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Practical Experiment on Filament Making Setup for FDM 3D Printer Material from Waste Plastic Bottle

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Abstract: The increasing concern over plastic waste management and the growing demand for sustainable manufacturing have driven innovative solutions such as recycling plastic waste into 3D printing filament. This practical experiment focuses on the design, development, and performance analysis of a filament making setup that converts waste plastic bottles (primarily PET - Polyethylene Terephthalate) into usable filament for Fused Deposition Modelling (FDM) 3D printers.

In the experimental setup, waste plastic bottles were collected, cleaned, dried, and shredded into fine flakes using a plastic shredder. These flakes were then fed into a filament extruder where controlled heating, melting, and extrusion processes converted the plastic into continuous filament strands. Key parameters such as extrusion temperature, nozzle diameter, cooling rate, and pulling speed were carefully optimized to produce filament of consistent diameter (typically 1.75 mm ± 0.05 mm), ensuring compatibility with standard FDM 3D printers.

The produced filament was subsequently tested in an FDM 3D printer to evaluate printability, mechanical properties, surface finish, and dimensional accuracy of printed parts. The results demonstrated that recycled PET filament showed satisfactory performance for prototyping applications, with good adhesion, minimal warping, and acceptable mechanical strength for non-critical components. However, certain limitations such as moisture sensitivity, color variation, and minor inconsistencies in diameter were observed.

This experiment not only highlights the technical feasibility of converting waste plastic into 3D printing filament but also contributes towards environmental sustainability by promoting circular economy practices in additive manufacturing. The study suggests that with further refinement and quality control, recycled filament production can serve as a cost-effective and eco-friendly alternative to virgin 3D printing materials.

Keywords: 3D Printing, FDM, Filament Making, Waste Plastic Bottle, PET Recycling, Sustainable Manufacturing, Circular Economy, Additive Manufacturing.

I. INTRODUCTION

3D printing, especially FDM technology, has made it easy to create parts and prototypes, but it also increases the use of plastic, adding to environmental problems. At the same time, waste plastic bottles — mainly made of PET — continue to pile up around the world.

This experiment aims to find a simple solution by turning waste plastic bottles into usable filament for 3D printers. The process includes shredding the bottles, melting the plastic, and forming it into filament that can be used in FDM printers. The final filament is tested to see how well it prints and performs.

By doing this, we can reduce plastic waste and lower the cost of 3D printing materials, while promoting recycling and sustainability.

II. LITERATURE REVIEW

1) *Filament for a 3D Printer from Pet Bottles- Simple Machine Igor Tylman and Kazimierz Dzierżek Department of Robotics and Mechatronics, Faculty of Mechanical Engineering, Bialystok University of Technology, Bialystok, Poland International Journal of Mechanical Engineering and Robotics Research Vol. 9, No. 10, October 2020.*

The article presents a method to create filaments from recycled plastic bottles. It covers the mechanical design, electrical and electronic systems for controlling the process, and the actual filament creation process. Finally, the article compares the properties of the recycled filament with commercially available filaments.

2) *V. Mirón, S. Ferrándiz*, D. Juárez, A. Mengual Universitat Politècnica de València, Plaza Ferrándiz Carbonell, s/n, Alcoi 03801, Spain Manufacturing Engineering Society International Conference 2017, MESIC 2017, 28-30 June 2017, Vigo (Pontevedra), Spain.*

The abstract explains that the project aims to create a durable and resistant filament from recycled plastic bottles. The filament is tested for its tensile strength and compared to commercial filaments. The goal is to reduce reliance on commercial filament suppliers by producing filament independently.

