

## **Development of a Rice-Straw Disc Chipper**

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### **ABSTRACT**

The aims of this research are to develop manufacture and evaluate a rice-straw disc chipper. The disc chipper consists of frame, feeding duct, and rotating disc with three knives, fixed knife, suction fan and 5.6-kW electric motor. The studied performance-factors are: cutting-knife speeds of 800, 1000, 1200, and 1400 rpm (16.76, 20.94, 25.13 and 29.31 m/s), clearances between rotating knives and disc of 5, 10, 15 and 20 mm and rice-straw moisture contents of 14, 18, 22 and 26 % in wet base. The main results were summarized in the following points: \* The maximum average of cutting length of 25.2 mm was obtained by using fan, cutting-knives speed of 800 rpm (16.76 m/s), rice-straw moisture content of 26 % and clearance of 20 mm. Meanwhile, the minimum average of cutting length of 4.3 mm was obtained by using the chipping machine without fan, cutting-knives speed of 1400 rpm (29.31 m/s), rice-straw moisture content of 14 % and clearance of 5 mm. \* The maximum machine productivity of 333.6 kg/h was obtained by using fan, cutting-knives speed of 1400 rpm (29.31 m/s), rice-straw moisture content of 26 % and clearance of 20 mm. Meanwhile, the minimum machine productivity of 66.2 kg/h was obtained by using the chipping machine without fan, cutting-knives speed of 800 rpm (16.76 m/s), rice-straw moisture content of 14 % and clearance of 5 mm. \* The minimum production cost of 34.4 L.E./ton was obtained by using rice-straw moisture content of 26 % and at optimum knives-speed of 1400 rpm (29.31 m/s) using fan and clearance of 20 mm.

### **INTRODUCTION**

Rice straw is one of the most residue problems in Egypt. The cultivated area of rice is about 1.14 million feddans in year 2015 that produced about 4.104 million ton rice straw (the production per feddan is about 3.6 ton/fed). Rice straw was utilized from about 2.5 million ton in different uses. Remain quantity is burned to give the chance to prepare the field for planting the next crop (Bulletin of Central Administration for Agricultural Extension Service in 2015). There are great efforts towards recycling rice straw in a useful uses will help keeping safety on environment in addition to increase the national income of country.

Therefore, the rice-straw chopping process is very necessary as a pretreatment to reuse the rice straw in different uses such as animal fodder and compost. The chopping process can be done by using variable type of chopping machines, but the productivity of these choppers is still little, not covering the farmer needs in addition to the high operation and production cost of the rice-straw chopping process (Arif, 1999). Luis et al. (1993) mentioned that in compost practice the appropriate cutting length of rice straw, which can be used in composting should be within the range of about 1.27–7.62 cm. El-Iraqi and El-Khawaga (2003) designed and evaluated a machine for cutting crop residues. It was found that the maximum percentage cutting-length of rice straw less than 5 cm about 87.80 % was investigated at using feeding rate of 0.771 ton/h and cutting speed 10.09 m/s. Also, the energy requirement was 6.36 kW.h/ton. The maximum operating and production costs were 5.10 L.E/h and 6.61 L.E/ton for cut rice straw residues. El-Fatih et al. (2010) modified and evaluated chopper for rice straw composting. It was found that by increasing the cutting-drum speed from 56.6 m/s to 70.7 m/s the productivity increased from 489 kg/h to 1150 kg/h, from 430 kg/h to 976 kg/h and from 350 kg/h to 600 kg/h for 35 mm, 25

mm, and 9 mm concave-hole diameters respectively. Also, by increasing the cutting-drum speed from 56.6 m/s to 70.7 m/s the consumed power increased from 2.15 kW to 3.4 kW, from 3 kW to 4.2 kW and from 4.3 kW to 6.71 kW for 35 mm, 25 mm, and 9 mm concave-hole diameters respectively. Meanwhile, by increasing the cutting drum speed from 56.6 m/s to 70.7 m/s the specific energy decreased from 4.4 kW.h/ton to 2.96 kW.h/ton, from 6.98 kW.h/ton to 4.3 kW.h/ton and from 12.29 kW.h/ton to 11.18 kW.h/ton for 35 mm, 25 mm and 9 mm concave-hole diameters respectively. Abo-Elasaad (2016) and Abo-Habaga et al. (2015) developed a rice-straw bales chopper. It was found that the maximum value of power requirement and specific energy about 7.17 kW and 7.75 kW. h/t were obtained by using cutting-knives speed of 1260 rpm (26.4 m/s) and 750 rpm (15.71 m/s), platform tilt-angle of 30 degree with using 24 cutting knives respectively. Meanwhile, the minimum values of power requirement and specific energy about 3.72 kW and 5.07 kW.h/t were obtained by using cutting-knives speed of 750 rpm (15.71 m/s) and 1260 rpm (26.4 m/s), platform tilt-angle of 20 degree with using 12 cutting knives respectively.

