Dinamika Teknik Mesin 12(2) (2022) 122-128

Dinamika Teknik Mesin
Jurnal Keilmuan dan Terapan Teknik Mesin
http://dinamika.unram.ac.id/index.php/DTM/index

# Performance of crusher machine for crushing coconut coir into cocopeat and coco fibre

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*ARTICLE INFO*

*Article History:*
*Received 28 February 2022*
*Accepted 19 September 2022*
*Available online 01 October 2022*

*Keywords:*
*Crusher machine*
*Coconut coir*
*Cocopeat*
*Coco fibre*
*Performance*

*ABSTRACT*

*The abundant resources of coconut coir in Indonesia, especially a tiny village in Kulon Progo district, namely Kadigunung, hadn't been used before this research. It was thrown away and mostly just burned by the villagers. Even though it can be used to become natural organic fertilizer for agriculture, most of the population members are making a living as farmers. But there is a problem when processing to make the fertilizer, and it is the use of conventional manner to crush the coconut coir into cocopeat and coco fibre. So they needed appropriate technology and crusher machines. It is a gasoline-powered crushing device with 5.5 hp and 2000 rpm. It has 21 moving and 12 fixed blades. The research data were obtained by digital tachometer and sound level meter measurements. Other data were also measured by formula calculation. The results of this research involved the data of fuel consumption, the machine's capacity, depreciation of raw coconut coir, noise level, linear v-belt velocity, and rpm of the blade shaft. They were 1.8 L, 0.05 kg, 99.3 dB, 2π m/s, and 330 rpm, respectively. So it can be inferred that the crushing machine is a good performance.*

*Dinamika Teknik Mesin, Vol. 12, No. 2, Oktober 2022,* ***p. ISSN: 2088-088X, e. ISSN:*** **2502-1729**

## 1. INTRODUCTION

Cocopeat and coco fiber, there were references (Müssig, 2010) that have explained that in coconut coir there were two kinds of apart, cocopeat or he called in his book pith tissues about 70% and 30% coco fiber, or he called fiber bundles. The ratio of yield coco fiber with cocopeat, in short, medium, and long length was on average 10:30:60. Another study has made characterization of coconut coir (Israel et al., 2011; Krishnan, 2013) with the same idea as the above.

Many applications of coconut coir in engineering. First, Coconut coir is used to be adsorbent for removing cationic dye from aqueous solution, which is low cost. It has a solid ability to adsorption the dye to increase it. It is an effective, low-cost adsorbent for removal processing (Etim et al., 2016). It has been the same application (Shankar et al., 2014) in removal processing. At the same time, another study of coco coir was applied in surface plastering with reinforced hydraulic cement mortar. It has characteristics such as being more muscular, more toughness, and more ductility than cement-lime-sand, which is brittle and can improve flexural

https://doi.org/10.29303/dtm.v12i2.517

strength, too (Sathiparan et al., 2017). Finally, a study made ultrasonic dyeing sustainable of wool with a raw material of coconut coir extract. It has exceptional color characteristics compared to a chemical substance (Adeel et al., 2020).

Not only on objects but coconut coir is also applied to humans, for example, human hair. It is fit too and eco-friendly to be applied to human hair (Senthilnathan et al., 2014). In agriculture, there have conducted an experiment to use coconut coir substrate to control tomato plant irrigation (Sánchez-Molina et al., 2015).

Fiber of coconut coir that used, according to research (Fangueiro & Rana, 2016), to make biopolymer or biocomposite is considered characteristic of mechanical properties (strength, stiffness, strain, toughness, and damping), physical properties (morphology and microfibril angle/ MFA) and chemical compositions (hemicellulose, cellulose, and lignin content). Another research in bioresource technology, like the above, concerns coconut coir (Patel et al., 2020). They make biotransformation by methanotrophs immobilized on coconut coir. In other research (Hirunlabh et al., 2003), they have researched coconut coir and combined it with durian peel to make insulating particle boards. From the analysis, the Durian insulating board had more void than the coconut coir insulating board. So the conductivity of the coconut coir insulating board was better than Durian insulating board. Although in the fermentation process to make organic fertilizer, we only considered the physical property a little and focused more on chemical composition. Cocopeat and coco fiber have been used as the medium for fermentation to become organic fertilizers. Somehow, cocopeat is more valuable to the fermentation process than Coco Fiber. Cocopeat, by the physical property, has a smaller particle size. Yet, it contains both macro and micronutrients such as Potassium (K), Phosphor (P), Calcium (Ca), Sodium (Na), and other minerals. The most container is Potassium (K) in the Cocopeat (Anzani, 2016).

