



# Development of Shredding Machine for Plastic Recycling

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**Abstract:** This paper covers a project to fulfill the requirement for the award of the Bachelor's Degree of Mechanical Engineering with Honours at Universiti Tun Hussein Onn Malaysia to develop a shredding machine for plastic recycling. Its objective is to shred the plastic waste before it is being melted to create new precious plastic. The main goal of this project is to develop the shredder and propose the improvement after testing the shredder. The shredder was enabling us to shred plastic into smaller pieces for more efficient waste management. This project there describes the design of the shredder and the mechanism used in the shredder. This project is done for recycling plastic waste in the university.

**Keywords:** Develop, Plastic, Recycling, Waste, Shredder, Waste Management

## 1. Introduction

Plastic is a lightweight substance that has led to various product inventions and technologies. Plastic is made up of synthetic organic polymers widely used in various applications such as water bottles, clothing, food packaging, medical supplies, electronic goods, construction materials, and others (Proshad R. et al., 2017). However, plastic demand is increasing at an unprecedented rate, and so plastic waste is produced. The massive growth of Malaysia's economy has resulted in the rise of the waste produced, with the national average is 0.5-0.8 kg/person/day. However, the numbers have risen to 1.7kg/person/day in the cities. Hundreds of millions of tonnes of plastic end up in the landfill. This massive dump expands every day as more garbage comes in and begins to take up space. When the plastics on the landfill are squeezed between layers of other junk, rainwater flows into the waste and collects water-soluble chemicals, some of which are highly poisonous. Together, they produce a toxic stew called leachate that will pass into groundwater, soil, and waterways to poison ecosystems and threaten wildlife. A plastic bottle will take an agonizing 1,000 years to decompose. Plastic is a regular utility that is useful in just about any sector but needs careful disposal, or it can become a threat to the atmosphere.

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This research aims to develop a shredding machine for plastic recycling that will shred plastic. This project is one of the recycling machines that will support the whole ecosystem of plastic recycling activities in UTHM.

## 2. Materials and methods.

### 2.1 Machine description

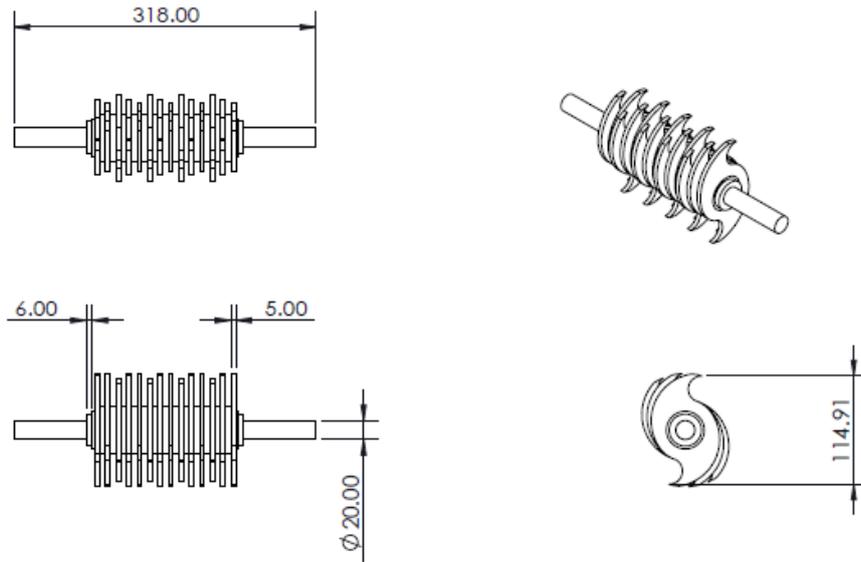
The shredding machine for plastic recycling in this study consists of six main parts: motor, worm gearbox, shredder box, hopper, sieve, and framework. The motor provides the rotation which is needed to rotate the blade shaft. The worm gearbox will provide a significant reduction ratio of the speed output of the motor. The shredder box is the place where the shredding work was performed. The hopper is the part that channeled the plastic waste into the shredder box. Sieve works as a filter that ensures only tiny particles pass through the sieve hole—the framework functions as the mounting place of the machine components.

