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CUTTING SPEED ANALYSIS OF ORGANIC WASTE CHOPPING MACHINE FLYWHEEL MODEL LEVEL CONTROL

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Abstract. This machine is used to chop leaves, twigs and branches into very small pieces, to avoid the bad smell due to the decay of organic waste and can be used as compost. The amount of cutting speed on the organic waste chopping machine with a chopping time of 2.5 kg of ketapang leaves is the average time obtained without flywheels 2.0 minutes and with flywheels 1.7 minutes, a time difference of 0.3 minutes. The chopping time of 2.5 kg of ketapang branches with an average time obtained without a flywheel of 2.2 minutes and with a flywheel of 2.0 minutes, a time difference of 0.2 minutes. The chopping time of teak branches is 2.5 kg with an average time obtained without a flywheel of 2.6 minutes and with a flywheel of 2.0 minutes, so the time difference is 0.6 minutes. So the cutting speed using a flywheel is better. The results of the productivity obtained on the organic waste chopping machine, for the results of leaf chopping productivity without a flywheel of 48% and those using a flywheel of 58%, and the results of leaf chopping with a flywheel are 10% more productive, for the productivity of chopping twigs without a flywheel of 44% and those using a flywheel of 49%, so the results of chopping twigs with a flywheel are 5% more productive, and the results of chopping branches without a flywheel of 37% and those using a flywheel of 49%, so the results of chopping branches with a flywheel are 12% more productive.

Keywords : analysis, machine cutting speed, organic waste and flywheel.

1. INTRODUCTION

Technology development basically aims to answer the need for equipment efficiency, both existing and still being designed. So an effective technology utilization effort must first be able to produce effective products, one of which is the application of appropriate machines for chopping organic waste, the success of this machine must be based on the usefulness of the products produced with the level of effectiveness. Waste chopping tools in general that are usually used are not equipped with flywheels. But with the development of technology, there has begun to develop appropriate tools in the form of organic waste chopping tools that can chop organic waste such as leaves, twigs and branches, various types of organic waste on the Bali State Polytechnic campus.

This chopping machine is equipped with a flywheel to increase the torque of the rotary knife rotation so that the rotary knife rotation remains stable when chopping hard enough organic waste. And this chopping machine is used to chop several types of organic waste from leaves, twigs and tree branches. With an area of approximately 12 hectares of Bali State Polytechnic campus park and the waste generated per day reaching approximately 10 m3, then based on this background the author tries to analyze the cutting speed of the flywheel model organic waste chopping machine and measure how much organic waste is chopped so that this tool can be said to be effective.

Organic waste is waste from organic materials that can be decomposed by microbes, organic waste consists of wet and dry waste that can be reprocessed into functional products, organic waste is actually classified as environmentally friendly waste because it can be decomposed naturally by microbes, but natural decomposition takes time. So when organic waste is not processed quickly and accumulates, it can cause unpleasant odors, as shown in Figure 1. For the decomposition process to be faster, human intervention is needed, by utilizing appropriate technology, namely an organic waste reading machine that can produce economic value.

Figure 1. organic waste

A combustion motor is a type of heat engine that includes an internal combustion engine. Internal Combustion Engine (I.C. Engine) is a heat engine that converts the chemical energy of fuel into mechanical work, namely in the form of shaft rotation. In gasoline engines with the Otto cycle, two types of engines are known, namely 4-stroke (four-stroke) and 2-stroke (two-stroke) engines. For a 4-stroke engine, there are 4 piston movements or 2 crankshaft rotations for each combustion cycle, while for a 2-stroke engine, there are 2 piston movements or 1 crankshaft rotation for each combustion cycle [1][2][3].

Flywheel or rila wheel or force balancing wheel is one of the round-shaped engine elements with a large mass weight and is directly connected to the crankshaft, usually located before or after the connecting device for out-put. This flywheel functions as a force balancer and regulates engine rotation so that engine rotation can run properly. The working principle of this flywheel is to keep the engine rotation running normally and not rigidly so that the resulting out-put can be controlled [4][5], the shape of the Flywheel model as shown in Figure 2.

