Analysis of the Performance of an Organic Waste Shredder and Mixer Equipped with Slicer and Hammer Blades

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Abstract

This research focuses on the performance analysis of an organic waste shredding and mixing machine equipped with slicer and hammer-type blades. The study addresses three main research questions: (1) What is the production capacity of the shredding machine using slicer and hammer blades in processing organic waste? (2) How efficient is the machine in managing organic waste with these blade types? (3) What is the final quality of the results from the shredding and mixing processes performed by the machine? The methodology involves tool design, performance testing, and analysis. Data collection was carried out through interviews, observations, and literature studies, focusing on three aspects: (1) the production capacity of the machine with slicer and hammer-type blades (2) the operational efficiency in processing organic waste, and (3) the final quality of the shredded and mixed material. Based on the analysis, the following results were obtained: (1) The average effective working capacity of the machine was 138.85 kg/hour, while the theoretical working capacity averaged 237.78 kg/hour. (2) The average efficiency of the machine using slicer and hammer blades was 58%. (3) The shredded and mixed output showed good final quality, supported by an optimal mixing moment, indicating effective machine performance in processing organic waste.

Keywords: Production capacity, efficiency, final quality.

I. INTRODUCTION

Waste has long been regarded as something with no use value[1]. In recent decades, the issue of waste has escalated into a pressing global environmental concern, causing negative impacts on ecosystems and reducing the living space for living beings [2]. The accumulation of waste, particularly in residential areas and tourist sites, poses a serious threat to environmental health and public comfort [3]. Ironically, most of the causes of this problem stem from human activities ranging from consumption patterns, irresponsible littering behavior, to inefficient waste management systems [4]. One of the most commonly generated types of waste is organic waste, such as food scraps, leaves, and garden waste [5]. Organic waste is actually biodegradable and has the potential to be reused, especially as raw material for composting [6]. Unfortunately, many households simply dispose of organic waste or burn it, which leads to air pollution and wastes opportunities to create added value. A concrete example can be found in Sukoharjo Regency, where there is an educational tourism area known as *Taman Tanggul Jebol*. This park is located along a riverbank and is surrounded by teak trees that constantly shed their leaves. Without proper handling, these leaves accumulate and may reduce the park's aesthetics, air quality, and overall visitor comfort.

In an effort to accelerate the process of converting organic waste into compost, one effective approach is to reduce the particle size of the organic materials [7]. The process of chopping or shredding organic matter into smaller pieces speeds up microbial activity during decomposition. Therefore, the use of an organic waste shredder machine is highly important. This machine is designed to cut waste into smaller parts so that the composting process can proceed more efficiently and in a controlled manner [8]. However, several shredder machines that have been developed still face performance limitations, particularly in terms of cutting efficiency and the uniformity of the shredded output [9]. To address these issues, innovation has been introduced through the modification of an organic waste shredder and mixer machine, by adopting two types of blades: *slincer-type blades* and *hammer-type blades*. This modification aims to enhance the machine's ability to shred dry leaves, especially teak leaves, which are known for their toughness and fibrous texture. The use of this dual-blade

combination is expected to produce finer, more uniform shreds that are easier to mix and process into compost [10].

To support the development of this machine, a comprehensive performance analysis was conducted. The analysis includes measuring production capacity, work efficiency, and the quality of the final shredded product. This study not only aims to optimize machine performance but also to contribute significantly to organic waste management efforts in the community, particularly in public areas such as *Taman Tanggul Jebol*. The results of this research are expected to serve as a reference for developing small- to medium-scale waste processing technology and to promote the application of sustainability principles in environmental management.