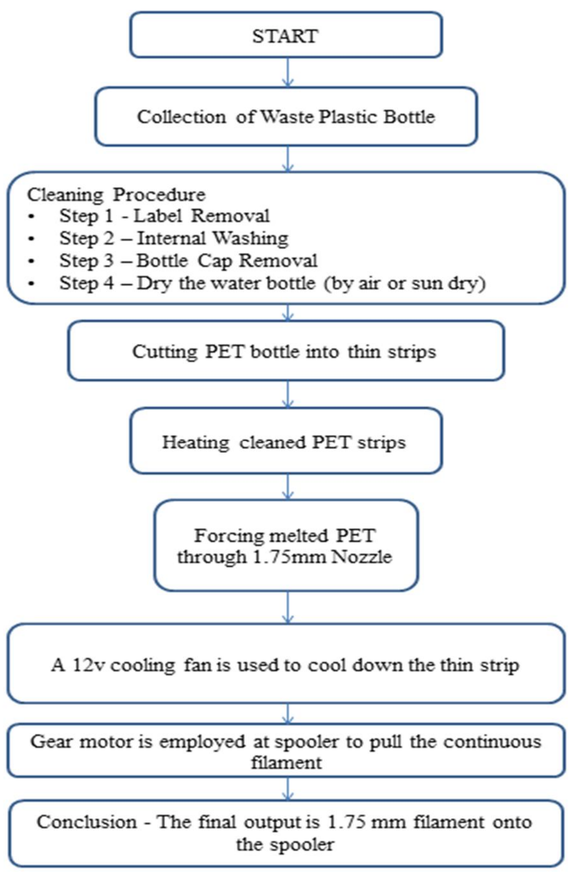
3) *A review on the fused deposition modelling (FDM) 3D printing Ruben Bayu Kristiawan, Fitrian Imaduddin*, Dody Ariawan, Ubaidillah, and Zainal Arifin.*

The study reviews factors affecting 3D printing results using FDM. It explores filament manufacturing, material types, and printing parameters. The impact of individual parameters and their interactions on printing outcomes is analysed. The study highlights the significance of optimizing critical parameters for improved FDM printing and filament manufacturing. It identifies areas for future research to further refine the process.

4) *3D printing filament as a second life of waste plastics Katarzyna Mikula1 &DawidSkrzypczak1 & Grzegorz Izydorczyk1 & Jolanta Warchoł1 & Konstantinos Moustakas2 & Katarzyna Chojnacka1 & Anna Witek-Krowiak1*

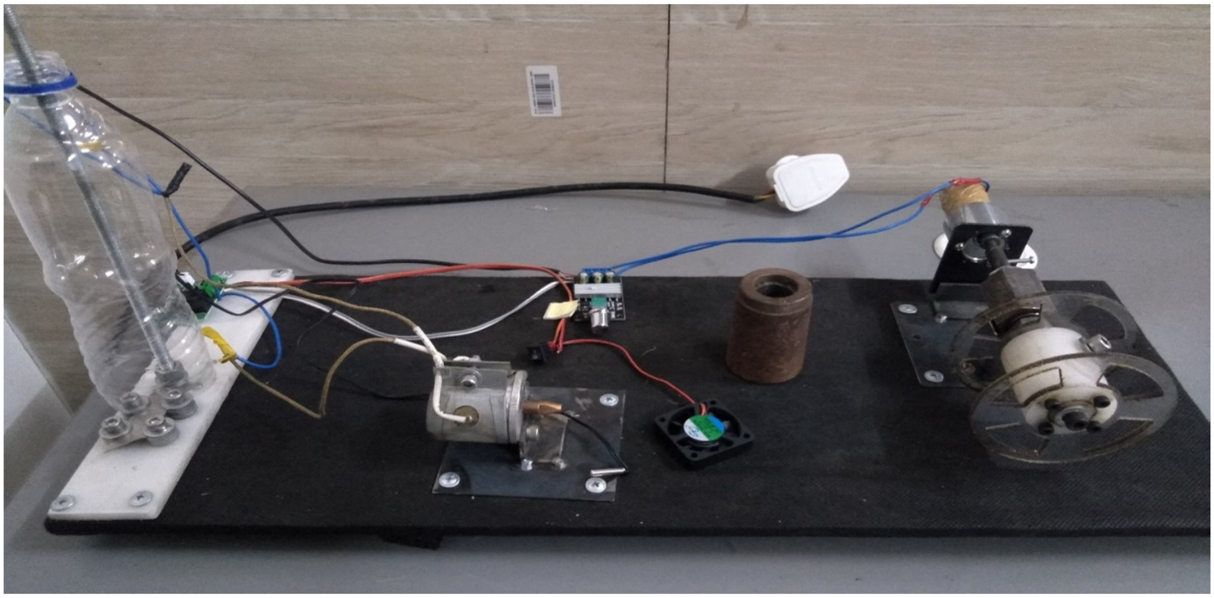
Plastic waste has become a significant environmental concern. Recycling offers a solution to this problem. 3D printing technology provides an opportunity to reuse plastic waste by converting it into printable filaments. This paper reviews the production of 3D printer filaments from recycled polymers. It explores the recycling process, the impact on material properties, and commercially available recycled filaments. Additionally, it discusses devices that enable self-production of filaments from plastic waste. The goal is to promote sustainable practices and reduce reliance on traditional waste management methods.