Figure 2. Flywheel

Cutting is the process of mechanically separating a solid material along a specific line by a cutting tool. The cutting tool is described as a material blade (knife) with a sharp edge. This cutting causes a material to have 2 new shapes called pieces or flakes, which are smaller than the original. The cutting process begins with the intersection (contact) between the blade and the cutting material. as shown in Figure 3 [6][7][8].

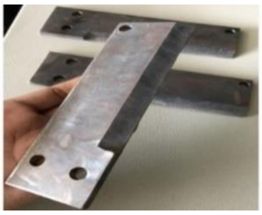

Figure 3. Cutting Blade

The shaft is one of the most important parts of the engine. Almost all machines forward the power of rotation with the intermediation of the shaft. Shafts can generally be installed gears, pulleys, and naf that rotate with the shaft. The loading on the shaft depends on the amount of power and rotation that is forwarded, as well as the effect of the force generated by the parts that are supported and rotate with the shaft [9][10][11].

Bearing is one part of the machine element that serves to support the shaft so that rotation can take place safely [12][13]. Bearings can be classified on the basis of bearing movement against the shaft, namely, glide bearings, and rolling bearings. On the basis of the direction of the load on the shaft, namely, radial bearings, and axial bearings.

The pulley serves to forward and change the rotation along with the belt from the driving source to the shaft or component to be driven. Belt pulleys are made of cast iron or steel. For lightweight construction set pulleys of aluminum alloy. There are various types of pulleys on the belt according to the belt being driven, namely pulleys for flat belts, pulleys for V belts and pulleys for rotating belts [14][15][16].
Belts or belts are made of rubber and have trapezium containers with weaves, teterons and the like used as belt cores to carry large pulls. The V-belt is wrapped around a V-shaped pulley groove. The twisted part of the belt will bend so that its inner width will increase and the friction force will also increase due to the influence of the wedge shape, which will result in large power transmission at relatively low tension [14][16].

Productivity is often identified with efficiency in the sense of a ratio between outputs and inputs. As a measure of efficiency or productivity of human labor, the ratio is generally in the form of output produced by work activities divided by the hours of work contributed as a source of input with rupiah or other units of production as the benchmark dimension [17].

The purpose of this study is to determine the cutting speed and productivity results on the flywheel model organic waste chopping machine and without flywheels. In the analysis of this flywheel model organic waste chopping machine, only analyzes the cutting speed of the knife, and analyzes the effect of using flywheels and without using flywheels on the cutting speed.

2. METHODS

The design of this research is analytical research, that is analyzing the effect of the cutting speed of the flywheel model organic waste chopping machine on the results of its chopping and conducting machine trials on chopping organic waste. The first test tested the cutting speed without using the Flywheel and the second test tested the cutting speed using the Flywheel.

The location for conducting research on analyzing the cutting speed of the flywheel model organic waste chopping machine from start to finish, at the Bali State Polytechnic Campus, part of the Maintenance and Repair Engineering Service Unit (UPT-PP), especially in the garden section. The research time was 4 months, from February 1st, 2022, to May 2nd, 2022.

Data sources are obtained through surveys in the field by studying data on productivity and the advantages and disadvantages of the machine (flywheel model organic waste chopping machine), also studying theories related to analysis, literature, journals, and other sources.

In this study, instruments or tools are needed that support the process of collecting analysis data from material preparation to obtaining test result data. The instruments needed are stopwatches, pushrods, tachometers, and digital scales.

