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PROCEEDINGS

Adaptive Quality Enhancement in Robotic Laser-Directed Energy Deposition Through Melt Pool Simulation

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ABSTRACT

Robotic Laser-Directed Energy Deposition (L-DED) offers significant advantages in terms of workplace size and kinematic flexibility for part fabrication. However, its potential is hindered by challenges such as toolpath precision and speed inconsistency compared to traditional CNC machines. These limitations critically affect melt pool dynamics, temperature consistency, and ultimately, the geometric integrity of fabricated parts, areas that are still not thoroughly understood or quantified.

This preliminary research aims to investigate the impact of these inaccuracies on melt pool morphology and part quality, utilizing in-situ collected speed/position data with a digital twin model, notably the Eagar-Tsai model. The goal is to quantify the melt pool deviations introduced by speed inaccuracy in a single track, linear tool path.

The key to this research lies in the development of a simulation environment that accurately resembles the real-world printing tool path alongside a predictive model for precise melt pool characteristic determination under varying laser velocities. This comprehensive analysis aims to unlock new understanding and quantification of the discrepancies influencing the L-DED process, setting a foundation for enhancing reliability, efficiency, and quality in manufacturing applications. The findings from this research could pave the way for more reliable, material-efficient, and optimized use of robotic L-DED in various industries, ultimately leading to improved part quality and reduced waste.

KEYWORDS

Additive manufacturing; directed energy deposition; surface monitoring; melt pool simulation; Eagar-Tsai Model

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