4th World Conference on
Sustainability, Energy and Environment

Vienna, Austria 27 – 29 November 2024

Advancing Sustainable Filament Production: Optimized Recycling and Mechanical Testing of Polypropylene for FDM Applications

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Abstract

An Increasing environmental concern over plastic waste have heightened interest in sustainable polymer recycling, especially for polypropylene, which is widely used in textile industry spool cones. This study investigates the potential of recycling polypropylene from these spools to create filament for 3D printing, using Fused Deposition Modelling (FDM) technology. The research involves three primary phases: collecting and preparing post-consumer polypropylene spools, extruding the recycled polypropylene into filament, and optimizing the filament properties for effective use in 3D printing. The recycling process starts with cleaning, shredding, and treating the polypropylene spools to ensure consistent feedstock quality. During filament extrusion, critical parameters such as temperature, screw speed, and cooling rates are carefully adjusted to achieve a uniform filament diameter and minimize distortion. The mechanical properties of the recycled filaments, including tensile strength, elongation at break, and Young's modulus, are tested through tensile analysis on dog-bone-shaped samples printed in various orientations (0°, 45°, and 90°). The filament's effectiveness for FDM printing is evaluated by measuring dimensional accuracy, surface finish, and layer adhesion on both standard test specimens and more complex shapes. The study demonstrates that recycled polypropylene could serve as a sustainable option for 3D printing applications. With suitable optimization, recycled filaments may perform comparably to virgin materials, thus supporting waste reduction and advancing circular economy principles in additive manufacturing. Future research will focus on long-term performance assessments and further improvements to the recycling process, broadening the material's potential use across a wider range of applications.

Keywords: Polypropylene Recycling, Tensile testing, Fused Deposition Modelling (FDM), Circular Economy, Additive Manufacturing.