع غير نظيف.

وبناء علي ما سبق تم اجراء الاتي :

أ- تصميم درفيل التلقيم واضافته لوحدة التغذية.

ب- تطوير وتصميم مروحة الطرد وعمل الرسومات الهندسية .

ج- تطوير وتصميم درفيل القطع وعمل الرسومات الهندسية .

د- اعادة تنفيذ النموذج الاولي للالة عمليا بخامات من السوق المحلي.

هـ- أجراء الاختبارات والتجارب الحقلية علي النموذج المصمم ومصنع محليا.

ومن النتائج المتحصل عليها :

١- الخواص الطبيعية : من الخواص الطبيعية وجد أن إنتاج الفدان من حطب القطن ٩,٥ طن تقريبا ، حطب الذرة ٧,٢ طن تقريبا ، قش الأرز ٢ طن تقريبا

٢- القدرات المطلوبة : الجداول التالية تبين القدرات الكلية المطلوبة للتشغيل ، والقدرة اللازمة للتقطيع فقط وذلك قبل وبعد التطوير عند السرعات المختلفة :

النتائج قبل التطوير

سرعة درفيل التقطيع لفة/د (م/ث)	حطب القطن			حطب الذرة			وحدة القدرة
	قدرة التشغيل	القدرة الكلية	القدرة اللازمة للقطع	قدرة التشغيل	القدرة الكلية	القدرة اللازمة للقطع	
2450	6.560	8.453	1.893	6.560	7.453	0.893	Hp
(71.8m/s)	4.822	6.213	1.391	4.822	5.478	0.656	kW
2800	8.394	11.49	3.096	8.394	10.49	2.096	Hp
(82 m/s)	6.169	8.445	2.331	6.169	7.710	1.540	kW
3150	10.25	14.95	4.704	10.25	13.50	3.250	Hp
(92.3 m/s)	7.534	10.172	3.457	7.534	9.555	2.388	kW
3500	14.49	21.138	6.648	14.49	19.00	4.510	Hp
(102.57m/s)	10.65	15.536	4.88s	10.65	13.377	3.315	kW

النتائج بعد التطوير

سرعة درفيل التقطيع لفة/د (م/ث)	حطب الذرة			حطب الذرة			قش أرز			وحدة القدرة
	قدرة التشغيل	القدرة الكلية	قدرة القطع	قدرة التشغيل	القدرة الكلية	قدرة القطع	قدرة التشغيل	القدرة الكلية	قدرة القطع	
2450rpm	11.270	17.900	6.770	11.27	16.60	5.336	11.27	17.00	5.73	Hp
(71.8m/s)	8.283	13.156	4.976	8.283	12.20	3.922	8.28	12.50	4.21	kW
400 rpm	15.400	23.450	8.050	15.4	21.78	6.386	15.40	22.59	7.18	Hp
(82 m/s)	11.319	17.235	5.917	11.319	16.00	4.694	11.32	16.60	5.28	kW
3150 rpm	17.400	28.450	11.05	17.4	25.99	8.600	17.40	26.57	9.17	Hp
(92.3m/s)	12.789	20.910	8.122	12.789	19.10	6.321	12.79	19.53	6.74	kW
3500rpm	21.000	35.350	14.35	21.0	31.27	10.27	21.00	33.05	10.05	Hp
(102.57m/s)	15.440	25.980	10.54	15.44	22.98	7.548	15.44	24.29	7.387	kW

٣- التكاليف : باعتبار العمر الافتراضي ٥ سنوات كانت تكاليف الآلة ٥,٨٢ جنيه مصري / ساعة الجرار (نصر ٦٥ح) ١٤ جنيه مصري / ساعة بإجمالي ٢٠ جنيه مصري / ساعة .