Powder Gas Jet Stream Characterisation in Laser Directed Energy Deposition

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According to the American Society for Testing and Materials (ASTM) 52900:2021, the Laser Directed Energy Deposition process (L-DEDp) is an additive manufacturing technique that uses a laser as a thermal energy source to fuse powder material as it is deposited onto a substrate, where it melts and solidifies to form a continuous track. The powder particles are transported by inert gases, such as argon, forming a powder gas jet stream (PGJS). These gases not only transport the particles but also protect the deposition zone from oxidation and help to prevent optics from contamination. Furthermore, nozzle geometry, powder morphology, and particle distribution are key parameters that directly impact the characteristics of the PGJS, influencing process stability and consequently affecting material structure, surface quality, and the level of defects. Existing methods like modelling, numerical simulation, and camera-based systems have been used to study PGJS dynamics, but these are often limited by their dependence on specific setups. It results in a notable challenge to qualify and quantify the geometric characteristics of the PGJS, based on the process parameters utilised, making the generalisation of the analysis and quality more difficult.

Therefore, the current work focuses on methods to evaluate the PGJS and the main features that should be evaluated. A top review on the current state-of-the-art characterization systems available in the market (High TRL and MRL) will be presented, as well as evaluation of results delivered by each of them. The influence of process parameters as powder alloy (density), particle size distribution, powder mass flow rate, carrier gas, and shielding gas will be presented.