Fatigue behavior analysis in reinforced PLA parts manufactured by FDM

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Abstract. Fused Material Deposition Modelling (FDM) is one of the most extensive 3D printing processes. However, its integration and application to structural parts remain limited to some extent, due to the polymeric materials that can be processed, generally PLA and ABS. FDM printing involves a large number of manufacturing parameters, which can also influence the mechanical properties of the final part. Although the static mechanical properties of FDM components are well documented, the dynamic mechanical properties are not yet fully analyzed. Similarly, in the field of composite materials, reinforced thermoplastics are increasingly used in structural load-bearing applications due to its high specific strength and ease of processing. Therefore, it is necessary to focus on the reinforcement influence on the mechanical behavior of printed parts. The fatigue response of these materials is strongly influenced by the anisotropy of the properties, due to the orientation and composition of the reinforcement. It should be noted that, despite the fact that short-fiber or particle-reinforced polymers generally fail in a macroscopically brittle manner, the underlying failure mechanisms are, nevertheless, not due to crack growth. Difficulty in correctly identifying underlying failure mechanisms, during material characterization, can lead to erroneous conclusions in service life predictions. Consequently, present work focuses on the reinforcement influence analysis on the fatigue behavior with PLA-based parts manufactured by FDM, showing how the fatigue behavior life worsen with short fiber and particle reinforcement.

Introduction

Today, Additive Manufacturing (AM) is constantly growing. One of the main developing areas is focused on the improvement of the materials used in this technology, such as reinforced polymers, ceramics, metals, etc. AM allows the production of highly complex shapes and geometries, reducing one of the main disadvantages compared to more conventional manufacturing processes, the material waste. However, AM represents a major disadvantage as well, as parts are usually obtained with poorer surface quality and lower geometrical accuracy, compared to other traditional manufacturing processes, such as machining [1,2].

Initially, additive manufacturing was used for prototyping tooling or rapid machining due to its easy manufacture and economical savings. Combined with other technologies, can significantly reduce product times and costs [3]. However, the tolerances usually required for more accurate parts are very difficult to achieve, considering the geometrical deviations mentioned above. Although this feature is improving due to advances in this technology [4].

The need for this improvement and the search for materials with better mechanical properties have given rise to a new range of materials. Most of them are based on PLA and ABS, improving their mechanical properties by adding short or continuous fibers such as carbon fiber (CF) or glass fiber (GF). These additives are included in different percentages depending on the composition, which are optimal regarding their mechanical properties or dimensional deviations [5].

The material used in this study is a PLA-based reinforced filament. PLA materials are, along with ABS, one of the most widely used materials in additive manufacturing. Due to the general low


