PET Bottle Recycling: Its Use as 3D Printing Filament and its Properties

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***Abstract*— Plastic waste is currently a global problem that is expected to grow in the following years and much of this plastic waste comes from Polyethylene Terephthalate (PET) bottles. Thus, recycling these bottles has become an urgent need due to an increase in their manufacture and the damage this causes to the environment this brings. One of the latest recycling techniques is the transformation of these PET bottles into 3D printers filament. In this paper, this recycling option will be explored. To this objective, the work is divided into three parts. In the first one, the current situation of the waste generated by PET bottles and their recycling will be analysed. In the second part, the method for transforming recovered PET bottles into 3D printer filament will be presented. Finally, the properties of the 3D printing filament obtained will be discussed. It is expected that this paper may bring visibility to the fact that a currently highly demanded product can be obtained through the recycling of bottles.**

***Resumen*— Los residuos plásticos son un problema global que está pronosticado que aumente en los años venideros, y mucho de este plástico proviene de las botellas de Tereftalato de Polietileno (más conocido por sus siglas en ingles "PET"). Por este motivo el reciclaje de botellas se ha convertido en una necesidad urgente debido a la creciente producción de éstas y el daño al medioambiente que esto produce. Una de las nuevas técnicas para hacer esto es la trasformación de las botellas plásticas en filamento para impresoras 3D. En este trabajo se explorará esta opción de reciclaje. Con este objetivo, el trabajo esta dividido en tres partes. En la primera se analizará la situación actual y proyección a futuro de los residuos generados por las botellas plásticas y su reciclaje. En la segunda parte se analizará en profundidad el método para la transformación de las botellas plásticas recuperadas en filamento para impresora 3D. Finalmente, se expondrán las propiedades del filamento para impresión 3D obtenido. La expectativa es que con este trabajo se haga visible que un producto muy demandado actualmente puede ser obtenido a partir del reciclaje de botellas.**

I. Introduction

The production of Polyethylene Terephthalate (PET) bottles increases every day and even if recycling also increases, it does not do so in the same proportion, lagging in the number of bottles recycled compared to those produced daily. It is important to note the significant impact plastic bottles have on the environment, including the pollution of oceans, landfills, and other natural habitats.

Although the production of new PET bottles will not stop, the objective is to reduce the impact on climate change and provide a new option to control production as the United Nations states in its Sustainable Development Goals (SDGs), especially in relation to SDG Nº 12 "Ensure sustainable consumption and production patterns" and SDG Nº 13 "Take urgent action to combat climate change and its impacts" [1]. To achieve these goals, an innovative option is presented in this paper, which adds to the increasingly growing alternatives for recycling.

Recycling has become an imperative need in the current times due to the pollution produced by almost every product used daily. Some of this contamination comes from their manufacture while some other when they are used. Because of this, almost every day a new proposal for a recycling method or for a product made from recycled material comes out to reduce pollution and fight climate change.

Making 3D printer filament from recycled PET bottles is both a new recycling method and a product made from recycled material. The resulting PET filament has properties that differentiate it from the rest on the market, making it an option capable of offering new possibilities and competitiveness.

The purpose of this paper is to introduce the recycling of PET bottles as a viable option for reducing plastic waste and as a competitive material in the 3D printing filament market. In order to achieve this aim, the paper is organized into three parts. In the first part, we will describe the current state of PET bottle recycling and its prospects both textually and graphically. In the second part, we will present a new recycling method to complement the existing ones mentioned in the first part. In the third part, we will explain the properties of the product obtained through the recycling process described in the second part. It is expected that this paper may shed light on this innovative option and help add one more tool in the fight against climate change.

II. Pollution made by PET Bottles

PET has become an increasingly common source of waste in the modern society. In recent years, concerns about the environmental impact of plastic waste have led to increased efforts to recycle PET bottles. In the next paragraphs the current state of PET recycling, the challenges that must be overcome to achieve a more sustainable future and the current projection towards it will be explored.

A. Current State of PET Recycling

In 2018, only 8.7% of the total plastic waste generated in the United States was recycled. Among these, PET bottles and jars had a recycling rate of 29.1% [2]. Similarly, the European Union aimed for a plastic packaging collection rate of 22.5% but exceeded it by reaching 38% as shown in Fig. 1.