II. METHOD

In the development of the Analysis of the Performance of an Organic Waste Shredder and Mixer Equipped with Slicer and Hammer Blades, there are several stages that must be followed to ensure that the product development proceeds according to plan and functions as intended.
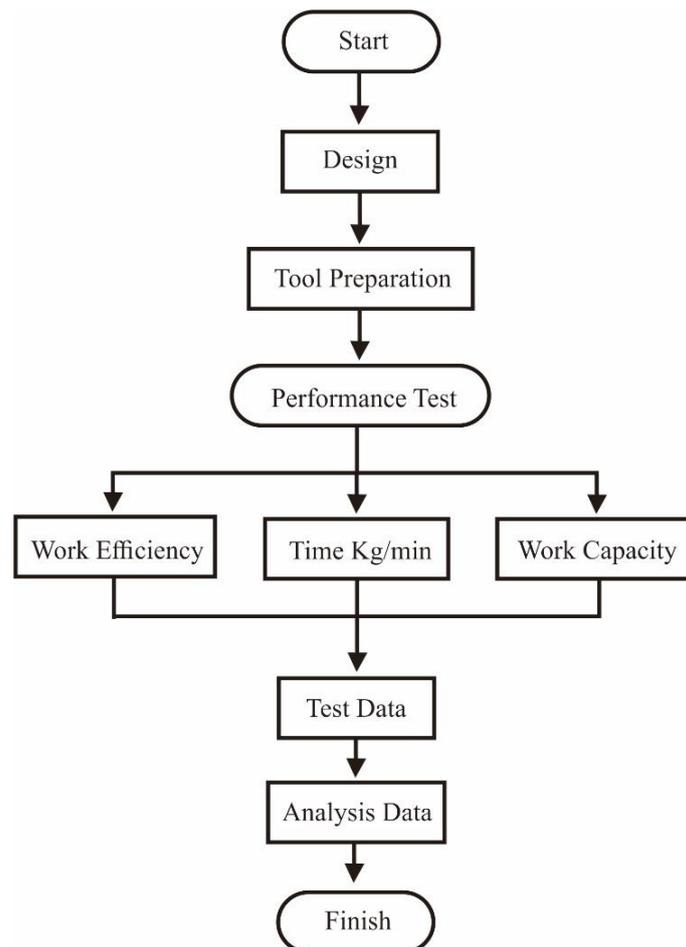

Figure 1 Research Flow

This research begins with the initial stage (*Start*), which marks the commencement of the entire experimental process, namely the performance testing of the organic waste shredder and mixer machine. In this stage, the researchers define the objectives and scope of the study, including problem identification and the research methods to be employed. The next step is the *Design* phase. During this stage, the researchers carry out both conceptual and technical design of the machine. This process includes selecting the types of blades (slicer and hammer), determining the drive motor, the transmission system (such as pulleys and V-belts), and designing the mixing mechanism. The design is developed to ensure that the machine can perform the shredding and mixing functions according to the desired specifications. Once the design is completed, the process moves to the *Tool Preparation* stage. In this phase, all machine components are assembled and functionally tested. The researchers ensure that each part of the machine operates properly and is safe to use during testing. The core

stage of this research is the *Performance Test*. The machine is operated using test materials in the form of dry organic waste, specifically teak leaves. During this stage, observations are made on the machine's performance throughout the shredding and mixing process. The results from this test serve as the basis for evaluating the machine's performance. After testing, the machine's performance is analyzed based on three main indicators: Work Efficiency, which measures how effectively the machine uses time and energy to produce a certain amount of shredded material, Time per Kilogram (Time Kg/min), which assesses the processing speed in relation to the material's weight over time, and Work Capacity, which indicates the volume of material the machine can process in kilograms per hour.

