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Manufacturing Process of Cutting Edge of Shredder Plastic Machine Using Material Mild Steel

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ABSTRACT

Plastic waste is a type of waste that is difficult for the soil to decompose and of course its volume increases all the time, however we still need plastic in our daily lives for various needs, for this we need tools that are able to recycle plastic so that it can be reused and become more valuable material. In recycling plastic waste, plastic shredding machines are used to chop plastic waste with various types of cutting edges, various manufacturing methods and various types of chopped products that are formed later. The aim of this research is to recreate or manufacture plastic chopping cutting edges by testing PET plastic chopping with different masses, by manufacturing using a hand grinder as the cutting tool. On a PET type plastic cup with a mass of 20 grams, it took 215 seconds to produce a chop with the smallest dimensions, namely 1mm – 6.35mm. With the cutting blade that has been made, it can chop PET type plastic with the smallest dimensions possible.

Keywords: *Shredding Plastic Machine, PET Plastic, Cutting Edge, Time, Manufacturing Process*

1. INTRODUCTION

Plastic waste is a type of waste with characteristics that are difficult to decompose and it even takes tens or hundreds of years for plastic waste to be completely degraded and its volume also increases from year to year [1]. However, humans also need plastic for their daily lives, so to meet this need it is necessary to process plastic waste to be recycled into new plastic.

There are several methods that can be used in plastic recycling, including mechanical recycling, feedstock recycling and energy recovery, and etc. Therefore, the concept of a plastic shredding machine is one of the recycling methods needed so that recycled plastic flakes can have a high selling value [2].

In general, in order for plastic waste to be processed by a waste industry, it must first change the plastic waste into a certain form such as granules, seeds/pellets, powder, fragments where the size of the PET type plastic shreds is 2.5cm – 3.5cm so that it can be processed into plastic pellets. new.

For this reason, a machine is needed that can process this task, such as a plastic chopping machine to chop large plastic into small pieces, then flow it into a plastic storage hopper and process it in a plastic injection machine, then heat it until it melts and process it in a mold.

The aim of this research is to develop a plastic chopping machine with crusher type cutting edges. The machine must be able to chop plastic efficiently with cutting edge dimensions that have been adjusted and remanufactured on the cutting edge. At this stage the research focused on manufacturing cutting blades and testing the work of cutting blades on plastic chopping machines in order to obtain chopped results with

dimensions that comply with the standard chopped results.

2. METHOD

2.1 Flow Chart

The flow diagram is carried out in several stages as shown in Figure 1.

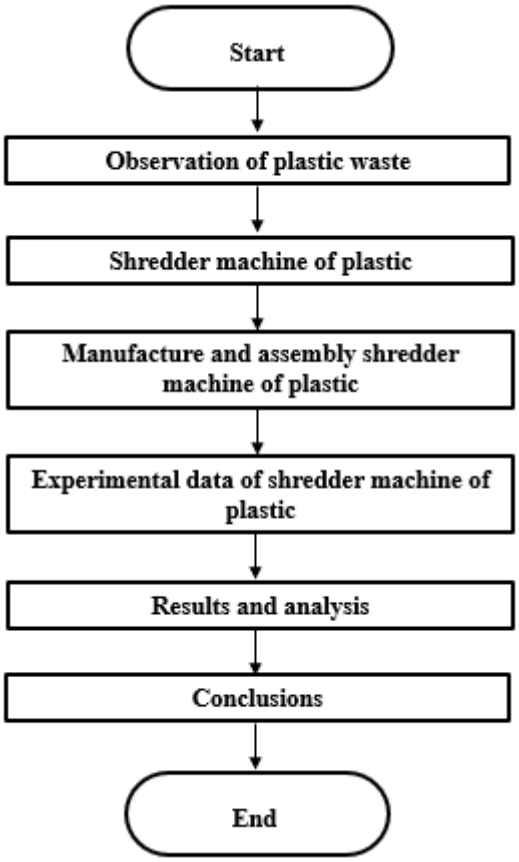

Figure 1. Flow chart diagram

2.2 Plastic

Plastic is a material whose use can be found in every everyday product. Based on research on the impact of plastic use, use of plastic that does not meet the requirements will cause various health problems, such as triggering cancer and tissue damage in the human body (carcinogenic). Burning plastic waste will produce gas that pollutes the air and is dangerous for human respiratory health. Meanwhile, if plastic waste is landfilled, it will pollute the surrounding land and water [3].

