ABSTRACT

Wire-arc additive manufacturing is an upcoming technology that allows for free-form, near net shape manufacturing of large components using a welding process. This process is rapidly becoming a more efficient way to produce complex components using available welding wire. Due to its common use in critical industries that require large and complex parts, aluminium is a promising material for use in the additive manufacturing industry.

The critical nature of these components, however, require extensive knowledge of material properties such as tensile strengths and fatigue behaviour – which is currently very limited. Optimisation of parameters such as inter-pass temperature has been proposed to improve deposited material quality, but the relationship between inter-pass temperature and mehcnaicl and fatigue properties is not well understood. Furthermore, due to the significant effect of build direction on WAAM materials, specimen orientation was also considered.

Using AML3D's proprietary WAM manufacturing technique, test pieces were produced using aluminium alloy 5183 at inter-pass temperatures of 100^{o}C and 150^{o}C. Tensile, hardness and fatigue testing were then completed, along with microstructural assessments, fatigue fractography and elemental analysis.

Inter-pass temperature was shown to have no significant effect on tensile or hardness properties, with reported yield and ultimate tensile strengths of 129.5 and 272.8 MPa respectively. The increased inter-pass temperature did however have a noticeable effect on fatigue life, with low-medium cycle fatigue life showing an increase of approximately 20%. Build direction was shown to have no significant effect on tensile properties but showed a noticeable effect on both hardness and fatigue life. Metallographic examination and fatigue fractography highlighted large amounts of internal porosity, with most fatigue fractures initiating at sites of porosity.

The increased inter-pass temperature resulted in an approximate 43% increase in production efficiency, highlighting the potential benefits of optimising the inter-pass temperature. The presence of internal defects, however, need to be closely monitored as these initiate the majority of failures. Further work investigating the effect of inter-pass temperature and welding process on porosity is suggested, while continuing to optimise production efficiency of the WAAM process.