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# Construction of Plastic Waste Extruding Machine to Produce Filaments of 3D Printing Machine

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**Abstract—This paper presents the design and development of plastic waste extruding machine to provide 3D printing filaments. The motivation of this research is to create a 3D printer filament from plastic waste using simple machine components. In addition, another goal is to redesign an autonomous-extruding machine to manufacture 3D printing filament. The research process begins with design, needs analysis, machine rebuilding and electrical assembly, machine function testing, analysis of filament, and filament testing in a 3D printing machine. The categories of shredded plastic material were plastic cups (polypropylene, PP) and a mixture of plastic bottles (polyethylene tereptthalate, PET) and plastic cups (polypropylene, PP). The analysis of the research was the capacity of the extrusion machine, the best temperature in producing filaments based on shapes and sizes, and testing of 3D printing filaments of plastic waste which was applied to the 3D printing machine. The result showed that 190°C was the greater temperature to heat the barrel, the machine capacity of each plastic waste category, and the characteristic plastic waste was almost similar compared to the market filament of polylactic acid (PLA) in terms of filament size and 3D printing machine parameter.**

**Keywords—Extruding machine, 3D printing filament, polypropylene, polyethylene terephthalate.**

## I. Introduction

3D printing machine is currently being developed by industrial manufacturers. The 3D printing machine is one of the additive manufacturing technologies which can create objects from plastic material. Plastic categories include Polyethylene Terephthalate, Polypropylene, High Density Polyethylene, Low Density Polyethylene, and Polystyrene. Among the five sorts of plastic, some are frequently used as household materials that become plastic waste yet are not recycled. They are plastic bottles from Polyethylene Terephthalate and plastic cups from Polypropylene. By utilizing an extruding machine, it is trusted that plastic waste that can be processed can be reused for different purposes. Efforts to use 3D printing machines to create plastic waste into valuable components really assist reduce plastic waste.

In the world of mechanical engineering applications, 3D printing machines are very useful for research and development because they can make complex components in the manufacturing process. Apart from that, 3D printing also offers other benefits such as; being easy to manufacture because it only relies on drawings or so-called Computer-Aided Design (CAD), and also produces products with high precision [1]. Because of the advantages of the 3D printing machine, so many industries have started a business to manufacture components from 3D printing machines and applied their machines to create products simply [2].

Plastics are currently one of the environmental issues that every country in the world cares about. The source of the negative effects of plastic is the toxicity available in the plastic itself [3]. This effect will certainly affect the condition of the environment, humans, and marine life. Based on a research report written by the College of Engineering, University of Georgia, USA, that around 275 million tons of plastic waste were generated in 192 coastal countries in 2010, of which 4.8 to 12.7 million tons of plastic waste entered the oceans [4]. From this research, Indonesia is the second-largest country after China which produces plastic waste. According to data compiled by The Ocean Cleanup Foundation, The Netherlands, plastic waste spreads to the oceans through rivers of around 1.15 to 2.41 million tons annually [5]. In fact, water pollution became a big issue due to bad sanitation that could affect the health risk to the people [6].

Until now the handling of plastic waste has not been paid much attention to several manufacturing industries in producing goods because the manufacturing industry players do not place the main focus on environmental issues. In addition, some industries only use plastic as a material in production without thinking about recycling it into new products. This resulted in the absence of handling plastic waste from the industry itself, even though the level of plastic waste produced in the world continued to increase to around 381 million tons in 2015 [7].

To reduce plastic waste, researchers began to innovate through plastic waste extrusion machines. Bhavesh Variya et al. Has designed a plastic extrusion machine that will be used to recycle plastic [8]. The core process in extruding plastics is heating the plastic. The temperature when heating the plastic can be adjusted based on the sensor used in the engine. Jialin Xu et al. studied the temperature regulation of plastic extrusion heaters based on simulations [9]. 3D printing machines also became popular in society. Because the process to create 3D printing machines was relatively easy, some tried to manufacture the machine personally [10] - [11].

The common material of 3D printer machines is plastic such as polyactic acid (PLA), acetonitrile butadiene styrene (ABS), high impact polystrene (HIPS) dan polyvinyl alcohol (PVA). On the contrary, V. Miron studied filament of 3D printers with materials of tailor which was considered satisfaction to be applied in 3D printing machines [12]. Recycled plastic of polyethylene terephthalate (PET) had also been researched by Mark Exconde. By redesigning the breadboard to the light lamp, PET material as sources of filament could be formed to be breadboard using a 3D printer machine [13].

