Residual stress verified by the distortion of additive manufacturing 3D part in multi-scale modelling approach

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Selective Laser Melting (SLM) is an additive manufacturing technique in which three-dimensional (3D) parts are produced by selectively melting defined areas of a metal powder layer using a controlled laser beam. In SLM process, the high cooling rate (10³ -10⁶ K/s) and high thermal gradient around the laser irradiated zones cause large tensile residual stress [1]. This high tensile residual stress reduces the part dimension accuracy and detrimentally affects the performance of the end-use parts [2]. Using the traditional simulation approach, in which the millions of laser scan pass is to be simulated using heat transfer and coupled thermal mechanical analysis, would need a very long computational time [3]. In particular, the authors in literature [4] used super computer which has 500 cores to simulate the residual stress in AM-processed part. Due to the discussed issues, the present study proposed the multi-scale simulation to rapidly predict the residual stress and distortion of 3D printed part. Firstly, the heat transfer simulation was employed to calculate the thermal distribution in micro-scale model (melt pool simulation). Then, the heating time and cooling time in the micro-scale model was extracted and correlated to part scale simulation model. It is observed that the maximum simulated distortion is 0.9 mm, while that obtained in the experiment is 1.1 mm. The computational time is 3 hours. Therefore, it can be concluded that the simulation model is feasible to rapidly predict the distortion of 3D printed part with acceptable accuracy.

References