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PROCEEDINGS

Numerical Study of Fracture Mechanisms in Metal Powder Bed Fusion Additive Manufacturing Processes

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ABSTRACT
Powder-Bed Fusion (PBF) is a prominent metal additive manufacturing technology known for its adaptability and commercial viability. However, it is often hindered by defects such as voids, un-melted particles, microcracking, and columnar grains, which are generally more pronounced than those found in traditional manufacturing methods. Microcracking, in particular, poses a significant challenge, limiting the use of PBF materials in safety-critical applications across various industries. This study presents an advanced computational framework that effectively addresses the complex interactions of thermal, fluid dynamics, structural mechanics, crystallization, and fracture phenomena at meso and macroscopic levels. This framework has been rigorously tested through physical experiments, which corroborated the simulation results with real-time observations and microstructural analyses. The findings elucidate the interplay between defect formation, grain growth, and microcracking, establishing a comprehensive understanding of the process-microstructure-property-performance relationship in PBF AM metals. This insight is crucial for improving the fracture and fatigue performance of the final products, enhancing their reliability for critical applications.

KEYWORDS
Additive manufacturing; defect formation; microcracking; thermomechanical simulation

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