Design And Development of Coconut Husk Extraction Machine

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Abstract. Coconut husk as by-product of coconut is very potential material for many applications. The coconut coir consists of coconut fibre and cocopeat. The improvement made in this research is to design a machine that suits the need of local coconut industry in Sumatera Barat. This machine is powered by 22 HP engine diesel that rotates at 1100 RPM. This engine is connected to rotary knife through double pulley-belt transmission system. The pulleys have 14:25 ratio with the lower side being installed to the engine and the other to the axis. There were 19 knives put to the axis with angle difference of 60 degree. This rotary knife was perpendicular to the axis to increase the effectiveness during the ripping process. The separation mechanism was done by using lines and holes in the cylindrical tube of the machine. The tube has diameter 596 mm. The capacity derived was 123 kg/hour. Dimension of the machine is 2270 x 900 x 1323.13 mm. This machine works for separating coconut fibre and cocopeat.

Keywords: Coconut husk; coconut fibre; cocopeat; extraction machine.

1. Introduction

Coconut husk is part that covers hard shell of the coconut with a thickness of 5-10 cm. The husk colour is bright green while the external appearance is also bright green when it is still immature and brown when it is fully ripe. The husk consists of fibres which are embedded with coir dust. Husk has the characteristic of retaining water. According to the United Coconut Association of the Philippines (UCAP), the average weight of the husk of the coconut fruit is 0.4 kg. It has been established that 30% of the husk can be obtained as commercial coir fibre. Of this extractible fibre, 40% is the coarse type usually referred to as bristle fibre and 60% is the finer material mattress fibre. The coir dust constitutes the remaining 70% [1]. Coconut husk is usually considered as waste, stacked under the coconut plant and left to rot after being dehusked using human power or machine [2]–[4].

Coconut fibres as part of of coconut husk, traditionally is used for making brooms, mats, ropes and other household appliances. However. The roles were much less popular than plastics. Fortunately, Technological developments in physical-chemical properties of fibre and consumer awareness to return to natural resources increase coconut fibre application as raw material for industrial carpet, upholstery, vehicle dashboards, mattresses, pillows and hardboards. Coconut fibre is also used for erosion control and sound absorbtion. Coconut coir fibres which are processed into coir fibre sheets are used for lining car seats, spring beds and others. Some advantages of using coconut fibre is the lightweight, high strength and, the ability to withstand with heat and saline water. In addition, it is is renewable and cost-effective [5].

Some machines were developed for handling the process coconut husk. For instance, the dehusking machine which uses rollers combination with the gripping action of the spike to tear the husk from the nut leaving the nut intact. [6]. To produce the coco fibre (coconut fibre) and cocopeat (coconut dust require a coconut husk extractor machine. The previous machine which is developed by using 6.5 HP engine has lower capacity of 10 kilograms per hour. The machine is considered was not optimal yet.[7]. Other machine which is powered 3 phase 5 hp ac motor. The driven shaft is directly connected

to the motor. This rotating shaft has blades for breaking the husk. The fibres and dust were also separated. The result obtained fibres with length varying from 5-6cm. [8]. Other research using machine with blades arranged in a spiral on the shaft reached efficiency 97.8 %. However, the investment cost was quite higher.

2. Materials and Methods

The need of coconut industrial processing is to have optimal machine for efficiency. Some machines were also developed for a specific purpose [10], [11]. This research initially based on from surveying the level of coconut production in West Sumatra, as well as the district and studying the existing machines in the literature and in the field. Seeing its potential is still very large, processing coconut fibre can be a promising business. This research also consider the capacity, simplicity and price variable of the machine,

This machine has the functions to break down or separate coconut fibre and dust. The working principle of this coconut husk decomposition machine is to hit the separate parts of fibre and dust from the coconut fruit which has been fed to the machine hopper. The machine can produce coir (coconut fibre) and cocopeat which has high economic value.

The design was done carefully by considering operational costs and results. The design of the machine can be seen in Fig.1.

