

Theoretical Modeling and Experimental Validation of Deposition Path Planning for an Enhanced Load-Bearing Performance in Large-Format Additive Manufactured Short Carbon Fiber/Polyamide 6 Components

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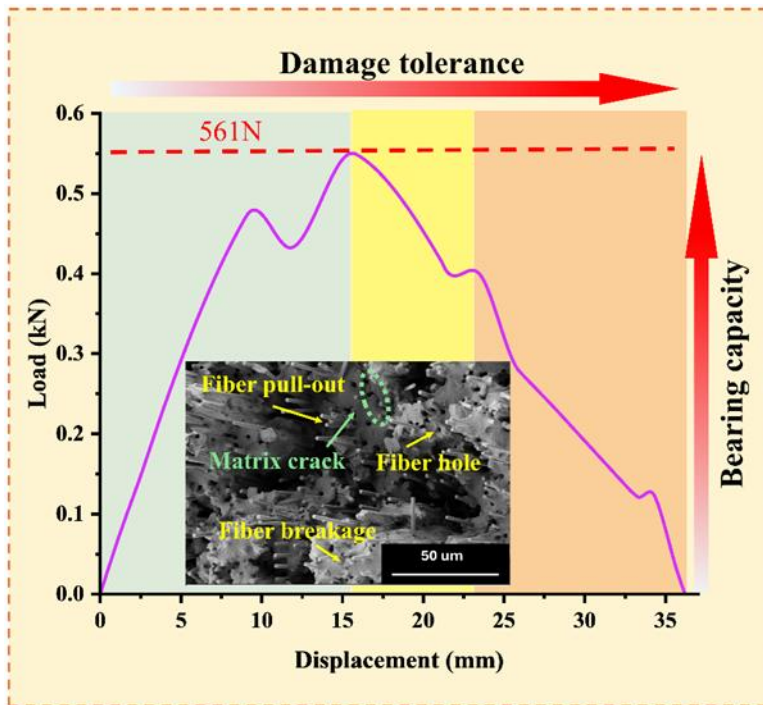
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Abstract

Large-format fiber additive manufacturing (LFAM) has gained significant industrial traction across aerospace, marine, energy, and architectural sectors due to its unparalleled design freedom, rapid production rate, scalable build volume, and cost-effective material utilization. However, the absence of load-driven deposition path planning methodologies remains a critical technological gap. This study develops a strip-shaped bead-based path optimization framework for LFAM-processed short carbon fiber/polyamide 6 (SCF/PA6) composite components, integrating stiffness-maximization sensitivity analysis with clustering operation and averaging processing for fiber orientation prediction and path planning, using Visio to generate deposition paths. The prediction model is validated by comparing with the same load case, Physical bearing performance tests are conducted on SCF/PA6 composite components produced by LFAM. The experimental results confirmed the prediction accuracy and efficiency of the model, indicating that the optimized component using this research

method peak load increased by 157% (561N) and the damage tolerance was significantly improved. The proposed methodology not only establishes an effective protocol for manufacturing performance-specific structures but also pioneers a paradigm-shifting approach for next-generation functional component fabrication, where mechanical properties can be precisely engineered through computational path design.

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Innovative Description: A strip-shaped bead-based path optimization framework for large-format fiber additive manufacturing-processed short carbon fiber/polyamide 6 components, integrating stiffness-maximization sensitivity analysis with clustering operation and averaging processing.