DEVELOPING AND MAXIMIZING THE PERFORMANCE OF LOCAL THRESHING MACHINE FOR SMALL HOLDING TO SUIT CHOPPING AND SHREDDING CROPS RESIDUES

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ABSTRACT

Stationary threshing and winnowing machine model El-Haddad-WZ-1 for small holding was designed by ***El-Haddad, 2000*** *in Agricultural Engineering Dept., Faculty of Agric., Kafr El-Sheikh University. It was tested in Rice Mechanization Center for threshing and winnowing of rice crop. It was used to chop and shred rice straw crop to maximize the performance of this machine and increasing yearly working hours, Results of the original machine showed that, it can not cut rice straw into small pieces without accumulation problems occurred in the threshing chamber especially with feeding of complete stalks sample at high moisture content. This problem causes wasting time, less productivity, and increase cost. Consequently, it is necessary to develop this machine for the young farmer to cut some crop residues as rice straw, corn stalks and cotton stalks. The machine after modification was operated at four cylinder speeds, 4.55, 6.07, 7. 59 and 9.11 m/s (300, 400, 500 and 600 r.p.m.), four feed rates of 2, 4, 6 and 8 kg/min, and three levels of moisture contents of 22.3, 25.5 and 30.3% (wb) for rice straw, respectively. Machine performance, chopping machine capacity (kg/min), cutting length of straw, power consumption (kW), useful power (kW), unit energy (kW.h/Mg) and criterion function cost, were studied in this research. Results of the development machine showed that the percentage of small cutting lengths, were increased by increasing cylinder speed and feed rates and decreased by increasing the moisture contents. The maximum of the percentage of small cutting lengths were (21% $\geq$ 0.5 cm, 50 % from 0.5 to 1 cm, 12% from 1 to 2 cm and 17% from 2 to 3 cm), at cylinder speed 9.11 m/s (600 r.p.m.) and moisture content of 22.3% in straw and feed rate 8 kg/min.*

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INTRODUCTION

Crop residues are one of the most critical problems, which face the Egyptian farmer. The quantity of crop residues in Egypt reached about 18.7-25 million ton per year and national income might be increased with 1.6 billion LE/year if we try recycle it, **(El-Berry et al., 2001 and Awady et al., 2001).** Up to date, stationary threshing and winnowing machines in Egypt are considered as big size, high cost and need high source of power. Although most of the Egyptian farms are divided into small holdings, 52% of the total arable area is divided into plots less than 5 feddans (2.1 hectare), 11.1% of this area is divided into plots of 5-10 fed., 10.3% of this area is divided into plots 10-20 fed. And the rest of this area is divided into plots of more than 20 fed**. (Helmy, 1988).** All kinds of stationary threshing and winnowing machines in Egypt can not cut rice straw into small pieces without increasing grain damage and accumulation problems occurred in the threshing chamber especially with high moisture content. Some crops residues recirculation operating adds suffering and exhaustion for the Egyptian farmer, consequently, it is necessary for the farmer to have chopping machine for some crop residues as rice straw, corn stalks and cotton stalks.

Therefore, it was necessary to develop local threshing and winnowing machine for small holding to suit chopping and shredding crops residues with avoiding the accumulation problem in the threshing chamber. In addition, it gives the desired cutting lengths from crop residues suitable for different uses.

The objectives of the present study are: (1) to evaluate the performance of development machine, (2) to study the effect of the influence of cylinder peripheral speeds, feed rates, crop moisture contents on the following: (a) machine capacity, (b) cutting length of straw, (c) power requirement (d) operating cost.

REVIEW OF LITERATURE

Yumnam and Pratap (1991) indicated that for rotary blade, the minimum power requirement was observed at blade bevel angle between 25° and 30°. However, experiments on counter edge cutting of rye grass, luccern and oats suggest an optimum blade angle between 17° and 25°. Although the minimum energy requirement was obtained for 25°, little difference was observed in energy requirement over a range of 25° to 50° blade bevel angle. **El-Zemeity (1997)** found that using local thresher at drum speed (1000 rpm), feed rate (15 kg/min.) and moisture content of wheat straw (8.1 %) gave the highest values of straw lengths < 2 cm (43.2 %), loss straw (11.2 %), cutting efficiency (99.1 %) and distribution area of straw on ground (12.46 m^2). Also it gave the lowest values of straw lengths > 4 cm (7.9 %) and operating efficiency of thresher (88.8 %). **Mady (1999)** developed a manual cutting machine suitable for mechanical cutting of corn stalks at different moisture contents and study the effect of feeding drum speed, knife rotary speed and knife type on the cutting length, useful power requirements and machine productivity. He found that the sharp knife was suitable for cutting the wet bulk of corn stalks, while the notched knife was the suitable for cutting dry bulk of corn stalks. The high moisture content of corn stalks gave low power requirements for cutting. **Habib et al. (2000)** found that the parameters governing the amount of energy consumed in the cutting process could be categorized into four parameters' groups. Decreasing this amounts of cutting energy means increasing the performance of the cutting process. The first group G_1 is related to the cutting tool geometry, especially the edge angle. The second parameters group G_2 is related to the performance of the machine. This group depends on the feeding speed (V) and tool rotational speed (N). The third group G_3 is related to the plant material. On the other hand, the last group G_4 is a mixed parameters group including the tool geometry and plant material properties. **El-Berry et al. (2001)** evaluated Hematol chopper in rice straw chopping and compare it with the Balady thresher. The following results were obtained: 1- Hematol chopper: The productivity was between 200 to 430 kg/h, straw length from 10 to 20 cm, machine energy requirement 29.34 MJ/ton and the cost of chopping one ton of rice straw was 32.5 LE. 2-Balady thresher: The productivity was between 530 to 825 kg/h, straw length from 2.5 to 10 cm, machine energy requirement 18.9 MJ/ton and the cost of chopping one ton of rice straw was 18.2 LE. **Suliman et al. (2004)** developed the performance of cutting knives in crop residues shredder by improving of mechanical properties of cutting knives, found that, using new material leads to decrease the wear rate from 9.67 g/h with original knives to 3.98 g/h with modified knives. The proper selection of new material leads to decrease the sharp edge angle of modified knives to 20 degree without deformation.