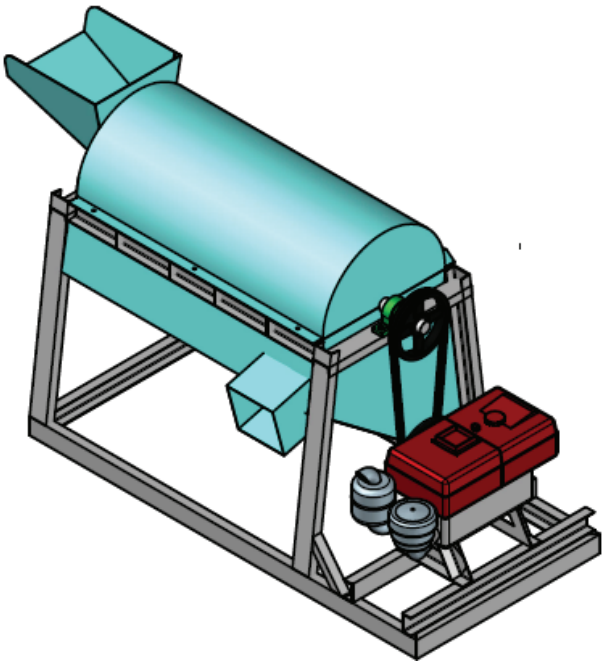


Fig. 1. Design of the machine

Functional design include hopper as inlet of coconut husk must have width which guarantee coconut husk can enter the processing continuously, knife or blade for tearing the husk. The knife should not cut the fibre and could deliver the fibre to the outlet. The source of power is engine diesel since it more reliable than electrical motor in term of availability in west Sumatera. The power is distributed through belt and pulley as transmission system. Product is separated by filter so that it has two different outlet. One outlet is for coconut dusk and the other outlet is for coconut fibre. Parts detail of the machine can be seen in Fig.2.

Calculation of engine diesel power

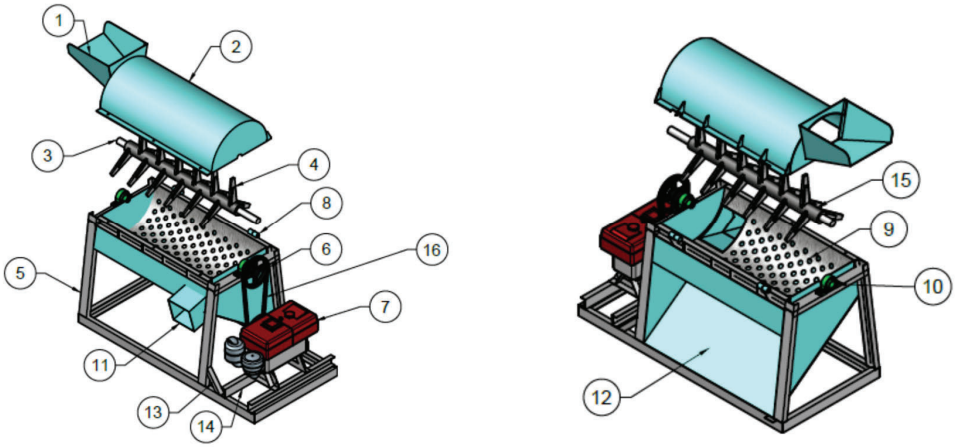
Power of the engine depends on the load. By the load average that is hold by the axis is 100 kg, speed is 1100 rpm, and pulley 254 mm, the approach formula to find out the power are as follows :

$$F = m.g \quad (1)$$

$$T = F.r \quad (2)$$
$$\omega = (2.\pi.n)/60 \quad (3)$$
$$P = T.\omega \quad (4)$$

Where: F - force, [N]
m - mass, [m]
g - gravitation, [m/s]
T - Torque, [Nm]
R -radius, [m]
ω -angular speed, [rad/s]
n -speed, [rpm]
P- Power, [W]

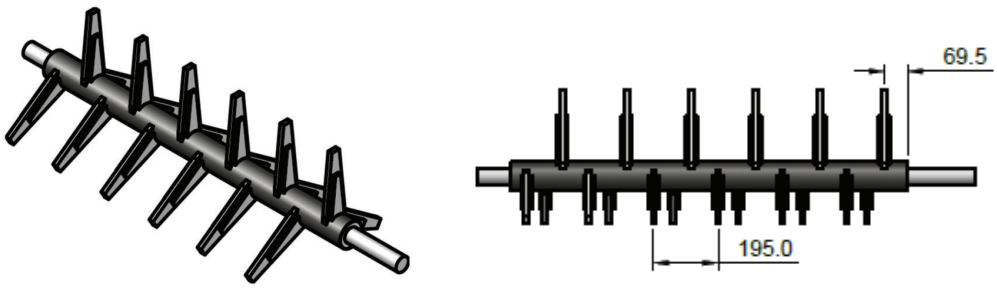
The minimum power of the engine need was 14,324 Watt or 19.207 HP.
Therefore, in the application the engine used is 22 HP.