The research procedure for analyzing the problem of productivity on the results of shredding organic waste shredding tools is as follows:
a) Weighing the materials to be tested
b) Prepare a stopwatch and tachometer
c) Starting the combustion motor
d) Measuring the RPM of the combustion motor with a tachometer
e) Putting the material that has been weighed into the chopping machine
f) Measuring the time with a stopwatch while the machine is chopping
g) Ending machine operation
h) Weighing back the material that has been chopped
i) Recording the data obtained
j) Cleaning the machine

3. RESULTS AND DISCUSSION

3.1 Results

1) The tool to be analyzed has the function to chop leaves, twigs, and branches. The working concept of this tool is that the rotation of the combustion motor is forwarded by the pulley to the shaft where on the shaft there are 4 chopping knives and 1 fixed knife.

Caption:
1. Motor fuel
2. Order
3. Enumerator room
4. Blade shaft
5. Funnel input
6. Flywheel

Figure 4. Flywheel model organic waste shredder

The initial stage before the testing process of the organic waste chopper is to prepare raw materials in the form of leaves, twigs and branches that will be tested for the efficient level of the tool. Next, measure the weight of the leaves and twigs to be tested.

2) Working Principle of Tool
The working principle of the organic waste chopping machine with flywheels is that first the rotation of the gasoline motor will be forwarded using a V-belt pulley to the shaft, this machine uses two shafts, namely the shaft for the chopping knife and the shaft for the roll pusher, in the chopping knife shaft there are four chopping blades, one fixed knife. When each raw material consisting of leaves, twigs and branches is inserted into the organic waste chopping machine with flywheels, the waste will be pulled by the roll pusher into the chopping knife. When twigs, branches and leaves are chopped, the results will be pushed to the output of the machine, so that the chopped results will move out through the drain contained in the organic waste chopping machine with the flywheel.

3) Ability of Organic Waste to Hold the Load Under the Knife
a) Leaf
Leaf hardness is data that must be known to start calculations on leaf chopping knives, in this test using ketapang leaves. The specifications of the flywheel model organic waste chopping machine knife are:

Chopping blade = 31 cm
Fixed blade = 31 cm
Thickness of chopping blade = 3 mm
Thickness of fixed blade = 10 mm
Number of chopping blades = 4 pc
Number of fixed blades = 1 pc

How to test leaf hardness:
1) Collect approximately 1 kg of leaves and tie them together, to make sure it can use scales.
2) Place the leaves on the anvil where the test piece is placed.
3) Give a load on the pressing pad. Perform pressure using a leaf chopper knife until the leaf breaks or the maximum load has occurred.

Table 1. Leaf Testing

Leaf Type	Number of Leaf (Kg)	Load
Ketapang	1	2,2 kg

b) Twig
The hardness of the twig is the data that must be known to start the calculation on the twig chopping knife. In this analysis, the author tested Ketapang twigs.
How to test the hardness of twigs:
1) Cut twigs with a diameter of 2 cm with a length of 10 cm as many as 4 pieces.
2) Place the twig on the anvil where the test piece is placed.
3) Give a load on the pressure pad. Do it until the twig is broken or the maximum load has occurred.

Table 2. Twig Testing

Number of twig (pcs)	Load
4	4,93 kg

c) Branch
1) The hardness of the branch is the data that must be known to start the calculation on the chopping blade. In this analysis the author tested teak branches as the main material. In accordance with the procedure used.
How to test the hardness of the branch:
1) Take a branch weighing 1 kg.
2) Place the branch on the anvil where the test object is placed.
3) Give a load on the pressure pad and then do it until the branch breaks or the maximum load has occurred.