However, the research of extruding machines studying the construction of machines at most focused on producing filament result conventionally. In addition, the filament produced by the extruding machine was not intended for 3D printing filament. This paper studies that the extruding machine produces filament for 3D printing machines which would be compared with the market 3D printing filament. The scope of this study is that good filament from plastic waste can be applied in 3D printing machines with categories of nozzles in the machines. The recruitments of good filament were considered by observing hot end temperature, machine table temperature, filler percentage, printing speed, and nozzle size and visual of filament surface. In addition, the capacity of extruding machine to produce 3D printing filament was measured. The way to produce its filament is to reconstruct the extruding machine to be autonomous in operation.

## II. Methodology of Mechanical Design

To get the ideal condition of the machine, the first step of reconstruction is to consider the design of the machine. The machine was designed using CAD software. Several considerations to produce the filament of 3D printing machines through the extruding machine are (1) the size of the filament should be on average, (2) the structure does not contain any bubble inside, and (3) the result of the filament is not burnt.

The first generation of the extruding machine only focused on recycling plastic waste of polyethylene. The main process of the machine was heating the barrel in which the small pieces of plastic were ready to be burnt. The analysis of the previous machine was the barrel temperature to heat the plastic, filament size, and surface roughness of filament. From those analyses, the filament with 190°C was the best temperature to produce filament based on solid size from the average diameter and surface roughness test [14].

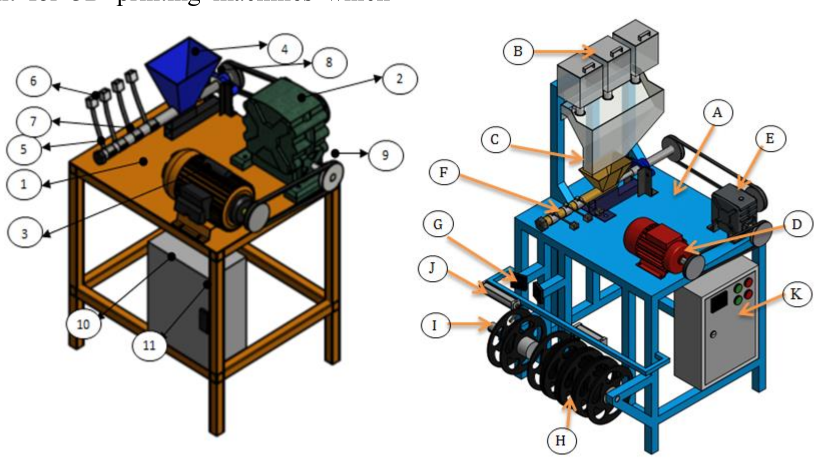
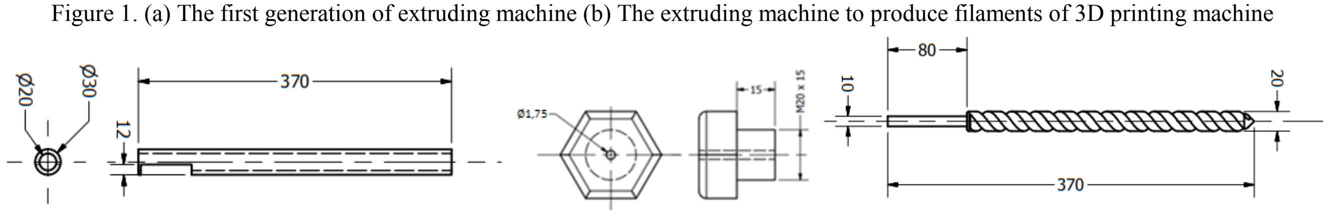



Figure 1. (a) The first generation of extruding machine (b) The extruding machine to produce filaments of 3D printing machine




(a) (b) (c)

Figure 2. Designs of (a) barrel (b) nozzle and (c) lead screw

Table 1. Comparison between the existing method and the proposed method

| Features | Existing method [14] | Proposed method |
|---|---|---|
| Operation | Push button | Android application |
| Rolling method | Conventional | Automatic |
| Plastic waste | Polyethylene terepththalate | Polypropylene and polyethylene terepththalate |
| Product result | Line filament | 3D printing filament |

The components of the previous extruding machine were (1) frame, (2) reducer, (3) motor, (4) hopper, (5) nozzle screw, (6) band heater, (7) barrel set, (8) bearing, (9) pulley and belt transmission, (10) electrical box, and (11) thermostat. Steel is the material used for barrels. Screws are paired up inside the barrel to push the plastic out. The nozzle is a component that molds the extruded plastic after the plastic has been heated. The nozzle circle is 4 mm in diameter, which means the solid filament result should be about 4 mm in diameter.

