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**Enhancing 3D Printed Part Performance Through Design
Optimization**

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ABSTRACT

The advancement of additive manufacturing has transformed the production of complex components, enabling the creation of geometries that were previously impossible with traditional manufacturing. However, maximizing the performance of 3D printed parts remains a critical challenge due to constraints in material properties, printing processes, and structural integrity. This study investigates systematic approaches to enhancing the mechanical and functional performance of 3D printed components through design optimization. By integrating computational modeling, topology optimization, and parametric design techniques, the research explores how design modifications can reduce weight, improve load distribution, and enhance durability without compromising manufacturability. Special attention is given to the influence of layer orientation, infill patterns, and support structures on part performance, as these factors significantly affect strength, stiffness, and surface quality. Experimental validation is conducted using various polymers and metal-based printing materials, demonstrating that optimized designs can achieve up to 30% improvement in mechanical efficiency compared to standard geometries. The findings highlight the importance of aligning design strategies with process parameters and material characteristics to achieve performance-driven results. Furthermore, the study provides a framework for iterative optimization, allowing designers to balance competing objectives such as strength, weight, and print time. This work contributes to the growing body of knowledge in additive manufacturing by offering practical insights and methodologies for improving part performance, ultimately supporting the broader adoption of 3D printing in high-performance engineering applications.