Accurate prediction of melt pool shapes in laser powder bed fusion by the non-linear temperature equation including phase changes

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ABSTRACT

We present a validation of a physical model [1] whose discretization was thoroughly verified in [2,3]. It is based on a transient temperature equation (including phase change) with respect to the experimental set AMB2018-02 [4] provided within the additive manufacturing benchmark series established at the National Institute of Standards and Technology, USA. We aim at predicting the following quantities of interest: width, depth, and length of the melt pool by numerical simulation and report also on the obtainable numerical results of the cooling rate. We first assume the laser to possess an elliptical shape and demonstrate that a well calibrated, purely thermal model based on isotropic thermal conductivity is able to predict all the quantities of interest up to a deviation of maximum 7.3% from the experimentally measured values. However, it is interesting to observe that if we directly introduce, the measured power density distribution provided by NIST Lab in the model a deviation of 19.3% from the experimental values results. This motivates a model update by introducing anisotropic conductivity which is intended to be a simplistic model for heat convection inside the melt pool. Such an anisotropic model enables the prediction of all quantities of interest mentioned above with a maximum deviation from the experimental values of 6.5%. We note that, although more predictive, the anisotropic model induces only a marginal increase in computational complexity.

REFERENCES

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