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Effect of the number of blades in palm oil chopping machine

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ABSTRACT

A single hectare of oil palms may yield 10 tons of fronds annually, with young oil palms producing 40–56 fronds and mature oil palms producing 40–48 fronds. One kind of solid debris that comes from making palm oil is called palm oil fronds. A method is required to lessen palm frond waste because substantial volumes of it will still need to degrade. Waste palm fronds are reduced in size and broken down more quickly with the assistance of a chopping machine. But for slicing palm frond trash, the frond machines that are now in use are not the best. The purpose of this study is to ascertain whether adding more blades to a chopping machine's cutting knife can enhance the chopping process. Two designs with 19 and 26 blades were manufactured and tested for the research, and the results were compared with the cutting knife design from the prior study, which had 24 blades. According to the test results, adding additional blades to the cutting knife will improve the machine's effective capacity by 14.22% and decrease the size of waste palm fronds and leaves, allowing the machine to operate more efficiently. In addition, reducing the size of palm fronds with more knives can make them easier to break down.

Keywords: Waste; palm oil; chopping machine

1. INTRODUCTION

The plant known as palm oil (elaeis guineensis) is native to West African tropical rainforests. Plantations and processing facilities for palm oil are expanding quickly in Indonesia, Malaysia, Nigeria, Thailand, and other countries [1]. As the most popular agricultural product that brings in significant amounts of foreign cash and taxes, palm oil is a plantation commodity that plays a significant role in the Indonesian economy [2]. Indonesia's palm oil is distributed throughout Aceh, Java, Kalimantan, Sulawesi, and the east coast of Sumatra [3]. The total area under oil palm plantations in Indonesia was 14,456,611 Ha in 2019. The country produced 47,120,247 tons of crude palm oil (CPO) and 9,424,049 tons of palm kernel oil (PKO) in total. The total amount of palm oil exported was 28,279,350 tons, valued at 14,716,275 US dollars [4]. Palm oil waste is produced in significant quantities by major oil palm plants and oil extraction. Gas, liquid, and solid waste are all components of palm oil waste [5]. The fiber, kernel, and shell of palm fronds are among the solid wastes [6]. Palm fronds, an organic waste product of harvesting palm oil, can be composted [7]. Petioles, rachis, and leaves make up palm fronds [8]. A single hectare of palm trees may yield 10 tons of fronds annually. Young palm trees have 40–56 fronds, whereas old palm trees have 40–48 fronds [9]. Because of the high levels of lignin, hemicellulose, and cellulose in both young and old palm fronds, these fronds are difficult to disintegrate and take a long time to do so. The natural decomposition time for fronds is about four months [10]. Long-term disintegration of palm fronds (about 4 months) can result in a buildup that can harbor pests and diseases; this can be avoided by slicing the palm fronds to a smaller size [8]. Palm fronds cut down to size can be composted. Palm frond trash will be more easily destroyed by degrading bacteria if the shreds are smaller in size [11]. Palm fronds and leaves release many nutrients, including N, P, and K, during the decomposition process, which is necessary for palm oil [12].

During their decomposition, palm fronds and leaves produce a variety of nutrients, including N, P, and K, which is essential for the production of palm oil [13]. Using a chopping machine will minimize the size of the palm fronds and enhance the chopping capacity [14]. According to Setiawan, a chopping machine with 6.5 HP and 3,600 rpm can cut 114 kg of palm fronds every hour [15]. According to Rala, slicing palm fronds at 1,600 RPM yields 607.68 kg/hour, 1,200 RPM yields 576.91 kg/hour, and 800 RPM yields 341.87 kg/hour [16]. Arriyani demonstrates that 244.06 kg of cutting can be done per hour at 1,300 rpm and 7 HP [8]. Susilo also performed another chop with 7 HP, 1,450 rpm, and 24 spiral blades, producing 206 kg of chop per hour [11]. Research has shown that engine capacity can be impacted by rotational speed. But in addition to rotation speed, the quantity of knives on a machine can also have an impact on its capacity. The quantity of blades utilized during the chopping procedure is not explained by some studies.