MATERIAL AND METHODS

3.1. Prototype structural design

The present study included original machine **(El-Haddad, 2000)** and the machine after development in (2008–2009) to suit chopping and shredding crops residues for small holding. It was developed by Dr. Wagdy El-Haddad. This machine was developed to satisfy the Egyptian farmers requirements. It was manufactured in a private workshop in Kafr El-Sheikh. The following points were taken into consideration during the development and the construction:

1-All parts made from local materials. The machine has a simple mechanism and cheap. 2-Possibility of shredding and chopping crops residues and threshing different cereal crops. 3- Using special system to cut straw by using cut knives, removable and installation. 4- Easy of operation, adjustment, repairs, and maintenance.

3.2. Machine description

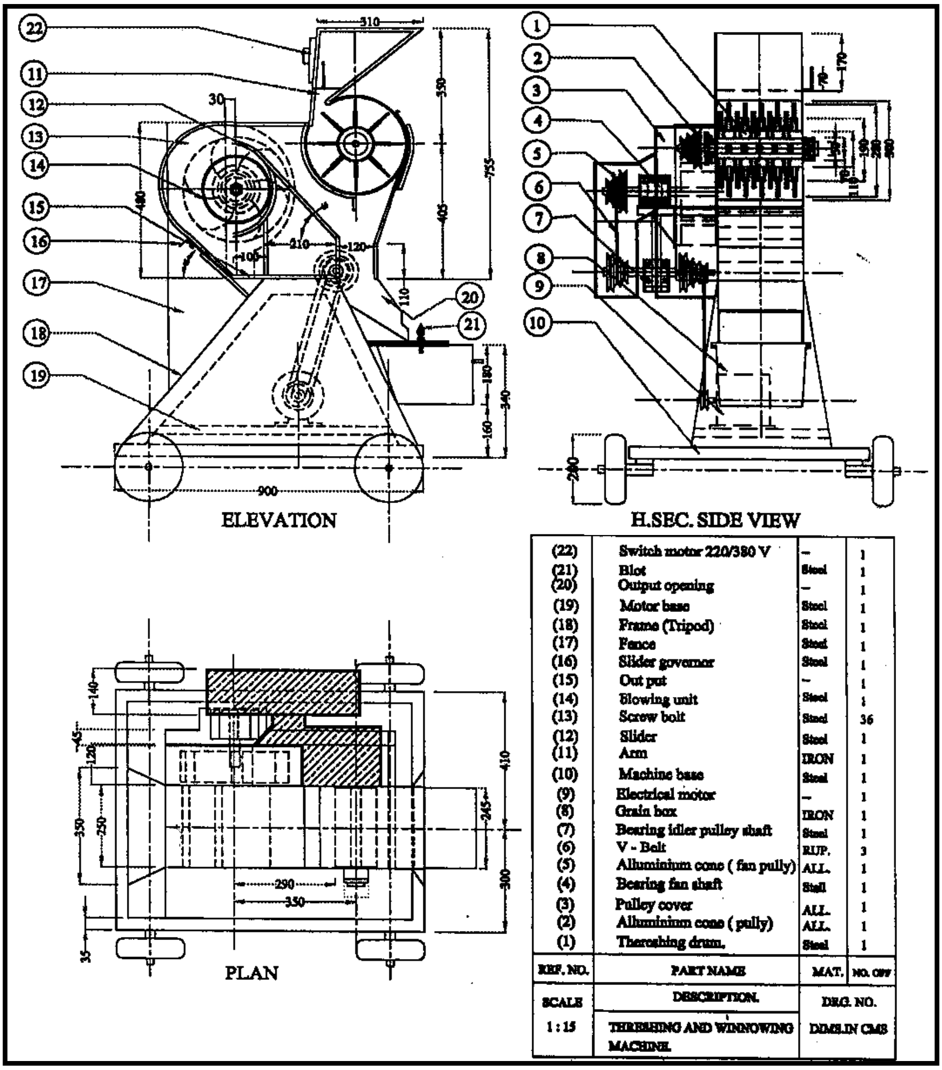
3.2.1. Toothed threshing unit before modification

The machine used in this study is photographed in Figure (1a) and sketched in Figure (1b) had two major components, threshing and winnowing unites of grain. The threshing unit consists of a cylinder 29 cm. diameter and 24 cm. long mounted on two ball bearings fixed on steel frame by four screw bolts for each ball bearing. The threshing cylinder consists of 40 steel knives. Each knife is fixed by welding with two knifes other welded to a steel pipe of 0.50 cm. thickness, 10 cm diameter and 24 cm long. So that distance between two adjacent knifes is 5 cm. A steel shaft 2.5 cm. diameter is fixed to the central steel pipe inner hole of the discs are welded. More details for this machine are found in **El-Haddad (2000)**

Fig. 1a: The original machine

3.2.2. Toothed threshing unit after modification

The chopping unit: To change threshing cylinder to chopping cylinder, especially with rice straw the operation theory of this chopping machine depends upon shearing force through four rotating knives fixed on threshing cylinder by screw bolts with fixed knife on steel frame threshing chamber



REF. NO.	PART NAME	MAT.	NO. OFF
(22)	Switch motor 220/380 V	–	1
(21)	Blot	Steel	1
(20)	Output opening	–	1
(19)	Motor base	Steel	1
(18)	Frame (Tripod)	Steel	1
(17)	Fence	Steel	1
(16)	Slider governor	Steel	1
(15)	Out put	–	1
(14)	Blowing unit	Steel	1
(13)	Screw bolt	Steel	36
(12)	Slider	Steel	1
(11)	Arm	IRON	1
(10)	Machine base	Steel	1
(9)	Electrical motor	–	1
(8)	Grain box	IRON	1
(7)	Bearing idler pulley shaft	Steel	1
(6)	V - Belt	RUP.	3
(5)	Alluminium cone (fan pully)	ALL.	1
(4)	Bearing fan shaft	Stell	1
(3)	Pulley cover	ALL.	1
(2)	Alluminium cone (pully)	ALL.	1
(1)	Theroshing drum.	Steel	1
SCALE 1 : 15	DESCRIPTION. THRESHING AND WINNOWING MACHINE.	DRG. NO. DIMS.IN CMS	

Fig.1b: Threshing and winnowing machine model El-Haddad WZ -1 for small holding, (Original machine). Designed and constructed by (El-Haddad, 2000) and patent applied for 280 – 84

-The machine has obtained a prize competition for the best innovations and inventions of industrial from Arab Organization for Industrialization (factory of kader El Harbi).

