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Sawdust Machine Prototype for Utilizing Wood Waste and Trees Pruning Products

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ABSTRACT

This research aims to manufacture and test the sawdust machine for utilizing wooden waste and trees-branches. The results of preliminary tests revealed that the machine achieved a satisfactory performance by using (N_k) = six knives. The test results of the produced sawdust analysis show that the percentage of the particle size which greater than 25 mm is directly proportional to M.C. At using E_{L2} = 4 mm, more than 80 % f sawdust produced will be almost similar sizes (particle sizes less than 25 mm and greater than 2.54 mm). It is recommended to use E_{L2} = 4 mm to produce a uniform size sawdust nearly. The minimum value of the machine productivity was 62 kg/hr at M.C.$_1$ = 9.3 % using E_{L1} = 2 mm and N_{d1} = 1500 rpm. While the maximum value of the machine productivity was 198 kg/hr at M.C.$_3$ = 21.8 % using E_{L3} = 6 mm and N_{d3} = 2100 rpm. Also, the results indicated that the required power to operate the machine increased by increasing N_d, E_L and M.C. The minimum value of the required power was 0.8 kW at M.C.$_1$ = 9.3 % using E_{L1} = 2 mm and N_{d1} = 1500 rpm. While the maximum value of the required power was 3.2 kW at M.C.$_3$ = 21.8 % using E_{L3} = 6 mm and N_{d3} = 2100 rpm. The total costs for operating the machine and the production cost were 16.4 L.E./h and 82.8 L.E./Mg respectively under the same operating conditions.

keywords: Sawdust machines, agro-industrial waste, wood energy, logging waste.

INTRODUCTION

The mechanical processing of wood waste whether agricultural or industrial (Wood residues from trees branches and manufacture of furniture) is considered the best primary method (Eco-friendly) through converting these wastes into biomass energy.The resulting biomass is sawdust that widely used for drying floors in poultry farms and stables. Also, it is used as a raw material for many industries, such as parquet making, plywood and blockboard. *(Ibrahim and Mohamed, 2018)* stated that in Egypt, the agricultural crop residues especially horticulture are considered one of the most important problems that face the environment and farmers. The mechanical treatment is the primary step and suitable solution for using raw materials in several processes. From a point of view, the tree-branches chopping is necessary as a pretreatment to different uses. Mechanical treatment of the tree-branches is done in order to convert it to small pieces, which are suitable for compost and energy briquette, but the productivity of these choppers is still little, not covering the farmer's needs in addition to the high operation and production cost are available in the market. *(Adhikari and Ozarska, 2018)* mentioned that amidst growing environmental consciousness and increasing demand for timber products, the importance of fulfilling the growing demand for these products on the one hand, and at the same minimizing environmental impacts, is increasingly recognized. While *(FAO, 2001)* had predicted that by the end of 2020, the global consumption of industrial timber products will increase by 45%. *(Salamat et al., 2018)* conclude that the sawdust wood was effective on a simple and effective eco-friendly approach for the valorization of waste of the wood industry in the environmental application as adsorbent biomaterials. The biomaterial was characterized using various instrumental techniques. (*Owoyemi et al., 2016)* mentioned that wood industries produce large volumes of residues that must be utilized, marketed or properly disposed of. Heaps of wood residues are common features in wood industries throughout the year. The impact of improper disposal of waste wood on the environment affects both the aquatic and terrestrial ecosystems. Also burning of waste wood releases greenhouse gases into the atmosphere causing various health issues. Reuse/recycling of these wood residues will reduce environmental pollution, create wealth and employment. These resources (wood waste and tree cut-offs) are not adequately utilized to satisfy the countries' bio-resources needs and energy. These wood wastes are not well managed. *(Rominiyi et al., 2017)* reported that sawdust can become a valuable commodity which is considered in three ways: Manufacturing, Energy and Agricultural utilization. The sawdust is burnt in an updraft gasifier under a limited supply of air to obtain producer gas which is carbon II oxide and hydrogen as main components. The sawdust and other biomass materials are mixed in certain proportions, then bound together and palletized to a small block called briquettes. The material was also considered to be composted by mixing it with animal digestion or wood ashes and calcium carbonate to form fertilizers. The sawdust and wood shavings can be used for particleboard as well as oil production. *(Alexandru, 2002)* said that sawdust can become a valuable commodity either as a raw material in manufacturing industries for wood boards, light construction materials such as shelves, notice boards, wall and roof sheeting for mobile houses, as an insulator in the refrigerating system and cold conservation of in Energy industries as the fuel burned