### 2.2 Materials

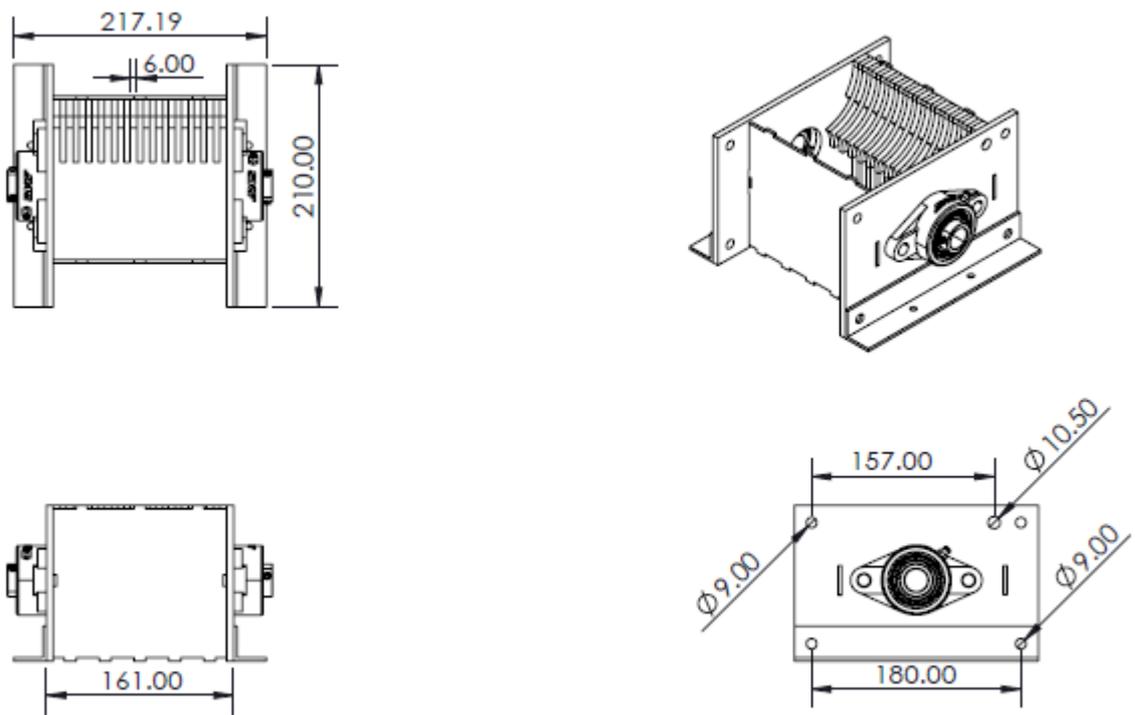
**Table 1 shows the summary of the materials for components of the machines**

No	Component	Material / Specifications	Functions and description
1	Motor	AC motor (1 Hp)	Converts electrical energy into the rotational mechanical energy required to rotate the shaft.
2	Worm gearbox	WPA-60	They lower the input speed so that the output is the right speed, and they increase the torque produced by the motor.
3	Shredder box	AISI304 Stainless steel	The place for shredding plastic and housing for the blade shaft and blades
4	Hopper	Steel	Channel in which plastic waste is poured at regular intervals and from which the plastic waste is supplied to the shredder box
5	Sieve	AISI304 Stainless steel	The filter of the shredded plastic as the end product of the maximum shredded plastic size is the size of the hole on the sieve.
6	Framework	Rectangular hollow tube steel	A platform where all the components can be mounted on.

Figure 1 until Figure 5 shows the components orthographic and isometric views of the shredding machine.