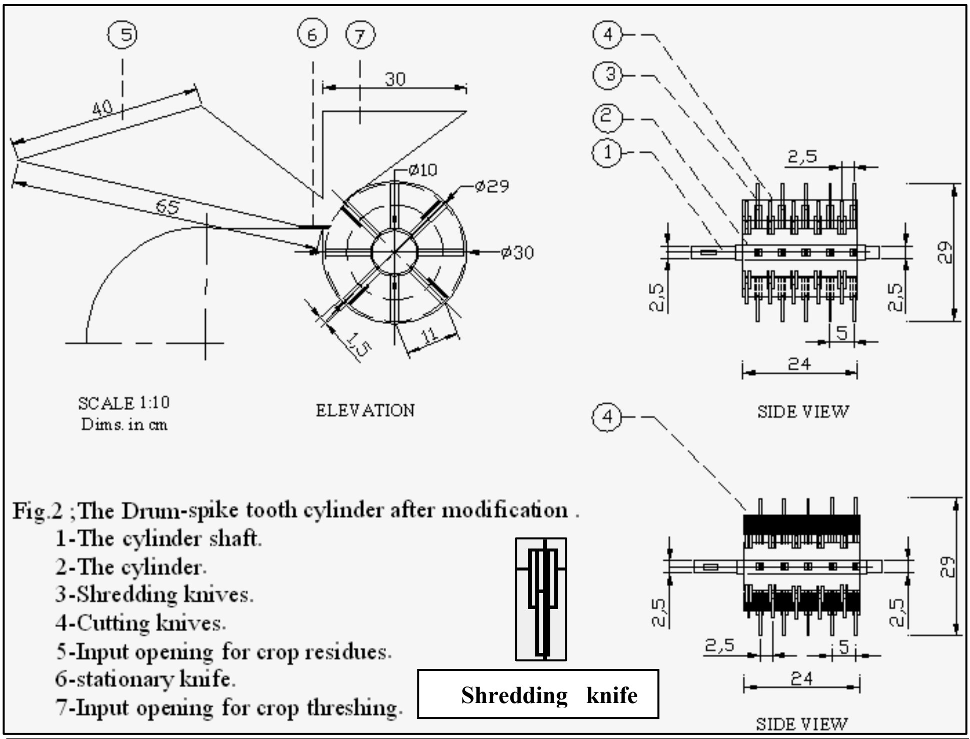


Fig. 2a: The drum- spike tooth cylinder after modification

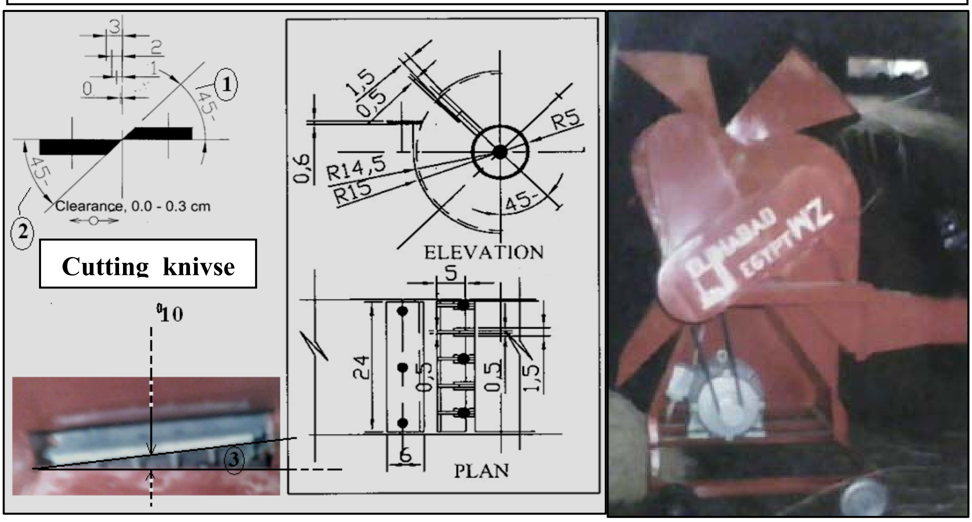


Fig. 2b: The angle of incidence of the edges of the moving knives (1), stationary knife (2), the angle of inclination on the fixed knife (3), diminutions and the machine after modification

Chopping knives specification: Total of 4 knives, 24 cm long, 5 cm wide and 0.5 cm thick flats bolted to threshing knives as in (Fig 2a, b & c). The material of the knives is C 95 steel as in (Table 1) and each chopping knife is fixed with three threshing knives by means of three 9 mm screw bolts. The cutting angle of the knife is 10^o (the angle of inclination on the fixed knife). The knives are arranged on the cylinder in order to minimize the torque necessary for chopping.

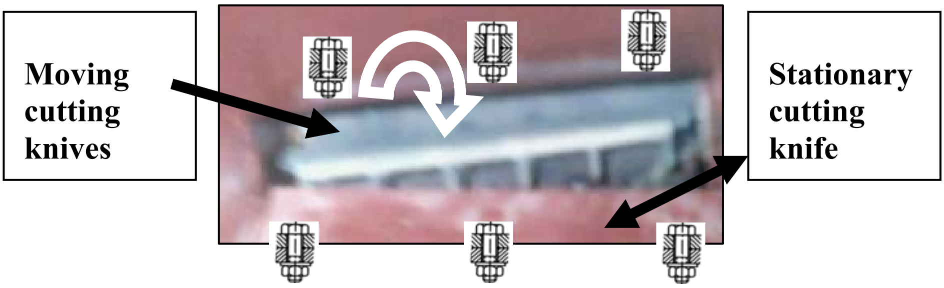


Fig. 2c: The fixed of chopping knives (after modification)

A stationary knife: (24 cm long, 6 cm wide and 0.6cm thick) is fixed to the frame of the machine by means of three bolts. The angle of incidence of the edges of the moving knife and stationary knife is 45° upwards the dorsal surface of the moving knife and downward for stationary knife Fig.(2b), to facilitate the adjustments of clearance between them, to obtain proper chopping. The clearance between the moving knives and stationary knife has range from (0.00 to 0.3 cm). The chopping and threshing chamber was constructed from steel sheet 3 mm thick welded together as shown in Figure (2a). The cover chopping chamber has two opening; the first opening is used to feed crop for threshing and the second opening is used to feed straw (residual) for cutting.

Table 1: Physical properties of chopping knives materials

Material	Ultimate tensile strength kg/mm^2	Yield strength (tensile) kg/mm^2	Yield stress (shear) kg/mm^2	Working tension kg/mm^2	Stress shear kg/mm^2	E x10^4 kg/mm^2	G x10^4 kg/mm^2
C 95 steel	**135**	**90**	**57**	**47**	**28**	**2.0**	**0.77**

E= Modulus of Elasticity = the ratio of stress and strain for tensile or compressive stresses and strains- G= Modulus of Rigidity or shear Modulus for shear stress =2E (1+1/m), 1/m=Poisson' s Ratio, varies from 0.25 to 0.33 for most of the materials.

