

Validation of plane stress assumption on SS316L specimen with one layer.

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Additive manufacturing (AM) techniques are based on layer-by-layer accumulation of molten material [1]. Compared with traditional manufacturing, Additive Manufacturing (AM) has the ability to produce complex components with less waste of materials and energy [1]. The processes used in this work is the Wire arc additive manufacturing (WAAM) technique. This technique has the potential to build up parts to tens of meters with relatively low forming costs and high manufacturing efficiencies [2]. In the WAAM process, the metallic wire is heated by the electric arc, then melted and transferred to the molten pool. In this work, the Gas Metal Arc welding – Cold Metal Transfer process (GMAW-CMT) was employed. The Cold Metal Transfer process uses low welding energy with a high control of deposition rate. Understanding the generation of residual stresses during the WAAM operation is of high interest especially in the aim to improve the mechanical properties of the part such as: fatigue life, ...

In this study, the investigated specimens consisted of one layer only deposited on the edge and along the length of parent material hold vertically, see figure 1. Both the parent material and the filler wire are in stainless steel 316L. The experimental setup has been chosen in order to build AM parts under plane stress assumption so the analysis is reduced to two dimensions. The Neutron Strain Scanning technique has been used to characterise the strain and stress fields in the specimens (parent material and deposit). The strain-stress measurements were performed at the Institute Laue Langevin, SALSA diffractometer, Grenoble (France). The stress field is deduced from the strain measurements according to two approaches for determining the reference lattice parameter d_0 (or diffracted angle θ_0) [3]. The first approach is based on a reference specimen (comb-like) in order to cause “strain free” conditions in the area of neutron scanning whereas the second approach is based on plane stress assumption ($\sigma_{normal} = \sigma_{yy} = 0$). The reference $2\theta_0$ angle was only available along line V55. The validation of the two approaches was of high interest in order to compute the residual stresses along two other lines : V25 and V85 as shown in figure 1.

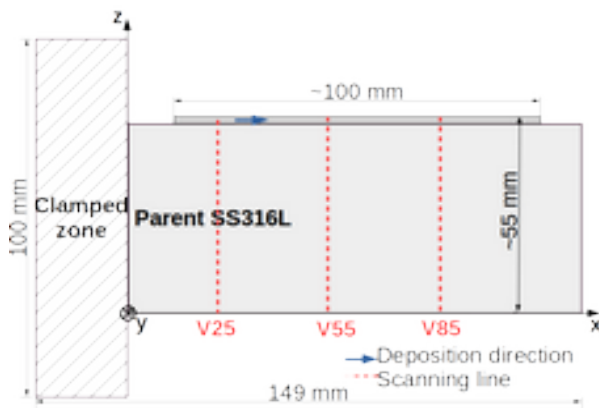


Figure 1 : location of the lines (red) where were performed the neutron strain measurements.

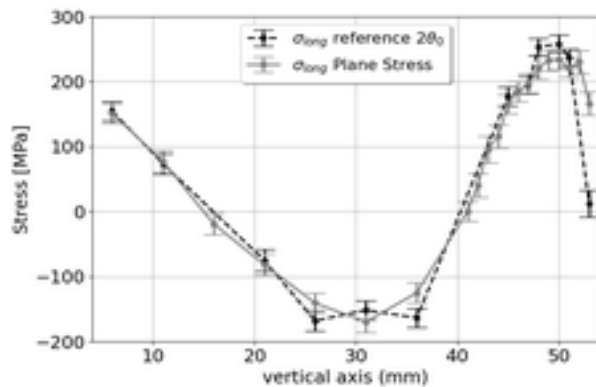


Figure 2 : comparison between the longitudinal stress calculated under plane stress and with reference $2\theta_0$ at the section V55.

The calculated residual longitudinal stress along line V55 are presented in figure 2. The two distribution are quite similar according the two considered approaches. In figure 2, one point was measured in the deposit at $z \sim 54$ mm. The first method gave a value close to zero while the second was around 180 MPa. The greatest discrepancy is observed in the deposit. The deposit (so melted zone) and the top zone of the parent are tensile while the core of the parent is compressive. The bottom part is also tensile due to the force balance in the parent. The parent was deformed under the thermal cycle with a bending towards the z direction. The results displayed in figure 2 validated the two approaches but some care has to be made in the melted zone (due to large grain size that are not shown here).

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