(a) (b)

Fig. 2. Part of the machine (a) front side (b) back side

1.Hopper 2.top Cylinder,3. Axis 4. Knife 5.Frame 6. Pulley 7. Engine Diesel 8. Hinge 9. Filter 10. Bearing UCP 11. Cocofibre Outlet 12.Coconut dust outlet 13. Frame Stabilizer 14. Engine Stand 15. Knife axis 16. V Belt



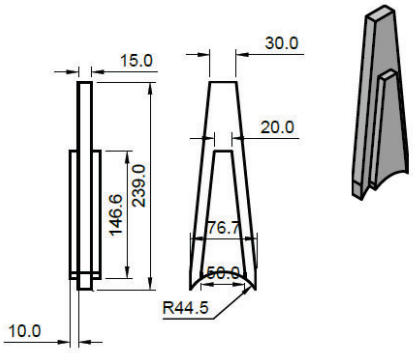
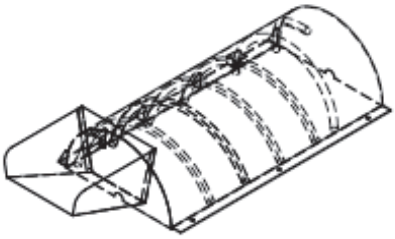


Fig. 3 . Design of the knife

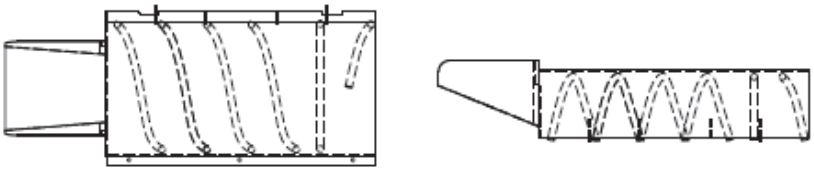
The design of the knives surface in Fig.3 is made rectangular to increase the effectiveness as suggested by [12]. However, the knives were modified to have trapezoidal side to strengthen the collision between coir and wall. Torque of axis is calculated as below.

$$Q = FQ/L \quad (5)$$

Where: Q - Load per milimeter, [kg/mm]
FQ - Load handle by axis
L - Length of axis, [mm]

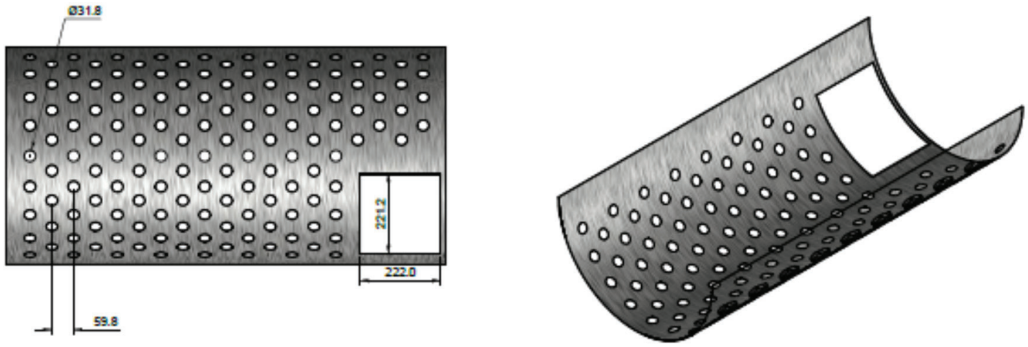


(a)



(b) (c)

Fig. 4 . Top half of cylinder



(a) (b)

Fig. 5. Bottom half of cylinder

Tube wall of the machine consists of two part with unique function. The top half in Fig.4 has grooves that has function to hold coconut husk to hit by knives and direct coconut fibre to the outlet. The coconut fibre outlet is shown as rectangle hole that is located at the end of the bottom half cylinder in Fig.5.

The bottom half cylinder has function as filtering to cocopeat before entering outlet under the machine.

3. Results

The cocopeat and coconut fibre separator machine in Fig.6 has dimension 2270 x 900 x 1323.13 mm. Improvement which were conducted in this research is to design machine that suit the need of local coconut industry in Sumatera Barat. This machine is look like a cylinder with one inlet and two outlets. The input was coconut husk, the outlets are for coconut dusk and coconut fibre respectively.

This machine was powered by 22 HP engine diesel that rotate at 1100 RPM. This engine is connected to rotary knife through double pulley-belt transmission system. The pulleys have ratio 14:25 with the lower installed to engine and the other to the axis.

There were 19 knives put to the axis with angle difference is 60 degree. This rotary knife was perpendicular to the axis to increase the effectiveness during ripping process. Separation mechanism was done by using line and hole in the cylindrical tube of the machine. The tube has diameter 596 mm.

