Numerical modelling of thermal behaviour during selective laser melting of Ti6Al4V

Daniel Higgins*, **Gasser Abdelal and Brian Falzon**

* School of Mechanical and Aerospace Engineering
Queens University Belfast
Stranmillis Road, Belfast, BT9 5AH, United Kingdom
E-mail: dhiggins10@qub.ac.uk

ABSTRACT

Additive manufacturing (AM) of metal parts has seen a signifiant increase in use for a number of industries within the last decade. Metal AM production is mainly carried out by powder-bed technologies such as selective laser melting (SLM). One of the biggest obstacles to AM being used for more applications is ensuring part quality is consistent. The thermal history during the SLM process is essential in determining the microstructure and thus a parts surface quality and mechanical properties [1][2].

In this work the numerical simulation of SLM to predict temperature distribution and melt pool dimensions is presented. A transient model predicting the thermal behaviour of SLM Ti6Al4V powder has been developed using finite element analysis. The model takes into account the physical phenomena (thermal conduction, radiation, convection) in SLM, temperature dependent thermal physical material properties (thermal conductivity, specific heat, density) and phase changes (solid, liquid, powder).

The 3D model was created using finite element software Abaqus. User subroutine DFLUX models the moving heat source using a Gaussian laser beam distribution and material behaviour has been modelled using the UMATHT subroutine, taking into account latent heat due to phase changes. A single powder bed layer on top of a solid base material has been simulated using multiple scan paths.

The effects of laser beam parameters on temperature distribution and melt pool dimensions have been investigated. A strong influence on thermal evolution through changing laser parameters was observed. Laser power and beam radius were the most signifiant, increasing both values provided an increase in temperature distribution and melt pool dimensions.

The model was compared with numerical and experimental results available from literature and showed good agreement. The model can be used to help identify areas of weakness such as insufficient heating that occur with changing processing parameters. Additionally the thermal behaviour predicted in this model can be used in the future to predict residual stresses and microstructure evolution.

REFERENCES

[1] Zhang, Yi, et al. ”Additive manufacturing of metallic materials: A review.” Journal of Materials Engineering and Performance 27.1 (2018): 1-13.

[2] Yan, Zhaorui, et al. ”Review on thermal analysis in laser-based additive manufacturing.” Optics & Laser Technology 106 (2018): 427-441.