There are several types of plastic based on their uses, here are several types of plastic that are commonly used [4]: PETE or PET (Polyethylene Terephthalate), HDPE (*High Density Polyethylene*), PVC (*Polyvinyl Chloride*), LDPE (*Low Density Polyethylene*), PP (*Polypropylene*), PS (*Polystyrene*).

2.3 Plastic shredding machine

Plastic shredding machines are used to cut plastic bottles into smaller sizes. Used plastic beverage cups and bottles are examples of shredded plastic. Plastic can be broken into flakes in several steps.

At first, the plastic is fed into the machine through a funnel. After that, the plastic will be chopped or mixed with a knife into small pieces and then filtered. Flakes that are too large will be cut again into smaller pieces so that the filter can pass through them. The desired result is flakes that have passed through a sieve [5].

Different types of mechanisms in the plastic cutting process were found in a number of studies that have been carried out. The crusher and scissor type is a type of plastic shredding mechanism. The crusher type mechanism has two forms: a knife with two blades or a hook knife with several blades. However, the number of blades required for the crushing mechanism must match the width of the plastic holding hopper.

The scissor-type plastic chopper mechanism is rectangular in shape with sharp blades. The blades of the scissor-type mechanism are connected to the drive shaft, which allows the cutting force generated by the rotation of the machine. In scissor type mechanisms, a minimum of five blades are used. Thus, the scissor type plastic chopping machine has fewer blades than the crusher type plastic chopping machine[6].

There are two types of machines most often used to grind plastic waste, namely crushers and shredders. The two plastic grinding machines are different in chopping used plastic [7].

1. Crusher Type Plastic Shredding Machine

Tiger nails are a type of knife used in crusher milling machines. This plastic milling machine cuts the plastic to be cut and is placed between two knives, a stationary knife and a rotating knife

Figure 2. Crusher Plastic Shredding Machine Type

In general, the two knives look lined up like teeth. In a rotating knife, each row has four seeds, whereas in a rotating axle there are three rows. So, there are about twelve knives in one machine. For knives that don't move, their position will be attached to the wall of the room. The presence of a driving motor causes the machine's rotating blades to rotate at high speed. Later, the drive motor pulley will be connected to the chopping machine pulley.

2. Shreder Type Plastic Shredding Machine

A shredder type machine is a machine that can also be used to grind plastic waste. This plastic grinding machine shreds, but has weaknesses compared to other types of crushers. This is because this shredder machine works slower. However, the strength of this type of machine because it uses a gearbox or worm speed

reducer is its advantage. The knife used is not like a regular knife which is flat and long but has a round shape. On a certain side of this machine there is a ganco which is used to cut plastic into pieces. Based on the type of chopping machine, each has its own advantages and disadvantages, which can be seen in the following table:

a. Crusher Shredding Machine

Advantages: Works fast, can produce desired dimensions, maximum cutting system.

Disadvantages: Not suitable for hard materials

Types of plastic that can be shredded: PET, PP, LDPE

b. Shredder Shredding Machine

Advantages: Can be used on hard materials

Disadvantages: Works slowly, the resulting dimensions are relatively large

Type of plastic that can be shredded: HDPE

2.4 Plastic Waste Processing

A plastic is made through the stages of combining several large molecules or also known as the polymerization stage. According to the National Oceanic and Atmospheric Administration (NOOA), decomposing plastic using natural methods takes a very long time. It takes around 10 to 20 years to decompose one plastic bag, and it takes even more time for a plastic bottle, namely up to 450 years. In an effort to prevent environmental pollution, processing plastic waste is one method to help prevent environmental pollution. Collecting single-use plastics to then recycle them into new plastic pellets to meet human needs, the impact is not only for the environment, but also for the recycling industry which can absorb labor to support the community's economy [8]. The stages of processing plastic waste into plastic pellets are as follows:

