A Coupled Fluid-Granular Approach to Modelling Powder Stream in Directed Energy Deposition

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Metal-based additive manufacturing (AM) is generally regarded as a disruptive technology across a wide range of industries. Directed Energy Deposition (DED) in particular exhibits a high potential for space applications due to no imposed limitation on the size of manufactured objects and the ability to operate in micro-gravity conditions. DED however remains hindered by poor deposition quality and reproducibility, which at least partly appear to originate in the powder stream condition. Increased accuracy of the blown powder dynamics arguably represents a crucial ingredient of next-generation DED models. Powder stream is usually modelled with the use of computational fluid dynamics (CFD) as a two-phase flow problem involving a dispersed second phase. Powder particle collisions and their interaction with the melt-pool cannot be accounted for by these models and are regularly disregarded as negligible on account of these particles occupying a relatively small volume fraction in the carrier gas flow. Recent studies however suggest inter-particle interactions might have an important influence on the dynamics of the powder stream.

A fully coupled CFD-DEM model of powder stream in DED is proposed as an answer to these open challenges by parallel application of state-of-the-art open-source Finite Volume Method (FVM) and Discrete Element Method (DEM) solvers to resolve the gaseous and powder phase respectively. Four-way coupling of the particle-laden flow is ensured by accounting for the drag force of the carrier gas on the powder particles, the resulting reactive force of the powder particles on the surrounding gas as well as inter-particle interactions as an essential influence on powder stream dynamics.