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On the modelling of powder flow, material addition and thermal behaviours in LENS process

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

Accurate numerical modelling of this additive manufacturing process is really a challenge due to involving in multiple physical-mechanical interactions along with the mass and heat flows. This research first reviews the existing metal powders technologies using and especially focusing on the LENS process. Then, powder dynamics for the metal powders being conveyed by carrier gas within the internal passages of laser deposition head and after being ejected from the nozzles are modelled and analysed to give a better understanding of the key physical stage during the LENS process. Material addition on the deposition layer is modelled by using finite element addition; thermal behaviours of substrate and temperature distribution caused by the moving laser beam during the LENS process are also studied by using FEM analysis. An in-depth study of the powder flow and its dynamics in LENS process via numerical simulation will facilitate subsequent research on mass addition on the deposited layers. An accurate thermal-mechanical model could be applied to further investigate the interactions between laser, molten pool and deposited track and finally predict the residual stress and possible cracks on the deposited layers. This research will be particularly useful for investigating the production of key complex components which are made by LENS process due to difficult-to-machine materials properties and have more demanding requirement on their functional performance.

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

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