1. Waste Collection, collect plastic waste including plastic bottles, plastic cups, buckets, jars, packaging, household equipment and so on.
2. Sorting, in plastic sorting, it is adjusted to the plastic code, color and other parts that need to be separated. By code: Polyethylene Terephthalate (PET), High Density Polyethylene (HDPE), Polyvinyl Chloride (PVC), Low Density Polyethylene (LDPE), Polyprohylene (PP), Polystryrene (PS). By color: this sorting collects plastic based on plastic size combined according to color. This color separation also affects the selling value, because clear or transparent colors have a higher selling value. Parts that need to be separated: in this process, separation is carried out to separate parts that are integrated with the main plastic, but have different types. For example, in a plastic bottle there are 3 parts, namely the bottle cap, packaging label and the body of the bottle itself. The separation aims to enable the polymerization process to become plastic pellets.
3. Enumeration, the aim of the shredding process is to cut the plastic into small pieces, with a shredded mesh size of 2.5cm to 3.5cm. The enumeration process is carried out once based on each type of plastic. Chopping can be done using two techniques, namely dry chopping or without water and wet chopping or with water. The wet chopping process can be done at the same time as cleaning so that it is more effective
4. Washing, washing is determined based on the dirty level of plastic in grades A and B, where grade A has low dirty contamination and is rinsed up to 2 times, while grade B has high contamination, rinsing can be up to 3 times due to contamination such as adhering to IV fluids, grease, oil, glue and others.
5. Drying, the drying process aims to reduce the water content in the chopped plastic so that it does not become damp. Drying can be done by drying on asphalt or tarpaulin or using an oven on an industrial scale.
6. Packaging, the resulting chopped plastic that has been recycled is then converted into plastic pellets and packaged in containers to make it easier to mobilize to the next process or stage to become new items that can be reused.

2.5 Types of Plastic Shredding Knives

The types and types of chopping knives vary based on the need for use, including [4]:

1. Type Claw, this type of knife has a sharp tip and a curved back that is similar to a tiger's claw, which is why it is called a tiger's claw. This type of knife is very good for destroying plastic waste such as buckets, chairs, helmets, and others. The purpose of shaping like this is to reduce the load on the driving machine when the knife touches the plastic waste (cuts it).

2. Type Flake, slightly further back from the nail (blade) this type of knife has a depression or curve shape that is similar to a claw, only the depression is not as deep as the claw. This type of knife is very good for chopping plastic waste from mineral water bottles.

3. Type Flat, this type of knife has one column along the length of the axle if the axle is short, but if the axle is long, it is usually divided into 2 or more columns, which means that most of the axle's circle consists of 3 rows. This type is very suitable for chopping plastic bags.

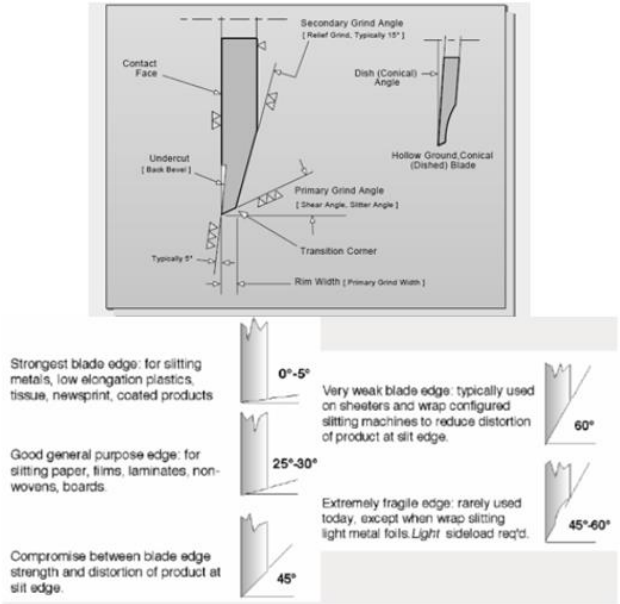

Figure 3. Geometry of Shear Plate[9]

2.6 Blade Geometry

Simple shearing process. When the upper blade moves downwards, both will cut the material until the

material's shear stress exceeds its limit. The thickness of the workpiece determines the success of the shearing process. The blade can penetrate between 30 and 60 percent of the workpiece thickness. The geometry of the shearing blade must be considered in addition to the thickness of the workpiece [10]. Figure 3 shows that a good turning angle for a blade cutter is between 0 and 5 degrees. When two types of material rub against each other, a cutting process occurs. To ensure this process takes place, it is clear that a tool material that is superior to the material used for the workpiece is required. This advantage can be achieved because the chisels are made by considering various aspects, such as

1. Hardness
2. Ductility
3. Tensile stress
4. Shear stress
5. Cutting speed

Shearing or cutting large sheets and producing small sheets by relying on the principle of shear stress.

