Modelling of powders dynamics for 3D printing of metal powders deposition

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Application of 3D printing technologies for manufacturing metal products, are receiving ever-increasing attentions in advanced manufacturing fields e.g. aerospace, automobile and biomedical engineering. Laser metal deposition (LMD) is one of the promising 3D printing techniques suitable for depositing fully-densed critical metal components of complex geometry layer-by-layer. Based on directed energy deposition, LMD sprays metal powders into a moving molten pool generated by energy-intensive laser and consequently deposits solid tracks on the substrate surface with the movement of laser spot.

Accurate numerical modelling of this 3D printing process is really a challenge due to involving in multiple physical-mechanical actions along with the mass and heat flows. This research reviews the existing 3D printing technologies using metal powders and especially focusing on the LMD process. To facilitate the numerical modelling, the 3D printing process for LMD is decomposed into several interlinked physical stages, including (1) powders convey and dynamics, (2) laser- metal powders interaction, (3) formation of molten pool due to laser irradiation with mass and heat addition; (4) solidification of molten pool and formation of solid tracks on the substrate.

In this research, gas-powder flow within the internal passages of laser deposition head and powder dynamics after being ejected from the nozzles are modelled and analyzed to give a better understanding of the key physics during the LMD process. An in-depth study of the powder flow and its dynamics in LMD via numerical simulation will definitely facilitate subsequent formation mechanism of molten pool and deposited tracks. The proposed CFD model of powder convey and dynamics will finally assist in accurately simulating the whole LMD process and consequently help enhance the functionality-related performance of LMDed components.

Keywords: 3D printing; powder flow; LENS process; powder dynamics

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