#### **The objectives of this research are:**

- Developing, manufacturing and testing of a disc chipper for agricultural residues.
- Studying the effect of performance factors such as “cutting-knives speed, rice-straw moisture content, and clearance” on cutting length, machine capacity, power requirements and costs of the developed rice-straw disc chipper.

### **MATERIALS AND METHODS**

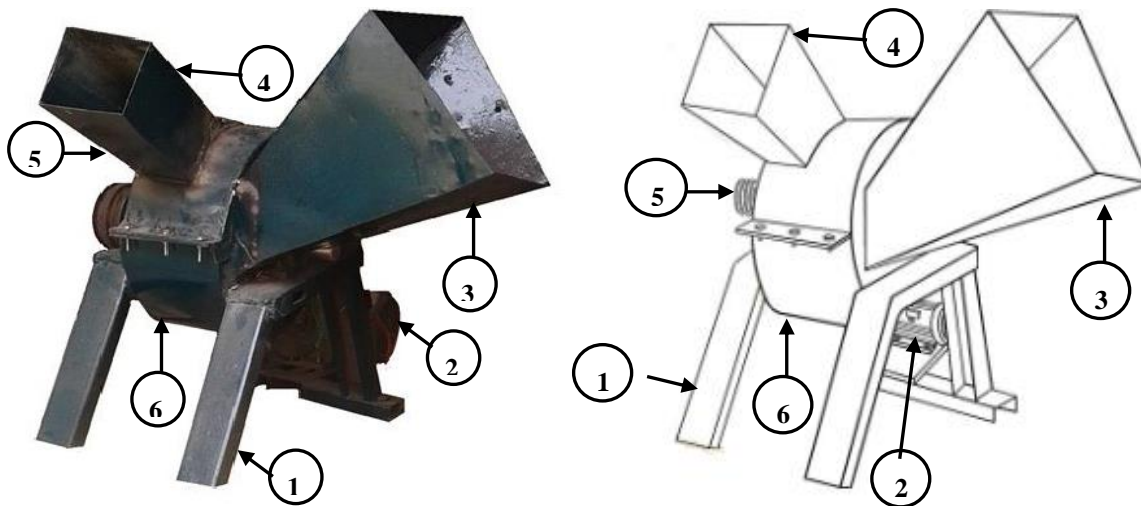
#### **Materials**

#### **Developed disc-chipper for rice straw**

The developed disc-chipper photograph and isometric sketch is shown in Fig. 1. The developed disc-chipper consists of the following parts:

- (1) **Frame:** The frame was made of U-angle steel with dimensions of 100 x 50 x 5 mm. The overall length, width and height of the frame are 1200, 600 and 500 mm respectively.
- (2) **Feeding duct:** The feeding duct was made of iron sheet with thickness of 3 mm. The inlet opening of

feeding duct has dimensions of 300 x 400 mm. The duct opening in the direction of knives disc has dimensions of 130 mm (in the direction of knife width) x 200 mm (upper the knife). The depth of feeding duct is 600 mm.



**Fig. 1. Photograph and isometric sketch of the developed disc-chipper for rice straw**  
 (1) Frame, (2) 7.5-hp motor, (3) Feeding duct, (4) Outlet duct, (5) Cutting and fan shaft pulley, and (6) Cutting-knives disc and fan housing.

**(3) Cutting unit:**

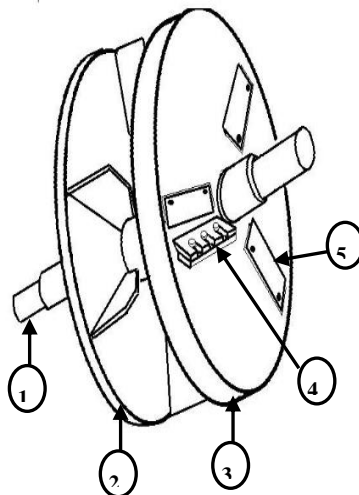
The cutting-unit consists of the following parts:

- (a) **Cutting-unit housing:** The circular cutting-housing was made of sheet steel with 5 mm thickness. The cutting housing has diameter of 430 mm and width of 400 mm. The housing was divided into two equal-parts. The bottom part was welded with the frame. The upper part was bolted with the bottom part.
- (b) **Rotating cutting-knives disc:** The three rotating cutting-knives disc made of sheet steel with 30 mm thickness. The cutting knives disc has diameter of 400 mm. And it has a center hole with diameter of 65 mm and peripheral sluts with length of 150 mm and width of 45 mm. Each slit has solid groove with depth of 5 mm (equal to knife thickness) and 30 mm width for knife support. The rotating cutting-knives disc was assembled with a shaft by a key with length of 40 mm, width of 20 and height of 15 mm.
- (c) **Rotating cutting-knives:** The three rotating cutting-knives were made of alloy steel “K100” with 5 mm thickness, 40 mm width and 150 mm length. The knives were bolted in disc slut-grooves by two bolts with diameter of 12 mm. Each knife has 2 holes with 12 mm diameter. The steel type of the cutting knife was named “Bohler K100 or DIN 1.2080”. The rotating cutting-knives clearance can be adjusted by two nuts and bolts. The two nuts with diameter of 10 mm were welded behind the cutting-knives disc in two edges of each knife slit. The clearance can be adjusted by two bolts of 10 mm diameter. The sketch of rotating disc, shaft and knives, fixed knife and suction fan assembly is shown in Fig. 2.

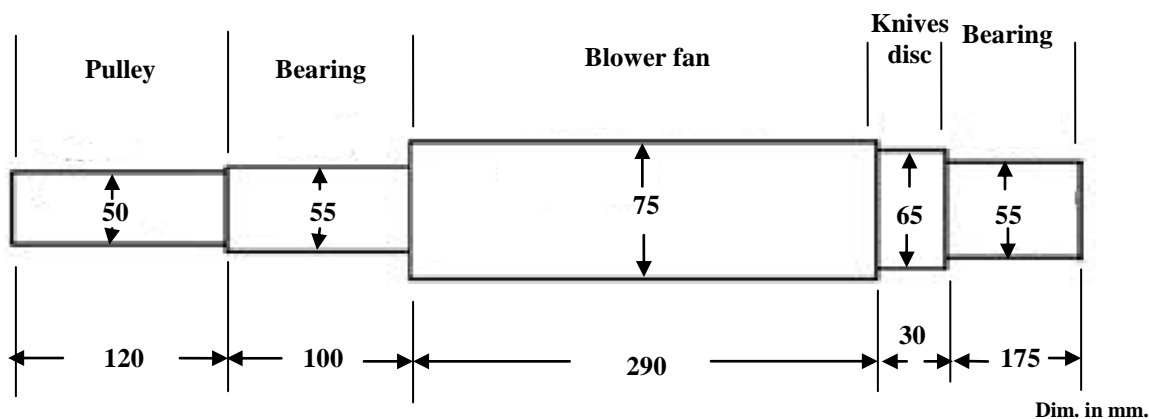
- (d) **Fixed cutting-knife:** The fixed cutting-knife was made of alloy steel “K100” with 5 mm thickness, 40 mm width and 150 mm length. The fixed knife was horizontally bolted with a plate. The plate of 15 mm thickness, 40 mm width and 150 mm length was welded with frame. The plate has 3 sluts with width of 12 mm and length of 30 mm. The sluts were used to adjust the constant distance between rotating and fixed knives after changing the tested clearances.

The hardness of the knife steel was in the range of 63 – 65 HRC (Hardness Rockwell Scale).

- (e) **Knives disc and blower-fan shaft:** The disc and fan shaft made of steel with maximum diameter of 75 mm and maximum length of 715 mm. The shaft was mounted with the machine frame by two ball-bearings. The sketch and dimensions details of the shaft were shown in Fig. 3.
- (4) **Suction fan:** Suction fan consists of a flange, ring and 6 vanes. The flange has diameter of 400 mm and thickness of 6 mm. The ring with diameter of 75 mm, length of 70 mm and thickness of 10 mm was welded with a flange. Six vanes with length of 140 mm, height of 140 mm and thickness of 4 mm were welded peripherally on the flange. The gap between cutting-knives disc and the suction fan is 130 mm.
- (5) **Outlet duct:** The outlet duct of cutting rice-straw was made of sheet steel with thickness of 3 mm. The outlet duct opening in the direction of the fan has dimensions of 150 x 150 mm. And the outlet duct opening has dimensions of 200 x 200 mm. The depth of outlet duct is 300 mm.



**Fig. 2. Sketch of rotating disc, shaft and knives, fixed knife and suction fan assembly**  
 (1) Shaft, (2) Suction fan, (3) Rotating disc, (4) Fixed knife and (5) Rotating knife.