The cutting force required when cutting can be determined using the formula (2.1)[10]:

$$P = \frac{t \times L \times 0{,}5\ \sigma yp}{10} \quad \text{.....(2.1)}$$

Where:

t = Thickness of the material sheet cut (mm)
L = Cutting length (mm)
σ_{yp} = Yield strength of the material cut (kg/mm^2)

If the space or clearance between the upper cutting edge and the lower cutting edge means the two fracture lines will meet, resulting in a better cutting method [9], the way to determine the cutting force is as follows:

$$F = A.fs \quad \text{.....(2.2)}$$

Where:

F = Force acting on the blade (N)
A = Cross-sectional area of the plastic to be cut
fs^2 = Shear stress of the material to be cut (N/m^2)

$$T = F.r \quad \text{.....(2.3)}$$

Where:

T = Torque on the blade (Nm)
F = Force acting on the cutting edge (N)
r = Radius of cutting edge

2.7 Procedure for Making Cutting Edges

Procedure for Making Cutting Edges:

1. Preparation
   - Determine the need for chopper cutting blades.
   - Make a sketch of the cutting edge of the plastic chopper.
   - Create a detailed image of the cutting-edge using simulation.
2. Manufacturing
   - Make a pattern on the plate to be cut using a marker.
   - Make a center punch at the center point of the material to be drilled so that the center point is not lost and makes it easier to drill the hole using a hand drill.
   - Make a hole in the material with a hole saw drill bit for the inner diameter of the cutting blade and ring which will later become the shaft entry.
   - Perforate the plate according to the pattern made and marked by a center punch with a hand drill with a drill bit.
   - Cut the outer diameter of the ring using a hand drill with a hole saw drill bit.
   - Cut the plate according to the pattern with a hand grinder.
   - Make a hole for the peg in the inner diameter of the cutting blade and ring.
   - Repeat these steps until the number of cutting edges has been determined.
   - Assemble the cutting blade and ring on the chopper box.

2.8 Research Procedures and variables

The research procedures carried out using a crusher type plastic chopping machine are as follows:

1. Prepare plastic waste to be used in the shredding process.
2. Clean and dry plastic waste
3. Weigh the plastic.
4. Separate each variation by stacking them.
5. Put the plastic into the plastic chopping machine.
6. Record the time of the enumeration process.
7. Classify the count results.
8. Measure the dimensions of the chopped results using a ruler.
9. Collect data on the results of the census that has been carried out.
10. Repeat the test again using different plastic weight variations.
11. Carry out another enumeration from the results obtained up to 3 times in the enumeration process with different variations.

The variables used in this research are as follows (see Table 1):

1. Control Variable: Crusher type Plastic Shredding Machine.
2. Free Variable: Plastic Weight.
3. Dependent Variable: Plastic Chopping Yield.

Table 1. Independent Variables

Type of Plastic	Cup of Plastic (PET)		
Weight Plastic (gr)	20	40	60

2.9 Tools and materials

The tools and materials used are as follows:

1. Plastic Shredding Machine

   The plastic chopping machine used is a crusher type chopping machine with component specifications as follows (see Fig. 2 and Fig. 4):

   Shredding Machine : Crusher Type
   Frame Material : Steel
   Frame dimensions : 47cm x 28cm x 83cm
   Counter Box Dimensions : 15cm x 15cm x 16 cm
   Electric Motor : 1100W, 220V, 9.8A
   WPA Gear Box : Ratio 1:50
   Electric Motor Pulley : A1 x 10cm x 2.4cm
   Pulley Gear Box : A1 x 25cm x 1.2 cm

Belt	: A 38
Cutting Eyes	: 15 Cutting Eyes
Silent Cutting Bits 1	: 16 Cutting Bits
Silent Cutting Bits 2	: 15 Cutting Bits
Rings	: 16 Rings

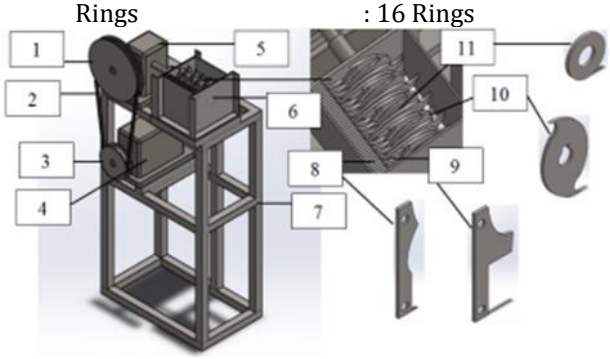

Figure 4. Plastic Shredder Machine

2. Drilling and grinding machine.
3. PET plastic.

4. RESULTS AND ANALYSIS

3.1 Cutting Edge Manufacturing

In this research, the manufacturing method used is manual, where manufacturing is carried out through a manufacturing process without automatic tools or commonly referred to as CNC (Computer Numerically Controlled). The manufacturing process begins with making a pattern on the plate or cutting-edge material, then continues with cutting with a hand grinder and punching holes in the material using a hand drill according to the pattern that has been made until it becomes a cutting edge that matches the design that has been made previously. following:

1. Make a pattern on the plate

The pattern is made with Solidwork at a scale of 1:1 followed by making a pattern on the plate according to the dimensions that have been made as shown Figs. 5 and 6.

