Optimisation of Ultra-Short Cycle Friction Stir Spot welding

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

Friction stir spot welding (FSSW) is a low heat input solid state process highly suitable for joining difficult-to-weld high strength aluminium alloys and for forming joints between dissimilar materials. However, the standard process has not been widely adopted in the automotive industry due to a number of perceived problems, which include too long a weld cycle time and the formation of a 'key hole' that causes cosmetic issues and weakens the joint. Recent research in LATEST2 has used a range of techniques, including 3D tomography, to gain a better understanding of the material flow, as well as thermal and microstructure modelling, to try to optimise the process for forming rapid welds in thin aluminium sheet.

This work has shown that the pin on the tool is not necessary in thin sheet welding. By removing the pin from the tool, we have demonstrated that it is possible to weld faster, simplify the process, and solve the keyhole issue. We have also evaluated the Refil™ variant of FSSW developed by HZG, which employs a two part tool that refills the hole as part of the weld cycle. By adopting the same systematic approach, we have shown that high quality welds can be produced within 1 second using the simple pinless tool and within 0.5 seconds with the Refil method. The welds are defect free and show full nugget pull-out-failures. As an added advantage the rapid welding cycle leads to no heat affected zone and after a paint bake cycle the welds become stronger than the parent material, due to the effect of the shorter natural ageing time of the weld zone on the artificial ageing kinetics. The properties of the optimised short cycle friction welds compare very favourably to those of conventional joining techniques such as SPR (Self Piercing Rivets) and RSW (Resistance Spot welding)

Fig. 3 Failure behaviour of a FSSW-Refil weld produced in 0.55 seconds, from 6111 1 mm thick sheet, during lap shear testing.

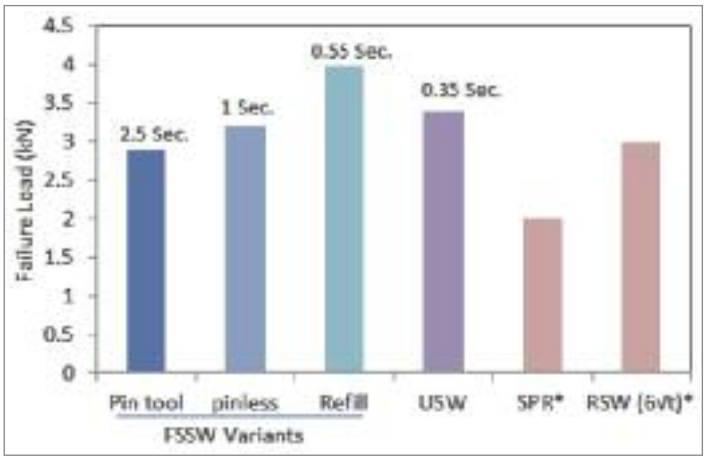

Fig. 4 Comparison of the lap shear test failure loads recorded, for conventional FSW, FSW with a pinless tool (developed in latest) and the FSSW-Refil method to benchmark data for USW and SPR* and RSW*

*Data taken from * L. Han et al. Materials and Design 31 (2010)

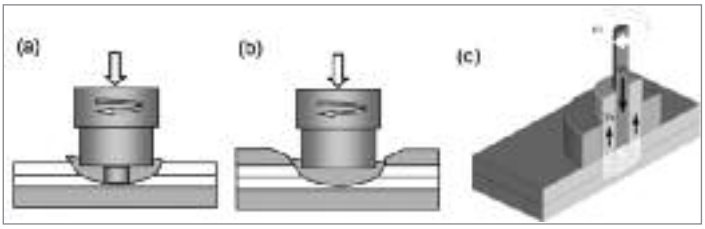

Fig. 1 Schematic diagrams of the (a) conventional FSSW, (b) Pinless FSSW and (c) Refil FSSW processes.

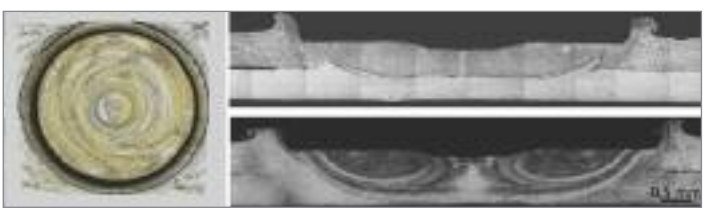

Fig. 2 Examples of flow studies of FSW with a pinless tool.

Partners: Jaguar Land Rover

Acknowledgements: Dr. Y. C. Chen, Mr B. Al-Zubaidy (PhD Student)

Publications: Y. C. Chen, S.F. Liu, D. Bakavos, and P. B. Prangnell, The Effect of a Paint Bake Treatment on Joint Performance in Friction Stir Spot Welding AA6111-T4 Sheet Using a Pinless Tool, Materials and Design, Materials Chemistry and Physics 141 (2013) pp. 768-775.

D. Bakavos, Y. C. Chen, L. Babout and P. B. Prangnell, Material Interactions in a Novel Pinless Tool Approach to Friction Stir Spot Welding Thin Aluminium Sheet, Materials Mater Trans, 42A (2011) pp. 1266-1282

Y. C. Chen and P. B. Prangnell, Accelerated Post-Weld Natural Ageing in Ultrasonic Welding Aluminium 6111-T4 Automotive Sheet, In Symposium 13th International Conference on Aluminum Alloys (ICAA13) Edited by: Hasso Weiland, Anthony D. Rollett, William A. Cassada, TMS, Pittsburgh, PA, (2012), pp 693-698.