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Process modelling of selective laser melting: Effects of powder bed quality and surface tension model

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Selective laser melting (SLM), an additive manufacturing (AM) technique utilised for metals, is attracting increasing interest in creating complex and high-quality components. Compared to the traditional welding of bulk materials, the powder bed melting process in SLM presents a more complex physical profile arising from the molten-material flow in the interparticle voids. This work employed a numerical method to explore the evolution of the interfaces between different phases and understand this complexity. The interface features influence the defects of SLM-produced parts, including pore formation, fatigue life, and mechanical strength. Computational fluid dynamics (CFD) and discrete element method (DEM) were used to reproduce the melting and layering process, respectively. Compared with the CFD-DEM coupling method, the sequential method ignores the motion of particles during the melting while overcoming the inherent limitations of mesh size in the coupling method. In a fully resolved fashion, this CFD model can use a smaller mesh and accurately simulate the interactions between the laser beam and powder bed with fine-size particles. The simulated results were validated by benchmark experiments using the Ti-6Al-4V (Ti64) powder. This validated work further investigates the influence of packing quality, laser power, and surface tension model on the evolution of interfaces, and provides an effective way to evaluate the effects of processing parameters.

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