ABSTRACT

Laser cladding is gaining ever-increasing popularity as a weld deposition technique compared to other conventional methods because of its many advantages, *viz.*, controlled and precise deposition with focused laser beam generating high power densities, fast heating and cooling rates producing fine meta-stable phases and a wide variety of microstructures with novel properties. However, repeatability and reproducibility in multiple overlapped layers' deposition for coating and fabricating components with desired mechanical properties, like in conventional processes is one of the major limitations for its widespread applications. A large number of process parameters including system dependent ones make the reproduction of results elsewhere difficult.

In laser cladding, as in other thermal deposition processes, mechanical properties of fabricated parts are dictated by the developed microstructure which is controlled by the thermal history of the process. Therefore, developing a better understanding of the process and control over its thermal history to obtain consistent microstructure and mechanical properties in the whole part is much needed. Hence, the current study focuses on the monitoring of molten pool thermal history i.e. heating rate, cooling rate, molten pool lifetime and solidification shelf time, and effects of process parameters on them and its correlation with the resulting microstructure and mechanical properties in laser cladding of different types of materials. Materials investigated include Inconel 718 and metal matrix composites consisting of Inconel 718 and WC, TiC and in-situ produced TiC. It has been found that the thermal history is most influenced by the laser scan speed and contains the signature of the evolved microstructure, elemental segregation and mode of solidification in Inconel 718, wetting of WC ceramic particles and decomposition, distribution and coalescence of TiC particles in MMC, all of which influence the resulting mechanical properties. Further, a process map based on PD/V^2 value, where P, D and V are laser power, beam diameter and scan speed respectively and molten pool lifetime has been built for obtaining an optimum range of laser process parameters for the desired clad quality. This work can be extended for ensuring reproducibility in laser additive manufacturing through online monitoring and controlling the molten pool thermal history.