Advanced inherent strain for distortion prediction in additive manufacturing

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ABSTRACT

Thermal stress and resulting part distortion during metal laser beam melting (LBM) may lead to quality issues and premature process termination. Numerical tools and modelling approaches can be combined to investigate and understand physical phenomena leading to those side effects.

The inherent strain method has first been introduced [1, 2, 3] for fast prediction of distortions in the metal welding context. It has since been applied to powder-based additive manufacturing processes, for instance in [4]. The main challenge with this method is the need for calibration of the inherent strains which are introduced in the static elastic analysis. The calibration is often achieved through an experimental campaign. However the latter is usually performed on simple geometries which are rarely representative of the target application. In particular, thin and thick structures do not behave the same way and this must be accounted for.

The present work presents an innovative numerical calibration of the inherent strains that account for geometrical features. The LBM process is simulated with a transient thermo-mechanical analysis combined with element activation of macro-layers. At this stage, the geometry is a series of simple geometrical features of different thicknesses. This leads to an inherent strain characterization for these geometrical features, as a function of variaous parameters such as the thickness, or the distance to the building plate. A geometrical segmentation method is then applied to the target geometry in order to recognize similar geometrical features. The inherent strain can thus be estimated at each point of the structure, based on enriched information compared to experimental values.

In the present work, this strategy is applied to U-shaped samples made of two different materials. The numerical results of the inherent strain method are compared to the more sophisticated transient thermo-mechanical model and to the experimental results.

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