It is different with filament used in 3D printing machine. The innovation has been applied to mold filaments for 3D printing machine. Three plastic boxes function to place the shredded plastic with each kind of plastic. In addition, the fan is available to freeze result of filaments after heating. This process is important to get the same diameter of filament before being rolled. The last innovation is automatic filament roller machine to entwine the filament. Complete components of the machines are (a) frame, (b) plastic boxes, (c) hopper, (d) motor AC, (e) reducer, (f) barrel, (g) fan, (h) ready-to be filled roller, (i) filament roller, (j) pneumatic, and (k) electronic box.

Figure 2 shows designs of barrel set to heat the plastic. At the end of barrel, there is a nozzle to mold the filament into size of 1.75 mm and 3 mm. The size was determined as original filaments produced in industry were those sizes. The matric drag is available on nozzles to replace easily. Lead screw has function to push the heated plastic into nozzle. The length and diameter of lead screw have been measured to get the ideal volume of heated plastic.

After finishing the extruding machine, 3D printing filament can be produced with the filament size of 1.75 mm and 3 mm, customized with the market filament. Combination between Polyethylene Terepththalate and Polypropylene has been tried in 3D printing machine. The trial and error method was done in order to get the suitable 3D printing filament in the 3D printing machine.

## III. RESULTD AND DISCUSSION

### *A. Mechanical Construction*

The assembly process of each component applied the SMAW welding method and the bolt-nut method. The first component to be assembled was the barrel welded to the stand. The barrel holder was made a hole to connect the barrel and its holder to the frame. After that, install the screw in the barrel. The process of joining components to the frame also used the bolt-nut method. Some of the components that were combined were the barrel and holder, bearings, electric motor and gearbox. After placing the components on the frame, the pulley was installed on the electric motor, gearbox and on the screw shaft. Then do the belt installation by paying attention to the alignment of the pulley side.

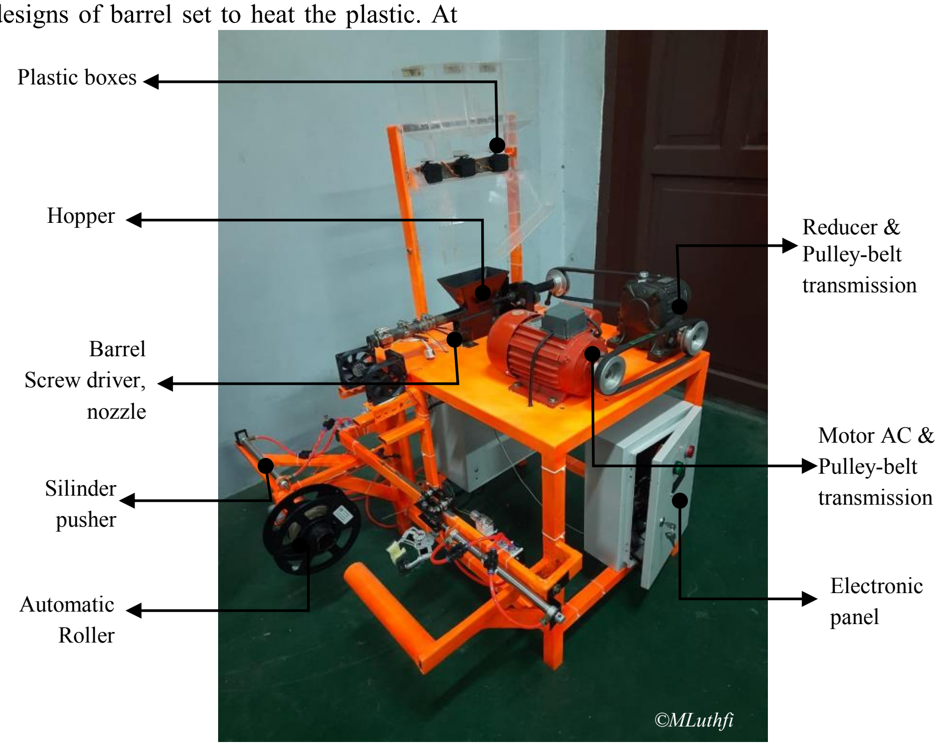



Figure 3. Construction of extruding machine

## *B. Electronic and Control Machine*

The automation system in this study was divided into two types, namely the extrusion process and the extruded filament handling process. In the extrusion process, the controlled components were three servo motors, AC motors, size of 16x2 display, 2 channel relays, and 3 heaters. The main control is the Arduino uno AT Mega 2560. Then the input used is the thermocouple and bluetooth HC-05 module which would be connected to the MIT APP inventor. MIT APP Inventor is Android application that is open source from Massachusetts Institute of Technology. On the other hand, in the filament handling process, the components used were servo motors, 2 5/2 valves, a 250mm cylinder, a DC motor, and a 220V relay. The main control for controlling was the Arduino uno AT Mega 2560 and the input used is an infrared sensor and a push button connected to a relay.

