Manufacturing Accuracy of Unsupported Inverted U-Type Thin-Walls in LPBF: Surface and Dimensional Analysis

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Abstract

Additive Manufacturing (AM) has revolutionized orthopaedic implant development by enabling the creation of porous, patient-specific structures that enhance bone-implant integration. However, despite continuous advances, over 10% of orthopaedic implants still fail due to poor osteointegration and bone resorption. As younger and more active patients increasingly require joint replacements, developing durable, infection-resistant implants capable of lifelong fixation has become critical.

This work presents the design and manufacturing feasibility of an innovative inverted U-type surface structure aimed at improving implant fixation and minimizing fracture-prone regions. This study explores its fabrication in Ti6Al4V by Laser Powder Bed Fusion (LPBF).

The inverted U-type structures were manufactured with inclination angles from 30° to 90° in 15° increments, allowing a systematic assessment of overhanging effects, wall inclination, and build orientation on component quality. Comprehensive analyses of surface morphology and dimensional accuracy, for both upward and downward surfaces, were conducted to identify the critical angles affecting manufacturability.

Results highlight the influence of inclination and build direction on surface finish and dimensional precision, providing essential insights for optimizing complex implant surface structures. These findings contribute to defining key design and process parameters for reliably producing osteogenic-stimulating geometries through LPBF, advancing the development of next-generation orthopaedic implants.

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