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Characterisation of innovative friction stir welding (FSW) joints for aeronautical structures

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ABSTRACT

Friction stir welding (FSW) is the fastest evolving joining technology and the principal prospective technique for implementing integral fuselage structure in aircraft manufacturing. The viability of FS welds is dependent upon mechanical properties and production turnovers, which are dependent on welding rates and tool design. This dissertation is about the multi-objective characterisation of aeronautical alloys (AA5083-H111, AA6056-T4, AA6082-H111) friction stir welded using the standard FSW tools, scrolled shoulder Triflat tool, and the Bobbin tool respectively.

The effects of defects and microstructure on the mechanical behaviour of AA5083-H111 welds made from the standard tool were examined. SEM analysis showed that tunnel defects resulted from partial consolidation at the root of the weld, and the microstructure of the weld zones determined the failure mechanisms along the weld.

The effect of welding and rotational speeds on the integrity of AA6056-T4 FS welds produced with scrolled shoulder Triflat tool was studied. Increased welding speeds and advance per revolution led to improvements in mechanical properties and reduction in residual stresses maxima. The retreating side TMAZ, which was the microhardness minimum and tensile residual stress maximum, was also the failure location in most of the welds, hence the microstructure and properties in this region were critical to the integrity of the weld. Bend properties of the welds from the Triflat tool were good, because of the absence of root flaws.

The influence of two different tool designs (standard tool and standard Bobbin tool) on mechanical behaviour and microstructure of AA6082-T6 was also studied. The standard tool produced welds with better static properties than the bobbin tool, but most of the specimens failed prematurely, and root bending resulted in cracks, because of alumina rich layers in the weld nugget and root flaws. Bobbin tool welds had lower mechanical properties (70% weld efficiency), the bend strength was better, with no flaws.

In the welds, the microstructure and microhardness which were influenced by the welding rates which determined static properties, failure locations and residual stress minima and maxima. The study also supported previous findings that the nature and distribution of precipitates in the 6XXX series aluminium FS welds was important for determining mechanical properties, unlike the 5083-H111 FS welds where the Hall-Petch effect was more influential.