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A. Design

The image below shows the design of the organic waste shredder and mixer machine, which consists of several main components: the shredding unit, electric motor (dynamo), mixing pulley, gasoline engine, and control panel.
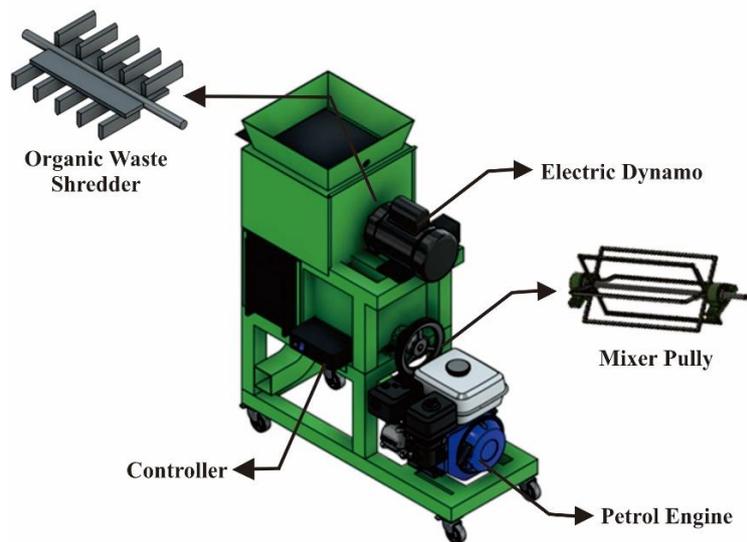

Figure 2 Design of a Machine for Shredding and Mixing Organic Waste

This machine is designed to process organic waste, such as dry leaves, through two main stages: shredding and mixing. The shredding process is carried out by cutting blades driven by an electric motor (dynamo), producing smaller and more uniform waste particles to accelerate the decomposition process. After being shredded, the material is evenly mixed using a mixing system powered by a gasoline engine, with power transmitted through a pulley and V-belt connected to the mixing shaft. The mixing pulley functions as the torque transmission medium from the gasoline engine to the mixing system. The control panel serves as the operational control unit of the machine, enabling functions such as activating the shredder motor and ensuring operational safety. The machine is designed to be portable, equipped with wheels at the base, making it easy to move and operate in various locations. This makes it highly effective for organic waste processing in household environments, agricultural areas, and public spaces.

B. Slicer and hummer type blades

In organic waste processing machine technology, particularly those designed for shredding and mixing, the selection of blade types is one of the key factors that affects work efficiency, the quality of the shredded output, and the overall durability of the machine. Two commonly used blade types in shredding systems are the slicer blade and the hammer blade. Each has distinct operational characteristics, but they complement each other in the organic waste processing workflow especially for materials such as dry teak leaves, agricultural waste, and both wet and dry household waste.

Figure 3 Slicer and Hummer Type Knife Blades

The slicer-type blade is designed to perform cutting through a smooth and precise slicing mechanism. This blade is typically sharp on one edge and extends in a straight line, enabling it to cut materials uniformly through rapid rotational motion. The working principle of this blade is similar to that of a kitchen knife or a meat slicer in the food industry, where the cutting is done using a shearing force rather than an impact force. The comparative aspects are as follows:

Tabel 1 Comparison of Slicer and Hummer Type Blades

No	Aspect	Slicer Knife	Hummer knife
1	How it works	Slicing or cutting	Hitting or striking
2	Final result	Smooth and orderly	Destroyed, irregular
3	Application	Leaves, soft waste	Hard materials, fibrous waste
4	Purpose of use	Initial cut	Continued destruction

Based on the comparison in the table above, combining both types of blades in a single machine is an efficient and innovative approach. The slicer functions to neatly cut organic materials into smaller pieces, while the hammer blade serves to crush and mix the material, making it easier to decompose and process into compost. The integration of these two blade types in one organic waste shredder and mixer machine enables the processing to be more efficient, effective, and versatile.

III. RESULTS AND DISCUSSION

This stage presents the results of a series of tests and performance analyses of the organic waste shredder and mixer machine. The testing was conducted to determine how effectively the machine can operate in shredding and mixing organic waste, particularly dry teak leaves, using slicer and hammer-type blades. In addition, the testing aimed to evaluate the machine's work capacity, operational efficiency, and the quality of the final output from the shredding and mixing processes. The data obtained from the trials were then analyzed to assess the overall performance of the machine and to determine the alignment between the planned design and its actual performance in the field.

