Residual stresses in titanium aerospace components formed via additive manufacture.

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Additive Manufacture (AM) using arc-wire based metal deposition has been suggested as one method to reduce the costs associated with production of titanium components, particularly within the aerospace sector. In the present study gas tungsten arc welding (GTAW) with automated wire addition was used to additively manufacture (AM) a representative thin-walled aerospace component from Ti-6Al-4V in a layer-wise manner. Residual strains, and hence stresses, were analysed quantitatively using neutron diffraction techniques on the KOWARI strain scanner at the OPAL research facility operated by the Australian Nuclear Science and Technology Organisation (ANSTO). Results showed that residual strains within such an AM sample could be measured with relative ease using the neutron diffraction method. Residual stress levels were found to be greatest in the longitudinal direction and concentrated at the interface between the base plate and deposited wall. Difficulties in measurement of lattice strains in some discrete locations were ascribed to the formation of the formation of localised texturing where α-Ti laths form in aligned colonies within prior β-Ti grain boundaries upon cooling. Observations of microstructure reveal 'basket-weave' morphology typical of welds in Ti-6Al-4V. Microhardness measurements show a drop in hardness in the top region of the deposit, indicating a dependence on thermal cycling from sequential welds.

Time-of-flight neutron diffraction has been proposed to analyse stresses in both the α-Ti and β-Ti phases simultaneously as well as inter-granular strains. This study forms part of a wider investigation into the suitability of arc-wire based deposition techniques for the additive manufacture of titanium components.