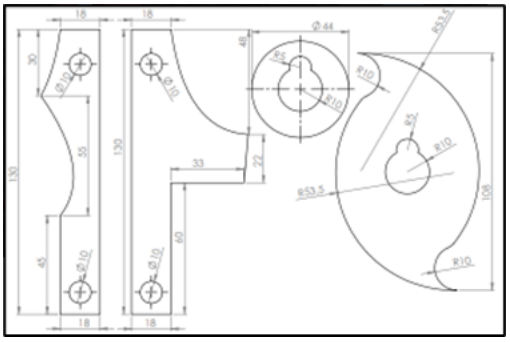

Figure 5. Dimension of cutting edge of plastic and ring

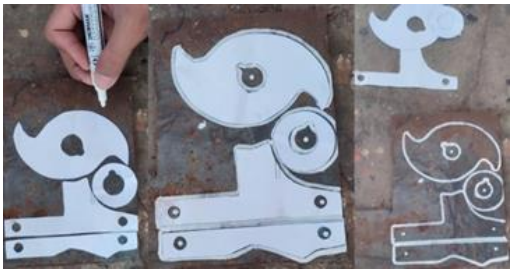

Figure 6. Pattern of of cutting edge of plastic and ring

2. Manufacturing process of shredder plastic machine component such as (see Fig. 7):

- Make a center punch on the plate
  Mark the plate with a center punch in a pattern that has previously been marked with a dot or at the center point of the diameter to be punched, namely at the center point of the cutting blade, ring and also on the still cutting blades 1 and 2 where a hole will later be made as the incoming shaft. The purpose of this marking is so that when the hand drill bit or hole saw drill bit does not miss the specified point.

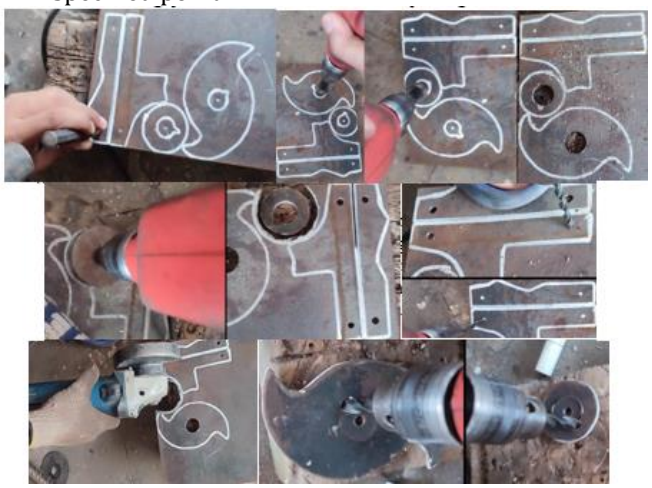

Figure 7. Manufacturing process of shredder plastic machine component

- Make a shaft hole in the cutting blade and ring
  Make a hole in the inner diameter of the cutting bit and ring. The drill bit used is a hole saw drill bit. The inner diameter of the cutting bit and ring is made the same, namely 20mm, using a 20mm hole saw drill bit as the entry point for the drive shaft later. When making a hole, make sure that the point The tip of the hole saw drill bit is right at the center punch mark that has been made on the plate, so that the hole saw drill bit does not move from the specified point and gets maximum results.
- Make a shaft hole in the silent cutting blades 1 & 2
  Make a hole in a stationary cutting bit with a drill bit diameter of 10mm, but to start making the hole, use a smaller size drill bit with the aim of making it easier to make a hole when using a 10mm drill bit and reducing the risk of the drill bit slipping or possibly broken drill bit. The hole point must be adjusted to the center punch mark so that the point does not move when making the hole.
- Cut the outer diameter of the ring
  Cut the outer diameter of the ring of the tool used, namely a hand drill with a drill bit diameter of 44mm, then adjust the center punch point with the tip of the hole saw drill bit, do it slowly so that the drill bit doesn't move, when cutting, try to press the hand drill bit by bit. a little so that the cuts made can produce maximum results.