In this study, a chopper machine equipped with several models of chopping knives will be used to chop palm oil waste (fronds), and the chopper's capability will be examined. The purpose of this study is to ascertain how many blades are needed when chopping the leaves and fronds of oil palms. Specifically, the cutting knife model employed in this study is a spiral-type cutting knife with 19, 24, and 26 blades. The input hopper, blade, belt, pulley, blade shaft, electric motor, machine frame, filter, and output hopper are among the parts of the chopping machine that Susilo used in earlier studies [11]. A spiral-type blade with 19 and 26 blades was employed in this investigation. To determine the ideal chopping capacity, the number of blades in the current design (19 and 26 blades) will be compared to the number of blades in Susilo's prior research (24 blades) [11].

2. METHOD

A Susilo-designed chopping machine is used in this study [11] It, as seen in, is made up of several parts, including an electric motor, machine frame, filter, output hopper, belt, pulley, blade shaft, input hopper, and blades Figure 1 [11]. Each of these parts has a specific purpose. For example, an input hopper keeps palm frond fragments from being thrown during the chopping process by providing a means of entering the palm fronds. Blades can to reduce the size of palm fronds by acting as palm frond cutters. As a connector, the pully transfers the rotation generated by the electric motor to the V-belt. The blade shaft serves as a connecting element between the blade and the pulley, which was previously powered by an electric motor. The electric motor's job is to transform electrical energy into mechanical energy so that the cutting knife can move. The machine is supported by the machine frame. The filter serves as a filter for the chop results' size. The output hopper serves as a location for the results of chopping at a specific size after they have been filtered by a filter.

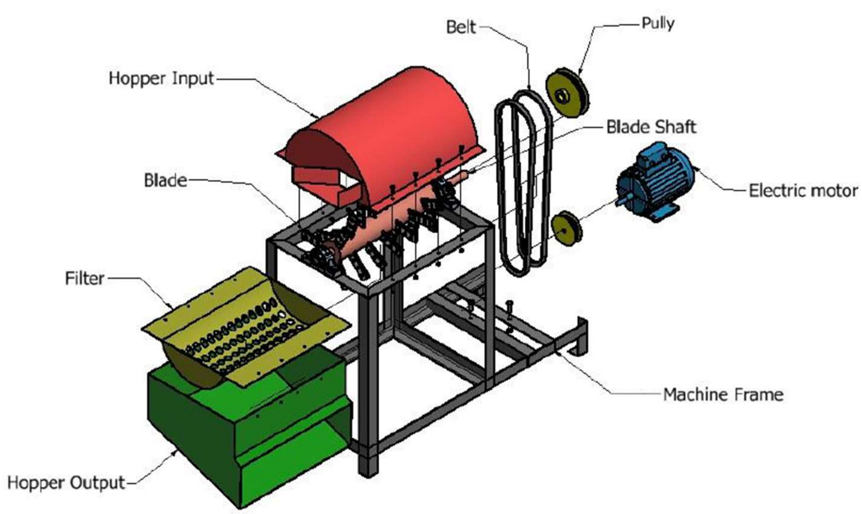

Figure 1. The design of the chopping machine [11]

The power and rotational speed of the electric motor, as well as the cutting knife, are some of the components that can impact the chopping machine's performance. The electric motor utilized in this study has the same power and speed as the one used in Susilo's research [11]. In the meantime, the cutting knife will be altered to have 19 or 26 blades, but it will still be compared to the 24-blade cutting knife used in earlier study. A pulley attached to an electric motor via a V-belt will drive the cutting knife attached to the shaft of a chopping machine. The palm frond will be chopped, or what is known as the chopping process, by the rotation created by the electric motor and the cutting knife. The huge palm fronds will be chopped into smaller pieces during the chopping process.

2.1 Research design

There are other steps to this research, such as creating the shaft and blade housing for the 19 and 26 blades that the chopping machine will use. CAD software was used to create the shaft and blade housing. Following the completion of the design phase, manufacture the shaft and blade housing by the blueprint. Machines for milling and welding are used in the manufacturing process. Following the completion of the manufacturing process, the blade is tested on an earlier Susilo-designed chopping machine [11]. Each experiment in machine testing contains flaws, which are analyzed to determine the machine's effective capability.

a. The design of the modification cutting knife

The cutting knife utilized in the palm frond chopping machine is one of the parts that will be examined in this study. Susilo's earlier research revealed that cutting blades possessed 24-blade spiral knives, as Figure 2 [11]. In earlier studies, cutting knives were changed to have 19 blades, as seen in Figure 3**,** and 26 blades, as seen in Figure 4. To find out how the space between the blades affects the size of the chopped results and variations in chopping capacity, adjust the cutting knife by adding or removing blades. With the aid of Autodesk Inventor, modifications were made.