A. Effective Working Capacity of Machines

The machine's effective working capacity is one of the main parameters used to assess the actual performance of a machine under real operational conditions. This capacity indicates how much material the machine can process within a certain time frame, serving as an indicator of the machine's efficiency and productivity during use. In general, the effective capacity is calculated based on the ratio between the total weight of the material shredded or processed and the machine's operating time during a single cycle or specific testing period. In the first test, the machine was tested using 2 kg of organic waste in the form of teak leaves for a duration of 47.59 seconds. The average effective working capacity of the machine was found to be 138.85 kg/hour, with the amount of shredded material output recorded at 1.83 kg. The test was conducted using the following formula:

$$EC \ (Effective \ Capacity) = \frac{\text{wight of output (kg)}}{\text{time (s)}} \ (kg/hour)$$

$$EC \ (Effective \ Capacity) = \frac{1,85}{0,01367} = 153,33 \ kg/hour$$

The experiment was conducted five times.

Tabel 2 Effective Work Capacity Results

Test	Raw Materials (kg)	Chopping Results (kg)	Chopping time (s)	Conversion from seconds to hours (3,600s)	Effective shredding capacity (kg/hour)
1	2	1,85	49,24	0,01367	135,33
2	2	1,82	46,44	0,0129	141,08
3	2	1,84	47,56	0,01321	139,24
4	2	1,81	45,68	0,01268	142,74
5	2	1,85	49,04	0,01362	135,82
Average	**2**	**1,83**	**47,59**	**0,013216**	**138,85**

Table 2 presents the results of five trials measuring the effective working capacity of the shredder machine using 2 kg of input material. The average output material was 1.83 kg, with an average shredding time of 47.59 seconds. From these trials, the average effective capacity was calculated to be 138.85 kg/hour.
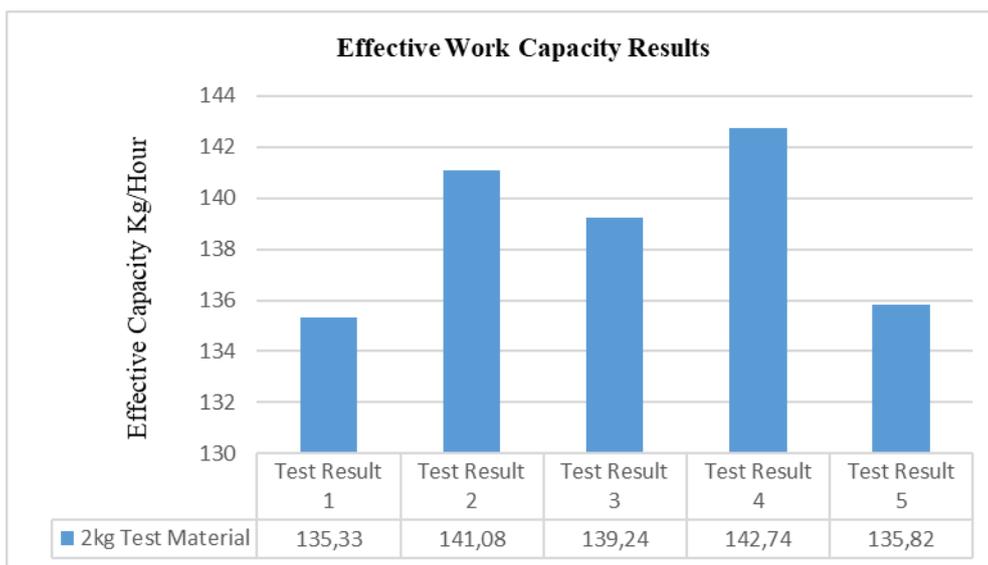.