The MIT Inventor application served to create an android-based control system. The application was developed by the Massachusetts Institute of Technology and can be accessed via the web. The application design featured an extruder motor button, a bluethooth connection button, a set time, a reset time, a display delay time, a temperature set, a heater temperature reading, and a plastic chopping valve button. To connect the android application with the microcontroller, the HC-05 Bluetooth module was used. The function of the HC-05 Bluetooth was to send serial information to the microcontroller.

To find out the best temperature for extruding plastic waste in chopped shape, testing was necessary. The data collection process was carried out on two types of plastic as a material, namely chopped plastic cups (*polypropylene*) and a mixture of chopped plastic bottles and plastic cups (*polyethylene terepththalate* and *polypropylene*). Each type of plastic was stored separately in a shredded storage box. Some of the tools used in data collection were; extrusion machine with 3 mm nozzle, stopwatch, 5 kg digital scale, and digital varnier caliper.

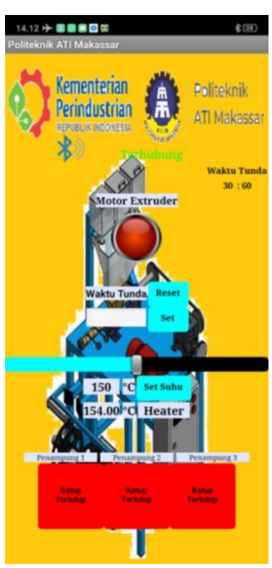



Figure 4. Android app view

## *C. Experimental Test*

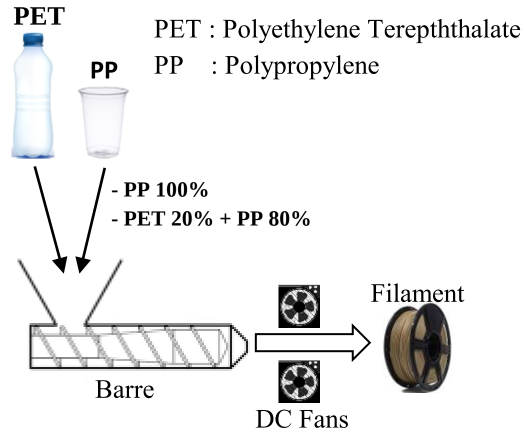



Figure 5. Android aplication view

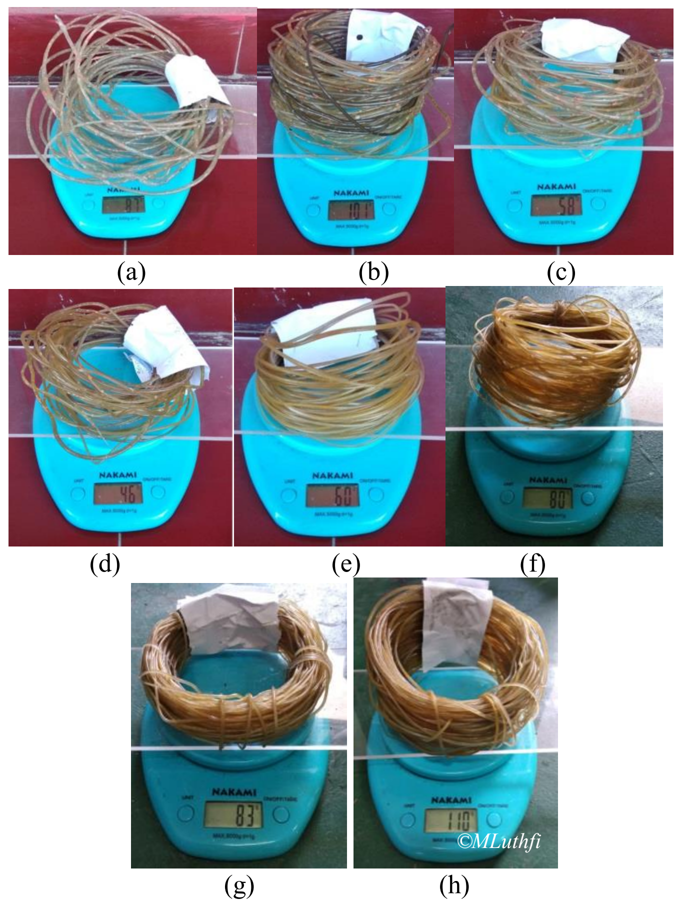



Figure 6. Extrusion result of polypropylene plastic waste with temperature of (a) 150°C, (b) 160°C, (c) 170°C, (d) 180°C, (e) 190°C, (f) 200°C, (g) 210°C, (h) 220°C

The process of extrusion started from the preparation of shredded plastic which put in a separate box. The shredded plastic entered to barrel through hopper. The filament would be formed by nozzle and be frozen by 2 DC fans. To get the ideal of motor speed, the researchers have been studied