**Figure 1: Blade shaft**



**Figure 2: Shredder box**

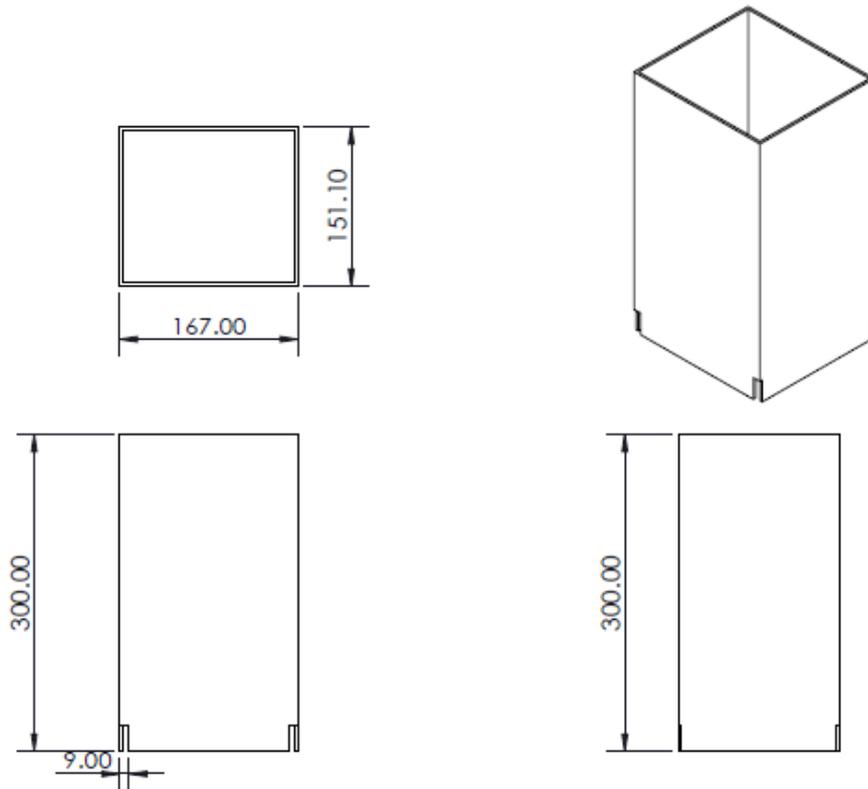


Figure 3: Hopper

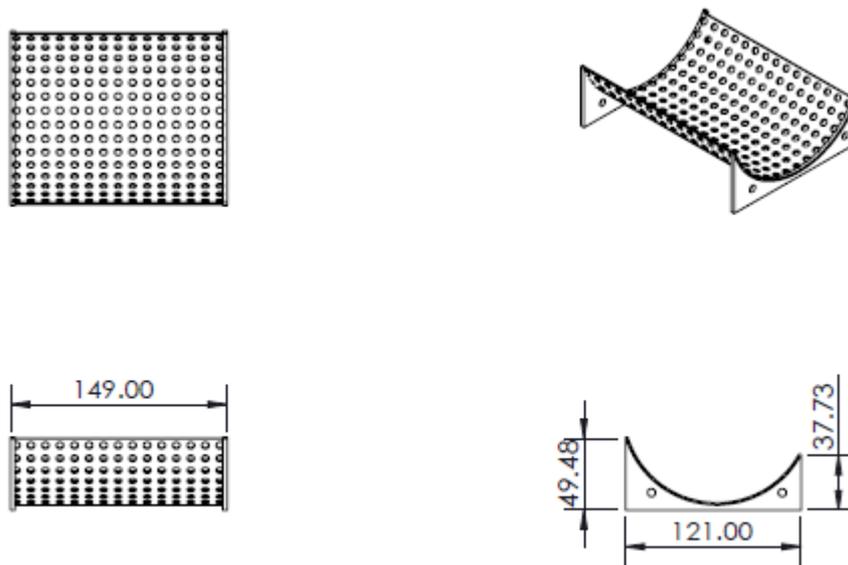
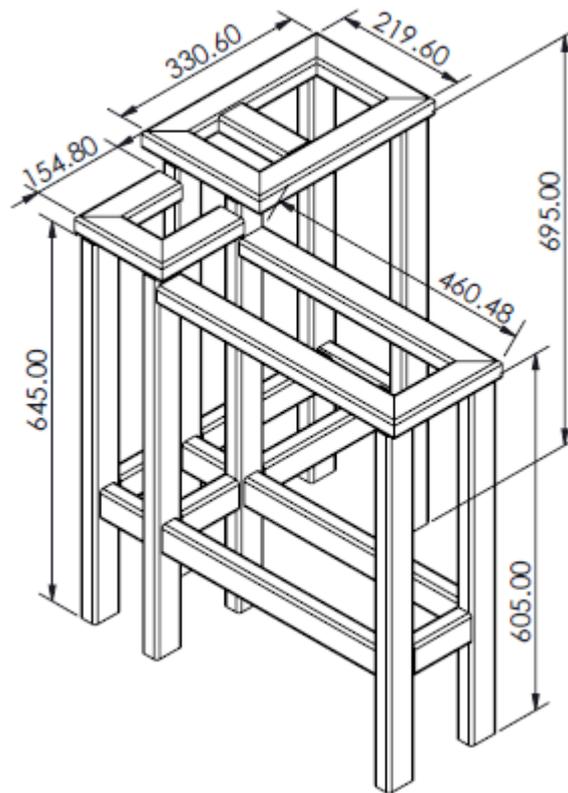