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directly or indirectly to produce wood gas, briquette, pellet, etc. All types of wood are used for the production of particleboard and plywood such as solid wood, solid wood residues (offcuts, trimmings), low-grade waste such as hogged sawmill waste, sawdust, planer shavings, etc. During the production process, about 17 % of the residues are generated in the form of trimmings. However, this amount is recycled. Also, about 5 % of screening fines and about 5 % sanding dust are generated as residues which are mainly used as boiler fuel for process steam generation *(FAO, 1998)*. *(Emerhi, 2011)* said that the production of briquettes from sawdust exemplifies the potential of appropriate technology for wood waste utilization. It saves trees that can prevent soil erosion and desertification by providing an alternative to burning wood for domestic and industrial heating and cooking. Also, it substitutes sawmilling waste for a valuable resource. It improves health by providing a cleaner-burning fuel and also provides a better alternative to firewood (40% more efficient, longer burning and better) as well as helping to protect the environment by reducing the number of trees cut for firewood. *Spinelli et al. (2013)* compared the effect of chipper type on productivity, power demand, fuel consumption and product quality. Tests were conducted on two commercial chipper models, a disc and a drum chipper. The disc chipper had a higher energy efficiency and used 19% less fuel per unit product. The drum chipper was 8% more productive since it cut with the same energy all along the length of its knives. The drum chipper produced smaller chips, with a higher incidence of fines. Feedstock type had a strong effect on productivity, energy efficiency and product quality. The effect of feedstock type was mainly related to piece size and maybe stronger than the effect of the chipper type. Based on the above, there is an urgent necessity to reduce the size of wooden waste and trees-branches and converting it into sawdust by mechanical processing as a primary method (Eco-friendly). Consequently, this sawdust will have various important uses that increase its economic value. From this point on, this research aims to design a sawdust machine for utilizing wooden waste and trees-branches. This machine is characterized by a simple design that can be manufactured in rural workshops from locally available materials. Local manufacturing of the sawdust machine may engender many micro-projects that provides various job opportunities for young people and contributes even slightly to solve the problem of unemployment.

MATERIALS AND METHODS

The prototype of the sawdust machine was constructed in a local workshop in Tahta Center, Sohag Governorate. All the experiments were carried out during the period from 1st of December 2019 to 30th of January 2020. All measurements were done using a random sample of wooden waste and pruning products of trees (mango, petiole of palm fronds, citrus trees).

Design description of the developed sawdust machine:

The technical specification of the developed sawdust machine and design-idea during the test are shown in Fig. (1). The design feature of the machine includes three major characteristics are a simple design, ease of use and its parts are locally available materials in addition to low costs manufacture and ease of fabrication.

Fig. 1. The developed prototype of the machine during experiments.

Components of the developed prototype of the machine:

The main components of the machine included: frame, electrical motor, rotating disc, feed hopper and outlet, as shown in Fig. (2).

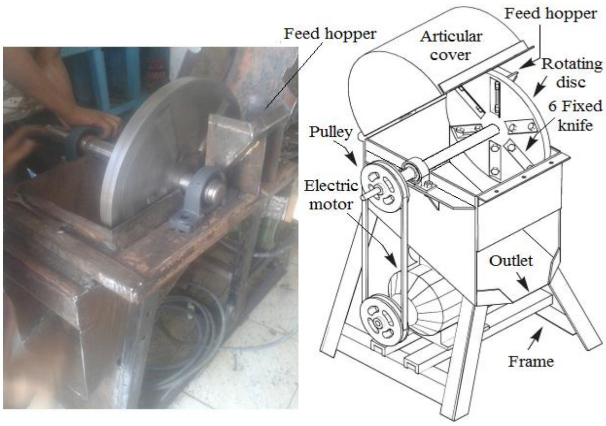

Fig. 2. The main components of the machine.