The feed mechanisms after modification is shown diagrammatically and photographed in Figure 2d. It consists of two opening a conical shape (30 cm long, 25 cm wide and 30 cm height) and (40 cm long, 40 cm wide and 65 cm height), respectively. **Concave sieve:** Perforated sheet metal 3 mm thick-perforations, (hole concave) 11 mm dia. round holes **3.2.3. Straw pieces pushed unit:** After modification the air suction was produced by a centrifugal blower which fixed on the side machine frame by welding as shown in Figure 2d, this blower has six curved blades.

- Blade dimensions: 10 cm wide, 15 cm long and 3 mm. thickness.
- Blower dimensions: 30cm diameter and 10cm. wide from sheet metal 3 mm thick.
- The inlet opening (suction opening) has a rectangular shape of 25 x 6 cm

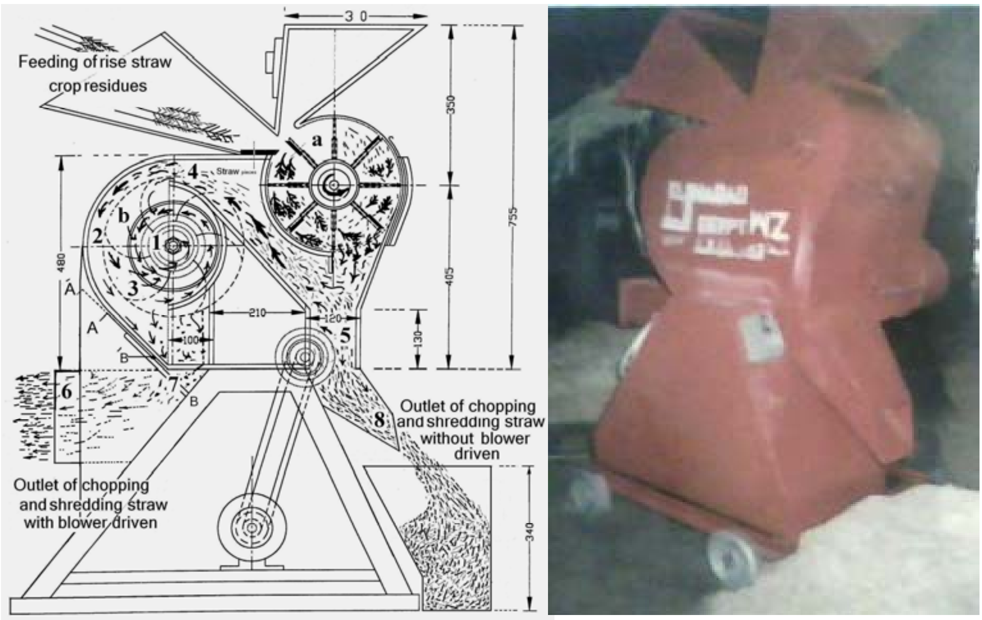


Figure 2d: The feed mechanisms and outlet of straw pieces after modification

while the outlet opening has a rectangular shape of 25 x 10 cm. controlling the air velocity was done by controlling the airflow rate via different diameter cone pulley is supported on the fan shaft (by changing the fan speed), without changing cross sectional areas of the air inlet.

3.2.4. Design of straw pushed unit as shown in Figure 2d, consists of:

1- A centrifugal blower. 2- Vortex chamber. 3- Distribute chamber the air suction. 4- The straw pieces and the chaff suction chamber. 5- The mixture of threshed falling chamber during the threshing. 6- The straw outlet opening with blower driven. 7- The grain losses outlet opening at the threshing. 8- The straw pieces outlet opening without blower driven, and has used for grain outlet when the threshing.

3.2.5. The source of power: The machine is driven by electric motor of about 2.25 kW (3 hp), at 800 r.p.m. as shown in Figures 2b & d.

3.2.6. Transmission of power: Rotary motion can be transmitted from one shaft to another in this machine by using three V-belt and five pulleys for V belt drives, as shown in Figures 1b and 2d.

Table 2 : The machine specifications before and after development.

Items	Specifications before development	Specifications after development
Length, cm	90-124	90-124
Width, cm	71	71
Height, cm	129-145	129-145
Mass, kg	154	172
Source of power	Self operated engine, 5 hp.(3.75 kW)	Electric motor of about 2.25 kW (3 hp)
Type of the cylinder	Spike tooth	Spike tooth + Flat knives
Length of the cylinder, cm	24	24
the cylinder Diameter, cm	29	29
Cylinder knives	Total of (40) peg teeth, (9.5) long, (1.5) wide and (0.5) cm thickness.	Total of (40) peg teeth, (9.5) long, (1.5) wide and (0.5) cm thickness.+4 cut knives (24)cm long, (5)cm wide and (0.6)cm thickness + **A stationary knife:** (24 cm long, 6 cm. wide and 0.7cm thick)
Input opening for crop, cm	30 x 25 x 30	(40 x 40 x 65)at chopping and (30x25x30)at threshing
Output opening for straw, cm	25 x 12	25 x 12 (with blower drive) and 19 x 12 (without blower drive)
Outlet opening for grain, cm	19 x 12 for grain outlet	19x12 for outlet straw pieces
Hole diameter for curved sieve, cm	1.1	1.1
Blower dimensions, cm	(30) diameter and (10) wide	(30) diameter and (10) wide
Blade dimensions, cm	(10) wide, (15) long and (0.3) thickness	(10)wide, (15)long and (0.3) thickness
Number of concave holes	26 per 10 x 10 cm^2	26 per 10 x 10 cm^2

3.3. Materials:

3.3.1. Crop residues materials: All crop residues materials (rice straw) were obtained during harvesting of rice, variety of Giza 177. in the Experimental Farm, Rice Mechanization Center, Meet El-Deeba, Kafr El-Sheikh Governorate. Samples of ten rice plants were taken to determine the mentioned specifications shown in Table (3).

Table 3 : Some physical properties of rice straw variety Giza 177.

Samples, No.	1	2	3	4	5	6	7	8	9	10	Total	Mean
Plant length,cm	87	86	89	84	93	82	88	85	91	85	870	87
Plant Dim, cm	0.27	0.32	0.34	0.31	0.41	0.29	0.34	0.37	0.43	0.28	0.336	3.36
Mass of straw, g	48	45	48	44	53	47	48	46	50	47	479	47.6
M. contents, %	30.3											

3.3.2. Samples preparation: Each rice straw crop sample (complete stalks) was massed and dropped into the machine opening feed, the cut straw were collected in a box below the machine. Machine was tested using four mass of sample of 2, 4, 6 and 8 kg, three straw moisture contents of 22.3, 25.5 and 30.3%.