Figure 4 Comparison of Each Effective Work Capacity Experiment

Figure 4 presents a diagram showing the results of five trials measuring the effective working capacity of the shredder machine, with the highest result recorded in the fourth trial at 142.74 kg/hour. To determine the theoretical capacity, which is used to compare with the machine's effective capacity and to obtain a good shredding efficiency rate, further calculations were conducted. In this study, the organic waste shredder machine uses an electric motor with a rotational speed of 1,400 rpm. The shredding system is equipped with 10 blades, each with a diameter of 0.02 meters and a thickness of 0.005 meters. Additionally, a single saw blade is included as a supplementary element to assist in cutting harder or more fibrous materials.The machine is designed to have a working capacity of approximately 1 kg/hour, tailored to the requirements of the testing process. The test material used in this study is dry teak leaves, a common type of organic waste found in park and residential environments. The teak leaves were prepared in bundles approximately 30 cm in length and 10 cm in diameter to ensure consistent size and volume during the shredding process.Teak leaves were chosen due to their stiff and fibrous physical characteristics, making them suitable for testing the effectiveness of the blades and the overall performance of the shredder. The formula used for the calculation is as follows:

$$\rho = \frac{massa\ (kg)}{volume\ (cm^3)}\ (kg/m^3)$$

$$\rho = \frac{1}{0,002355} = 424,62\ kg/m^3$$

This is the equation for the theoretical capacity in experiment 1:

$$= \frac{blade\ thickness\ x\ high\ contact\ x\ blade\ diameter\ x\ round\ x\ blade\ edge}{number\ of\ saws}$$

$$TC\ (Theoritical\ Capacity) = \frac{0{,}005\ x\ 2\ x\ 0{,}02\ x\ 2\ x\ 424{,}62\ x\ 1.400\ x\ 10}{10}$$

$$TC\ (Theoritical\ Capacity) = \frac{2.377{,}87}{10} = \mathbf{237{,}78\ kg/hour}$$

The experiment was conducted five times.

Tabel 3 Hasil Kapasitas Efektif Kerja

Test	Effective Capacity (kg/hour)	Leaf Density (kg/m^3)	Capacity Theoretical (kg/hour)
1	135,33	424,62	237,78
2	141,08	424,62	237,78
3	139,24	424,62	237,78
4	142,74	424,62	237,78
5	135,82	424,62	237,78

Table 3 shows the results of theoretical working capacity obtained from five exabperiments. The most effective result was obtained at a capacity of 142.74 kg/hour, and the theoretical capacity was obtained at 237.78 kg/hour.
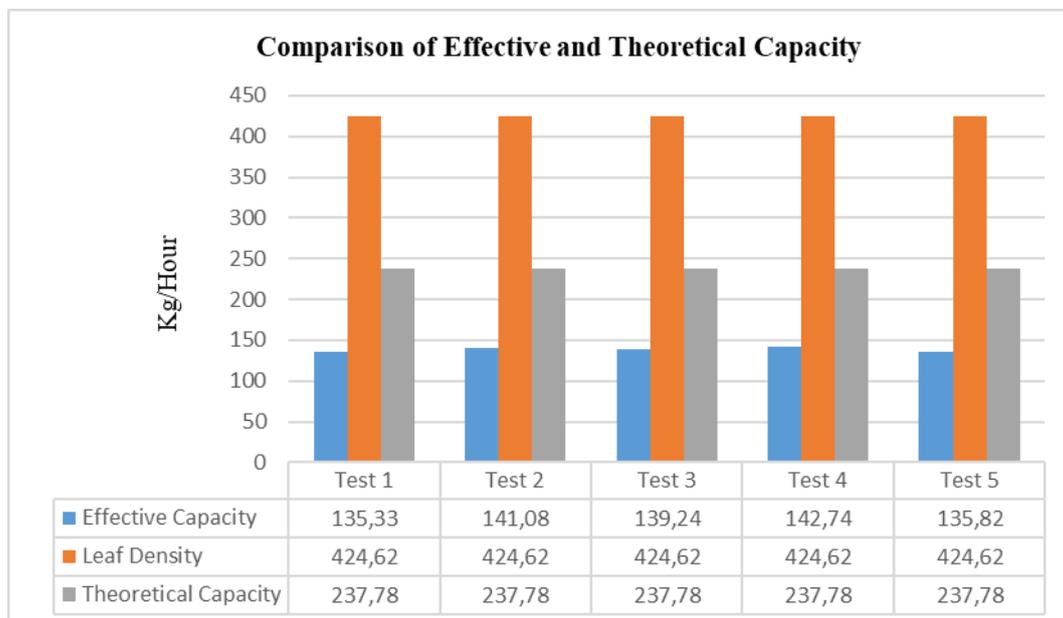

