Friction Stir Welding Aluminum to Steel Using Scribe Technology

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Introduction

- Friction stir welding is a solid-state welding process. A rotating tool is plunged between two clamped plates. Frictional heat is created plasticizing the material. As the tool travels down the joint, material is moved from the front of the tool to the back where it is consolidated.
- The objectives of this study are to determine the feasibility of friction stir lap welding 6022 aluminum and low carbon electro galvanized steel alloy panels, 1.0 mm and 0.7 mm thick respectively. A scribe tool will be tested in the joining of the two dissimilar metals. Tensile strengths for al-steel welds are wanted to be equivalent to al-al weld tensile strengths.

Broader Impact

- The ability to join aluminum to steel is beneficial to the automotive industry. Being able to replace steel with aluminum into a vehicles body or structure can offer weight savings thus reducing fuel consumption and increasing the performance of a vehicle.

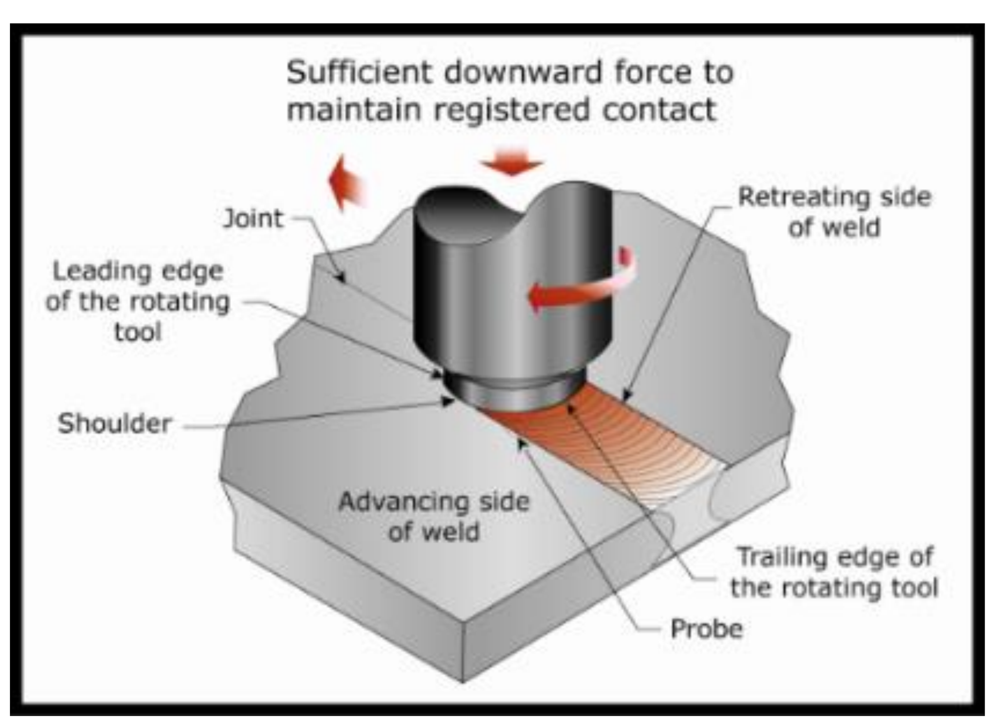

Figure 1. Diagram of FSW process (www.twi.co.uk)

Procedure

- Aluminum and steel panels friction stir lap welded using scribe tool
- Samples cross sectioned perpendicular to the direction of weld using a water jet cutting system
- Samples polished down to 0.5 micron then etched for microstructural characterization
- Metallurgical analysis- Optical microscope, Scanning Electron Microscope (SEM)
- Mechanical properties evaluation- Tensile and shear test

Results

Table 1. Welds 68-71 average failure loads during tensile lap shear test.