3.4. Tested factors: The experimental studies were confined to determine the effect of the following factors on cutting effectiveness for a new development of machine:

1-Four cylinder speeds 300, 400, 500 and 600 r.p.m. (4.55, 6.07, 7.59 and 9.11 m/s).

2-Four feeding rates (2, 4, 6 and 8 kg/min.).

3- Three straw moisture contents of (22.3, 25.5 and 30.3%).

-Air velocity, m/s from 5.2 to 8.6 m/s.

-The concave clearance for machine and for all experiments was kept constant at 10 mm at inlet and 4 mm at outlet. The clearance between the moving knives and stationary knife was kept constant at 0.5 mm.

3.5. Experimental procedures: In one complete experiment a test was carried out in the laboratory to determine the specifications of rice straw crop. In this experiment, capacity of machine, straw cutting length, consumed power, operation costs were determined.

a) The experiments: During the experiment and before the feeding process, speedometer was used for measuring the speed of cylinder shaft when the machine was unloaded and repeated again when the machine was on load. The feed rates were controlled by fixing the feeder labour and one assistant with feed rate ranged from 2, 4, 6 and 8 kg/min. for rice straw.

b) Measurements:

1. The moisture content of rice straw was determined. Samples were oven dried at 105°C for 24 hours. All moisture percentages were determined on wet basis to the following equation:

$$M.C,\ \% = \frac{\text{Weight of wet sample} - \text{Weight of dry sample}}{\text{Weight of wet sample}} \times 100 \quad \text{---- (1)}$$

2. Determination of capacity:

Time of cutting process was measured by means of a stop watch to determine, the capacity of machine; kg/sec. Machine productivity **(P_{ch})** was calculated by using the following formula:

$$\textbf{Chopping capacity } (P_{ch}) = P_w / t,\ (kg / h) \quad \text{-------------- (2)}$$

Where:

P_w = the mass of total rice straw, kg; and

t = the time consumed in chopping operation, h.

3. Measuring the straw length: Randomized samples were taken from each experiment to determine the actual mean straw length.

4. Power consumption: An ammeter and voltammeter were used for measuring current strength and potential difference, respectively before and during experiments. Readings of ampere (I) and volt (V) were taken before and during each treatment. The power consumption (p) was calculated from the values of Ampere (I) and Volt (V) by using the following **equation (Ibrahime, 1982):**

Total consumed power = Load

$$= \sqrt{3}\ I.V\ \eta \cos\theta / 1000, \quad (kW) \text{ ---- (3)}$$

Where:

I = Line current strength in Amperes.

V = Potential strength (voltage) being equal to 380V.

Cos θ = Power factor (being equal 0.84).

η = Mechanical efficiency assumed (95%).

Useful electric power (Pu) was calculated as following:

$$\mathbf{Pu = P - Pno,\ kW} \quad \text{---------------------------------(4)}$$

Where:

Pu = Useful consumed electric power in chopping , k W.

Pno = consumed power at no load, kW.

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

Specific energy (kW.h/Mg) = The consumed power (kW) / machine productivity (Mg/h)--- (5)

5. Operation costs:

The machine cost was determined by using the following formula **(Awady et al., 2003):**

$$C = P/h\ (1/a + i/2 + t + r) + (W.e) + m/144 \qquad \text{------ (6)}$$

Where:

C = Machine hourly cost, L.E/h;

P = Price of machine, L.E;

h = Yearly working hours, h;

a = Life expectancy of the machine, year;

i = Interest rate/year.

t = Taxes and over heads ratio, %.

r = Repairs and maintenance ratio, %

W = Power of motor, kW.

e = Hourly cost/kW.h.

m = The monthly average wage, L.E.

144 = The monthly average working hours.

Operating cost, LE/Mg = machine hourly cost, LE/h / capacity of machine, Mg/h --- ----(7)

Criterion cost, LE/Mg = operating cost LE/Mg+ losses cost, LE/Mg -- (8)

4. RESULTS AND DISCUSSION

Experiments were performed during (2008-2009) rice seasons at Meet El-Deeba Rice Mechanization Center of Agricultural Engineering Research Institute.

4.1. Machine capacity (feed rate), kg/min;

At chopping of rice straw crop the machine was operated at the cylinder speed varied from 4.55 to 9.11 m/s (300-600 r.p.m), under input capacities ranging from 120 - 480 kg/h, machine productivity (output straw after chopping and shredding operation) ranging from 60 - 240 kg/h, and moisture content of crop ranged from 22.3% to 30.3% in straw.

The effect of cylinder speed at different feed rate and crop moisture content is shown in Table 4.

4.2. Cutting length of straw:

Data and results of cutting length of straw as affected by different variables are shown in Table 4 and Figure (7a, b & c)

Table 4: Effect of cylinder speed on cutting length of straw, % at different feed rates with various moisture contents in straw.

Cylinder speed, m/s	Cut straw of length, cm	Moisture content of straw % (w.b)											
		22.3				25.5				30.3			
		Feed rates, kg/min.											
		2	4	6	8	2	4	6	8	2	4	6	8
		Cutting length of rice straw, %											
4.55	≥ - 0.5	15	16	17	18	13	14	15	16	11	12	13	14
	0.5-1	43	44	46	47	41	42	43	44	39	40	41	42
	1-2	5	6	8	9	4	5	6	7	2	3	4	5
	2-3	14	15	17	18	11	12	13	14	10	11	12	13
	3-4	9	10	12	8	7	8	9	10	5	6	7	8
	4-5	14	9	-	-	12	13	14	9	10	11	12	13
	5-6	-	-	-	-	12	6	-	-	23	17	11	5
6.07	≥ - 0.5	16	17	18	19	14	15	16	17	12	13	14	15
	0.5-1	44	46	47	48	42	43	44	45	40	41	42	43
	1-2	6	8	9	10	4	5	6	7	3	4	5	6
	2-3	15	17	18	19	13	14	15	16	11	12	13	14
	3-4	10	12	8	4	8	9	10	11	6	7	8	9
	4-5	9	-	-		13	14	9	4	10	11	12	13
	5-6	-	-	-		6	-	-	-	18	12	6	-
7.59	≥ - 0.5	17	18	19	20	15	16	17	18	13	14	15	16
	0.5-1	45	47	48	49	43	44	45	46	41	42	43	44
	1-2	7	9	10	11	5	6	7	8	4	5	6	7
	2-3	16	18	19	20	14	15	16	17	12	13	14	15
	3-4	11	8	4	-	9	10	11	11	7	8	9	10
	4-5	4	-	-	-	14	9	4	-	11	12	13	8
	5-6	-	-	-	-	-	-	-	-	12	6	-	-
9.11	≥ - 0.5	18	19	20	21	16	17	18	19	14	15	16	17
	0.5-1	46	48	49	50	44	45	46	47	42	43	44	45
	1-2	8	10	11	12	6	7	8	9	5	6	7	8
	2-3	17	19	20	17	15	16	17	18	13	14	15	16
	3-4	11	4	-	-	10	11	11	7	8	9	10	11
	4-5	-	-	-	-	9	4	-	-	12	13	8	3
	5-6	-	-	-	-	-	-	-	-	6	-	-	-