III. METHODS AND MATERIAL



IV. RESULT AND DISCUSSION

A. Setup -



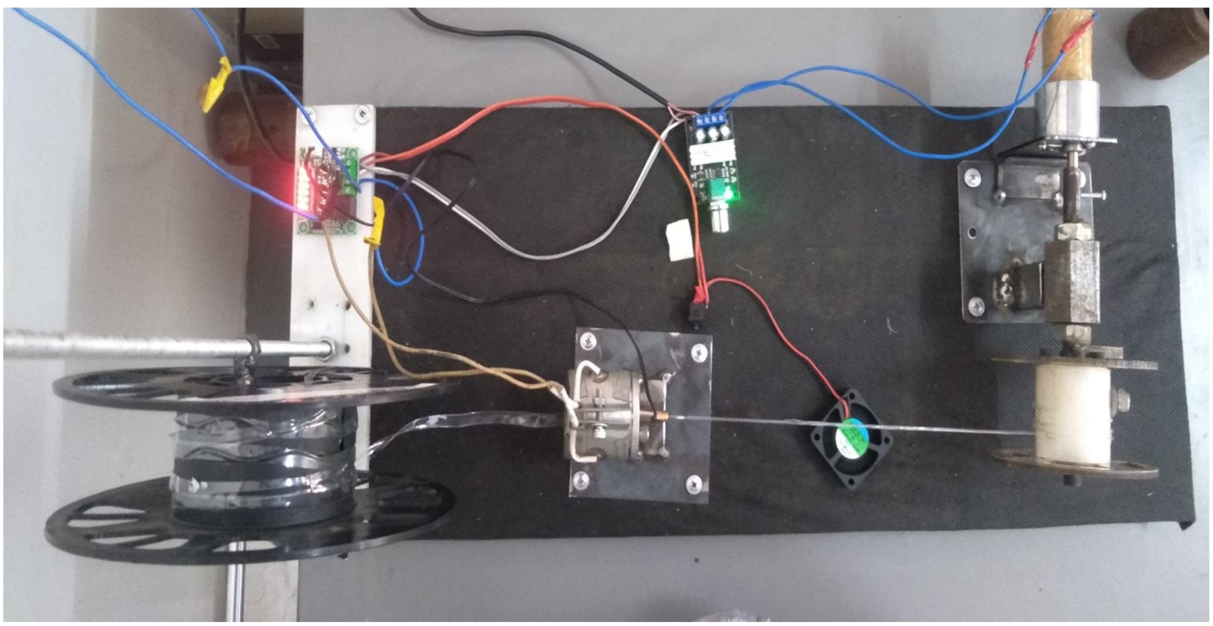


Fig. 1&2 Setup of Filament making

1) Component Descriptions

a) PET Bottle:
- Acts as the raw material source.
- PET (Polyethylene Terephthalate) is commonly used in beverage bottles and is recyclable.
- In this setup, the bottle is fed into the system for cutting and extrusion.

