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Manufacture of Composite Filament for 3D Printing from Short Glass Fibres and Recycled High-Density Polypropylene

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Extended Abstract

Material extrusion additive manufacturing is a potential candidate manufacturing method for the use of recycled high-density polyethylene (HDPE) plastics and off-cut glass fibres gathered from industrial. HDPE is one of the most challenging materials for 3D printing due to difficulties in adhering to the print bed and other polymers. The likelihood of volume shrinkage of HDPE during solidification and crystallization is another challenge to overcome if it is to be considered as a suitable printing material [1, 2]. These characteristics of HDPE also complicate the filament manufacturing process (a pre-requisite to 3D printing). This study involves the conversion of recycled HDPE products (waste materials) to 1.75mm diameter filament, with the selective addition of chopped fibres to enhance the relatively low-grade mechanical (stiffness, tensile) properties of recycled HDPE.

Off-cut glass fibres and recycled milk bottles made of HDPE were combined in a Noztek Touch Dual PID filament maker to produce short fibre reinforced filaments as an engineering grade feedstock for material extrusion manufacturing. To improve the mechanical properties of the filaments 0%, 2%, 5%, and 8% short glass fibre weight fractions were added to the extrusion process. The extruding parameters including motor speed, heating temperatures, cooling fan status, and pulling load were optimized and quality monitoring was done to assess surface quality, void content, and profile/ roundness. Microscopy images were obtained using a light microscopy instrument, Olympus BX51M to assess abovementioned factors and any unwanted inclusions through image processing techniques. A ZwickRoell Uniaxial tensile machine with a 100N load cell was employed to measure the tensile strength of reinforced HDPE filaments with different percentages of short glass fibres. The degradation during the melting and filament making process at 190^{o}C was confirmed by differential scanning calorimetry test results. In addition, printing parameters on a Creality CR-10 3D printer, including nozzle and bed temperatures, printing speed, layers height, etc. were optimized along with developing a method to reach the best adhesion between the printed part and the bed to reduce the effect of shrinkage during printing. The increased mechanical properties of recycled waste materials investigated in this work along with the uniform distribution of fibre into the matrix make them a good candidate for feedstock in material extrusion to produce products with high-strength, lightweight applications.

References

[1] G. C. Schirmeister, T. Hees, E. H. Licht, R. Mülhaupt, "3D printing of high density polyethylene by fused filament fabrication", Addit. Manuf., 2019, vol. 28, pp. 152-159.
[2] D. Gregor-Svetec, M. Leskovšek, U. V. Brodnjak, U. S. Elesini, D. Muck, R. Urbas, "Characteristics of HDPE/cardboard dust 3D printable composite filaments", J. Mater. Process. Technol., 2020, vol. 276, 116379.