4.2.1. Effect of cylinder speed on cutting length of straw:

The effect of cylinder speed on cutting length of straw as shown in Table 4 and Figure (3a, b & c) the percentage of small cutting lengths increased as the cylinder speed was increased at the constant feed rate and constant moisture contents in straw. Similar results were indicated by **Helmy (1988) and El-Zemeity (1997).**

Development machine at feed rate 2 kg/min. increasing cylinder speed from 4.55 to 9.11 m/s (300 to 600 r.p.m.) as in figure 3a & b, it was found that percentage of cutting lengths increased from (15% ≥ 0.5cm, 43%, from 0.5 to 1 cm, 5%, from 1 to 2 cm, 14%, from 2 to 3 cm, 9%, from 3 to 4, and 14%, from 4 to 5 cm) to (18% ≥ 0.5 cm, 46%, from 0.5 to 1 cm, 8%, from 1 to 2 cm, 17%, from 2 to 3 cm and 11%, from 3 to 4 cm). The cutting length of 4 to 5 cm and 5 to 6 cm did not appear at cylinder speed 9.11 m/s (600 r.p.m.) at moisture contents of 22.3% in straw. The previous results indicated that, cutting length of straw %, increased with the increase of cylinder speed at all combination of other variables.

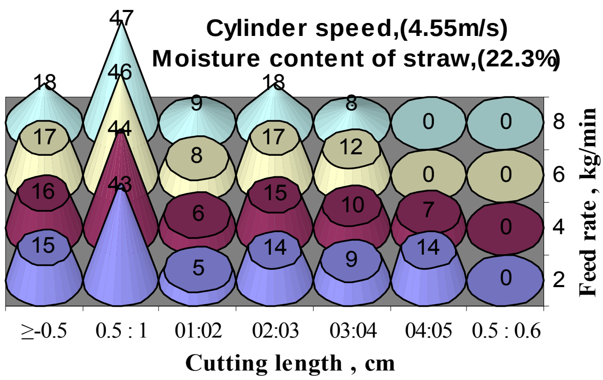


Fig .(3a): Effect of cylinder speed and different feed rates on cutting length of straw,%

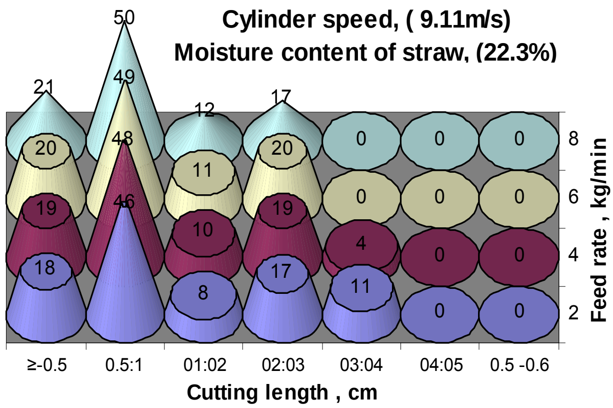


Fig .(3 b): Effect of cylinder speed and different feed rates on cutting length of straw,%

4.2.2. Effect of feed rate on cutting length of straw:

As the feed rate increased at constant variables, the cutting length of straw %, increased for development machine as shown in Table 4 and Figure (3a & b). Similar results was indicated by **Helmy (1988) and El-Zemeity (1997).** Developing machine at cylinder speed 4.55 m/s (300 r.p.m.) when the feed rate increased from 2 to 8kg/min. the cutting lengths of straw %, increased from (15% ≥ 0.5 cm, 43%, from 0.5 to 1 cm, 5%, from 1 to 2 cm, 14%, from 2 to 3 cm 9%, form 3 to 4 cm and 14%, from 4 to 5 cm) to (18% ≥ 0.5cm, 47%, from 0.5 to 1 cm, 9 %, from 1 to 2 cm, 18%, from 2 to 3 cm and 8%, from 3 to 4 cm). The cutting length of 4 to 5 cm and 5 to 6 cm did not appear at feed rate 8 kg/min. and moisture contents of 22.3 % in straw. Generally, the cutting length of straw %, increased with the increase of feed rat at all combination of other variables.

4.2.3. Effect of moisture content on cutting length of straw:

Table 4 and Figure 3a & c show that, as the moisture content of the crop increased at constant variables, the cutting length of straw %, was decreased for threshing machine.

Developing machine at feed rate 2 kg/min. and cylinder speed of 4.55 m/s (300r.p.m), when the moisture content increased from 22.3 % to 30.3 % in straw. The cutting length of straw %, decreased from (15% ≥ 0.5 cm, 43 %, from 0.5 to 1 cm, 5 %, from 1 to 2 cm, 14%, from 2 to 3 cm, 9 %, from 3 to 4 cm and 14%, from 4 to 5 cm) to (11 % ≥ 0.5 cm, 39 %, from 0.5 to 1 cm, 2%, from 1 to 2 cm, 10 %, from 2 to 3 cm, 5%, from 3 to 4 cm,10 %, from 4 to 5 cm and 23 %, from 5 to 6 cm). Generally, the cutting length of straw %, decreased with the

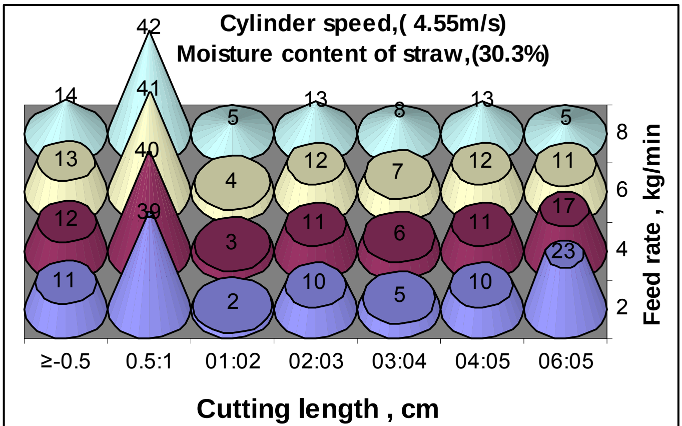


Fig .(3 c): Effect of cylinder speed and different feed rates on cutting length of straw,%

increased in moisture content at all combination of other variables at different feed rates with various moisture contents in straw.