**Fig. 3. Sketch and dimensions of the cutting-knives disc and blower shaft**

- (6) **Electric motor:** Three phase induction electric-motor of 5.6 kW (7.5 hp) and 1800 rpm was assembled with the frame to drive all rotating parts of the machine by means of pulleys and v-belts. The electric motor is equipped with the movable base using four bolts to be able to replace and change the tested pulleys.
- (6) **Power transmission-unit:** The power was transmitted from the electric motor by means of pulleys and v-belts drives. The motor-shaft pulley with tested diameters of 156, 133, 111 and 89 mm is equipped the cutting-knives shaft pulley with diameter of 200 mm. The tested blower-fan speed equal to the tested cutting-knife speeds because the blower and knives-disc were assembled with the same shaft. Table 1 shows the tested motor cutting shaft pulley diameters and cutting-knife and fan speeds.

**Table 1. Tested motor, cutting shaft pulley diameters and cutting-knife and fan speeds.**

Cutting-shaft pulley diameter, mm.	Motor-shaft pulley diameter, mm.	Cutting-knives speed, rpm.	Cutting-knives speed, m/s.	Fan speed, rpm.
	89	800	16.76	800
	111	1000	20.94	1000
200	133	1200	25.13	1200
	156	1400	29.31	1400

**Rice straw:** Rice straw with moisture contents of 14, 18, 22 and 26 % wet base were used in the experimental tests.

**Methods:**

**(1) Studied factors.**

The experiments were conducted to study some factors affecting the disc-chipper performance such as cutting-knives speed, rice-straw moisture content and clearance. The studied parameters were as follows:

- (a) **Cutting-knives speeds:** The tested chipping-knife speeds were 800, 1000, 1200, and 1400 rpm (16.76, 20.94, 25.13 and 29.31 m/s).
- (b) **Clearances:** The tested clearances between rotating knives and disc were 5, 10, 15 and 20 mm.
- (c) **Rice-straw moisture contents:** The tested rice-straw moisture contents were 14, 18, 22 and 26 % in wet base.
- (d) **Fan existing:** The developed disc-chipper was tested with and without fan. The cutting straw was collected from a gate underneath the cutting-disc housing for testing the chipper without fan.

**(2) Measurements:**

- (a) **Average and cutting-length of rice-straw:** Average cutting-length for rice straw which produced from disc chipper was measured from sample of 200 g for each treatment.

(b) **Machine productivity:** Machine productivity was calculated by using the following equation:

$$P = W / t \dots\dots\dots(1)$$

Where: P : Machine productivity, kg/h, W: Mass of the rice straw bale, kg and t : Time, h.

(d) **Power requirement and specific energy:** The electrical power requirement (kW) was calculated by using the clamp meter to measure the line current strength in Amperes (I) and potential difference values (v). The required power of developed disc-chipper (P) was calculated according to Kurt, 1979 by using the following equation:

$$P = \sqrt{3} \times I \times V \times \eta \times \text{Cos } \theta / 1000 \dots\dots\dots(2)$$

Where: P: Power requirement for the cutting machine in kW, I : Line current intensity in amperes, V: Potential difference (Voltage) being equal to 380 V, Cos  $\theta$  : Power factor (being equal to 0.85),  $\sqrt{3}$  : Coefficient current three phase (being equal 1.73) and  $\eta$ : Mechanical efficiency assumed (95 %).

The specific energy was calculated by using the following equation:

$$\text{Specific energy, kW.h/ton} = \frac{\text{Power, kW}}{\text{Productivity, ton/h}}$$

(e) **Estimating the costs of using the machine:** Cost of operation was calculated according to the equation given by Awady, 1978, in the following form:

$$C = p/h (1/a + i + t/2 + r) + (Ec * Ep) + m/144 \dots (4)$$

Where: C: hourly cost, LE/h, P: price of machine, LE, h: yearly working hours, h, a: life expectancy of the machine, year, i: interest rate/year, t: taxes, (0.05), r: overheads and indirect cost ratio (0.03), Ec: Electricity consumption kW.h/h, Ep: Electricity price L.E./kW.h, m: Monthly wage and "144" are estimated monthly working hours. Notice that all units have to be consistent to result in L.E/h.

Production cost was calculated according to the following equation:

$$\text{Production cost, L.E./ton} = \frac{\text{Operation cost, L. E./ h}}{\text{Machine productivity, ton/h}} \dots (5)$$

## RESULTS AND DISCUSSION

### (1) Effect of cutting-knives speed, rice-straw moisture content, clearance and fan existing on average of cutting-length.

Figs. 4 and 5 show the effect of cutting-knives speed and rice-straw moisture content, clearance and fan existing on average of cutting length.

The maximum average of cutting length of 25.2 mm as obtained by using fan, cutting-knives speed of 800 rpm (16.76 m/s), rice-straw moisture content of 26 % and clearance of 20 mm. Meanwhile, the minimum average of cutting length of 4.3 mm was obtained by using the chipping machine without fan, cutting-knives speed of 1400 rpm (29.31 m/s), rice-straw moisture content of 14 % and clearance of 5 mm.

