Computational Modeling of SLM Additive Manufacturing of Metals

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ABSTRACT

Additive manufacturing (AM) is a technology that can create 3D structures by depositing or melting material in a layer-by-layer manner. AM has gained popularity because it can create complex structures, with little or no material wastage. Materials such as polymers, metals, and ceramics have widely been used in the AM process. This paper focuses on the metal-based powder bed fusion AM approach, specifically the selective laser melting (SLM) technique. In this method, multiple successive layers of metal powder are heated via laser to construct a structure. During the fusion process, large thermal gradients develop near the laser spot accompanied by rapid cooling. The repetitive hot and cold cycles associated with the AM causes localized compression and tension giving rise to significant residual stresses. This in turn may produce localized deformation resulting in shape loss, detachment from the support structures, or even structural failure. Numerous parameters determine the thermal gradient, which include the thermal characteristics of the powder, bed temperature, and part size. In order to determine the parameter dependence on the process, an Ansys additive model was developed. Subsequently, the resultant displacement and stress values in the model were compared with the experimental data. An efficient parameters calibration procedure is proposed to generate an accurate numerical model. This investigation further describes the associated problem formulation, numerical method and identifies the essential parameters in the SLM simulation. Three numerical studies were conducted using experimental data [1] on vertical prism, horizontal prism and L-shaped structures. The study will further highlight the effect of process parameters on residual stress and deformation using thermo-mechanical numerical models.

REFERENCES

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