Weld #	Materials	Weld Geometry	Travel Speed	Failure Load	
64	Al-Steel	Al-Advancing	20 IPM	588.6 lbf ± 29.5	2.6kN ± 0.13
65	Al-Steel	Al-Advancing	30 IPM	547.4 lbf ± 79.6	2.4 kN ± 0.35
66	Al-Steel	Al-Retreating	20 IPM	819.1 lbf ± 80.2	3.6 kN ± 0.36
67	Al-Steel	Al-Retreating	30 IPM	732.7 lbf ±43.0	3.3 kN ± 0.19
68	Al-Al	Al-top sheet retreating	20 IPM	953.7 lbf ± 39.5	4.2 kN ± 0.17
69	Al-Al	Al-top sheet retreating	30 IPM	977.1 lbf ± 46.1	4.3kN ± 0.2
70	Al-Al	Al-top sheet advancing	20 IPM	1028.9 lbf ±12.0	4.6 kN ± 0.05
71	Al-Al	Al-top sheet advancing	30 IPM	1030.7 lbf ± 4.9	4.6 kN ± 0.02

* 1.0" X 6.0" samples tested in unguided set up

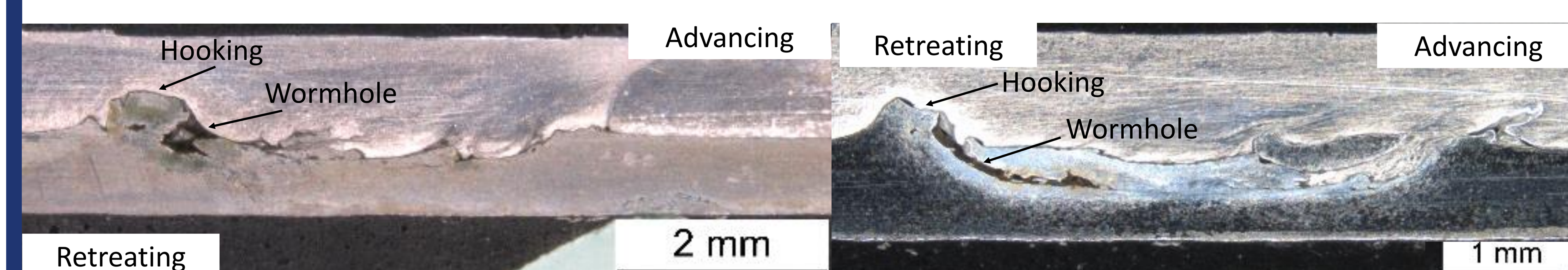

Figure 2. Welds 66 and 67 macrographs respectively

Figure 3. Weld made with scribe tool.

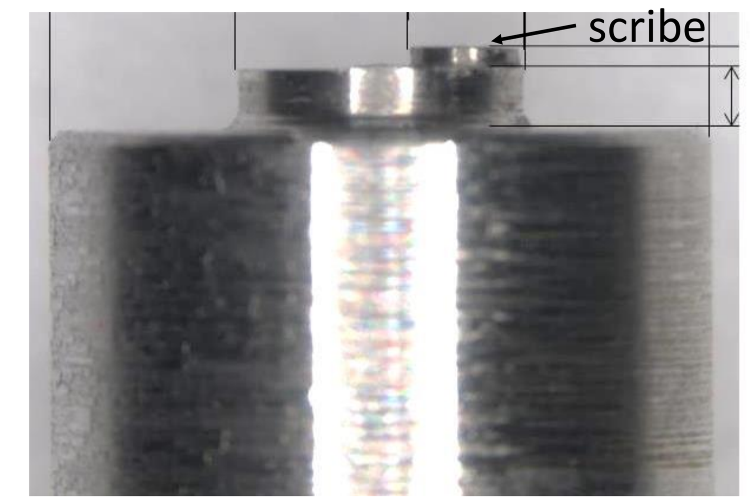

Figure 4. Tool design with scribe.

- On the retreating side, a high hooking feature is present
- Tensile test results show that when the hooking feature is on the aluminum loaded side, the failure load increases and the failure location predominantly occurs above this hooking feature in the HAZ.
- When the travel speed increases larger wormholes appear
- 20 IPM produces a higher failure load

Conclusions

- Aluminum and steel can be joined by FSW with a scribe tool
- Current parameters didn't satisfy strength requirements
- Use of a scribe made of tungsten reduces the wearing of the tool
- The use of the scribe results in more mechanical interlocking at the interface

Future Work

- Further experimentation with weld parameters
- A look at the weld interface to see if zinc coating is causing a braze bond
- Investigation of intermetallic compounds (IMC's) with SEM

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