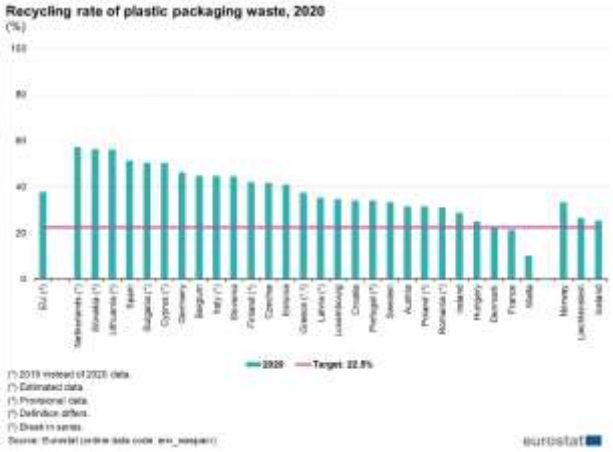

Fig. 1. Recycling rate of plastic packaging waste, 2020 [5]

B. Challenges in PET Recycling

The low recycling rates of PET products can be attributed to various factors, such as inadequate collection and sorting infrastructure, high contamination levels, and low demand for recycled PET. Furthermore, there is a lack of standardization in recycling processes, which affects the quality and consistency of recycled PET. These challenges highlight the need for a circular economy approach, where PET products are designed for recyclability, and a closed-loop recycling system is established [4] [5].

C. Future Projections of PET Recycling

Several initiatives are being taken to improve the PET recycling landscape. The European Union has set a target to recycle 65% of all plastic packaging waste by 2025 and 70% of plastic packaging waste by 2030 [6]. PETCORE Europe, a trade association for PET recyclers, aims to achieve a 90% collection rate for PET bottles by 2029 [7]. Furthermore, advances in technology can improve the quality and quantity of recycled PET.

III. Recycled PET for 3D Printing Filament

The manufacture of filament for 3D printer is a new way of using recycled PET that leads to many uses, due to the versatility of creations made with a 3D printer. In the following paragraphs the most easily industrialized method of transforming recycled PET into 3D printer filament ready to use are explored.

A. Preparing the PET Bottles

The first step in the process is to collect and sort the PET waste according to their color, type, and quality. Once classified, they must be cut into small pieces of similar size [8].

B. Dehumidifying the Small Pieces of PET

The small pieces of plastic are then dried using a dehumidifier or a dryer to remove any moisture. Moisture can negatively affect the quality of the final filament [8].

C. Loading and Melting the PET Pieces into the Extruder

The dried cut PET is loaded into the hopper of the extruder machine. The machine will then automatically feed the plastic into the extruder barrel [8].

The plastic is melted down in the extruder barrel using heat and friction. The temperature and speed of the extruder can be adjusted to achieve the desired melting point and flow rate [8].

D. Extruding the Plastic

The melted plastic is then extruded through a nozzle to create a long, thin strand of filament. The diameter of the filament can be adjusted by changing the size of the nozzle [8].

E. Cooling and Winding the Filament onto a Spool

The extruded filament is cooled down using a cooling fan or water bath to solidify it into a stable shape [8], then the cooled filament is wound onto a spool using a spooling machine. The spooling machine can be set to wind the filament at a specific speed and tension to ensure consistent and uniform filament quality to later be used in useful applications as shown in Fig. 2 [8].

Fig. 2. Objects printed using the manufactured filament [8]

IV. Recycled PET for 3D Printing Filament Properties

The characteristics of the 3D printing filament obtained from the recycling of PET bottles make it a product ready to compete in the market. In the following paragraphs, we will compare the properties of the product with what is available in the market.

A. Tensile strength

The tensile strength of filament obtained from recycled PET can vary depending on the quality of the recycled plastic used and the extrusion process. It may have lower tensile strength compared to filaments made from materials such as ABS or nylon [9][10].

B. Flexibility

Filament obtained from recycled PET may have lower flexibility compared to some other types of filaments. This

can make it more prone to cracking or breaking under stress [9][10].

C. Heat resistance

Filament obtained from recycled PET has good heat resistance [9].

D. Water resistance

Filament obtained from recycled PET has good water resistance and can be used for applications that require water resistance.

E. UV resistance

Filament obtained from recycled PET may have lower UV resistance compared to some other filaments. This can make it more prone to fading or degradation when exposed to sunlight.

F. Printability

Filament obtained from recycled PET may require higher extrusion temperatures or slower print speeds compared to some other filaments. It may also tend to warp or shrink during printing [9][10].

The material properties of filament obtained from recycled PET can vary depending on the quality of the recycled plastic used and the extrusion process. While it may not have the same strength, flexibility, or chemical resistance as some other filaments, it offers a more sustainable option for 3D printing and can be used for a wide range of applications that require heat and water resistance.

V. Conclusion

PET contamination is a serious problem and although efforts to recycle are increasing it is important to add the manufacture of 3d printing filament from recycled PET to those efforts because it is a good and innovative solution, that provides a material that is competitively priced and has a development process that is not overly complicated to work with. Also possesses interesting properties that can be exploited in several markets.

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