Abundant resources of coconut coir in a small village in Kulon Progo, Kadigunung, haven't been used before this research. Even though it can be used as the raw material of organic fertilizer, it is not easy to process. They only use a conventional manner to crush the coconut coir. Hence, we proposed using appropriate technology, namely the crusher Machine. There is a crushing Machine to crush crop residues (Jibrin et al., 2013), but coconut coir is too hard to overcome. The other crushing machine is also used for plastic bottles because many plastics are not managed (Anugrah et al., 2020), but the crushing machine for plastic is different from coconut coir.

Research (Villa, 2016) researched the design and development of a coconut husk or coconut coir mini-chipper machine to utilize agricultural products in small-scale production. The device was connected and driven by a 6 HP Diesel engine. This research aims to increase efficiency, ease of operation, and expenditure. The capacity of the machine was 155 kilograms in an hour. And in an hour, it processed 282 pcs with an approximate weight of 169 kg. So, only 8% of dust or waste appeared that could be produced.

Moreover, the fuel consumption of diesel was 0.72 liters. In the same type of machine, (Djiwo and Setyawan, 2016) analyzed the performance of the coconut coir crusher machine to improve quality and increase the number of production cocopeat and coco fibers. As a result, the machine has been replicated in the home industry and promoted both the quality and quantity of the products.

This research in this paper was conducted to design and test the crusher machine that can separate coconut coir to cocopeat and coco fiber with different dimensions and construction powered by the motor driver. First, the motor driver is chosen with the gasoline engine. It is used because have enough power and is more responsive than the Diesel engine. Then the research objective also analyzes the performance of the crusher machine.

## 2. MATERIALS AND METHODS

### 2.1 Design of coconut coir crushing machine

Figure 1 shows an isometric view of the coconut coir crusher machine's model. The device used a gasoline engine with 5.5 HP. The ratio of a pulley after rounding off is about 6:1. There are 21 moving and 12 fixed blades, as shown in Figure 2 and Figure 3.

https://doi.org/10.29303/dtm.v12i2.517

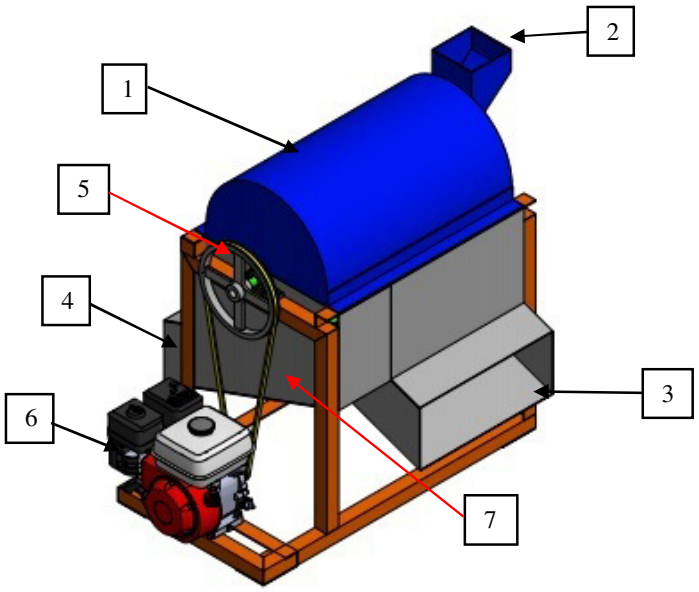


Figure 1. Isometric design of coconut coir crusher machine. 1. cover, 2. coconut coir inlet, 3. cocopeat outlet, 4. coco fiber outlet, 5. driven pulley, 6. drive engine, 7. v-belt

Figure 2 presents a picture from the top view without a Cover so that the blades can be observed clearly. Again, the moving blades' color is green, while the fixed blades' color is orange.

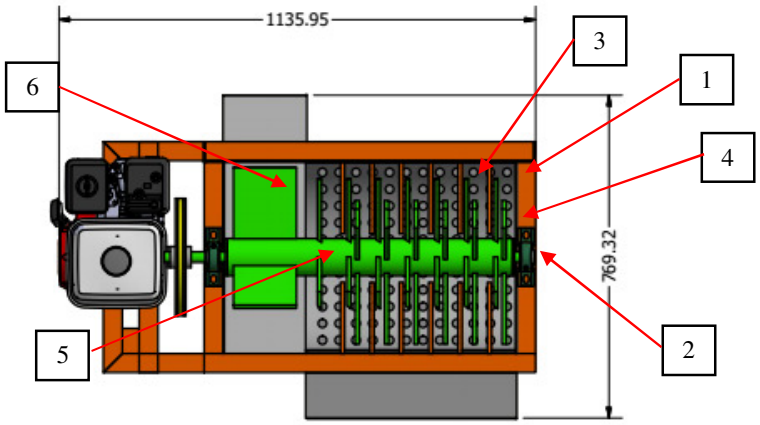


Figure 2. Top view design without the cover of coconut coir crusher machine. 1. filter, 2. pillow block bearing, 3. static blade, 4. dynamic blade, 5. blade shaft, 6. pusher fan

