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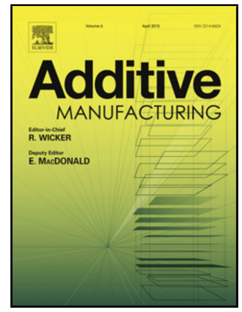

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Recycled Polyethylene Terephthalate as a New FFF Feedstock Material

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Abstract

Reclaimed materials such as waste plastics can be utilized in additive manufacturing to improve the self-reliance of warfighters on forward operating bases by cutting costs and decreasing the demand for the frequent resupplying of parts by the supply chain. In addition, the use of waste materials in additive manufacturing in the private sector would reduce cost and increase sustainability, providing a high-value output for used plastics. Experimentation is conducted to process polyethylene terephthalate bottles and packaging into filament that can then be used for additive manufacturing methods like fused filament fabrication, without the use of additives or modification to the polymer. The chemistry of different polyethylene terephthalate recycled feedstocks was evaluated and found to be identical, and thus mixed feedstock processing is a suitable approach. Rheological data showed drying of the recycled polyethylene terephthalate led to an increase in the polymer's viscosity. Thermal and mechanical properties were evaluated for filament with different processing conditions, as well as printed and molded specimens. Crystallinity ranged from 12.2 for the water cooled filament, compared to 24.9 % for the filament without any active cooling. Tensile results show that the elongation to failure was similar to an injection molded part (3.5 %) and tensile strength of 35.1 ± 8 MPa was comparable to commercial polycarbonate-ABS filament, demonstrating the robustness of the material. In addition, three point bending tests showed a similar load at failure for a select long-lead military part printed from the recycled filament compared to parts printed from commercial filament. Thus filament from recycled polyethylene terephthalate has the capability for replacing commercial filament in printing a diverse range of plastic parts.

1. Introduction

Additive manufacturing (AM) is a type of manufacturing process that builds custom products, generally in a layer-by-layer fashion, from a three dimensional (3D) computer-aided design (CAD) model. Plastics, metals, ceramics, composite and even biological materials can be joined in this fashion to generate 3D objects [1-3]. The potential applications of AM technologies are extensive—everything from pre-production models and temporary parts to end-use aircraft parts and medical implants [4]. AM offers many advantages over traditional manufacturing, including increased part complexity and reduced time and cost for one-off items [5,6]. This greatly enables new product development and drastically reduces the time from production to market [7,8]. While AM offers many important advantages, there are several challenges, including slow build rates, high production costs for scale up, post-processing requirements, limited build