

Assessment of the Advantages of Static Shoulder FSW for Joining Aluminium Aerospace Alloys

P. B. Prangnell, J. D. Robson
LATEST2, School of Materials
The University of Manchester

Friction Stir Welding (FSW) is now a well-established process that is widely used to join aluminium alloys owing to the excellent weld properties that can be obtained. The technology was originally developed in the UK by the The Welding Institute (TWI) and involves translating a rotating tool along the join line between two butted plates, which forges the two weld members together without melting. Stationary (Static) Shoulder Friction Stir Welding (SS-FSW) is a new variant of FSW that was developed to improve the weldability of titanium alloys because the low thermal conductivity of titanium results in the rotating tool shoulder creating a severe temperature gradient through the plate thickness. However, it could be envisaged that with all materials SS-FSW would be advantageous when welding thicker gauges. This is because in conventional FSW heat is generated predominately under the tool shoulder and with thicker material it is not normally possible to maintain a high enough temperature at the base of the weld to avoid pin failures unless a low travel speed is used. Furthermore, SS-FSW can provide several additional advantages over the conventional method: i) a non-rotating shoulder irons the surface and leads to an improvement in surface quality (Figure 1); ii) the shoulder acts as a heat sink rather than a source so that the heat distribution becomes narrower at the top surface and more symmetric about the plate mid-plane (Figure 2-3) which leads to narrower welds with a reduced heat affected zone width, as well as lower levels of distortion. However, with a conventional tool the power generated by the pin at a fixed rpm is typically only 20-30% of that of the tool shoulder so that the same welding conditions are not appropriate for both processes.

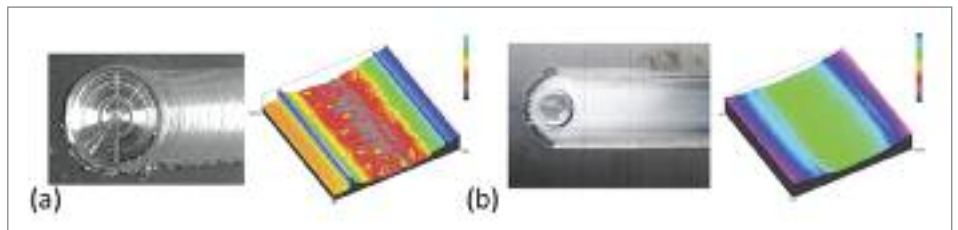


Fig. 1 Comparison of the difference in surface roughness between (a) conventional FSW and (b) static shoulder FSW.

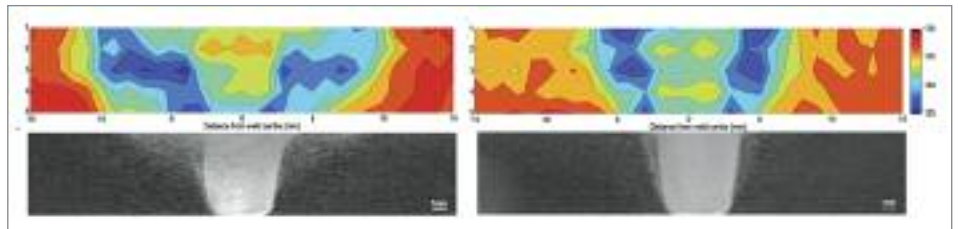


Fig. 2 The difference in HAZ profile for the two processes variants ((a) FSW, (b) SS-FSW) under optimised conditions.

Surprisingly, despite these clear advantages static shoulder FSW has largely been ignored by the aluminium welding community. In LATEST2 we have thus developed a systematic approach for comparing the two processes when applied to joining high strength aluminium aerospace alloys. The approach we adopted was to use an identical shoulder and pin geometry for each method and to first understand and model the relationship between the heat input and the welding parameters, so that both processes can be compared using a rational selection of welding conditions. Modelling has also been used to fit the thermal field for each process and predict the systematic effect of varying the contribution of the shoulder on the HAZ shape. We have also studied the surface finish that can be achieved and the formation of weld defects that can be specific to the SS-FSW process.

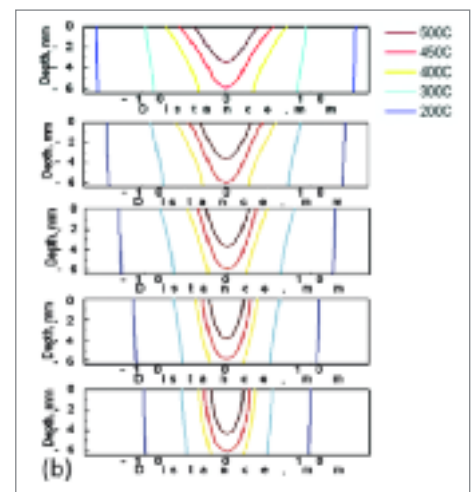


Fig. 3 Thermal model showing the effect of reducing the shoulder power input while increasing the probe power to maintain the same weld temperature near the weld root.

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Publications: H. Wu, Y. C. Chen, D. Strong, and P. B. Prangnell, Assessment of the Advantages of Static Shoulder FSW for Joining Aluminium Aerospace Alloys, Thermec, Las Vegas, USA, December 2013 – in press