4.3. The power requirement: Short-time, peak power requirements for the cylinder may be 2 or 3 times as great as the average requirement. The engine needs to have considerable reserve power to be able to handle these peaks without stalling or causing undesirable speed reductions **(Kepner et al., 1982).**

4.3.1. Effect of cylinder speed and feed rate on power requirement:

a- The consumed power, kW, was increased by increasing cylinder speed, feed rate at constant moisture contents of straw. The maximum consumed power was 1.598 kW, at cylinder speed 9.11 m/s (600 r.p.m.), feed rate 8 kg/min. and moisture content of 30.3 % in straw. Table 5 and Fig. 8a shows that, at feeding rate of 2kg/min, increasing cylinder speed from 4.55 to 9.11 m/s tends to increase consumed power from 0.863 to 1.509 kW. Also at the same cylinder speed (9.11m/s), increasing feed rate from 2 to 8 kg/min tends to increase the consumed power from 1.509 to 1.598kW. This result was related to the torque and the speed. When cylinder speed increased the capacity and the feed rate increased which as a results of more torque to cut the straw. Similar results were obtained by **El-Berry et al. (2001)**, **Suliman et al. (2004)** and **El-Haddad (2004).**

b - The useful power, kW, was increased by increasing cylinder speed, feed rate at constant moisture contents in straw as shown in Table 5. The maximum useful power was 0.136 kW, at cylinder speed 9.11 m/s (600 r.p.m.), feed rate 8 kg/min. and moisture content of 30.3 % in straw. At cylinder speed of 9.11 m/s, when the feed rate increased from 2 to 8kg/min. the useful power also increased from 0.047 to 0.136 kW. However, it increased from 0.073 to 0.136 kW when the cylinder speed

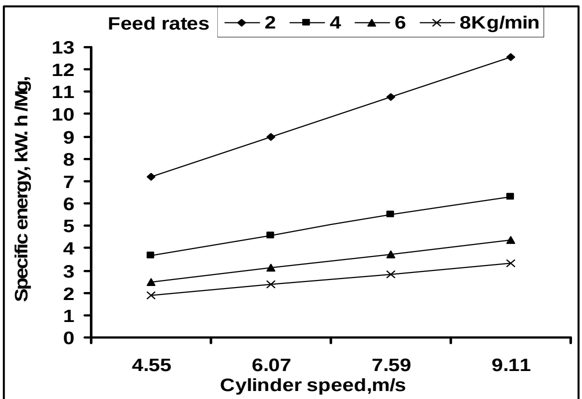


Fig. 8: Effect of cylinder speed and feed rate on specific energy, kW. h /Mg.

increased from 4.55 to 9.11 m/s at 8 kg/min. feed rate. This is due to the increasing of current consumption as a result of the increasing of cylinder speed and feed rate.

c- The specific energy, (kW h/ Mg.) is the best indictor to show the effect of both cylinder speed and feed rate. It was increased by increasing the cylinder speed. The maximum specific energy was 12.575kW.h /Mg at cylinder speed 9.11 m/s (600 r.p.m.), feed rate 2kg/min. and moisture content of 30.3 %, in straw as shown in Table 5. At cylinder speed of 4.55 m/s, when feed rate increased from 2 to 8 kg/min, the specific energy decreased from 7.192 to 1.902kW.h/Mg. Also, at the feed rate 2 kg/min. increasing cylinder speed from 4.55 to 9.11 m/s tends to increase specific energy from 7.192 to12.575 kW.h/Mg.

Table 5 : Effect of cylinder speed and feed rate on consumed power, useful power and specific energy at constant moisture content (30.3 %) in straw.

Power requirements	Feed rates, kg/min	Cylinder speed, m/s			
		4.55	6.07	7.59	9.11
Consumed power, kW	2	0.863	1.078	1.294	1.509
	4	0.879	1.099	1.319	1.538
	6	0.896	1.119	1.344	1.568
	8	0.913	1.141	1.369	1.598
Useful power, kW	2	0.023	0.028	0.041	0.047
	4	0.039	0.049	0.066	0.076
	6	0.056	0.069	0.092	0.106
	8	0.073	0.091	0.116	0.136
Specific energy, kW.h/Mg.	2	7.192	8.983	10.783	12.575
	4	3.663	4.579	5.496	6.408
	6	2.489	3.108	3.733	4.356
	8	1.902	2.377	2.852	3.329

4.4. Criterion Function Cost of the developed Machine:

The criterion function of the developed machine at four feed rates at constant cylinder speed 9.11 m/s was calculated as summarized in Table

6. The result revealed that the criterion function cost was decreased from129.75 to 32.438 LE/t when the feed rate increased from 2 to 8 kg/min.

Table 6: Criterion function cost of the developed machine at four feed rates at cylinder speed 9.11 m/s at constant moisture content 30.3 % of rise straw.

Feed rates, (Straw stalks) **Kg/min**	**Machine hourly cost, LE/h**	**Chopping productivity, Mg/h**	**Operating cost, LE/Mg**	**Chopping losses costs, LE/Mg**	**Criterion cost, LE/Mg**
2	7.785	0.06	129.750	0.00	129.750
4	7.785	0.12	64.875	0.00	64.875
6	7.785	0.18	43.250	0.00	43.250
8	7.785	0.24	32.438	0.00	32.438

C = P/h (1/a +i/2 + t + r) + (W.e) + m/144								
Cost items,								
P, L.E	**h,** h	**a,** year	**i,%** year	**t,** %	**r,** %	**W,** kW	**e,** kW/h, L.E	**m,** L.E
3000	**500**	**10**	**13**	**5**	**50**	**2.25**	**0.01**	**500**

CONCLUSION

The conclusions of this study are summarized as follow:

1-The drum speed of 9.11m/s (600 r.p.m) gave the highest values of machine productivity and the lowest values of big cutting lengths for rice straw.

2-The percentage of small cutting lengths, were increased by increasing cylinder speed and feed rates and decreased by increasing the moisture contents.