Figure 3 presents a side view design without a cover height of 745 mm. The design was adjusted to a small scale for the home industry for farmers in Kulon Progo. The machine's length of no longer than 1.2 meters and width of no longer than 0.8 meters is the right size for small-scale industry.

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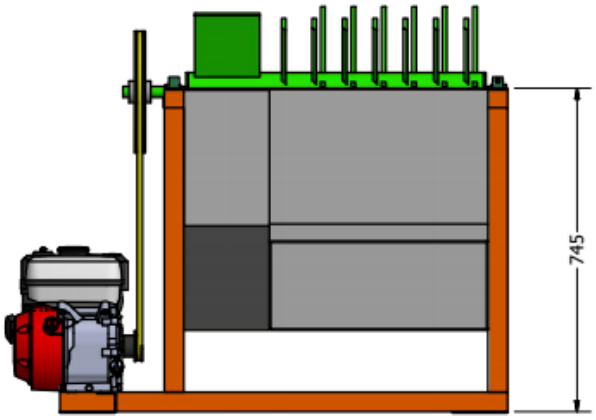


Figure 3. Side view design without cover of coconut coir crusher machine

**2.2 Method of Research**

The research was conducted to get the value of the parameters which indicate the performance of this machine, including fuel consumption, the capacity of the machine, depreciation of raw coconut fiber, noise level, linear v-belt velocity, and rpm of the blade shaft. It was conducted with the sound level meter and digital tachometer for noise and rpm of the blade shaft. Others were measured using the formula calculation.

The crushing machine moved using a gasoline engine with 5.5 HP. The initial setup of rotating velocity constantly spined in 2000 rpm. Fuel consumption was tested for one hour when this machine was operating. The machine separated both cocopeat and coco fiber from coconut coir. It is shown in Figure 4, the right side is cocopeat, and the left side is coco fiber.

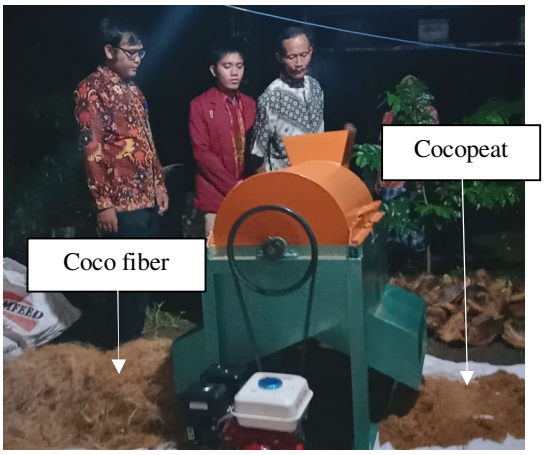


Figure 4. Testing coconut coir crusher machine

Another test has also been conducted to audit energy conservation potential in Coir Industry (Kamaleswaran et al., 2015). It moves by using a 60 HP and 50 HP induction motor. It needed massive power consumption, almost 40 kW at the highest power consumption.

**3. RESULT AND DISCUSSION**

**3.2 Result of testing the process of crushing and segregating coconut coir**

The results of this research, including fuel consumption, capacity of machine, depreciation of raw coconut coir, noise level, linear v-belt velocity, and rpm of the blade shaft.The fuel consumption of this engine was 1.8 liters for an hour. The data depicted in Table 1 were tested the process of crushing and segregating coconut coir to cocopeat and coco fiber in a minute with a coconut coir crushing machine.

https://doi.org/10.29303/dtm.v12i2.517

Table 1. Testing the process of crushing and segregating coconut coir to cocopeat and coco fiber in a minute with the crusher machine

| Number | Cocopeat (kg/min) | Coco fiber (kg/min) |
|---|---|---|
| 1 | 1.1 | 1.3 |
| 2 | 0.8 | 1.05 |
| 3 | 1 | 1.4 |
| 4 | 1 | 1.55 |
| 5 | 1.2 | 1.4 |
| Average | 1.02 | 1.34 |

There were five tests in the testing. The average values were 1.34 kg/min of coco fiber and 1.02 kg/min of cocopeat. So, this machine's capacity was 141.6 kg per hour, producing 61.2 kg of cocopeat and 80.4 kg of coco fiber. Whereas the other similar research results (Prashant et al., 2014), the crusher machine's capacity (called extraction machine) is only about 100 kg per hour.