to do trial and error on machine. In result, the speed of motor to drive filament was 72 RPM and the speed of motor to roll the filament was 54 RPM. The tests have been carried out many times to get the best parameter of barrel temperature. However, the extrusion test for the shredded plastic bottles of the polyethylene terepththalate did not come out of the nozzle. This was because the type of material and the thickness of the plastic in the plastic bottle were different. So that in the plastic bottle extrusion test, it is necessary to combine it with polypropylene plastic cups. The greatest combination between both was 80% of polypropylene and 20% of polyethylene terepththalate. In addition, polypropylene plastic cup could become solid filament in some temperature of barrel.

In Figure 6, it can be seen the comparison of the extrusion of plastic glass in the form of filaments. Experiments were carried out by comparing the temperature of the barrel in melting the plastic, from a temperature of 150°C to 220°C. From the visual, the temperature of 190°C had a perfect filament shape. This was different from the temperature of 150°C to 180°C, which had white spots which indicated that the plastic was not completely melted. However, for extruded filaments a temperature of 200°C to 220°C had a non-straight structure as well as 190°C.

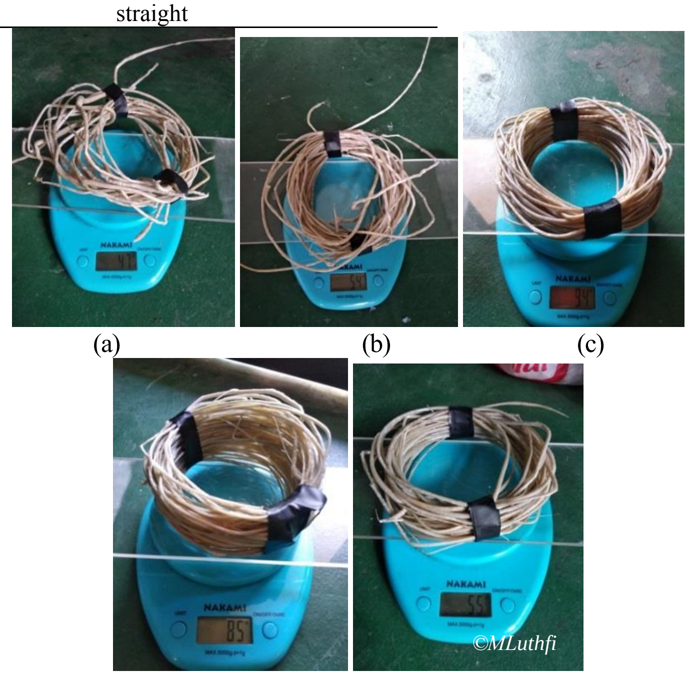
In table 2, It appears that the data from the extrusion of polypropyleneplastic plastic cups with temperature variations. Any temperature set from 150°C to 220°C could melt shredded plastic cups. The fastest extrusion time was 220°C and the longest was 150°C. In data collection, the weight of the extruded plastic glass was also calculated. From this data, a benchmark for how much chopped plastic cup was needed when extruding can be taken.