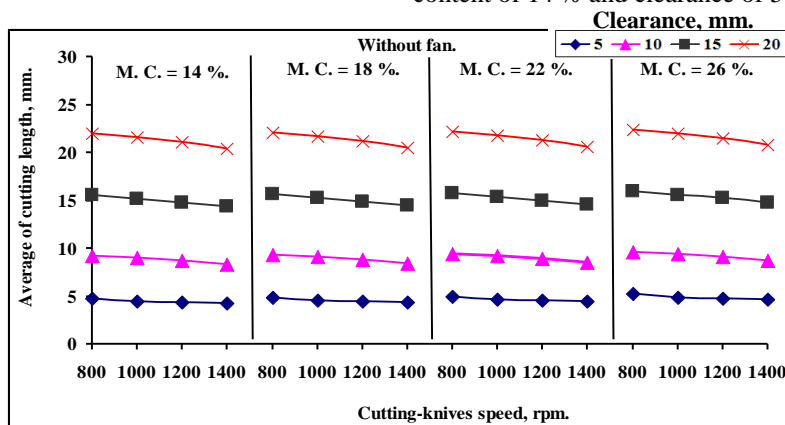


Fig. 4. Effect of cutting-knives speed and rice-straw moisture content “M. C.”, clearance and without fan on average of cutting length.

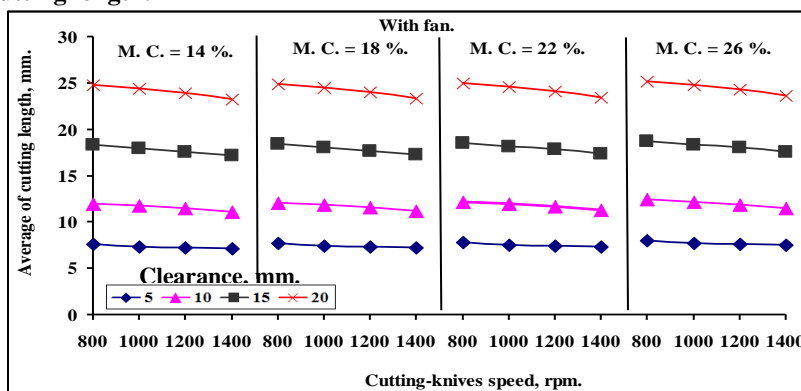


Fig. 5. Effect of cutting-knives speed and rice-straw moisture content “M. C.”, clearance and with fan on average of cutting length.

**(a) Effect of cutting-knives speed.**

By increasing cutting-knives speed from 800 to 1400 rpm (from 16.76 to 29.31 m/s) the average of cutting length decreased by 7.85 and 6.47 % without and with using the fan respectively at all tested rice-straw moisture contents and clearances.

The decreasing of average cutting-length of rice straw by increasing cutting-knives speed is due to increasing number of hits of cutting knives to rice straw.

**(b) Effect of rice-straw moisture content.**

By increasing rice-straw moisture content from 14 to 26 % the average of cutting length increased by 3.13 and 2.57 % without and with using fan respectively at all tested cutting-knife speeds and clearances.

The increasing of average cutting-length of rice straw by increasing rice-straw moisture content is due to causing bending of rice-straw stalks which faces the knives disc.

**(c) Effect of clearance.**

By increasing clearance from 5 to 20 % the average of cutting length increased by 78.2 and 69.2 % without and with using fan respectively at all tested cutting-knife speeds and rice-straw moisture contents.

The increasing of average cutting-length of rice straw by increasing clearance is due to increasing spacing between rotating cutting-knives and disc and in

addition to escaping of rice-straw stalks from the disc-knife sluts.

**(d) Effect of fan existing.**

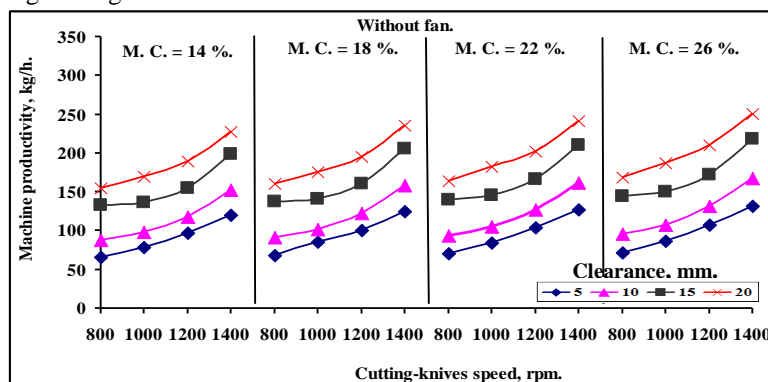
The maximum of average cutting-length of 15.4 mm was obtained by using the fan. Meanwhile, the minimum of average cutting-length of 12.6 mm was obtained without fan and at all tested cutting-knife speeds, rice-straw moisture contents and clearances.

