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ADVANCING SUSTAINABLE ADDITIVE MANUFACTURING IN SPACE VIA IN-SITU DATA MINING: CHALLENGES AND FUTURE PROSPECTS

Abstract

Additive Manufacturing (AM) technologies have introduced a ground-breaking production paradigm to address the advancing challenges of the rapidly expanding space economy. A primary challenge confronting AM is ensuring first-time-right production, a critical factor for sustainability. This challenge is magnified when dealing with large scales, new materials, metamaterials, innovative shapes and varied environmental conditions. Achieving this target not only reduces waste and resource consumption, but also addresses the space industry's drive for efficiency. Streamlining qualification and certification processes is essential for reducing lead times and costs, a necessity in the face of the sector's increasing competitiveness. This paper provides an overview of some recent advances in the field of in-situ sensing and monitoring technologies for AM in the space sector. Presented methods rely on in-situ big data streams gathered in metal powder bed fusion (PBF) via high-resolution imaging of every layer and on infrared thermal video imaging of salient process dynamics. The paper underscores the application of advanced data analytics, Artificial Intelligence (AI), and machine learning techniques, developed and validated within the ESA-funded IAMSPACE project, for effective in-line inspection and rapid anomaly detection. It explores a range of defects, including geometric deviations, volumetric inaccuracies, inadequate bonding, and microstructural anomalies due to improper cooling. Additionally, the study demonstrates how in-situ captured spatio-temporal thermal data can be enhanced through simulation to construct a digital twin of the AM process. Through real-world case studies, the paper showcases the potential of these innovative approaches to promote sustainable manufacturing practices within the space industry.