Table 3. Branch testing

Branch type	Number of branch (pc)	Load
1 Teak	1	5,12 Kg

3.2 Data Testing
Based on the results of productivity testing of the flywheel model organic waste chopping machine, the following data will be used as a reference in determining the comparison between testing organic waste chopping machines using flywheels with organic waste chopping machines without flywheels. from the results of the analysis, it can be explained in the form of a table below:

Table 4. Leaf chopping test results
Leaf Testing Without Flywheel

Testing Number	Cutting Speed (Rpm)	Input (Kg)	Time (Minute)	Output (Kg)	Productivity (%)
1	2800	2.5	2.1	2.44	46 %
2	2800	2.5	2.0	2.42	48 %
3	2800	2.5	2.0	2.41	48 %
Average	2800	2.5	2.0	2.42	48 %

Table 5. Leaf chopping test results
Leaf Testing With Flywheel

Testing Number	Cutting Speed (Rpm)	Input (Kg	Time (Minute)	Output (Kg)	Productivity (%)
1	2800	2.5	1.7	2.45	58 %
2	2800	2.5	1.6	2.43	61 %
3	2800	2.5	1.8	2.46	55 %
Average	2800	2.5	1.7	2.45	58 %

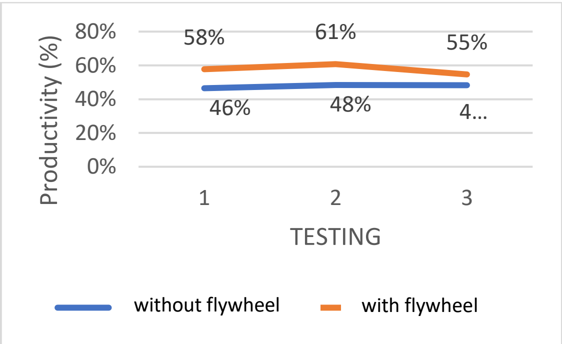

Figure 5. Graph of leaf shredding productivity results

Based on Figure 5 above, it can be concluded that leaf chopping on machines without using flywheels is 46%, 48%, 48% and with flywheels amounting to 58%, 61%, 55%. This means that by using a flywheel the results of chopped leaves are more productive by 10%.

Table 6. Twig chopping test results
Twig Testing Without Flywheel

Testing Number	Cutting Speed (Rpm)	Input (Kg)	Time (Minute)	Output (Kg)	Productivity (%)
1	2800	2.5	2.3	2.43	42%
2	2800	2.5	2.1	2.46	47%
3	2800	2.5	2.2	2.42	44%
Average	2800	2.5	2.2	2.44	44%

Table 7. Twig chopping test results
Twig Testing with Flywheel

Testing Number	Cutting Speed (Rpm)	Input (Kg)	Time (Minute)	Output (Kg)	Productivity (%)
1	2800	2.5	2.1	2.44	46 %
2	2800	2.5	1.9	2.45	52 %
3	2800	2.5	2.0	2.41	48 %
Average	2800	2.5	2.0	2.43	49 %

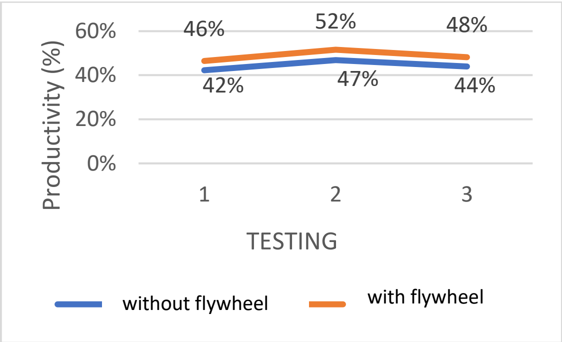

Figure 6. Graph of twig shredding productivity results

Based on Figure 3.3 above, it can be concluded that the chopping of twigs on the machine without using flywheels is 42%, 47%, 44% and with flywheels amounting to 46%, 52%, 48%. This means that by using flywheels the results of chopped twigs are more productive by 5%.

Table 8. Branch Chopping Test Results
Branch Testing Without Flywheel

Testing Number	Cutting Speed (Rpm)	Input (Kg)	Time (minute)	Output (Kg)	Productivity (%)
1	2800	2.5	2.5	2.42	39 %
2	2800	2.5	2.7	2.41	36 %
3	2800	2.5	2.6	2.42	37 %
Average	2800	2.5	2.6	2.42	37 %

Based on Figure 3.4 above, it can be concluded that the chopping of branches on the machine without using flywheels is 39%, 36%, 37% and with flywheels amounting to 46%, 49%, 46%. This means that by using a flywheel the chopped branches are more productive by 12%.