Table 2. Experiment for obtaining the contents both of cocopeat and coco fiber in 1 kg coconut coir

| Number | Cocopeat weight (kg) | Coco fiber weight (kg) | Depreciation (kg) |
|---|---|---|---|
| 1 | 0.35 | 0.6 | 0.05 |
| 2 | 0.3 | 0.65 | 0.05 |
| 3 | 0.4 | 0.55 | 0.05 |
| 4 | 0.3 | 0.65 | 0.05 |
| 5 | 0.4 | 0.55 | 0.05 |
| Average | 0.35 | 0.6 | 0.05 |

Based on Table 2 above, know that 1 kg coconut coir after being processed and segregated in the crusher machine on average became 0.35 kg of cocopeat and 0.6 kg of coco fiber. There was 0.05 kg of depreciation in the form of dust. The reduction was only 5% of total weight.

**3.2 Sound level meter**

Noise level test measured by sound level meter illustrated in Figure 5. The standard noise level must be conditioned to activity in a location, and there were seven parts of activity time L1-L7 (Wati, 2020). We took L2, taken at 13.00 o'clock represented 09.00 until 14.00 o'clock. The result was 99.3 dB. Same way, research (Ardiansyah et al., 2013) which was obtained the noise level of the cutting machine of around 98.5 dB, so it was also upper the threshold of the standard noise level. Ardiansyah et al. (2013) also found the influence of noise level on blood pressure and work stress. It indicated that when operating the machine, the operator had to use earplugs and earmuffs for the safety of hearing according to a noise level threshold of 85 dB for 8 hours of normal working time (Regulation of the Minister of Health of the Republic of Indonesia Number 70 of 2016 concerning Standards and Requirements for Health in the Industrial Work Environment, 2017).


Figure 5. Measure noise level of coconut coir crushing machine when in process with sound level meter

https://doi.org/10.29303/dtm.v12i2.517

### 3.3 Linear V-Belt Velocity

The equation used to calculate linear velocity (Sutowo et al., 2000) by:

$$V = \frac{\pi . d_p . n_1}{60.1000} \quad (1)$$

And in here also used it, so:

$$V = \frac{\pi . 60.2000}{60.1000} \quad (2)$$

$$V = 2\pi \text{ m/s} \quad (3)$$

$V$ = 6,28 m/s (4)

The linear velocity also affected the blade shaft's rotation velocity or rpm. The faster the linear velocity, the faster the blade shaft. The result 6,28 m/s included fast because the machine in Sutowo et al. (2000) only 3 m/s and for enough crushing plastic.

### 3.4 Rpm of the blade shaft

The rotating velocity of the blade shaft measured by the Digital Tachometer was 330.4 rpm, illustrated in Figure 6. The rotating speed of the drive shaft was 2000 rpm while 330.4 rpm for the blade shaft, so the ratio of the pulley was 6:1. According to Prashant et al. (2014) recommended reducing the rpm of the blade shaft so that the torque will increase, surely with considering rpm needed. They also used the same ratio, 6:1 is the best ratio of the pulley for coconut fiber extraction or crusher machine.


Figure 6. Measure rpm of blade shaft of coconut coir crushing machine with digital tachometer

## 4. CONCLUSION

The results of this research included fuel consumption, the capacity of the machine, depreciation of raw coconut coir, noise level, linear v-belt velocity, and rpm of the blade shaft. They were 1.8 L, 141.6 kg per hour, 5%, 99.3 dB, 2π m/s, and 330 rpm, respectively. The crusher machine is in good performance based on the data because the result of research before only had a capacity of 100 kg per hour.

## ACKNOWLEDGEMENT

The author would like to thank Lembaga Penelitian, Publikasi, dan Pengabdian Masyarakat (LP3M) Universitas Muhammadiyah Yogyakarta for funding this research through the Internal Community Service Grant Scheme of Universitas Muhammadiyah Yogyakarta Fiscal Year 2019 with letter of decree: No. 2816/SK-LP3M/I/2019.

## NOTATION LIST

$V$ : Linear velocity (m/s)
$d_p$ : Diameter of drive pulley (mm)
$n_1$ : Rotating speed of drive shaft (rpm)
$\pi$ : Constant in math is the ratio of the circumference of a circle to its diameter, 22/7

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