- Cut the plate according to the pattern and dimensions
  At this stage the cutting is carried out using a hand grinder with a cutting blade. The cutting stage begins with cutting straight patterns followed by cutting radii on the cutting blade until all the patterns are cut from the plate.
- Make a peg hole on the inner diameter of the cutting edge and ring
  Using a hand drill with a drill bit diameter of 5mm then continuing with 10mm, do it slowly to get maximum results.
- Do the same steps until you have the required number of cutting edges, still cutting edges and rings. The number of cutting edges and rings needed is:
  a. Cutting edges = 15 cutting edges
  b. Stationary cutting edge 1 = 16 cutting edges
  c. Silent cutting edge 2 = 15 cutting edges
  d. Rings = 16 rings
- Assemble the cutting edge, stationary cutting edge and ring on the chopper box.
  Assembly is carried out when all the cutting blades are ready to use and make sure that there are no cutting residues that are still attached to the cutting blades or rings, wear gloves when installing the cutting blades on the chopping box to avoid the sharpness of the cutting blades, after that, install the chopping box on the frame. chopping machine as shown Figure 8.

Figure 8. Assembly of cutting edge in the shredder plastic machine

The working time to complete the manufacture of each type of plastic cutting edge chopping machine can be seen in the following Table 2. From the Table 2, the total time required to manufacture each cutting edge and ring is obtained with a total time of 2056 minutes or 34 hours 16 minutes to complete the manufacturing of the cutting edge.

3.2. Mechanics Analysis

In this mechanical analysis, we will discuss the shearing cutting process, where shearing is the process of cutting large sheets and producing small sheets, while the equations used include:

$$P = \frac{t \times L \times 0{,}5\ \sigma yp}{10} \quad \text{.....(2.1)}$$

Where:

t = *thickness* material plate (mm)
L= *Length* of cutting (mm)
σyp= *Yield Strength* (kg/mm^2)

Table 2. Cutting Edge Manufacturing Time

Type of cutting edge	Amount of cutting edge	Time (minute)	Time Total (minute)
Cutting edge 	15	54	810
Cutting edge static 1 	16	46	736
Cutting edge static 2 	15	18	270
Ring 	16	15	240
Time total of manufacturing of cutting edge			2056 menit

The yield strength value of PET plastic is 60

PET σyp = 60 Mpa = 60 N/mm^2 = 6,12 kg/mm^2

After obtaining the σyp value, Fplastic can be obtained for PET type plastic

$$\text{FplasticPET} = \frac{\text{t x L x 0,5 } \sigma yp}{10}$$
$$= \frac{\text{1mm x 100mm x 0,5 x 6,12}}{10}$$
$$= 30{,}6 \text{ kg}$$

The length of the cutting edge is 108mm and the combined material thickness is 1mm. So for the process of chopping plastic to occur, the cutting force must be greater than the force needed to chop the plastic. With the radius formed at the end of the cutting edge resulting from the rotation of the cutting edge, namely 54mm.

$$F = A.fs \quad \text{.....(2.2)}$$

The cross-sectional area of a PET plastic cup is yaitu 5 mm x 100 mm = 500 mm^2 and the shear stress of PET plastic is 0,10368 N/mm^2.

$$F = A.fs$$
$$F = 500mm^2.0{,}10368 \text{ N}/mm^2$$
$$F = 51{,}84 \text{ N}$$
$$T = F.r \quad \text{.....(2.3)}$$

After obtaining the cutting force on the cutting edge, the torque calculation can be obtained using the following formula:

$$T = F.r$$
$$T = 51{,}84\text{N x } 0{,}054\text{m}$$
$$T = 2{,}799 \text{ Nm}$$

After obtaining the value of the influence of torque, the force acting on the cutting edge can be determined using the general torque equation, namely:

$$Th = Fcutting\ edge.\ r$$
$$Fcutting\ edge = \frac{Th}{r}$$
$$Fcutting\ edge = 2{,}799 \text{ kg. m x } 54 \text{ mm}$$
$$Fcutting\ edge = 151{,}146 \text{ kg}$$

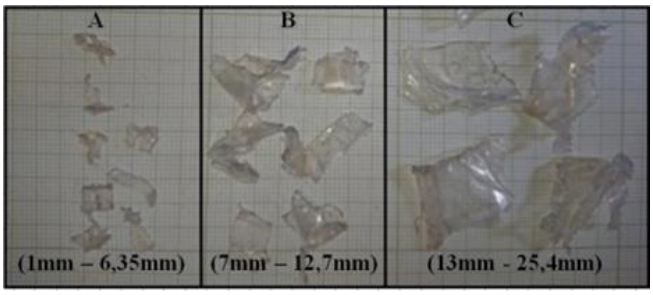

Figure 9. Plastic Chopping Results

3.3. Analysis of Counting Results

The process of chopping PET type plastic using a crusher type plastic chopping machine produces chopped results in the form of small pieces and flakes s shown in figure 9. With a weight input of 20 grams, 40 grams and 60 grams, the results of the chopping are listed in the following Table 3.

