In-Situ Sensing and Data Analytics for Rapid LPBF Qualification

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ABSTRACT

Laser powder bed fusion (LPBF) adoption for serial production is hindered by challenges in repeatability and the high cost and time of traditional empirical qualification methods. This necessitates a shift towards more efficient, model-based strategies. In-situ process monitoring (ISPM) offers a promising solution by capturing real-time process deviations across various modalities. This presentation demonstrates a multi-modal ISM approach using Optical Tomography (OT), Melt Pool Monitoring (MPM), and Powder Bed (PB) imaging to evaluate process variations critical for serial production. Statistical models were developed to correlate ISM signals, specifically the standard deviation of OT, with mechanical properties. Results showed strong predictive capability, with OT predicting yield strength (R^2=83%) and tensile strength (R^2=75%). Leveraging these findings, a data-driven framework that utilizes in-situ signals for enhanced mechanical property prediction significantly reduces mechanical testing by 50%. This unique approach substantially accelerates the LPBF qualification process, offering vital time and cost savings for scaling additive manufacturing for critical applications.