(a) (b)

Fig. 6 . The Coconut husk extractor machine, (a) outside, (b) inside

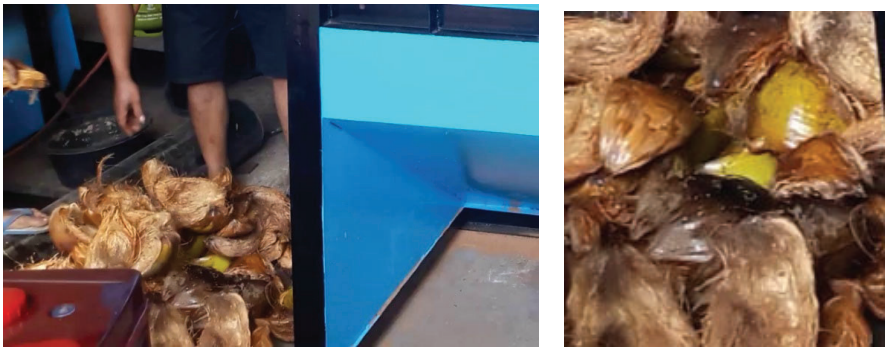


Fig. 7 . Raw material before processing

The raw materials were local coconut husk that is obtained from local market that processing coconut milk in West Sumatera. The extraction of coconut husk in Fig.7 was done by feeding the raw material into the inlet. Processing of the raw materials were conducted under wet condition with moisture content less than 50% since the husk was easier to be decorticated after being soaked overnight before processing [9]. Treatment of watering the material is implemented since after processing products were extracted more homogeneously under this condition and this will reduce light cocopeat particles that float in the air during processing.

Table 1. Performance test of the machine

	1st test	2nd test	3rd test	Average
Weight (kg)	~30	~30	~30	30
Processing time (s)	924	825	887	878.67

By extrapolating the result in table 1, capacity of the machine was about 123 kg/hour. This result may vary in different condition as it is affected by some factors such as type and volume of coconut husk and operator skill who feed the material to the inlet.

After processing product were cocopeat and coconut fibre as shown in Fig.8 and Fig.9 respectively. In addition, there was tendency of some short fibre (bristle) come along with cocopeat. However, this short bristle fibre can be easily separated by using sieve.

Fig. 8 . Material after processing: cocopeat

Fig. 9 . Material after processing: cocofibre

Machine operational cost economic analysis is calculated by following formulae step:

$$FC = D + I \quad (6)$$

$$D = \frac{P-S}{N} \quad (7)$$

$$I = \frac{i*P\,(N+1)}{2*N} \quad (8)$$

$$VC = FCs + W + M \quad (9)$$

$$M = \frac{2\%(P-S)/}{100\ hours} \quad (10)$$

$$CGP = \frac{\left\{\left(\frac{FC}{n}\right)+VC\right\}}{C} \quad (11)$$

Where:
FC- Fix Cost, [Rp/years] = Rp. 3,626,666 per year
D - Depreciation machine, [Rp/years] = Rp.1,920,000 per year
I - Capital interest, [Rp/years] = Rp.1,706,666 per year
P – Price [Rp] = Rp 32,000,000
S - End price of the machine, [Rp] = Rp 3,200,000
N - Economic life, [years] = 15 years
I - Interest rate of bank, [%] = 10 %
VC - Variable cost, [Rp/hours] = 47,760 Rp/hour
FCs - Fuel cost Consumptions, [Rp/hours] = 22,000 Rp/hour
W - Wage = 20.000 Rp/hour
M - Maintenance cost, [Rp/hours] = 5,760 Rp/hour
CGP - Cost of Goods Processing, [Rp/kg] = Rp 486.6 per kilogram
N - Working Hours per Years, [hours/years] = 300 hours/year
C - Capacity, [kg/hours] =123 kg/hour

While Break-even point is determined as follows

$$BEP = \frac{FC}{\left\{PSP - \left(\frac{VC}{C}\right) - RMP\right\}}$$

Where:
BEP- Break Event Point, Kg/years
RMP- Raw Material Prices, Rp/kg =1,250 Rp/kg
PSP- Product selling price after processing = 8,900 Rp/kg

Product selling price after processing is the price of coir and cocodust in the market multiplied with the amount of each product, so that Break-even point is found at 499 Kg/year.

4. Conclusions

Based on the results of the research, the capacity was 123 kilogram per hour. These results are considered in accordance with the initial design for handling coconut husk in West Sumatra. From economic analysis it is found Break Even Point 499 kilogram per year.

This target is quite promising since in Sumatera Barat, the raw materials is considered as waste and always available. The prominent innovation of this research is the use of a perpendicular knife by combining it with grooves placed on the tube wall that hold and direct coconut fibre to the outlet. As

for coconut dust, the separation utilizes knives collision with coir and filter it out to the bottom of tube wall

Acknowledgement

We would like to thank to Ministry of Research, Technology and Higher Education for funding the research through University Collaboration Research Scheme Grant (PKPT) between Andalas University and Payakumbuh State Polytechnic of Agriculture.

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