From the Table 3 and graphic as shown Figure 10, the results for the first count are obtained, namely by weight:

- 20 grams, It took 2.01 minutes and produced 57% of the chopped results with a size of 13mm – 25.4, 32% of the chopped results with a size of 7mm – 12.7mm and 11% of the chopped results with a size of 1mm – 6.35mm.
- 40gram, It took 4.4 minutes and produced 43% chopped results with sizes 13mm – 25.4, 36.5% chopped results with sizes 7mm – 12.7mm and 20.5% chopped results with sizes 1mm – 6.35mm.
- 60 grams, It took 7.1 minutes and produced 39.3% chopped results with sizes 13mm – 25.4, 37% chopped results with sizes 7mm – 12.7mm and 23.7% chopped results with sizes 1mm – 6.35mm.

Table 3. Results PET Type Plastic Cup Variables 1

Variable	Testing data of plastic Cup PET		
	20 gr	40 gr	60 gr
Time (second)	121 s	268 s	426 s
Thickness (mm)	0,5 mm	0,5 mm	0,5 mm
13 mm - 25,4 mm	11,4 gr	17,2 gr	23,6 gr
7 mm -12,7 mm	6,4 gr	14,6 gr	22,2 gr
1 mm - 6,35 mm	2,2 gr	8,2 gr	14,2 gr

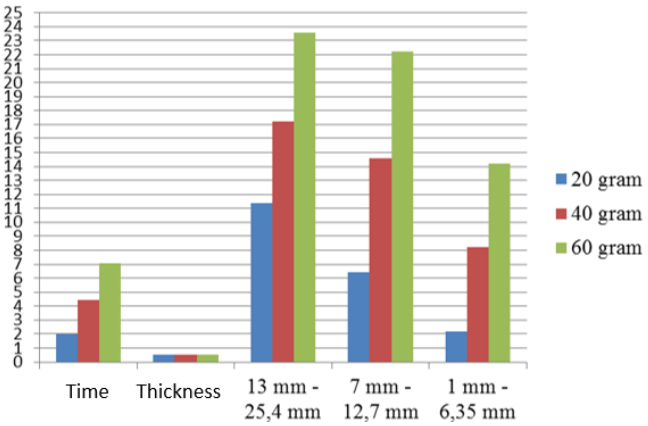

Figure 10. Results of PET Type Plastic Cup Variable 1

After the first enumeration process, the enumeration results will be enumerated again for the second enumeration process as shown in Table 4 and Figure 11.

Table 4. Results PET Type Plastic Cup Variables 2

Variable	Testing data of plastic Cup PET		
	20 gr	40 gr	60 gr
Time (second)	53 s	85 s	121 s
Thickness (mm)	0,5 mm	0,5 mm	0,5 mm
13 mm - 25,4 mm	7,9 gr	10,2 gr	17,8 gr
7 mm -12,7 mm	9,4 gr	17,6 gr	23,1 gr
1 mm - 6,35 mm	2,7 gr	12,2 gr	19,1 gr

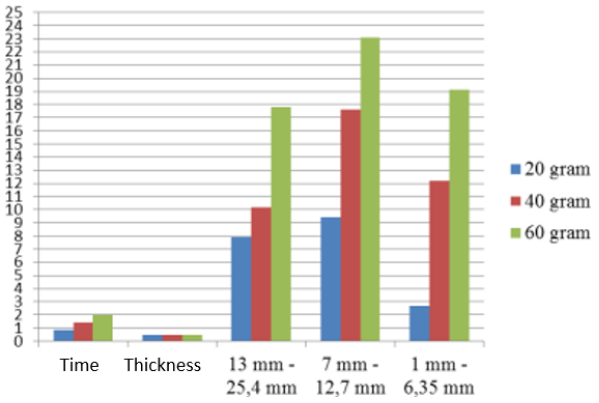

Figure 11. Results of PET Type Plastic Cup Variable 2

In this second counting process, the results will be counted again to see the comparison of the results. From the table and graphic image above, the results for the second count are obtained, namely:

- 20 grams, it takes 0.8 minutes and produces 39.5% of chopped results with a size of 13mm – 25.4, 47% of chopped results with a size of 7mm – 12.7mm and 13.5% of chopped results with a size of 1mm – 6.35mm.
- 40 grams, it took 1.4 minutes and produced 25.5% of chopped results with a size of 13mm – 25.4, 44% of chopped results with a size of 7mm – 12.7mm and 30.5% of chopped results with a size of 1mm – 6.35mm.
- 60 grams, it took 2 minutes and produced 29.7% of chopped results with a size of 13mm – 25.4, 38.5% of chopped results with a size of 7mm – 12.7mm and 31.8% of chopped results with a size of 1mm – 6.35mm.