Table 2. Extrusion result data of polypropylene plastic cups

| Temeperature (°C) | Time needed to release filament (Minutes) | Melted result | | | Total time (Minutes) | Berat (gram) |
|---|---|---|---|---|---|---|
| | | Solid (Yes/No) | Continuity (Yes/No) | Strightness (Straight/ non-straight) | | |
| 150 | 2,45 | Yes | Yes | Stright | 20 | 58 |
| 160 | 2,43 | Yes | Yes | Stright | 20 | 67 |
| 170 | 2,40 | Yes | Yes | Stright | 20 | 57 |
| 180 | 2,28 | Yes | Yes | Stright | 20 | 46 |
| 190 | 1,10 | Yes | Yes | Stright | 20 | 60 |
| 200 | 1,25 | Yes | Yes | Non-straight | 20 | 80 |
| 210 | 1,08 | Yes | Yes | Non-straight | 20 | 83 |
| 220 | 1,08 | Yes | Yes | Non-straight | 20 | 110 |

Table 3. Size of polypropylene plastic cups in diameter

| Number | Temperature | Test (multiply) | Solid diameter filament (mm) | |
|---|---|---|---|---|
| | | | Result | Average |
| | | 1 | 3,78 | |
| 1 | 150 | 2 | 4,10 | 3,73 |
| | | 3 | 3,31 | |
| | | 1 | 3,05 | |
| 2 | 160 | 2 | 2,35 | 2,76 |
| | | 3 | 2,90 | |
| | | 1 | 3,06 | |
| 3 | 170 | 2 | 2,90 | 2,74 |
| | | 3 | 2,28 | |
| | | 1 | 2,26 | |
| 4 | 180 | 2 | 2,88 | 2,69 |
| | | 3 | 2,94 | |
| | | 1 | 2,53 | |
| 5 | 190 | 2 | 2,81 | 2,57 |
| | | 3 | 2,38 | |
| | | 1 | 2,35 | |
| 6 | 200 | 2 | 2,12 | 2,38 |
| | | 3 | 2,67 | |
| | | 1 | 1,42 | |
| 7 | 210 | 2 | 2,16 | 1,85 |
| | | 3 | 1,99 | |
| | | 1 | 2,46 | |
| 8 | 220 | 2 | 2,85 | 2,68 |
| | | 3 | 2,75 | |




(a) (b) (c)

(d) (e)

Figure 7. extrusion result of mixed polyethylene terepththalate plastic bottles and polypropylene plastic cups with temperature of (a) 170°C, (b) 180°C, (c) 190°C, (d) 200°C, (e) 210°C

Table 3 shows the diameter size of the extruded plastic glass of polypropylene. The size of the nozzle was 3 mm. so that the extruded product should not be more than 3 mm and less than 2.5 mm. The process of measuring filaments used a digital vernier caliper with a Mitutoyo brand with a tolerance of 0.05mm. This measuring tool was used in order to get an accurate value. The measurement results showed that temperatures of 160°C, 170°C, 180°C and 190°C had a filament diameter of 2.5mm to 3mm, while the temperature of 150°C had a filament diameter of 3.73mm which exceeded the diameter of the nozzle. In addition, 200°C, 210°C, and 220°C had filament sizes which were considerably less than the size of the nozzle.

In figure 7, it appears the comparison of the extrusion results from the comparison between polyethylene terepththalate plastic bottles and polypropylene plastic cups in the form of filaments. The combination ratio was 80% polypropylene plastic cups and 20% polyethylene terepththalate plastic bottles. This test was carried out by comparing the hot temperature of the barrel in melting the shredded plastic, which was from a temperature of 150°C to 220°C. From the visual, the temperature of 190°C had a filament shape that was more perfect than the other filaments. However, for temperatures of 150°C, 160°C, and 220°C, there was no filament at all. This was different from the temperature of 170°C and 180°C, which had an irregular shape which indicated that the plastic was not completely melted. However, for extruded filaments, the temperature of 200°C and 210°C had a non-straight structure as well as 190°C.

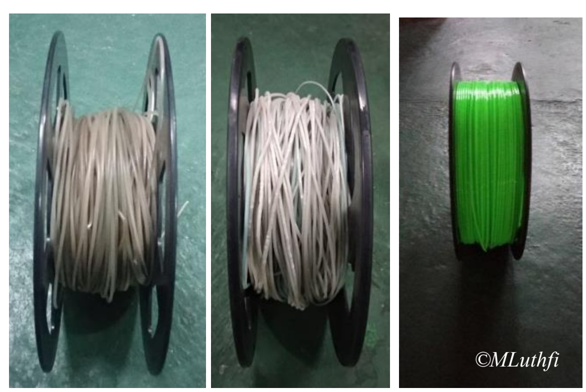
Table 4. Extrusion result data of mixed polyethylene terepththalate plastic bottles and polypropylene plastic cups