b) Cutter:
- Positioned to slit the PET bottle into thin strips.
- These strips are fed into the heating zone for melting.
- It is likely a rotary or blade-based mechanism driven by a motor.

c) Heater:
- Heats the PET strips to a specific melting temperature.
- Converts solid PET strips into a semi-molten state suitable for extrusion into filament.

d) Temperature Sensor:
- Monitors the heating zone's temperature.
- Ensures precise thermal control to avoid underheating or overheating of PET.
- Vital for maintaining filament quality and consistency.

e) Motor Driver / Motor Controller:
- Controls the speed and torque of the DC motor.
- Ensures synchronization between feeding, cutting, and filament pulling operations.
- Can be controlled manually or through a microcontroller (not shown here).

f) DC Johnson Gear Motor:
- Powers the extrusion or pulling mechanism.
- Its built-in gear system allows for high torque at low speeds, ideal for filament winding.
- Drives the mechanism pulling the molten PET into a fine filament.

g) Cooling Fan:
- Cools the freshly extruded filament to solidify it.
- Helps maintain dimensional accuracy and prevents deformation.
- Placed after the extrusion zone for effective cooling.

2) Purpose and Application

This system is designed for low-cost, sustainable filament production from plastic waste. It supports FDM 3D printing by enabling users to recycle PET bottles into usable printing material.

B. Outcomes from the PET Filament

Fig. 3 Experiment Outcome of Filament

The image shows a variety of 3D printed test samples produced using filament made from recycled PET plastic bottles. These prints demonstrate the functional feasibility of using PET waste as 3D printer filament but also reveal some key performance issues.

Outcome Analysis of the Printed Samples:

1) Positives

1. Filament Usability:
   - The filament was successfully extruded and used in a 3D printer.
   - Multiple geometries were printed, including:
     - Tensile test specimens
     - Small connectors or mechanical parts (plus-shaped)
     - A recognizable object (green Avengers logo)
2. Dimensional Capability:
   - The printer was able to produce small and medium-sized parts with reasonable shapes.

2) Challenges Observed

1. Surface Quality:
   - Many prints show stringing, rough surfaces, and inconsistent layer fusion.
   - These defects are likely due to irregular filament diameter, moisture in the filament, or improper extrusion temperature.
2. Layer Adhesion Issues:
   - Some parts (especially tensile bars) show delamination or weak interlayer bonding, which would reduce mechanical strength.
3. Nozzle Clogging or Flow Irregularity:
   - Some objects look under-extruded or globbed, indicating poor melt flow—possibly due to impurities in the filament or non-uniform melting of PET.
4. Color Uniformity:
   - Only one print (Avengers logo) appears colored (green), possibly due to dyed PET or post-processing. All other prints are translucent/white, indicating raw PET with no additives.

3) Overall Outcome Summary

- Proof of Concept: Achieved
- Printability: Moderate to low
- Surface Finish: Poor
- Structural Integrity: Inconsistent
- Suitability for End-use Parts: Limited without optimization

V. CONCLUSION

1) The proposed filament-making setup demonstrates a practical and sustainable solution to two significant modern challenges: plastic waste management and the high cost of 3D printing materials.

2) By repurposing PET bottles into functional 3D printing filament, this project aligns with circular economy principles and promotes eco-friendly additive manufacturing. The system's modular design—incorporating bottle cutting, extrusion, heating, cooling, and spooling—ensures consistent filament quality while maintaining affordability and ease of use.

3) Supported by relevant literature and CAD modelling, this setup holds strong potential for adoption by educational institutions, maker communities, and small-scale industries.

4) Thus, moving forward with this project is a step toward innovation-driven sustainability, and it deserves continued development, prototyping, and optimization.