The developed prototype of the sawdust machine consists of the following parts:

Frame:

The frame was fabricated from welded steel channel sections 50 × 50 × 3 mm thickness. The frame shape was formed with certain dimensions 600 mm width, 1200 mm length and 800 mm height. Two hinges are assembled at the cover of the frame to control the opening and closing.

Feed hopper:

The experimental hopper was constructed from an iron sheet, 3 mm thickness. Dimensions of the inlet, the depth of the feeding hopper and the angle of inclination were 180 x 120 mm, 200 mm and 45^o respectively.

Electric motor:

The electric motor of 5.6 kW, 89.50 % effective load and 1800 synchronous rpm (obtained from the nameplate) was used to rotate the disc that includes 6 fixed knives.

Rotating disc:

The rotating disc with a diameter of 400 mm and a thickness of 30 mm is connected with the power transmission shaft that is based on a pair of bearings. This rotating disc is made from medium carbon steel and turned by a lathe machine to fasten six fixed knives in the form of a polar array, as shown in Fig. (3). The fixed knives were made of tool steel K100 (Alloy steels) with 4 mm thickness, 30 mm width, 150 mm length and 15º cutting angle. The edges of the knives are controlled by bolts.

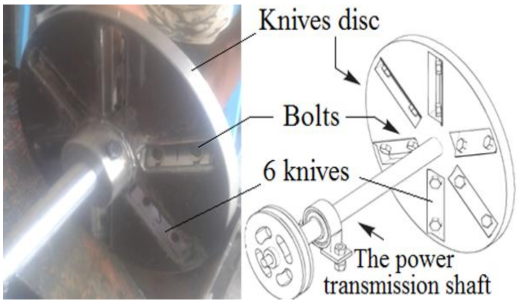

Fig. 3. Six knives distributed on the rotating disc.

The power transmission shaft design:

The affecting torques on the shaft are torsion moment (T) and bending moment (M). The torsion moment equals the output torque from the motor to the rotating disk. The bending moment equals the weight of the disc and the pulley multiplied by a torque arm.

The shaft is solid and made from medium carbon steel (σ_s = 120 MPa). The factor of safety (*K*) was estimated as follows, according to *(Elkaoud, 2015)*:

$$K = K_{static} \times K_{repeated} \times K_{shocks} \times K_{calculation} \times K_{life}$$

$$K = 2 \times 1.3 \times 1.2 \times 1.2 \times 1.2 = 4.5$$

The safe diameter (d) of the power transmission shaft can be calculated by the following equation:

$$d^3 = \frac{16\,K}{\pi . \sigma s} \sqrt{M^2 + T^2} \quad \ldots\ldots (1)$$

Where:

d = The safe diameter (d) of the power transmission shaft (cm).
K **= The factor of safety = 4.5**
σs = Yield stress for medium carbon steel = 120 MPa = 12 kN/cm²
M = Bending moment = Weight of the disc and the pulley × torque arm.
M = 225 × 12 = 2700 N.cm = 2.7 kN.cm.
T = The torsion moment = $\frac{60\,P}{2\,\pi\,N} = \frac{60\,(5.6 \times 1000)}{2\,\pi\,(1800)}$ **= 29.7 N.m.**
T = 2.97 kN.cm.
Thus, d = 1.97 cm.

The diameter of 20 mm. would be safe for the design of the power transmission shaft.

Variables of experiments:

The developed prototype of the machine was tested considering the possible variables related to prototype performance to realize the purpose of this research. Variables of experiments as following:

1. Wooden waste moisture content:

Tests were carried out under three values of the moisture contents given an indicator of the state of the wooden waste used. Soil moisture content was recorded at the beginning of each experiment, which resulted in the three different values of moisture as following:

M.C.₁ = 9.3 %, M.C.₂ = 13.8 % and M.C.₃= 21.8 %.