| Temeperature (°C) | Time needed to release filament (Minutes) | Melted result: Solid (Yes/No) | Continuity (Yes/No) | Strightness (Straight/ non-straight) | Total time (Minutes) | Berat (gram) |
|---|---|---|---|---|---|---|
| 150 | *No filament out* | | | | | |
| 160 | *No filament out* | | | | | |
| 170 | 1,31 | Yes | Yes | Straight | 20 | 47 |
| 180 | 1,22 | Yes | Yes | Straight | 20 | 54 |
| 190 | 1,14 | Yes | Yes | Straight | 20 | 94 |
| 200 | 0,59 | Yes | Yes | Non-Straight | 20 | 85 |
| 210 | 1,10 | Yes | Yes | Non-Straight | 20 | 55 |
| 220 | 1,06 | No | No | Non-Straight | *Non-measured* | |

In table 4, it can be seen the data from the extrusion of mixing between polyethylene terepththalate plastic bottles and polypropylene plastic cups with temperature variation settings. From a temperature set from 170°C to 210°C it can melt the chopped plastic. However, for a temperature of 220°C, it is too liquid to produce an unsustainable melt. Meanwhile, 150°C and 160°C did not produce plastic melt at all. In data collection, the weight of the extruded plastic was also calculated. From this data, a standard for how much chopped plastic was needed when extruding can be taken.

Table 5. Size of mixed polyethylene terepththalate plastic bottles and polypropylene plastic cups in diameter

| Number | Temperature | Test (multiply) | Solid diameter filament (mm): Result | Average |
|---|---|---|---|---|
| 1 | 170 | 1 | 3,04 | 2,66 |
| | | 2 | 3,40 | |
| | | 3 | 2,55 | |
| 2 | 180 | 1 | 2,10 | 2,51 |
| | | 2 | 3,30 | |
| | | 3 | 2,13 | |
| 3 | 190 | 1 | 2,68 | 2,64 |
| | | 2 | 2,73 | |
| | | 3 | 2,52 | |
| 4 | 200 | 1 | 2,50 | 2,63 |
| | | 2 | 2,74 | |
| | | 3 | 2,66 | |
| 5 | 210 | 1 | 2,44 | 2,59 |
| | | 2 | 2,80 | |
| | | 3 | 2,55 | |




(a) (b) (c)

Figure 8. Filaments of 3D printing from (a) polypropylene plastic cups, (b) polyethylene terepththalate plastic bottles, and (c) polylactic acid (PLA)

In table 5, it can be seen that the diameter size of the extrusion of between polyethylene terepththalate plastic bottles and polypropylene plastic cups is combined. The size of the nozzle was 3 mm. so that the extruded product should not be more than 3 mm and less than 2.5 mm. The process of measuring filaments used a digital varnier caliper with a Mitutoyo brand with a tolerance of 0.05mm. This measuring tool was used in order to get an accurate value. The measurement results showed that a temperature of 170 to 210°C had a filament diameter of 2.5mm to 3mm. However, temperatures of 170°C and 180°C had a diameter of more than 3 mm. In addition, for a temperature of 220°C there was a part of the filament diameter that was below 2.5 mm. This made the surface of the filament less flat. Unlike the case with temperatures of 190°C and 200°C which had a diameter range of 2.5 mm to 3 mm.

In general, there are two types of 3D printing filament sizes, 3 mm and 1.75 mm in diameter. However, the average 3D printing service entrepreneur has a machine with a choice of 1.75 mm filaments. So that in the production of plastic waste filaments in the extrusion machine using a nozzle that produces a filament size of 1.75 mm. Based on previous data collection, the extrusion temperature in the machine for producing filaments was 190°C. The motor speed was 72 RPM and the roll motor speed was 54 RPM.

Testing of extrusion machines by producing plastic waste filaments has been carried out. The weight of plastic waste tested starts from 50 grams, 100 grams and 150 grams. From this test, 3D printing filaments were obtained from plastic waste that was tested on a 3D printer machine. Seen in Figure 8 (a) and (b), the extrusion filaments were from plastic waste. From the visual, it can be seen that the PP filament had a brighter color than the PET and PP mixed filament, which is pale in color. Apart from that, PP filaments also had fine surface roughness, whereas mixed PET and PP filaments were very coarse.

From the machine function test, it can be seen the capacity of the extrusion machine in extruding plastic waste. It is found in table 6 that the machine capacity in extruding polypropylene plastic glass (PP) to produce 3D printing filaments is 83.11 grams/hour. In contrary, the machine capacity for extruding the combined PET and PP plastic was 179.84 grams/hour. So that it can be seen that the combined filament has a higher and faster production capacity. This is because PET plastic is too liquid when extruded.

