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Correlation between Surface Texture, Wettability and Mechanical Strength of Polylactic Acid Parts Fabricated by Fused Filament Fabrication

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Abstract: This research investigates the generation and evaluation of various geometric surface textures on PLA components produced via fused filament fabrication (FFF). Textures, including grooves, pyramids, and cylinders, were created at different depth levels on the PLA surfaces. The surface quality of these textures was assessed using a 3D optical system, focusing on area parameters such as Sa and Sz. The wettability of each texture was evaluated through contact angle and sliding angle tests, revealing the ability to modulate contact angles and achieve either hydrophobic or hydrophilic surfaces depending on the texture type. Subsequently, pairs of textured PLA pieces were bonded using a cyanoacrylate adhesive following standardised protocols, and shear tests were conducted to determine the maximum shear stress at bond (τ_{max}) of each texture. Notably, textured surfaces generally exhibited hydrophobic properties that reduce the adhesion between the adhesive and the piece, leading to reduced maximum shear stress at bond values compared to non-textured surfaces. However, groove textures notably increased τ_{max} values. The results were analysed to establish correlations between surface quality, wettability, and shear strength. This comprehensive evaluation aims to elucidate the influence of surface texture on the mechanical performance and adhesive properties of FFF-manufactured PLA components.

Keywords: textures; wettability; FFF; PLA; texture; shear strength; surface quality

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1. Introduction

Additive manufacturing by material extrusion, commonly known as fused filament fabrication (FFF), is experiencing increasing demand in various industries due to its ability to produce specific products with high precision and meet the requirements of different sectors [1]. This technology makes it possible to create complex geometries that cannot be achieved by other manufacturing processes, using a wide range of materials to create products with high functional performance [2]. Abel et al. [3] stated that with FFF it is possible to produce large and complex components quickly with high material efficiency and combinations of materials such as stainless steel.

Despite its many advantages, FFF technology has limitations in the production of large objects [4]. Silva et al. [5] pointed out that there are practical limits to the shape and size of structures that can be produced by FFF, which may limit the production of large objects due to surface quality and dimensional accuracy issues.

To overcome this limitation, the strategies developed involve dividing the product into sub-elements that are then assembled. This assembly is often carried out using adhesives, with cyanoacrylate being one of the most common [6]. Alvarez et al. [7] characterised and optimised mechanically interlocking adhesive bonds using cyanoacrylate on FFF ABS parts, achieving tensile and yield strengths close to those of the base material. The effectiveness

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