2. Speeds of the rotating disc (*N_d*):

Three different speeds of the rotating disc N_{d1} = 1500, N_{d2} = 1800 and N_{d3} = 2100 rpm.

3. The number of knives distributed on the rotating disc (N_k):

The developed prototype of the machine was tested with two, three and six knives distributed on the rotating disc.

4. The edge of the knives on the rotating disc (E_L):

The developed machine was tested under three edge of knives E_{L1} = 2, E_{L2} = 4 and E_{L3} = 6 mm.

Measurements:

1. Sieve analysis for the produced sawdust:

The size distribution of particles for the produced sawdust using sieves analysis is considered an important method to give an indication of the machine performance to the chopping of wooden waste and trees-branches. A set of sieves various were used to measure the produced sawdust size distribution. It consists of five sieves (25, 19, 9.5, 4.75 and 2.54 mm). A stack of sieves with accurately dimensioned holes between a mesh of wires is used to separate the particles into size bins. A known volume of the produced sawdust is put into the top of a stack of sieves arranged from coarse to fine. The stack of sieves is shaken for a standard period of time so that the particles are sorted into size bins.

2. Machine productivity:

Machine productivity (Q, kg/hr) was estimated by using the following equation:

$$Q = \frac{W_t}{t} \quad \ldots\ldots (2)$$

Where: Wt = Total weight of the produced sawdust (kg) at time t, (hr).

3. Required power and specific energy:

A clamp meter was used to measure the current intensity(I) and the potential difference(V) during the operation of the machine. The electrical power requirement was calculated using the following equation according to *(Kurt, 1979)*:

$$P = \sqrt{3} \times I \times V \times \eta_m \times \cos\varphi \quad \ldots\ldots (3)$$

Where:

P, W	=	**Required power to operate the machine.**
I, Amp.	=	**Current consumed with the load.**
V, volts	=	**Voltage difference.**
$\sqrt{3}$	=	**Coefficient current three-phase.**
η_m	=	**Mechanical efficiency (Assumed 85 %).**
$\cos\varphi$	=	**Power factor (0.85).**

The specific energy was calculated using the following equation:

$$Specific\ energy, kW.hr/kg = \frac{\text{Power requirement } (P), kW}{\text{productivity (Q), kg/hr}} \quad \ldots\ldots (4)$$

4. Cost estimation:

The total costs of the machine operating include fixed costs (depreciation, interest on investment, shelter, taxes and insurance) and variable costs (repair, maintenance and lubricants, electrical energy, and labor cost).

1. Fixed costs:

1. Depreciation rate:

Depreciation rate was estimated using the following equation:

$$D = \frac{P_m - S}{L_m} \quad \ldots\ldots (5)$$

Where:

D	=	**Depreciation rate (L.E./year).**
P_m	=	**The machine purchase price (Estimated price = 9000 L.E).**
S	=	**Salvage price (L.E) = 10 % purchase price *(Hunt, 1977)*.**
L_m	=	**Life-expectancy of the machine (10 years). Assumed that yearly operating days = 180 days/year and daily operating hours = 8 hours.**

2. Interest on investment:

Interest on investment was estimated using the following equation:

$$I = \frac{(P_m + S)\,i}{2} \quad \ldots\ldots (6)$$

Where:

I	=	**Interest on investment (L.E./year).**
i	=	**Interest is compounded annually (rate/year).**

3. Shelter, taxes and insurance:

Shelter, taxes and insurance costs were assumed 2 % the machine purchase price, according to *(Elkaoud, 2015).*

2. Variable costs:

1. Repair, maintenance and lubricants:

Repair, maintenance and lubricant costs were assumed 100 % of depreciation costs.

2. Electrical energy cost (Ec):

Ec (L.E./hr.) = Electricity consumption (kW) × Electricity price (Assumed 1.5 L.E./kW.hr).