Table 6. Capacity of PP filament and mixed PET and PP filament

| Weight of Plastic PP (gram) | Total time of extrusion | Weight of filament result (gram) | Smallest filament in diameter (mm) | Bigger filament in diameter (mm) | Machine capacity (gram/hr) |
|---|---|---|---|---|---|
| 50 | 27 min | 37 | 1,57 | 1,97 | 82,2 |
| 100 | 59 min | 82 | 1,67 | 1,98 | 83,38 |
| 150 | 1 hr 26 min | 120 | 1,64 | 2,03 | 83,72 |
| **Average Machine Capacity of PP filament** | | | | | **83,11** |

| Weight of PET Plastic Waste 20% (gram) | Weight of PP Plastic Waste 80% (gram) | Total time of extrusion | Weight of filament result (gram) | Smallest filament in diameter (mm) | Bigger filament in diameter (mm) | Machine capacity (gram/hr) |
|---|---|---|---|---|---|---|
| 10 | 40 | 16 min | 47 | 1,50 | 1,83 | 176,25 |
| 20 | 80 | 31 min | 94 | 1,52 | 1,98 | 181,93 |
| 30 | 120 | 44 min | 133 | 1,51 | 1,80 | 181,36 |
| **Average Machine Capacity of mixed PET and PP** | | | | | | **179,84** |

*D.Printing in 3D Printing Machine*

In this research, to determine the success of the plastic waste filament produced, it is necessary to experiment by printing several samples on a 3D printer machine. From this experiment, plastic waste filaments will be compared with market-type PLA filaments. To get the correct 3D printing parameters for plastic waste filaments, trial and error was carried out on several parameters. Among these parameters are hot end temperature, machine table temperature, filler percentage, printing speed, and nozzle size. Meanwhile, PLA filaments already have standard parameters according to the buyer's instructions for use. From the experiments conducted to print designs from plastic waste filaments, it was found that the best 3D printing parameters for plastic waste filaments, both types of PP and a combination of PET and PP, are clear in table 7.

Table 7. Parameter of 3D printing

| Parameter | Plastic Waste Filament | Filament of PLA |
|---|---|---|
| Temperature of hot end | 230°C | 210°C |

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| | | |
|---|---|---|
| Temperature of machine table | 50°C | 60°C |
| Filler percentage | 100% | 100% |
| Spee of printing | 100% | 100% |
| Size of nozzel | 1 mm | 0,4 mm |

Figure 9 shows the printout on a 3D printing machine using PLA filaments and plastic waste filaments both PP and mixed PET-PP. The print parameters on the machine use the parameters according to table 7. There are three images that were tested for printing. In terms of the dimensions of the printouts, plastic waste filaments were not much different from PLA filaments. Apart from that, from the visual results of the printouts, plastic waste filaments can be as thin as PLA filaments. Nonetheless, the color of the PP plastic waste filament is uneven. This is due to a mixture of plastic glass waste types. Meanwhile, the combined PET and PP filaments have an even color, that is, the color tends to be white.

(c)

Figure 9. Result of 3D printing machine form (a) PLA filament, (b) PP filament, and (c) combination of PET and PP filament

## IV. Conclusion

This paper explored the plastic waste extruding machine to create 3D printing filaments from polyethylene terepththalate plastic bottles and polypropylene plastic cups. The filament criteria of pure polypropylene plastic cups and mixed polyethylene terepththalate plastic bottles and polypropylene plastic cups were taken into account to distinguish with market filament of PLA. The filaments were printed in a 3D printing machine once they were manufactured. As a result of this research, the following statement may be made:

a. The best temperature to mold the plastic waste was 190°C not only for polypropylene plastic cups but also combined polyethylene terepththalate plastic bottles and polypropylene plastic cups.
b. 3D printing filaments made from plastic waste have been produced using extrusion machines. The types of plastic waste that can be produced are pure polypropylene plastic cups with a production capacity of 83.11 grams/hour and combined plastic waste between polyethylene terepththalate plastic bottles and polypropylene plastic cups with a production capacity of 179.84 grams/hour.
c. The characteristics of the plastic waste filament produced are almost in accordance with the market 3D printing filament of PLA. Some of the suits include; the size of the plastic waste filament is 1.75 mm ± 0.25 mm in diameter, the polypropylene filament and the combined polypropylene and polyethylene terepththalate filament can be used in a 3D printing machine, and the printed results of the plastic waste filament have no defects.

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