The increasing of average cutting-length of rice straw by using the fan is due to suction of rice-straw stalks by the fan which assist the stalks to escape from knives-disc sluts.

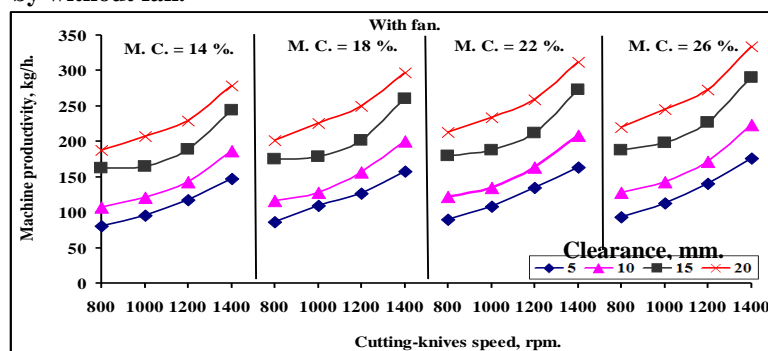
**(2) Effect of cutting-knives speed, rice-straw moisture content, clearance and fan existing on machine productivity.**

Figs. 6 and 7 show the effect of cutting-knives speed and rice-straw moisture content, clearance and fan existing on machine productivity.

The maximum machine productivity of 333.6 kg/h was obtained by using fan, cutting-knives speed of 1400 rpm (29.31 m/s), rice-straw moisture content of 26 % and clearance of 20 mm. Meanwhile, the minimum machine productivity of 66.2 kg/h was obtained by using the chipping machine without using fan, cutting-knives speed of 800 rpm (16.76 m/s), rice-straw moisture content of 14 % and clearance of 5 mm.



**Fig. 6. Effect of cutting-knives speed and rice-straw moisture content “M. C.” and clearance on machine productivity by without fan.**



**Fig. 7. Effect of cutting-knives speed and rice-straw moisture content “M. C.” and clearance on machine productivity by using fan.**

The increasing of machine productivity by increasing cutting-knives speed is due to decreasing of cutting time. Meanwhile, the increasing of machine productivity by increasing clearance and rice-straw moisture content is due to increasing the cutting-straw mass.

**(3) Effect of cutting-knives speed, rice-straw moisture content, clearance and fan existing on power requirement and specific energy.**

Figs. from 8 to 10 show the effect of cutting-knives speed and rice-straw moisture content, clearance and fan existing on power requirement and specific energy.

The maximum power requirement of 3.7 kW was obtained without using fan, cutting-knives speed of 1400 rpm (29.31 m/s), rice-straw moisture content of 26 % at all tested clearance. Meanwhile, the minimum

power requirement of 2 kW was obtained by using the chipping machine with fan, cutting-knives speed of 800 rpm (16.76 m/s), rice-straw moisture content of 14 % at all tested clearances.

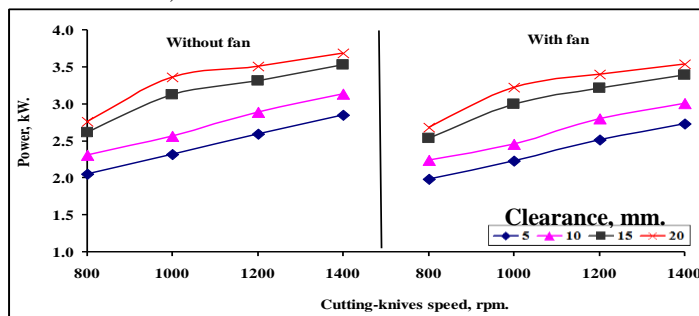


Fig. 8. Effect of cutting-knives speed and rice-straw moisture content and fan exciting on power requirement.

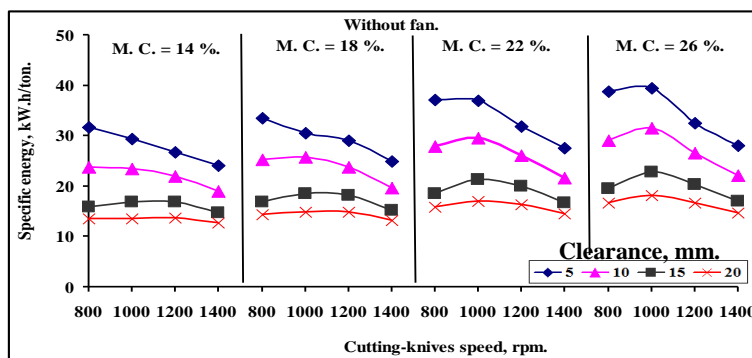


Fig. 9. Effect of cutting-knives speed and rice-straw moisture content “M. C.”, and clearance on specific energy without using fan.