Figure 4: Sieve



**Figure 5: Framework**

The torque of the motor with and without the gearbox can be calculated by using equation 1.

$$Torque = \frac{9.5488 \times Power(kW)}{speed (rpm)} \quad 1$$

## 2.2 Performance evaluation procedure

Polyethylene Terephthalate (PET) was used to test the performance of the plastic shredder machine. A motor shredded the plastic with an output torque of 300 Nm. The time taken off the plastic shredder to shred each type of plastic waste was recorded to determine the efficiency of the plastic shredder. The procedure was repeated with different weights of plastic waste to get the time taken and the plastic's weight. The shredding rate and shredding efficiency were determined by using equation 2 and equation 3.

$$Shredding Rate = \frac{m_i}{t} \quad \text{Eq. 2}$$

Where:

$m_i$  = weight of plastic waste (kg)

$t$  = shredding time taken (sec)

$$\text{Shredding Efficiency} = \frac{m_s}{m_i} \quad \text{Eq. 3}$$

Where:

$m_i$  = weight of plastic waste (kg)

$m_s$  = weight of shredded plastic (kg)

### 3. Results and Discussion

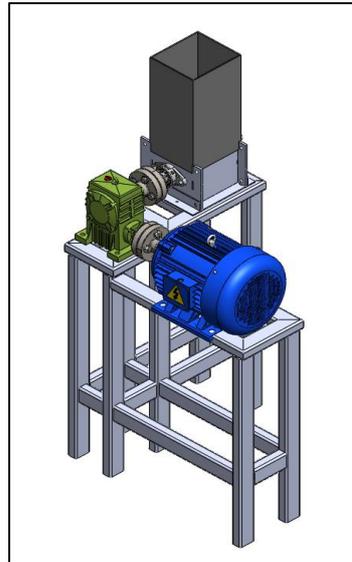
#### 3.1 Fabrication process

Table 2 shows the Bill of Engineering Measurement and Evaluation (BEME) of the machine. It can be seen that the cost of the shredding machine production is lower than the price of commercial products. Although the commercial products were built for a medium-scale recycling community, it is unreasonably overpriced for a small recycling community with approximately 20kg/day of production rate.

**Table 2: BEME**

<b>Description</b>	<b>Material</b>	<b>Quantity</b>	<b>Remarks</b>	<b>Price (RM)</b>
3mm plate	AISI304 Stainless steel	2ft x 3ft	Hardware store	100
5mm plate	AISI304 Stainless steel	13ft x 8ft	Hardware store	200
6mm plate	AISI304 Stainless steel	9ft x 4ft	Hardware store	200
Hexagon bar	AISI304 Stainless steel	32cm	Hardware store	15
3mm sheet	Steel	1ft x 2ft	Hardware store	20
Rectangular hollow tube	Steel	12ft	Hardware store	80
Coupling	FCL-100	2 unit	Hardware store	100
Worm gearbox	WPA-60	1 unit	Hardware store	250
Motor	JY2A-4	1 unit	Automation lab UTHM	0
Bearing	UCFL_204	2 unit	KROMME lab UTHM	0
			<b>TOTAL</b>	965

Figure 6 shows the drawing of the machine model. Figure 7 and Figure 8 show the finished shredding machine.