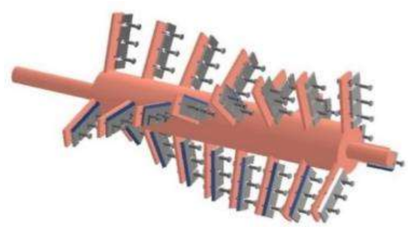

Figure 2**.** Previous blade design (24 blades) [11]

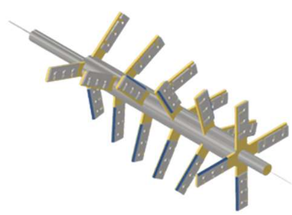

Figure 3**.** Design of 19 blades.

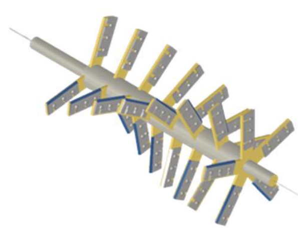

Figure 4**.** Design of 26 blades

b. Manufacturing of shaft and blade holder

Welding and milling are the methods used to create a range of designed knives. The shaft and blade housing are made by the milling technique. To make welding the blade holder to the shaft easier, the 1" ST 37 shaft is machined to form a groove for the blade housing. Following the completion of the blade housing groove, the iron blade housing, which has an L-shaped form and measures 40 x 40 mm, is hollowed out using a milling process. To make a bolt hole to attach the blade to the blade housing, a hole must be drilled into the blade housing. As seen in Figure 5. The drilled blade housing is subsequently electric welded to the shaft by the housing's groove.

Figure 5. Welding process of blade shaft

c. Machine testing

All of the knives 19-, 24-, and 26-blade knives—were subjected to machine testing utilizing a multitude of chopping apparatuses that Susilo had previously employed [11]. Includes a 2-horsepower electric motor rotating at 1450 rpm. A minute was counted after 2.5 kg of palm fronds were inserted into the input hopper to conduct the test. The output hopper will release the chopped palm fronds. For every number of blades, the counting process was repeated three times. The results of each repetition were noted, and the average was calculated.

d. Machine effective capacity analysis

The ratio of the mass of chopped palm fronds to the chopping time is the machine's effective capacity. The machine's effective capacity is then determined by analyzing the testing average. examination of the acquired equipment's capabilities. The formula can be used to calculate the tool's capacity [8],

$$K_{em} = \frac{mk}{t} \quad (1)$$

With,

K_{em} : Machine Effective Capacity (kg/h)
mk : Chopped Weight (kg)
t : Chopping time (h)

3. RESULTS AND DISCUSSION

A chopping machine with a 2-horsepower motor and a 1450 rpm rotation speed is used for the chopping operation. It contains knives with 19, 24, and 26 blades. During the chopping procedure, three repetitions of one minute were performed using 2.5 palm fronds per machine, for each number of blades. After that, the outcomes of doing the chopping operation again are averaged, as shown in Table 1 Meanwhile, the machine's effective capacity is seen in Figure 6.

Table 1. The Average of the chopping result

Blade	Time (h)	Material Weight	Chopped weight (kg)	Large Chopped Material (kg)	Not Chopped (kg)
19	0.016	2.5	1.34	0.55	0.58
24	0.016	2.5	1.49	0.7	0.24
26	0.016	2.5	1.75	0.36	0.24

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The palm fronds and leaves can be chopped well and are smaller than their original form, as shown in Figure 6.

Figure 6. Chopped palm fronds and leaves

The following is the effective capacity of a machine that uses 19, 24, and 26-blade knives, as shown in Figure 7.