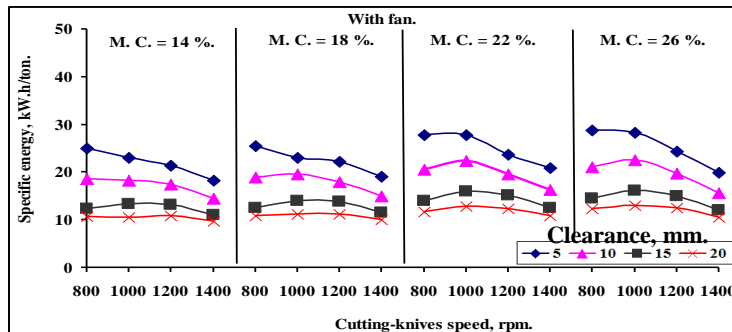


Fig. 10. Effect of cutting-knives speed and rice-straw moisture content “M. C.”, clearance and with using fan on specific energy.

The maximum specific energy of 39.42 kW.h/ton was obtained without fan, cutting-knives speed of 1000 rpm (20.94 m/s), rice-straw moisture content of 26 % and clearance of 5 mm. Meanwhile, the minimum specific energy of 9.71kW.h/ton was obtained by using the chipping machine with fan, cutting-knives speed of 1400 rpm (29.31 m/s), rice-straw moisture content of 14 % and clearance of 20 mm.

(4) Effect of rice-straw moisture content and clearance on operation and production costs.

Tables 2 and 3 shows the components of the Awady equation, operation and production costs of using the developed disc-chipper for rice straw at optimum cutting-knives speed of 1400 rpm (29.31 m/s) and with fan.

Table 2. The components of Awady equation.

p, L.E.	h, h	a, year	i	t	r	Ec, kW.h/h	Ep, L.E.	m, L.E
6000	3000	10	0.075	0.05	0.03	2.7 – 3.5	0.30	1500

Table 3 shows the effect of rice-straw moisture content and clearance on operation and production costs

at optimum cutting-knives speed of 1400 rpm (29.31 m/s) and with fan.

**Table 3. Effect of rice-straw moisture content and clearance on operation and production costs at optimum cutting-knives speed of 1400 rpm (29.31 m/s) and with fan.**

Moisture content, %.	Clearance, mm.	Power, kW.	Operation cost, L.E./h.	Machine productivity, kg/h.	Production cost, L.E./ton.
14	5	2.7	11.2	147.7	75.9
	10			186.1	60.2
	15			243.9	46.0
18	20	3	11.3	278.2	40.3
	5			157.9	71.6
	10			200.5	56.4
22	15	3.4	11.4	260.6	43.3
	20			297.4	38.0
	5			163.0	70.1
26	10	3.5	11.5	208.6	54.8
	15			273.2	41.8
	20			311.8	36.6
	5			175.7	65.3
	10			223.1	51.4
	15			290.1	39.6
	20			333.6	34.4

The maximum operation cost of 11.5 L.E./h was obtained by using rice-straw moisture content of 26 % and at optimum knives-speed of 1400 rpm (29.31 m/s) with fan at all tested clearances. Meanwhile, the minimum operation cost of 11.2 L.E./h was obtained by using rice-straw moisture content of 14 % at optimum knives-speed of 1400 rpm (29.31 m/s) with fan at all tested clearances.

The maximum production cost of 75.9 L.E./ton was obtained by using rice-straw moisture content of 14 % and at optimum knives-speed of 1400 rpm (29.31 m/s) with fan and clearance of 5 mm.. Meanwhile, the minimum operation cost of 34.4 L.E./ton was obtained by using rice-straw moisture content of 26 % and at optimum knives-speed of 1400 rpm (29.31 m/s) with fan and clearance of 20 mm.

### CONCLUSION

The optimum conditions of developed disc-chipper for rice straw were: moisture content of 14 - 26 %, cutting-knives speed of 1400 rpm (29.31 m/s), and clearance of 5 - 20 mm and by using a fan. The results obtained at optimum conditions were: average cutting-length = 7.1 - 23.6 mm, machine-productivity = 147.7 - 333.6 - kg/h, power-requirement = 2.7 - 3.5 kW, specific-energy = 9.71 - 20.87 kW.h/ton and costs of 11.2 - 11.5 L. E./h and 34.4 - 75.9 L.E./ton.