Figure 5 Comparison of Each Effective Work Capacity Experiment

Figure 5 shows a comparison diagram of the results obtained from the effective capacity and theoretical capacity of each subsequent experiment, which yielded a calculation of the density of teak leaves of 424.62 kg/m³ and a theoretical capacity of 273.78 kg/m³.

B. Work Efficiency of Shredding Machines

Work efficiency refers to the ratio of effective working time to available working time. Effective working hours refer to the number of hours actually used for production activities. The calculation formula is as follows:

$$efficiency = \frac{EC}{TC}\ x\ 100\%$$

$$efficiency = \frac{135,33}{237,78} \; x \; 100\%$$

$$efficiency = \mathbf{57} \, \%$$

The results of the first experiment showed that the average efficiency of the grass chopper at a speed of 1,400 rpm was 58%.

Table 4 Machine performance efficiency results

Test	Effective working capacity (kg/hour)	Theoretical working capacity (kg/hour)	Work efficiency (100%)
1	135,33	237,78	57%
2	141,08	237,78	59%
3	139,24	237,78	58%
4	142,74	237,78	60%
5	135,82	237,78	57%
Average			58%

Table 4 shows the work efficiency results for each experiment. The most effective efficiency was obtained in experiment 4, at 60%, and the average efficiency for all experiments was 58%.
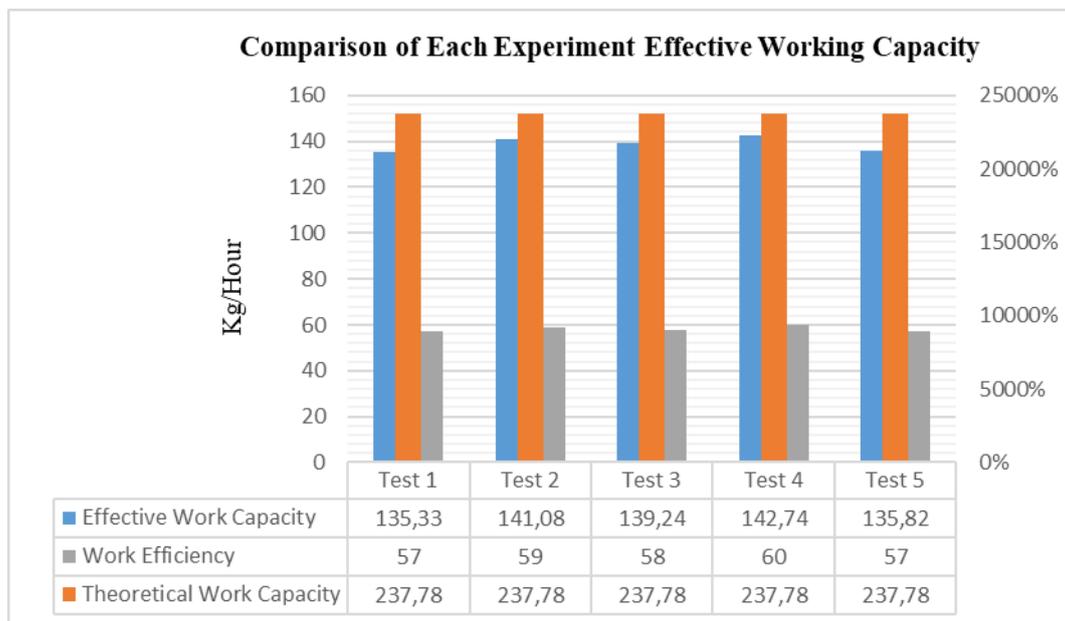
Figure 6 Comparison of Each Effective Work Capacity Experiment