Table 9. Branch Chopping Test Results
Branch Testing with Flywheel

Testing Number	Cutting Speed (Rpm)	*Input* (Kg)	Time (minute)	*Output* (Kg)	Productivity (%)
1	2800	2,5	2,1	2,41	46 %
2	2800	2,5	2,0	2,43	49 %
3	2800	2,5	1,9	2,44	51 %
Average	2800	2,5	2,0	2,43	49 %

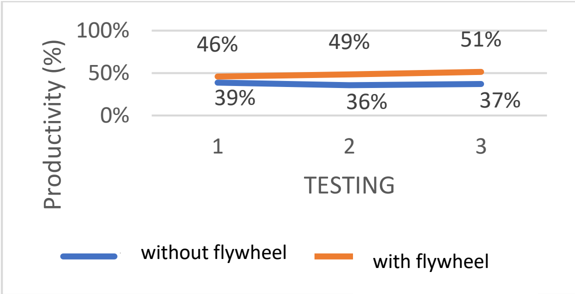

Figure 7. Graph of branch shredding productivity results

3.3 Effect of Time on Organic Waste Shredding

a) The shredding of Ketapang leaf type waste in 3 tests can be seen in Figure 8 below:

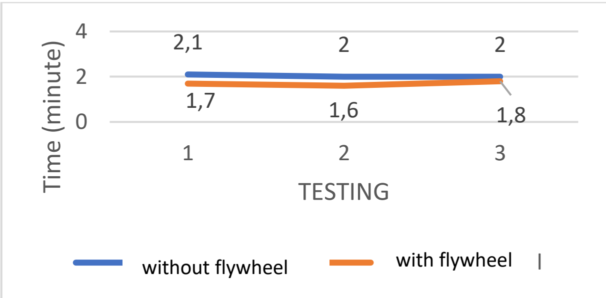

Figure 8. Comparison chart of leaf shredding time

Based on Figure 8, it can be seen that the chopping time of 2.5 kg of Ketapang leaves is the average time obtained without flywheels 2.0 minutes and with flywheels 1.7 minutes. And the time difference is 0.3 minutes.

b) Enumeration of Ketapang twig type waste in 3 tests can be seen in Figure 9 below:

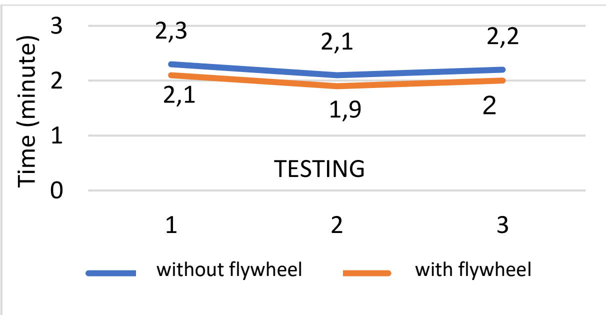

Figure 9. Comparison chart of twig shredding time

Based on Figure 9, it can be seen that the chopping time of 2.5 kg of Ketapang branches is the average time obtained without flywheels 2.2 minutes and with flywheels 2.0 minutes. And the time difference is 0.2 minutes.

c) The chopping of teak branch type waste in 3 tests can be seen in Figure 10 below:

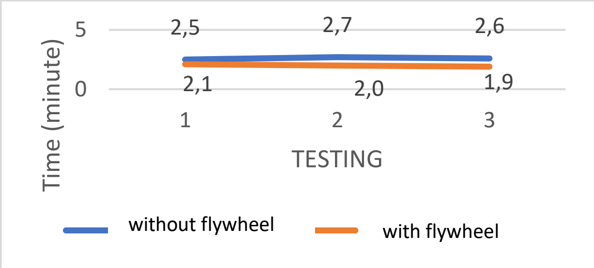

Figure 10. Comparison chart of branch shredding time

Based on Figure 10, it can be seen that the time of chopping teak branches as much as 2.5 Kg. The average time obtained without flywheels is 2.6 minutes and with flywheels is 2.0 minutes. And the time difference is 0.6 minutes.