**Figure 6: Drawing of the machine model**



**Figure 7: Finished shredding machine**



**Figure 8: Finished shredding machine presented by myself as scale**

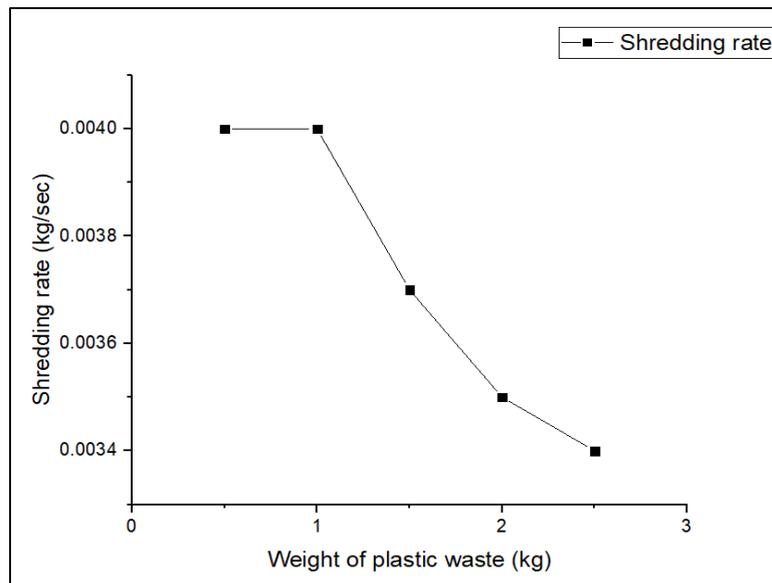
### 3.2 Performance evaluation

The results of the performance evaluation can be seen in Table 3.

**Table 3: Result of PET shredded**

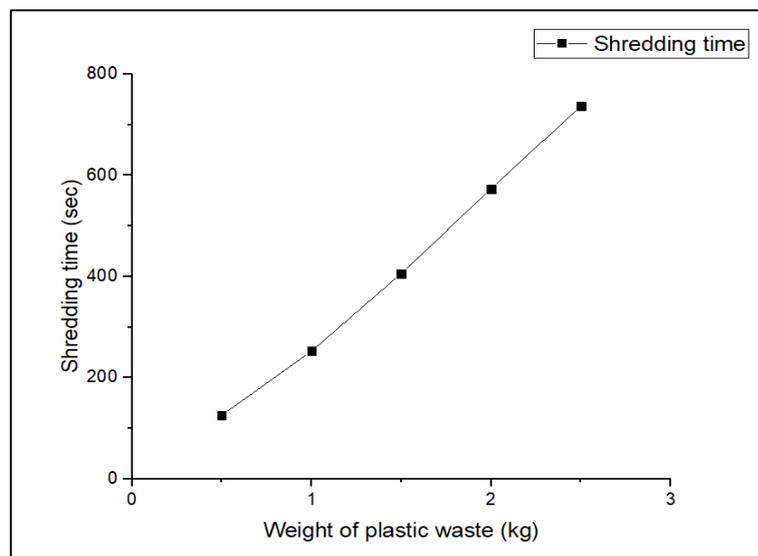
Readings	Test 1	Test 2	Test 3	Test 4	Test 5
Weight of plastic waste (kg)	0.5	1.0	1.5	2.0	2.5
Shredding time (sec)	125.3	252.6	405.8	573.5	737.3
Weight of shredded plastic (kg)	0.46	0.93	1.39	1.86	2.31

Shredding rate (kg/sec)	0.0040	0.0040	0.0037	0.0035	0.0034
Shredding efficiency	0.92	0.93	0.93	0.92	0.92



**Figure 9: Graph of shredding rate against the weight of plastic waste**

Figure 9 shows the graph of the shredding rate against the weight of plastic waste. Based on the graph, it can be seen that the shredding rate of the plastic is decreasing from 0.0040 to 0.0034 as the weight of plastic waste increased. This can happen due to the increasing volume of plastic on the sieve when the blades need to do more work to shred the plastic into a specific size where the shredded plastic could pass through the size of the plastic sieve hole. The shredding rate can be increased if the sieve hole is more significant, and it should not be a problem because the current sieve's hole results in too fine of the shredded plastic. Figure 10 shows the graph of shredding time against the weight of the plastic waste. It can be seen that the shredding time is directly proportional to the weight of plastic waste. Shredding time is related to the shredding rate as more waste will result in more time to shred. The shredding efficiency of the machine is constant from 0.5 kg to 2.5 kg, as can be seen from Table 2, which means the machine was functioning well for small and medium-scale recycling.



**Figure 10: Graph of shredding time against the weight of plastic waste**

#### 4. Conclusion

The goals of developing a machine that could shred plastic waste into flakes useful for small to medium-scale plastic recycling communities in university were achieved. This project is one of the recycling machines that will support the whole ecosystem of plastic recycling activities in UTHM. As a result, we can assist in maintaining our environment free of plastic waste litter.

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