Laser Metal Deposition of a Novel Construction Steel: Process Tuning Supported by In-situ Sensor Integration

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Laser-based Directed Energy Deposition (DED-LB) is a promising additive manufacturing technique for large-scale, complex components, particularly in construction applications. However, limited studies exist on the use of DED-LB for structural steels, which are often sensitive to process parameters. This work focuses on the study of a novel structural steel for construction applications, specifically developed for laser DED. A closed-loop control strategy was implemented, based on real-time monitoring of melt pool geometry and temperature. A coaxial system integrating a NIR camera and a dual-wavelength pyrometer was developed, along with dedicated algorithms for image processing and melt pool analysis. Process tuning enabled stable long-duration depositions, culminating in the fabrication of 100 mm-high hollow cylinders. The adaptive control of laser power, driven by melt pool feedback, significantly improved build quality and mitigated thermal issues observed in fixed-power configurations. Post-process analyses confirmed enhanced consistency and suitability for both small and large-scale features.