3. Labor cost:

Labor cost is defined as payment for an operator who operates the machine (L.E./h). Labor wage (One laborer) =10 L.E/h, according to *(Elkaoud, 2015).*

5. Production cost:

Production cost was calculated according to the following equation:

$$Production\ cost\ (L.E./kg) = \frac{Operation\ cost\ (L.E./hr)}{Machine\ productivity\ (kg/hr)}$$

RESULTS AND DISCUSSION

1. Effect of the number of knives (N_k) on the machine performance:

During the manufacture of the machine, sequences of tests were done to modify the sawdust machine for satisfactory performance. In the beginning, the machine prototype was fabricated with two knives distributed on the rotating disc. During the preliminary experiments, it was clear that the productivity of the machine is low and the machine vibrates significantly. When the number of knives was changed to three distributed on the disk, A slight improvement in machine performance was observed and when the number of knives increased to double, a significant improvement in machine performance was observed from the point of view of the machine productivity as well as vibration. Accordingly, the decision was the completion of the rest of the experiments using six knives distributed on the rotating disc.

2. Sieve analysis for the produced sawdust:

1. Effect of the wooden waste moisture content on the size of sawdust produced:

The developed prototype of the machine was tested under operating conditions 1800 rpm speed of the rotating disc and 4 mm length of the edge of knives to study the effect of the wooden waste moisture content on the size of sawdust produced. Fig. (4) shows the size distribution of particles for the sawdust produced under three values of soil moisture contents.

A slight percentage is 0.25 % of sawdust sample mass has particle sizes greater than 25 mm, 75.3 % of the sample mass has particle sizes less than 25 mm and greater than 2.54 mm and 24.5 % of the sample mass has particle sizes less than 2.54 mm by using the wooden waste that has a low moisture content 9.3 %. When the moisture content of wooden waste increased to 13.8 %, the size of particles that are greater than 25 mm increased to 1.3 % of sawdust sample mass. Also, the size of particles that are less than 25 mm and greater than 2.54 mm increased to 81 %. While that 17.7 % of the sample mass has particle sizes less than 2.54 mm. At 21.8 % moisture content, 2.8 % of sawdust sample mass has particle sizes greater than 25 mm, 97.2 % of the sample mass has particle sizes less than 25 mm and greater than 2.54 mm and 5.5 % of the sample mass has particle sizes less than 2.54 mm. It is clear that the percentage of the particle size which greater than 25 mm is directly proportional to the moisture content of wooden waste. This may be due to the particles wrapping around themselves during chipping and so their size will be increased. Therefore, it is recommended to use dry wooden waste to produce sawdust particles with small sizes.

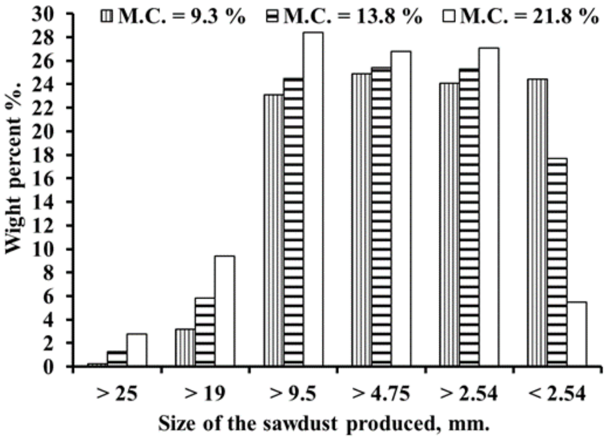

Fig. 4. The size distribution of particles for the sawdust produced under three values of soil moisture contents.

2. Effect of the speeds of the rotating disc (N_d) on the size of sawdust produced:

To study the effect of the speeds of the rotating disc (N_d) on the size of sawdust produced, the machine was tested under operating conditions 4 mm length of the edge of knives and using the wooden waste that has moisture content 13.8 %. Fig. (5) shows the size distribution of particles for the sawdust produced using three values of the rotating disc speed.

