The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5 – 9 June 2022, Oslo, Norway

Microstructural modelling of materials processed with wire arc additive manufacturing

Johannes A.W. van Dommelen, Tim F.W. van Nuland, Luca Palmeira Belotti, Johan P.M. Hoefnagels and Marc G.D. Geers

[1] Eindhoven University of Technology, P.O. Box 513, 5600 MB, Eindhoven, The Netherlands,
email: J.A.W.v.Dommelen@tue.nl, URL: www.tue.nl

Key Words: *additive manufacturing, anisotropy, crystal plasticity, representative microstructure, wire arc additive manufacturing.*

The wire and arc additive manufacturing (WAAM) technique can be used for manufacturing of large-scale (1 to >10 m) metallic components. During the WAAM process, using a wire as feedstock, new material is deposited in the local melt pool, which is created with an electric arc as the heat source. Thereby a new bead of solid metal is formed after the melt pool solidifies.

To take optimal benefit of the geometrical freedom for WAAM printed parts, a rigorous understanding of the effect of micro-structural characteristics on the resulting mechanical properties is required. These aspects are directly related to the manufacturing process, which determines the thermal-mechanical history of each material point. The influence of process parameters on the microstructure and thereby on the mechanical properties has been investigated in various empirical studies. This work aims to quantitatively model the effect of the WAAM-specific microstructure on the anisotropic mechanical properties.

The microstructure of 316L material manufactured with the WAAM technique is experimentally characterized using a range of microscopic techniques. For this material, a pronounced anisotropic grain morphology and texture is obtained. A three-dimensional periodic representative volume element (RVE) of this experimentally observed microstructure, having the size of a single bead, is constructed. The relationship between the microstructure and the anisotropic mechanical properties for products made with this large-scale deposition technique is investigated by means of computational modelling and is compared with experimental results. Process-related characteristics, such as morphology and orientation of grains, are included in a crystal plasticity based finite element model. The computational model is used to determine the three-dimensional anisotropic yield behaviour of the WAAM microstructure and to establish its relation to the processing-induced microstructure.