3-The maximum of the percentage of small cutting lengths were (21% $\geq$ 0.5 cm, 50 %, from 0.5 to 1 cm, 12 %, from 1 to 2cm and 17 %, from 2 to 3 cm), at cylinder speed, 9.11 m/s (600 r.p.m.), feed rate 8 kg/min. and moisture contents (22.3 %) in straw.

4- The minimum specific energy were obtained with feed rate of 8kg/min and drum speed of 4.55 m/s (300 r.p.m) and moisture contents (30.3 %) in straw.

5- The minimum total chopping cost for developed machine operated by electric motor was 7.785 LE/h; the criterion function cost was 32.438 LE/Mg.

RECOMMENDATION: From results of this study it is recommend that using the developed machine for cutting and shredding rice straw residues at drum speed of 9.11 m/s (600 r.p.m) and feed rate 480 kg/h at lowest values of moisture content with clearance 0.5 mm between the moving cutting knives and stationary cutting knife.

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الملخص العربي

تطوير وتعظيم الأداء لألة دراس محلية للحيازات الصغيرة لتناسب تقطيع وفرم مخلفات المحاصيل الزراعية

د/وجدى زغلول الحداد*

تم هذا العمل نتيجة لضعف الموارد الاقتصادية للمزارع الصغير وصغر الحيازات الزراعية والتى تمثل 52 % من اجمالى المساحة الكلية وحاجة اصحاب هذة الحيازات الى اقتناء الات صغيرة رخيصة السعر ومتعددة الاغراض وذات كفاءة عالية فى اداء العمليات مع تقليل الفواقد الى ادنى حد ممكن.

والهدف من البحث هو تطوير وتعظيم الأداء لألة دراس محلية للحيازات الصغيرة لتناسب فرم وتقطيع مخلفات المحاصيل الزراعية مع تجنب حدوث مشكلة التكدس (الازورار) خاصة مع محتويات الرطوبة المرتفعة بالإضافة إلى إعطاء اطوال القطع المرغوبة من مخلفات المحاصيل والتى تتناسب مع مختلف الاستخدامات. الأمر الذى دعا إلى تطوير الماكينة الحالية, حيث تم تصميم وتصنيع اربعة سكاكين من الصلب بطول 24 سم وعرض 5 سم وسمك 0,5 سم وزاوية الحد القاطع (45°) وتم تركيبها على درفيل الدراس بشكل منتظم بحيث يكون الدرفيل متزن اثناء الدوران وتكون قابلة للفك والتركيب –

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وتم اضافة مدخل اخر لدخول مخلفات المحصول (القش) الى غرفة التقطيع (45×45×65 سم) روعى امان العامل اثناء التشغيل, وتم اضافة سكينة ثابتة ابعادها (24× 6 ×0,6 سم) فى نهاية مدخل قادوس التلقيم وتميل على المستوى الافقى بزاوية (10°) وتمثل زاوية القطع لتقليل القدرة اللازمة لعملية القطع وتتحرك السكينة الثابتة أفقيا بحيث يمكن ضبط الخلوص بينها وبين السكاكين الاربعة المثبتة على درفيل الدراس وبذلك يعمل الدرفيل اولآ عملية القطع للمخلفات (بواسطة السكاكين الاربعة الدوارة والسكينة الثابتة) ثم الفرم بالسكاكين المسننة وهكذا تتعاقب عملية القطع ثم الفرم تبعا لسرعة دوران الدرفيل. وذلك مع استعمال غربال صدر اقطار ثقوبة 1,1 سم.

وقد تم دراسة المتغيرات الآتية على أداء الآلة وهى:-

* اربعة سرعات درفيل تراوحت من 4,55 إلى 9,11 م/ث (300 إلى 600 لفة/دقيقة)
* أربعة معدلات تغذية مداها من 120 إلى 480 كجم/ساعة
* ثلاثة محتويات رطوبة للمحصول مداها من 22,3% إلى 30,3% للقش على أساس رطب.

أوضحت نتائج التجارب أن :

1- **أقصى إنتاجية لقطع قش الأرز الخارجة** كانت 240كجم/ساعة عند سرعة أسطوانة الدراس 9,11 م/ث ومعدل تغذية سيقان القش 480 كجم/ساعة ومحتوى رطوبى 30,3% للقش على أساس رطب وحدة الطاقة المستهلكة 3,329 كيلو وات.ساعة/ ميجا جرام، طول قطع القش (17% ≥ 0,5 سم ، 45% من 0,5 إلى 1 سم ، 8 % من 1 إلى 2 سم، 16% من 2 إلى 3 سم ، 11% من 3 إلى 4 سم , 3 % من 4 الى 5 سم) على التوالى.

2- **النسبة المئوية لطول قطع القش ذات الأطوال الصغيرة** كانت تزداد بزيادة سرعة الأسطوانة وزيادة معدل التغذية وتتناقص النسبة المئوية لأطوال القش القصيرة بزيادة المحتوى الرطوبى. **وفى محصول قش الأرز** أعلى قيمة للنسبة المئوية لأطوال القش القصيرة كانت 21% ≥ 0,5سم ، 50 % من 0,5 إلى 1سم ، 12% من 1 إلى 2 سم ، 17% من 2 إلى 3 سم) عند سرعة أسطوانة 9,11 م/ث ومحتوى رطوبى 22,3 للقش ومعدل تغذية 8كجم/د.

3- **القدرة المستهلكة** فى تشغيل الآلة وعملية التقطيع تزداد بزيادة سرعة الدرفيل ومعدل التلقيم والمحتوى الرطوبى **وفى محصول قش الأرز** أقصى قيمة للقدرة المستهلكة 1,598 كيلووات عند سرعة درفيل 9,11 م/ث ومعدل تغذية 8 كجم/د ومحتوى رطوبى 30,3% للقش

4- **تكاليف التقطيع فى الماكينة المطورة فى فرم وتقطيع محصول قش الأرز** التكاليف الكلية كانت 7,785جنية/ساعة بينما الدالة المعيارية لها تكون 129,75جنية/ميجاجرام. وذلك عند إنتاجية 60كجم/ ساعة للقش المقطع والمفروم وسرعة درفيل 9,11 م/ث ومحتوى رطوبى ، 30,3% للقش ومعدل تغذية 2 كجم/د. والدالة المعيارية تناقصت الى 32,438 جنية/ميجاجرام. بزيادة الانتاجية الى 240كجم/ ساعة عند نفس عوامل التشغيل السابقة ومعدل تغذية 8 كجم/د.