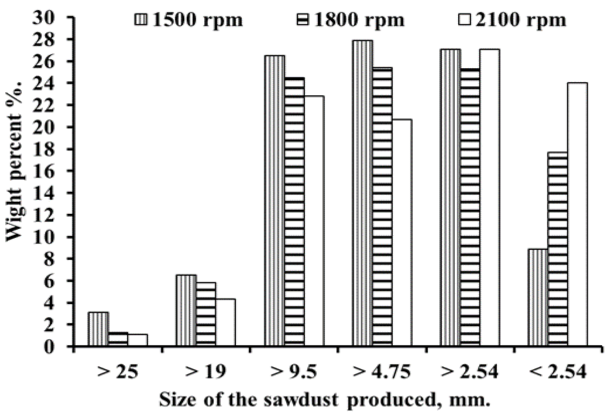

Fig. 5. The size distribution of particles for the sawdust produced using three values of the rotating disc speed.

Data shows that 88, 81 and 74.9 % of the sample mass has particle sizes less than 25 mm and greater than 2.54 mm using the speeds of the rotating disc 1500, 1800 and 2100 rpm respectively. Percentage of sawdust sample mass has particle sizes greater than 25 mm decreased from 3.1 to 1.1 % by increasing the speed from 1500 to 2100 rpm while that percentage of the sample mass has particle sizes less than 2.54 mm increased from 8.9 to 24 % by increasing the speed from 1500 to 2100 rpm. These results indicated that the chopping efficiency increased by increasing the speed of the rotating disc. This increase varies according to the variation of the wooden waste moisture content values.

3. Effect of the lengths of the edge of knives (E_L) on the size of sawdust produced:

To study the effect of the lengths of the edge of knives (E_L) on the size of sawdust produced, the machine was tested under operating conditions 1800 rpm speed of the rotating disc (N_d) and using the wooden waste that has moisture content 13.8 %. Fig. (6) shows the size distribution of particles for the sawdust produced using three values of E_L.

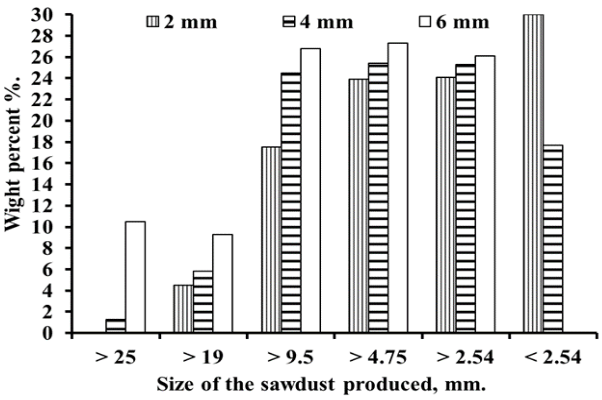

Fig. 6. The size distribution of particles for the sawdust produced using three values of E_L.

These results showed that by using 2 mm length of the edge of knives, 30 % of sawdust produced will be a powder (particle sizes less than 2.54 mm) while that by using 6 mm length of the edge of knives, 10.5 % of sawdust produced will be mulch (particle sizes greater than 25 mm). At using length 4 mm of the edge of knives, more than 80 % f sawdust produced will be almost similar sizes (particle sizes less than 25 mm and greater than 2.54 mm). Therefore, it is recommended to use length 4 mm of the edge of knives to produce a uniform size sawdust nearly.

3. Machine productivity:

Fig. (7) shows the effect of the speeds of the rotating disc (N_d), length of the edge of knives (E_L) and the wooden waste moisture content (M.C) on machine productivity.

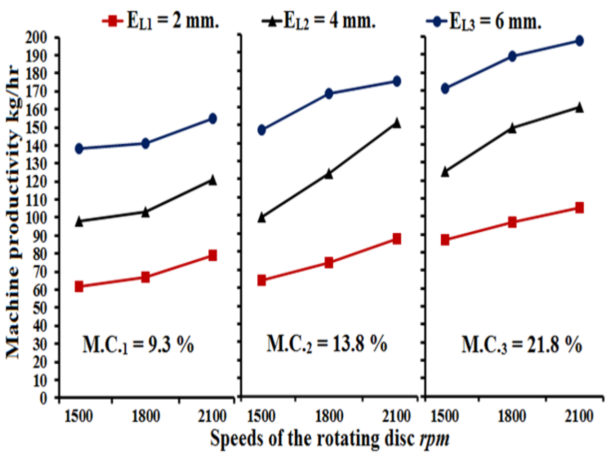

Fig. 7. The effect of N_d, E_L and M.C. on machine productivity.

