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**Abstracts**

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# A Semi-analytical Thermal Model of Selective Laser Melting Process

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Selective laser melting (SLM) is one of the most widely used additive manufacturing technique suitable for metallic materials. In SLM the product is fabricated in a layer-by-layer fashion where a laser beam is scanned over the powder bed to selectively melt and fuse powder particles according to a predetermined pattern. SLM can produce metallic components with complex geometry while creating virtually no porosity. However, SLM products suffer from substantial deformation and residual stresses that arise due to heating/cooling cycles and the associated thermal strains introduced during manufacturing. It is experimentally well established that not only SLM process parameters, but also the laser scanning strategy and the topology of the product have a substantial effect on the temperature transients of the part and henceforth on the degree of deformations and residual stresses [1]. In order to investigate the influence of the scanning strategy and part geometry on the temperature history of a part, temperature evolution during the process should be modelled while accounting for the moving laser spot. Temperature can achieve very high values in the vicinity of the laser and drops down abruptly with the increasing distance to the laser. As a result, steep temperature gradients are observed around the laser spot, with a dimension on the order of tens of micrometres. On the other hand, product has dimensions on the order of tens of millimetres. Therefore, in a numerical model, in order to capture the local high temperature gradient around the laser, a fine discretisation is required in the spatial domain, which in turn makes the model computationally prohibitive. Although some simplified thermal models [2, 3] are proposed, they all neglect the effect of the laser scanning history. As a result, these models are incapable of accounting for the influence of the scanning strategy.

A semi-analytical thermal model is presented to fill the gap between the efficiency and accuracy in predicting the temperature evolution in SLM process. The moving laser spot is represented with a finite number of point heat sources, which are activated at different time instances. An analytical temperature field is obtained first by summation of all the temperature fields due to each individual heat source in a semi-infinite space. Then the temperature field of the built part is constructed by the superposition of the analytical temperature field and a complimentary field which accounts for the boundary conditions. The steep temperature gradient is mainly captured by the analytical field and the complimentary field is solved numerically. The proposed model enables to decouple the numerical discretisation from the steep gradients in the temperature field associated with the localised laser heat input. Consequently, an accurate and numerically tractable simulation of the process is achieved. The accuracy of this semi-analytical model is validated by experiments. Case studies for building a complete layer using two different scanning strategies and subsequently building of multiple layers with constant and rotating scanning patterns in successive layers will be presented.

## References


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