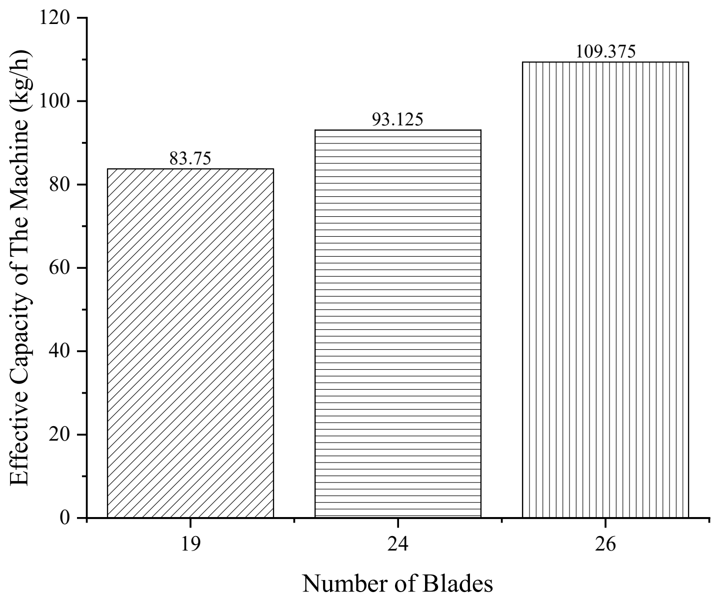

Figure 7. The effective capacity of the machine

19-, 24-, and 26-blade knives work well for chopping palm fronds and leaves. Nevertheless, there is still material that is not chopped, and huge chopped material while chopping palm fronds and leaves. The reason for unchopped material is that the palm fronds and leaves get lodged in the cutting knife's shaft, preventing the blade from cutting them. The space between the blades may be the source of unchopped material. Palm fronds and leaves that have been chopped but are still too big to fit through the filter are left in the machine instead of passing through. Table 1 shows that compared to 24-blade knives, more material is neither cut or lodged on the shaft of 19-blade knives. In contrast to 24-blade knives, 19-blade blades contain less big chopped material. This is because compared to 24-blade knives, there is less large-cut material on 19-blade blades since there is more material that is not chopped. In contrast, with 24-blade knives, there is more material left over than with 19-blade knives since less material is left uncut. Table 1 shows that while there are still a lot of large chopped materials, there are more chopped materials overall than there were with the 19-blade blades.

By upgrading to 26-blade knives, the limitations of the chopping results on 19 and 24-blade knives can be addressed. There is less unchopped material on knives with 26 blades than on those with 19 blades, and the same amount is on knives with 24 blades. But when the cutting blade gets bigger, the amount of unchopped material can decrease and increase the amount of chopped material. In comparison to knives with 19 and 24 blades, 26-blade knives can chop the most material in one minute. A 19-blade knife chops 1.34 kilogram of material per minute, a 24-blade knife chops 1.49 kg per minute, and a 26-blade knife chops 1.75 kg of material per minute. Using equation (1), it can be ascertained that the effective capacity of the machine for knives with 19 blades is 83.75 kg/h, for knives with 24 blades it is 93.125 kg/h, and for knives with 26-blades it is 109,375 kg/h. These findings indicate the variation in the effective capacity of the machine for each number of blades. The counting was completed in one minute. This indicates that the effective capacity of the chopping machine can be increased by up to 14.22% by increasing the number of blades on the cutting knife. This increase results from the closer spacing between the blades as the number of blades grows, which reduces the possibility of leaves and palm fronds becoming lodged in the shaft. The closer the blade distance, the smaller the palm fronds and leaves will be sliced for them to pass through the filter, in addition to boosting the machine's effective capacity. The size disparity between the 19, 24, and 26-blade knives illustrates this. To reduce the number of fronds and palm leaves that become lodged in the shaft, the average size of 19-blade knives is 40–70 mm, 24-blade knives are 20–40 mm, and 26-blade knives are 30–50 mm. When palm fronds and leaves are chopped with 24- and 26-blade knives, the average size of the resulting pieces is about equal. This identical size results from the 24- and 26-blade knives' blades being spaced the same apart

4. CONCLUSION

It is known from the experiments that have been conducted that adding additional blades will enhance the machine's effective capacity by up to 14.22%, resulting in a more efficient and ideal chopping operation. The machine's effective capacity is 83.75 kg/h for knives with 19 blades, 93.125 kg/h for knives with 24 blades, and 109,375 kg/h for knives with 26 blades. To facilitate decomposition or enable the material to be converted into charcoal, adding blades can help lower the material's size. Knives with 19 blades typically measure 40–70 mm, those with 24 blades 20–40 mm, and those with 26 blades 30–50 mm.

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