After carrying out the first and second enumeration processes, the enumeration process continues to the final enumeration process, namely the third enumeration process as shown in Table 5.

Table 5. Results PET Type Plastic Cup Variables 3

Variable	Testing data of plastic Cup PET		
	20 gr	40 gram	20 gr
Time (second)	41 s	74 s	113 s
Thickness (mm)	0,5 mm	0,5 mm	0,5 mm
13 mm - 25,4 mm	3,5 gr	5,6 gr	11,6 gr
7 mm -12,7 mm	7,4 gr	15,4 gr	25,4 gr
1 mm - 6,35 mm	9,1 gr	19,0 gr	23,0 gr

At this final stage of the enumeration process, the enumeration results from enumeration processes one and two are processed again. From the table 5, the results for the third count are obtained, namely by weight:

- 20 grams, it takes 0.6 minutes and produces 17.5% of chopped results with a size of 13mm – 25.4, 37% of chopped results with a size of 7mm – 12.7mm and 45.5% of chopped results with a size of 1mm – 6.35mm.
- 40 grams, it took 1.2 minutes and produced 14% of chopped results with a size of 13mm – 25.4, 38.5% of chopped results with a size of 7mm – 12.7mm and 47.5% of chopped results with a size of 1mm – 6.35mm.
- 60 grams, it took 1.8 minutes and produced 19.4% of chopped results with a size of 13mm – 25.4, 42.3% of chopped results with a size of 7mm – 12.7mm and 38.3% of chopped results with a size of 1mm – 6.35mm.

After carrying out the first counting process until the third counting process with different masses. The results obtained are that the greater the plastic mass, the longer the chopping time and if the smaller the chopping results from each stage of the chopping process, the faster the chopping process and also the more chopping stages, the more chopping results with the smallest size, namely 1mm - 6.35mm, So, the results of the chopping after being chopped up to the third chopping stage produce the smallest chopping results of 1mm to 6.35mm, which is in accordance with the specified standard of chopping results, namely less than 2.5cm - 3.5cm of chopping, which can then be continued for application of the chopping results. to the injection molding machine in the next research or can be processed to make new plastic pellets and have a high selling value.

5. CONCLUSIONS

Based on the results of the analysis of the research that has been carried out, conclusions can be drawn including the following

1. The cutting-edge manufacturing process is carried out using manual methods or without automatic tools such as CNC (Computer Numerically Controlled). The manufacturing process starts with making a pattern on the plate to cutting the plate according to the previously made dimensions. In the process of chopping 20 grams it produces 17.5% of the results of chopping with a size of 13mm - 25.4, 37% of the results of chopping with a size of 7mm - 12.7mm and 45.5% of the results of chopping with a size of 1mm - 6.35mm, 40 grams produces 14% of the results chopped with a size of 13mm – 25.4, 38.5% of the results of chopped with a size of 7mm – 12.7mm and 47.5% of the results of chopped with a size of 1mm – 6.35mm, 60gram produces 19.4% of the results of chopped with a size of 13mm – 25 .4, 42.3% of the results were chopped with a size of 7mm – 12.7mm and 38.3% of the results were chopped with a size of 1mm – 6.35mm. This chopping result is in accordance with the specified chopping standard, namely smaller than 2.5cm – 3.5cm
2. In making 15 cutting edges, 16 type 1 stationary cutting edges and 15 type 2 stationary cutting edges as well as 15 ready-to-use cutting edge rings, it took 2056 minutes or 34 hours 16 minutes or 1 day 10 hours and 16 minutes to complete the whole existing cutting edge. Trial of the cutting edge of the plastic chopper in chopping plastic cups in 3 times the chopping process with a mass of 20 grams took 215 seconds or 3.58 minutes, with a mass of 40 grams it took 427 seconds or 7.12 minutes, and with a mass of 60 grams it took 427 seconds or 7.12 minutes. 660 seconds or 11 minutes with the smallest chopped results with dimensions of 1mm – 6.35mm.

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