These results indicated that the machine productivity increased by increasing the speed of the rotating disc and length of the edge of knives. This increase varies according to the variation of the wooden waste moisture content values. By increasing the wooden waste moisture content from 9.3 to 21.8 % the machine productivity increased by an average of 25.5 % at all variables of experiments. The minimum value of the machine productivity was 62 kg/hr at the wooden waste moisture content of 9.3 % using 2 mm length of the edge of knives and 1500 rpm speed of the rotating disc. While the maximum value of the machine productivity was 198 kg/hr at the wooden waste moisture content of 21.8 % using 6 mm length of the edge of knives and 2100 rpm speed of the rotating disc.

4. Required power and specific energy:

The effect of the speeds of the rotating disc (N_d), length of the edge of knives (E_L) and the wooden waste moisture content (M.C.) on required power (P) to operate the machine is shown in Fig. (8). Generally, these results indicated that the required power to operate the machine increased by increasing the speeds of the rotating disc, length of the edge of knives and the wooden waste moisture content. The minimum value of the power required was 0.8 kW at the wooden waste moisture content of 9.3 % using 2 mm length of the edge of knives and 1500 rpm speed of the rotating disc.

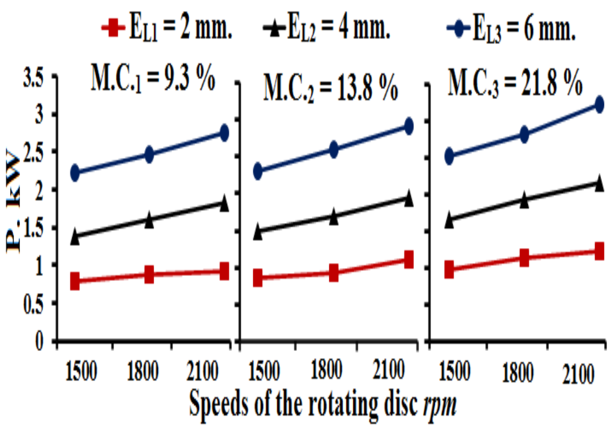

Fig. 8. The effect of N_d, E_L and M.C. on required power (P).

While the maximum value of the power required was 3.2 kW at the wooden waste moisture content of 21.8 % using 6 mm length of the edge of knives and 2100 rpm speed of the rotating disc. The specific energy was calculated by dividing the power required on the machine productivity. Results show that the minimum value of the specific energy was 10.9 kW.hr/Mg at the wooden waste moisture content of 21.8 % using 2 mm length of the edge of knives and 1500 rpm speed of the rotating disc. While the maximum value of the specific energy was 18.1 kW.hr/Mg at the wooden waste moisture content of 9.3 % using 6 mm length of the edge of knives and 2100 rpm speed of the rotating disc.

5. Cost estimation:

Costs of operating the sawdust machine were estimated at the maximum value of the power required.

Table (1) shows the costs of operating the sawdust machine. The results indicated that the total fixed costs were 1.0 L.E./hr. and the total variable costs were 15.4 L.E./hr. So, the total costs for operating the machine will be 16.4 L.E./h under the same operating conditions.

Table 1. Costs of operating the sawdust machine.

Items		Values
Fixed costs	Depreciation rate. L.E/year.	810
	Interest on investment. L.E/year.	396
	Shelter, taxes and insurance. L.E/year.	180
Total fixed costs. L.E./year.		1386
Total fixed costs. L.E./hr.		1.0
Variable costs	Repair, maintenance and lubricants. L.E/hr.	0.6
	Electrical energy cost. L.E/hr.	4.8
	Labor cost. L.E/hr.	10
Total variable costs. L.E./hr.		15.4
Total costs. L.E./h		16.4

6. Production cost:

Production cost was calculated by the maximum value of the machine productivity 198 kg/hr that it was obtained with the maximum value of the power required. Accordingly, the production cost will be 82.8 L.E./Mg.

