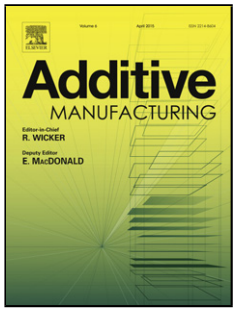

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Control of Residual Stress and Distortion in Aluminium Wire + Arc Additive Manufacture with Rolling

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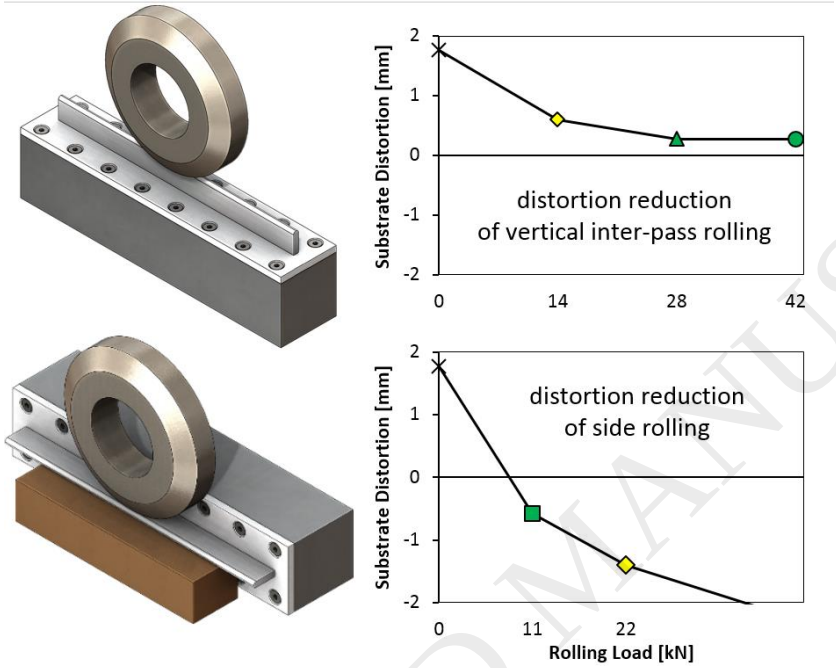
Graphical abstract



Abstract

Rolling can control residual stress and distortion in aluminium Wire + Arc Additively Manufactured (WAAM) walls. It was applied both vertically to each deposited layer (inter-pass) and to the side of the wall after deposition is completed. Distortion was virtually eliminated with the vertical inter-pass method (unlike other metals) and inverted with side rolling. Neutron diffraction stress measurements show that the deposited wall contains constant tensile residual stresses along the build direction that reach the flow strength of the alloy in longitudinal direction. Vertical inter-pass rolling eliminates the distortion, but produces a multi-directional stress field, with hydrostatic compressive stresses approximately 2 mm below the top surface and hydrostatic tension 5-10 mm below the surface. Side rolling was even more effective in stress and distortion control and produced fairly uniform longitudinal compressive stresses along the wall height. An interesting by-product of the neutron diffraction measurements is the observation of a significantly larger FCC aluminium unit cell in the inter-pass rolled walls. This is a result of less copper in solid solution with the aluminium matrix, indicating greater precipitation which could have contributed to the material's improved strength.