In Figure 6, we can observe the combination of work capacity and work efficiency percentage, which was lowest in test 1 and test 5 with an efficiency of 57% and highest in test 4 with an efficiency of 60%.

C. *Final Quality of Machine Work Results*

The final quality of the shredded dry teak leaves is in accordance with the machine's working capacity and the efficiency of the fine shredding, which can be easily mixed with other materials to produce organic fertilizer. To determine the quality of the mixing process, it is also necessary to achieve maximum machine torque. Based on the calculations, the resulting V-belt rotation speed is 3.81 m/s, with the drive machine having a specification of 3,600 rpm and a pulley diameter of 2.5 inches (63.5 mm). The resulting pulley rotation on the

mixer shaft is 1,125 rpm, generating a higher torque compared to its speed. The calculation is performed using the following formula:

$$VBelt = \frac{motor\ pulley\ diameter\ (mm)\ x\ engine\ speed\ (rpm)}{60.1000}$$

$$VBelt = \frac{63{,}5\ x\ 3.600}{60.000}$$

$$VBelt = \frac{228.600}{60.000} = 3{,}81\ m/s$$

Then calculate the revolutions on the agitator shaft:

$$Pulley\ rotation = \frac{motor\ pulley\ (mm)\ x\ engine\ speed\ (rpm)}{shaft\ pulley\ (mm)}$$

$$Pulley\ rotation = \frac{63{,}5\ x\ 3.600}{203{,}2} = 1.125\ rpm$$

With a V-belt speed of 3.81 m/s and a pulley rotation of 1,125 rpm, the final quality of the mixing process is optimized. As a result, the final quality of the mixing of shredded dry teak leaves with various additional materials can be maximized due to the optimal working torque of the machine, allowing the materials to blend thoroughly and evenly.

Figure 7 Machine Shredding Results

Figure 7 shows the shredded results of dry teak leaves that have undergone the shredding process using the organic waste shredder machine. The output appears in the form of small pieces with relatively uniform sizes. This indicates that the slicer and hammer blades on the machine function effectively in breaking down dry teak leaves into smaller parts. Visually, the texture of the shredded material appears fairly fine and consistent, with no large pieces or unshredded residues remaining. The size of these pieces is considered ideal for composting, as it increases the surface area of the material, thereby accelerating the decomposition process by microorganisms. The consistency and neatness of the shredded results serve as indicators that the machine operates efficiently and effectively, in line with its design objectives. Therefore, this machine has proven to be capable of processing organic waste into compost-ready material, particularly from fibrous and rigid materials such as teak leaves.

IV. CONCLUSION

Based on the results of the conducted research, it can be concluded that the organic waste shredder and mixer machine utilizing a combination of slicer and hammer blades is capable of operating optimally in processing organic materials, particularly dry teak leaves. This machine is able to produce shredded material with relatively uniform sizes, suitable for the composting process. From the test results, the average weight of the shredded output was 1.83 kg with a processing time of approximately 47.59 seconds, which, when converted, yields an effective working capacity of 138.85 kg per hour. This figure indicates that the machine has good productivity for medium-scale operations. The machine's operational system also proved to be efficient,

with an electric motor used to drive the shredding system and a gasoline engine powering the mixing system. This combination of power sources provides stability during the shredding process and sufficient force during mixing. The final shredded output demonstrated good and consistent quality, thus significantly supporting the acceleration of the decomposition process in compost production.

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