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Optimizing anisotropy in 3D-printed polymers through topology and print direction strategies

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ABSTRACT

This keynote explores the optimization of compliance and mass minimization in 3D-printed polymers fabricated using fused filament fabrication (FFF). By integrating topology optimization (TO) with print direction optimization, substantial improvements in mechanical performance can be achieved. TO enables significant mass reduction, cutting production costs while optimizing print orientation, enhancing stiffness, further reducing mass and forming a closed-loop design approach.

Although extensive research has been conducted separately on TO and print direction optimization, limited efforts have combined these techniques. Current commercial software lacks integrated tools for coupling topology and print orientation optimization. In this work, we present an in-house tool, "TPO" (Topology and Print Optimization), developed to address mass and compliance minimization problems using the method of moving asymptotes (MMA). MMA ensures robust optimization with guaranteed convergence and allows for the introduction of new design variables, offering flexibility for future enhancements.

Our methodology investigates mass and compliance minimization problems in 3D-printed polymers, highlighting the distinct outcomes of each approach. Using the modified solid isotropic material with penalization (SIMP) method, we evaluate trade-offs between compliance and mass reduction to identify optimal parameters for achieving desired mechanical properties. The results demonstrate the efficacy of the TPO code in delivering significant improvements in the performance of 3D-printed polymers, contributing to advanced design and manufacturing practices in additive manufacturing.