Powder-scale thermal simulation of Selective Laser Melting

Siby Jose[a,*], **Hesameddin Safari**[b], **Manfred Krafczyk**[b] **and Laura De Lorenzis**[a]

[a] Institute of Applied Mechanics
Technische Universität Braunschweig, Pockelsstr. 3, 38106 Braunschweig, Germany
e-mail: {siby.jose, l.delorenzis}@tu-braunschweig.de,
web page: https://www.tu-braunschweig.de/iam

[b] Institute for Computational Modeling in Civil Engineering
Technische Universität Braunschweig, Pockelsstr. 3, 38106 Braunschweig, Germany
e-mail: {hesam, kraft}@irmb.tu-bs.de,
web page: https://www.tu-braunschweig.de/irmb

ABSTRACT

The amount of mechanical components produced using additive manufacturing (AM) techniques, like Selective Laser Melting (SLM), shows an increasing trend. SLM is a powder bed based process, in which manufacturing of the part is done layer by layer. The material is transported onto a build platform by a coating system and a user-defined build strategy is followed to navigate the laser to fully melt the powder. The finished product is to appear later after the laser scans all layers. Following this route of fabrication can be advantageous, particularly for complex geometric structures which are difficult to be created by conventional manufacturing techniques, and has attracted interest from various industries, ranging from aviation to dentistry and gas power plant operations. Consequently, ensuring safety and quality of the manufactured components is of critical importance. Due to the numerous process parameters and complex physical phenomena, an improper choice of machine parameters can lead to defects, like surface irregularity, distortion, porosity, etc [1]. Therefore, efficient and accurate numerical models are required for a better understanding of the AM process.

Commonly used thermo-mechanical models based on a homogenized powder bed focus on temperature distribution and resulting residual stresses, aiming at identifying the influence of the thermal behaviour on the mechanical properties [2, 3]. However, with studies concentrating on the micro-scale (individual powder particles), in order to characterize the flow and solidification of the molten powder, better localized information could be obtained which can facilitate accurate input for the macro-scale model.

The main contribution of this work is to simulate the SLM process at the powder scale. To this end, a multiphase approach is considered taking into account localized information about change of phase from solid to liquid metal and the flow behaviour of the molten metal. With the resulting availability of accurate local information (e.g. temperature and flow dynamics) of the melt pool, better estimation of the process parameters is enabled.

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