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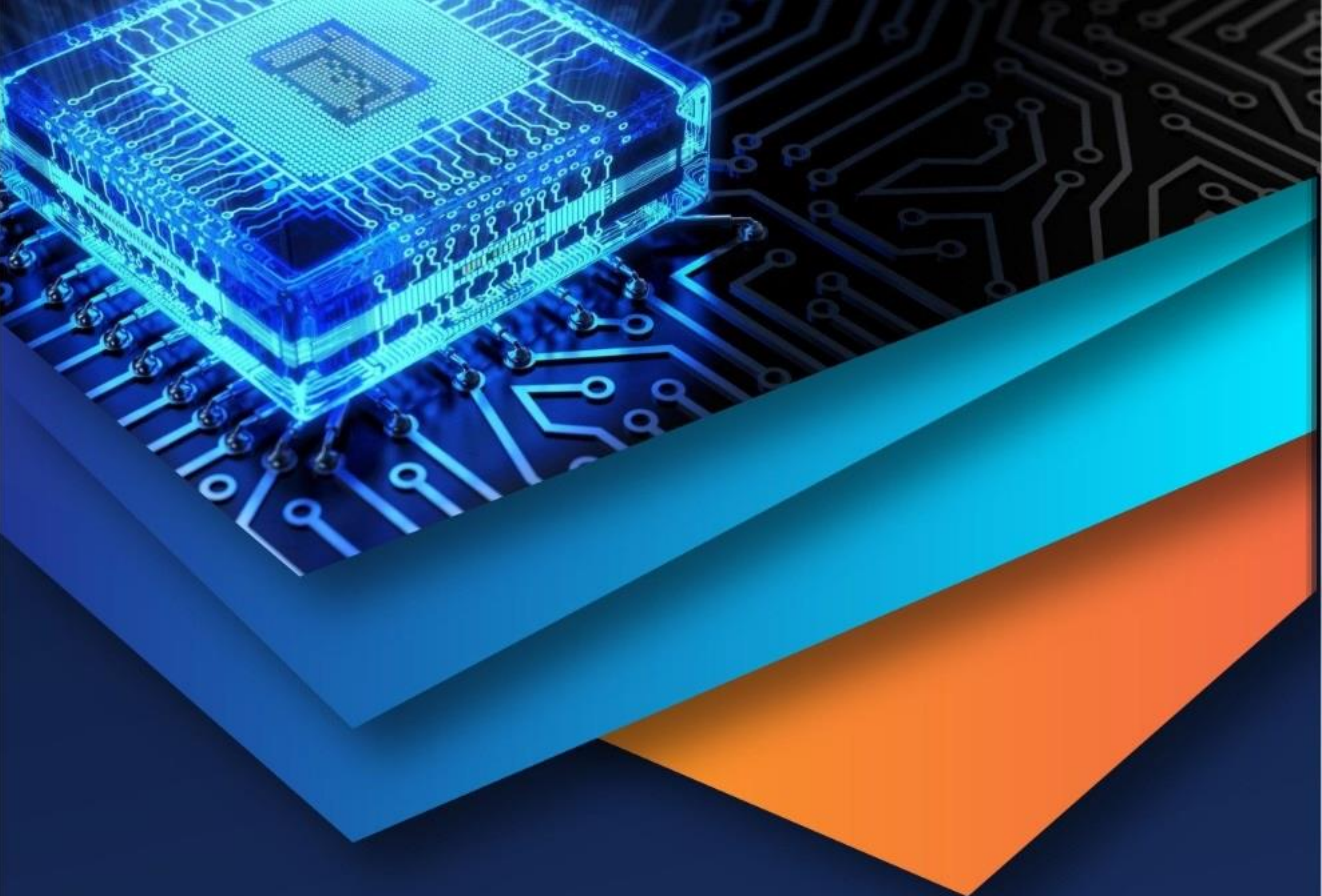

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