CONCLUSION

Overall results of this applied research may be concluded as follow:

- Design a prototype of the sawdust machine for utilizing wood waste. The sawdust will have various important uses that increase its economic value. The machine is characterized by a simple design that can be manufactured in rural workshops from locally available materials. Local manufacturing of the sawdust machine may engender many micro-projects that provides various job opportunities for young people.
- The test results of the produced sawdust analysis using sieves show that it is recommended to use dry wooden waste to produce sawdust particles with small sizes. The results of this test also showed that the chopping efficiency increased by increasing the speed of the rotating disc and this increase varies according to the variation of the wooden waste moisture content values. Also, it is recommended to use length 4 mm of the edge of knives to produce a uniform size sawdust nearly.
- The machine productivity increased by increasing the speed of the rotating disc and length of the edge of knives. This increase varies according to the variation of the wooden waste moisture content values.
- The minimum value of the power required was 0.8 kW at the wooden waste moisture content of 9.3 % using 2 mm length of the edge of knives and 1500 rpm speed of the rotating disc while the maximum value of the power required was 3.2 kW at the moisture content of 21.8 % using 6 mm length of the edge and 2100 rpm speed of the rotating disc. The total costs for operating the machine and the production cost were 16.4 L.E./h and 82.8 L.E./Mg respectively under the same operating conditions.

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نموذج لآلة نشارة للإستفادة من النفايات الخشبية ونواتج تقليم الأشجار

نبيل شـــعبان محمود القاعـــود

كلية الهندسة الزراعية بجامعة الأزهر فرع اسيوط.

تعتبر المعاملة الميكانيكية للنفايات الخشبية سواء كانت زراعية أو صناعية أفضل طريقة أولية (صديقة للبيئة) لتحويل النفايات إلى طاقة كتلة حيوية ذات قيمة إقتصادية يمكن الإستفادة منها. ويهدف هذا البحث إلى تصنيع واختبار نموذج لآلة نشارة تتميز بتصميم بسيط يمكن تصنيعه في الورش المحلية من المواد المتاحة محلياً وبالتالى قد تخلق العديد من المشاريع الصغيرة التي توفر فرص عمل متنوعة للشباب. اختبرت الآلة بإستخدام نفايات خشبية ذات ثلاث محتويات رطوبه ٩,٣ و ١٣,٨ و ٢١,٨ ٪ لدراسة أدائها تحت ظروف تشغيل تتمثل فى عدد السكاكين الموزعة على القرص ٢، ٤، ٦ سكاكين و ثلاث سرعات للقرص الدوار ١٥٠٠ ، ١٨٠٠ ، ٢١٠٠ لفة/دقيقة و ثلاث أطوال لحافة السكاكين ٢، ٤، ٦ مم. أوضحت نتائج الاختبارات الأولية أن الآلة حققت أداءً مرضيًا باستخدام (N_k) = ستة سكاكين. كما أظهرت نتائج اختبار تحليل نشارة الخشب الناتجة أن النســـبة المئوية لحجم الحبيبات التي تزيد عن ٢٥ مم تتناسب طرديا مع M.C. وعند استخدام E_{L2} = ٤ مم ستكون أكثر من ٨٠٪ من حبيبات نشارة الخشب المنتجة متجانسة تقريباً (أحجام الحبيبات أقل من ٢٥ مم وأكبر من ٢,٥٤ مم). و بالتالى يوصى باستخدام E_{L2} = ٤ مم لإنتاج نشارة خشب بحجم متجانس تقريبًا. أعطت الآلة أقصى إنتاجية ١٩٨ كجم / ساعة عند $M.C_3$ = ٢١,٨ ٪ باستخدام E_{L3} = ٦ مم و N_{d3} = ٢١٠٠ دورة في الدقيقة. وزادت القدرة المطلوبة لتشغيل الماكينة عن طريق زيادة N_d ، E_L ، M.C. و قد بلغ إجمالي تكاليف تشغيل الماكينة وتكلفة الإنتاج ١٦,٤ جنيهًا / ساعة و ٨٢,٨ جنيهاً / ميجاجرام على التوالي تحت ظروف التشغيل.