Optimising Fused Deposition Modelling (FDM) Parameters for Enhanced Mechanical Properties of 3D Printed Parts

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ABSTRACT

Background: Additive Manufacturing (AM) has revolutionized the manufacturing industry by enabling the fabrication of complex geometries and designs with ease. Fused Deposition Modelling (FDM) is one of the most commonly used techniques for 3D printing in AM, owing to its versatility and cost-effectiveness. However, the FDM process is complex and depends on multiple parameters, which makes it challenging to obtain high-quality and consistent 3D printed parts.

Objective: To address this challenge, this study focuses on the importance of understanding the process parameters that impact the quality of printed parts and the properties of the materials used in FDM.

Methods: The study begins with a comprehensive literature review that identifies raster angle and infill speed as two critical parameters that require thorough examination to optimise the mechanical properties of 3D printed parts. To investigate the impact of these parameters, the study employs seven different raster angles and the same fill speed to fabricate 3D parts using polylactic acid (PLA) as the thermoplastic material and identified the optimal printing orientation. The study further explores the effects different infill speeds on PLA 3D printed parts. A microstructural analysis of the fracture interface of 3D printed parts after conducting tensile tests is performed to gain insights into the material failure modes and causes. Additionally, this study closely examines the micro-level structural changes that occur on both the outer and inner surfaces of 3D parts fabricated, which sheds light on the impact of process parameters on the material properties. The optimised parameters of raster angle and infill speed are then applied to four different 3D printed materials: PETG, ABS, PLA tough, and Recycle PLA.

Tensile tests are conducted on these materials, and it is observed that the optimised parameter values raster angle [45° -45°] and infill speed 35 mm/s resulted in the strongest 3D parts. The findings of this study emphasize the need for researchers and engineers to consider process parameters in 3D printing to ensure high-quality parts and successful application of this technology in engineering contexts.

Conclusion: By optimising the process parameters, it is possible to obtain consistent and high-quality 3D printed parts with desirable mechanical properties. This study serves as a starting point for future research to investigate the impact of other process parameters and materials on the quality of 3D printed parts, leading to further advancements in the field of AM.