3.4 Chopping Leaves, Twigs and Branches Without Flywheel

The criteria for good chopped leaves, twigs and branches ranges from 1 cm to 3 cm after chopping. Because the smaller the size, the easier it is to decompose with the soil.

The following are photos of the chopped leaves, twigs and branches without using a flywheel:

1) The results of chopped leaves after being chopped by an organic waste chopping machine without a flywheel turned out to be chopped in accordance with, the size of the chopped results ranged from 1 cm - 1.9 cm, as in Figure 3.8 as follows.

Figure 11. Leaf shredding results without flywheel

2) The results of chopped twigs after being chopped by an organic waste chopping machine without flywheels turned out to be chopped according to the criteria, the size of the chopped results ranged from 1.5 cm – 2.7 cm, as in Figure 3.9 as follows.

Figure 12. Twigs shredding results without flywheel

3.5 Shredding Leaves, Twigs and Branches with Flywheel

The following are photos of the chopped leaves, twigs and branches without using flywheels:

1) The results of chopped leaves after being chopped by an organic waste chopping machine with a flywheel turned out to be chopped according to the criteria, the size of the chopped results ranged from 1.3 cm - 1.5 cm, as in Figure 13 as follows.

Figure 13. Results of leaf shredding with flywheel

2) The results of chopped twigs after being chopped by an organic waste chopping machine with flywheels turned out to be chopped according to the criteria, the size of the chopped results ranged from 1.3 cm - 2.4 cm, as in Figure 3.11 as follows.

Figure 14. The result of chopping branches with a flywheel

3) The results of chopped branches after being chopped by an organic waste chopping machine with a flywheel have met the criteria, which ranges from 1.2 cm to 2.2 cm, as shown in Figure 15 as follows.

Figure 15. The result of chopping branches with a flywheel

4. CONCLUSIONS

Based on the results of the above analysis it can be concluded:

a. From the test data that has been obtained, it can be concluded that the cutting speed on the organic waste chopping machine with a chopping time of 2.5 kg of Ketapang leaves is the average time obtained without flywheel 2.0 minutes and with flywheel 1.7 minutes, so the time difference is 0.3 minutes. For the chopping time of 2.5 kg of Ketapang branches, the average time obtained without a flywheel is 2.2 minutes and with a flywheel is 2.0 minutes, so the time difference is 0.2 minutes. When chopping teak branches as much as 2.5 kg, the average time obtained without a flywheel is 2.6 minutes and with a flywheel 2.0 minutes, so the time difference is 0.6 minutes, so the cutting speed using a flywheel is better.

b. From the test data that has been obtained, it can be concluded the results of the productivity of organic waste chopping machines. The productivity results of leaf chopping without flywheels are 48% and those using flywheels are 58%, so the results of leaf chopping with flywheels are 10% more productive. The productivity results of chopping twigs without flywheels are 44% and those using flywheels are 49%. Then the results of chopping twigs with flywheels are 5% more productive. The productivity results of chopping branches without a flywheel are 37% and those using a flywheel are 49%. Then the results of chopping branches with flywheels are 12% more productive, so chopping using a flywheel is better and more productive.

From the results of the productivity analysis of the organic waste chopper, the author can suggest for users of organic waste chopping machines with flywheel models to be careful when entering organic waste into the funnel / input because there is a pusher that will pull organic waste into the chopping knife, and readers who want to develop this analysis can use various types of organic waste, and don't forget to pay attention to work safety.

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