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### تطوير آلة لتقطيع قش الأرز

علاء حسن على محمد

معهد بحوث الهندسة الزراعية.

يهدف هذا البحث إلى تطوير آلة لتقطيع قش الأرز، مع دراسة العوامل المؤثرة على تصميمها وأدائها. وتتكون الآلة من إطار، صندوق تلقيم، قرص دوارة مثبتة عليه ثلاث سكاكين، سكين ثابتة، مروحة شفط وطراد القش المقطوع ومحرك قدرته 7.5 حصان. وكانت عوامل الدراسة كالتالي: أربع سرعات لسكاكين التقطيع: 800، 1000، 1200، 1400 لفة/د (16.76، 20.94، 25.3، 29.31 م/ث)، أربع نسب رطوبة قش الأرز: 14، 18، 22، 26 % على أساس رطب، وخلوصات 5، 10، 15، 20 مم، باستخدام وبدون استخدام مروحة الشفط والطراد. وكانت أهم النتائج المتحصل عليها كالتالي: (1) متوسط طول قش الأرز المقطوع: وجد أن أعلى طول قش الأرز المقطوع هو 25.2 مم وتم الحصول عليه عند سرعة سكاكين قطع 800 لفة/د (16.76 م/ث)، ونسبة رطوبة قش الأرز 26 % على أساس رطب، خلوص 20 مم، باستخدام مروحة الشفط. بينما وجد أن أقل متوسط لطول المقطوع هو 4.3 مم وتم الحصول عليه عند سرعة سكاكين قطع 1400 لفة/د (29.31 م/ث)، ونسبة رطوبة قش الأرز 14 % على أساس رطب، خلوص 5 مم، بدون مروحة الشفط. (2) إنتاجية الآلة: وجد أن أعلى إنتاجية للآلة هي 333.6 كج/س وتم الحصول عليه عند سرعة سكاكين قطع 1400 لفة/د (29.31 م/ث)، ونسبة رطوبة قش الأرز 26 % على أساس رطب، خلوص 5 مم، باستخدام مروحة الشفط. بينما وجد أن أقل إنتاجية للآلة هي 66.2 كج/س وتم الحصول عليه عند سرعة سكاكين قطع 800 لفة/د (16.76 م/ث)، ونسبة رطوبة قش الأرز 14 % على أساس رطب، خلوص 20 مم، باستخدام مروحة الشفط. (3) متطلبات القدرة: وجد أن أعلى قدرة هي 3.7 كيلوات وتم الحصول عليه عند سرعة سكاكين قطع 1400 لفة/د (29.31 م/ث)، ونسبة رطوبة قش الأرز 26 % على أساس رطب، عند كل الخلوصات، بدون مروحة الشفط. بينما وجد أن أقل قدرة هي 2 كيلوات وتم الحصول عليه عند سرعة سكاكين قطع 800 لفة/د (16.76 م/ث)، ونسبة رطوبة قش الأرز 14 % على أساس رطب، عند كل الخلوصات، وباستخدام مروحة الشفط. (4) الطاقة النوعية: وجد أن أعلى طاقة نوعية هي 39.42 كيلوات/س/طن وتم الحصول عليه عند سرعة سكاكين قطع 1000 لفة/د (20.94 م/ث)، ونسبة رطوبة قش الأرز 26 % على أساس رطب، خلوص 5 مم، بدون مروحة الشفط. بينما وجد أن أقل طاقة نوعية هي 9.71 كيلوات/س/طن وتم الحصول عليه عند سرعة سكاكين قطع 1400 لفة/د (29.31 م/ث)، ونسبة رطوبة قش الأرز 14 % على أساس رطب، خلوص 20 مم، وباستخدام مروحة الشفط. (5) تكاليف تشغيل الآلة: وجد أنه عند استخدام أنسب سرعة سكاكين تقطيع 1400 لفة/د دقيقة، نسب رطوبة قش تراوحت بين 14 - 26 % على أساس رطب، خلوصات تراوحت بين 5 - 20 مم وباستخدام مروحة الشفط تراوحت تكاليف التشغيل والإنتاج بين 11.2 - 11.5 جنيه/ساعة، 34.4 - 75.9 جنيه/طن. وبناءاً ما تم التوصل إليه في هذه الدراسة يوصى بتشغيل آلة التقطيع المطورة في تقطيع قش الأرز باستخدام سرعة سكاكين تقطيع 1400 لفة/د، ونسب رطوبة قش على أساس رطب تتراوح بين 14 - 26 %، وخلوصات تتراوح بين 5 - 20 مم حسب طول التقطيع المطلوب.