The simulation of powder particle effects on temperatures, thermal distortions and solidifications in laser additive manufacturing

Z. Zhang, X.X. Yao and P. Ge

State Key laboratory of Structural Analysis for Industrial Equipment, Department of Engineering Mechanics, Dalian University of Technology (No.2 Linggong Road), Dalian 116024, China

e-mail: zhangz@dlut.edu.cn, web page: http://www.dlut.edu.cn

ABSTRACT

In laser additive manufacturing, the interaction between powder particles and laser beam is one of the key factors determining temperature rises and following solidifications and thermal distortions in both laser sintering and melting additive manufacturing. The wave-particle dualism of light has been investigated for a long time. The light can be expressed by electromagnetic wave. This leads to the possibility to link the laser additive manufacturing with particle features and laser wavelength. Based on the analysis on laser particle interactions, the heat source models of selected laser sintering, selected laser melting and laser metal deposition additive manufacturing are further established. The effects of powder particles are considered as reduction ratio of laser and then combined with double ellipsoid model usually used in simulation of laser additive manufacturing [1]. Then, thermal distortions can be calculated by sequentially coupled thermo-mechanical model. The solidifications in partially melting of laser sintering and the melting of laser melting additive manufacturing can be then simulated by phase field model or Monte Carlo model [2-3]. In selected laser sintering additive manufacturing, the features of powder particles can be both considered in heat source model and phase field model. Different types of powders are selected for comparison. With the increase of powder particle radius, the porosity is increased and the density decreased. The blended powder with random distributions of radii can lead to lower porosity and higher density in laser sintering additive manufacturing. In laser metal deposition additive manufacturing, the particle features are considered in the heat source model for calculations of temperatures which are also measured by Infrared Radiation Thermometer for validation. The thermal distortions are validated by Three-Coordinates Measuring Machine. Controlling of flow rate and flow velocity of powders can be an efficient tool to affect the final thermal distortions in laser additive manufacturing. The solidification is simulated by proposed phase field method with experimental validation.

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REFERENCES

