Microstructural modeling of large scale additively manufactured metals

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ABSTRACT

For the additive manufacturing of large-scale ($\sim$ 1 to $>$ 10 m) metallic components, the wire + arc additive manufacturing (WAAM) technique is most suitable, due to its large metal feed rate. During the WAAM process, locally, part of the workpiece is melted, after which new metal material is deposited in the local melt pool. While the electric torch moves, the melt pool solidifies, leaving a new bead of solid metal. This technique is similar to multi-pass welding.

To ensure structural integrity of WAAM printed parts, a rigorous understanding of the micro-structural characteristics, residual stresses and resulting mechanical properties is required. Multiple process-related factors control these features, including the thermal-mechanical history of each material point. Various empirical studies have been performed on the influence of process parameters on the microstructure and thereby on its mechanical properties. A few studies have tried to quantitatively capture these effects in computational models.

In this contribution, the relationship between the microstructure and mechanical properties for products made with large-scale deposition techniques is studied by means of computational modeling. For this reason, a detailed model of the microstructure is made using representative volume elements having the size of a single bead. Process-related characteristics, such as morphology and orientation of grains are included by making use of a crystal plasticity based finite element method.

Experimentally obtained microstructural data indicates a highly anisotropic grain morphology and texture. An anisotropic Voronoi algorithm, which has been adopted from [1], is used to generate a representative volume element (RVE) of this highly anisotropic structure. An example of such an RVE is depicted in Figure 1. A comparison between the experimental data and the computational microstructure is made and the results of the developed framework are discussed.

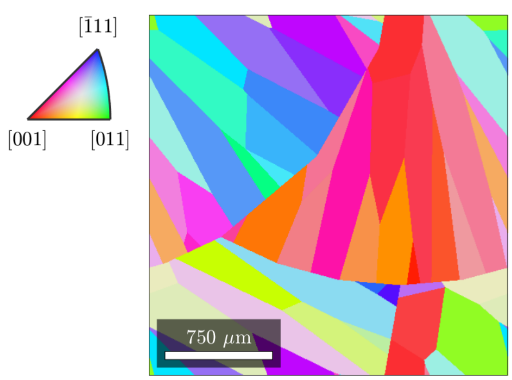

Figure 1: An example of an RVE of the microstructure of a WAAM processed metal. The colors correspond to the crystallographic directions in the (vertical) building direction.

REFERENCES

[1] Gasnier, J.-B, Figliuzzi, B., Faessel, M., Willot, F., Jeulin, D. and Trumel, H. 3D Morphological modeling of a polycrystalline microstructure with non-convex, anisotropic grains. *14th International Congress for Stereology and Image Analysis (ICSIA)*, Liège, Belgium, 2015.