FSW-Tech

Friction Stir Welding European Qualifications

CU12 – Case Studies

FSW Engineer

Co-funded by the
Erasmus+ Programme
of the European Union

12. Case Studies (CS)

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein - ERASMUS + KA2: 2017-1-SK01-KA202-035415

12.1 – CS1: Autoclave fixtures

APCO Technologies made large autoclave table for curing composite satellite components.

The table was produced using multiple plates and FSW. The final table surface plate was to measure 6.1m by 4.3m with a thickness of 20mm and made from four the aluminium-magnesium alloy AA5083 plates.

Welding on both size results in minimized distortion.

Additional processes include post-weld stress relieving heat treatment and plate machining. The welds could not be distinguished from the rest of the plate and are within the tolerances.

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein - ERASMUS + KA2: 2017-1-SK01-KA202-035415

12.2 – CS2: Vibration test tables

There are three possible ways to manufacture rigid structure:

- Subtractive manufacturing – starts with a single block of solid material and portions of the material are removed until the desired shape of fixture is reached. Disadvantage: generation of a scrap material. It is most expensive way to manufacture test table.
- Casting – provides a more rigid attachment than welded structures and are more flexible than welded fixtures
- Welded construction – has associated inherent weakness root cracks or blow holes

The alternative: **Friction stir welding**!

- ✓ Has the advantage that it breaks up the coarse silicon particles and heals any pores by the mechanical processing in aluminium alloys
- ✓ Offer lower distortion, lower heat input and lower shrinkage

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein - ERASMUS + KA2: 2017-1-SK01-KA202-035415

12.3 – CS3: Crack repairs

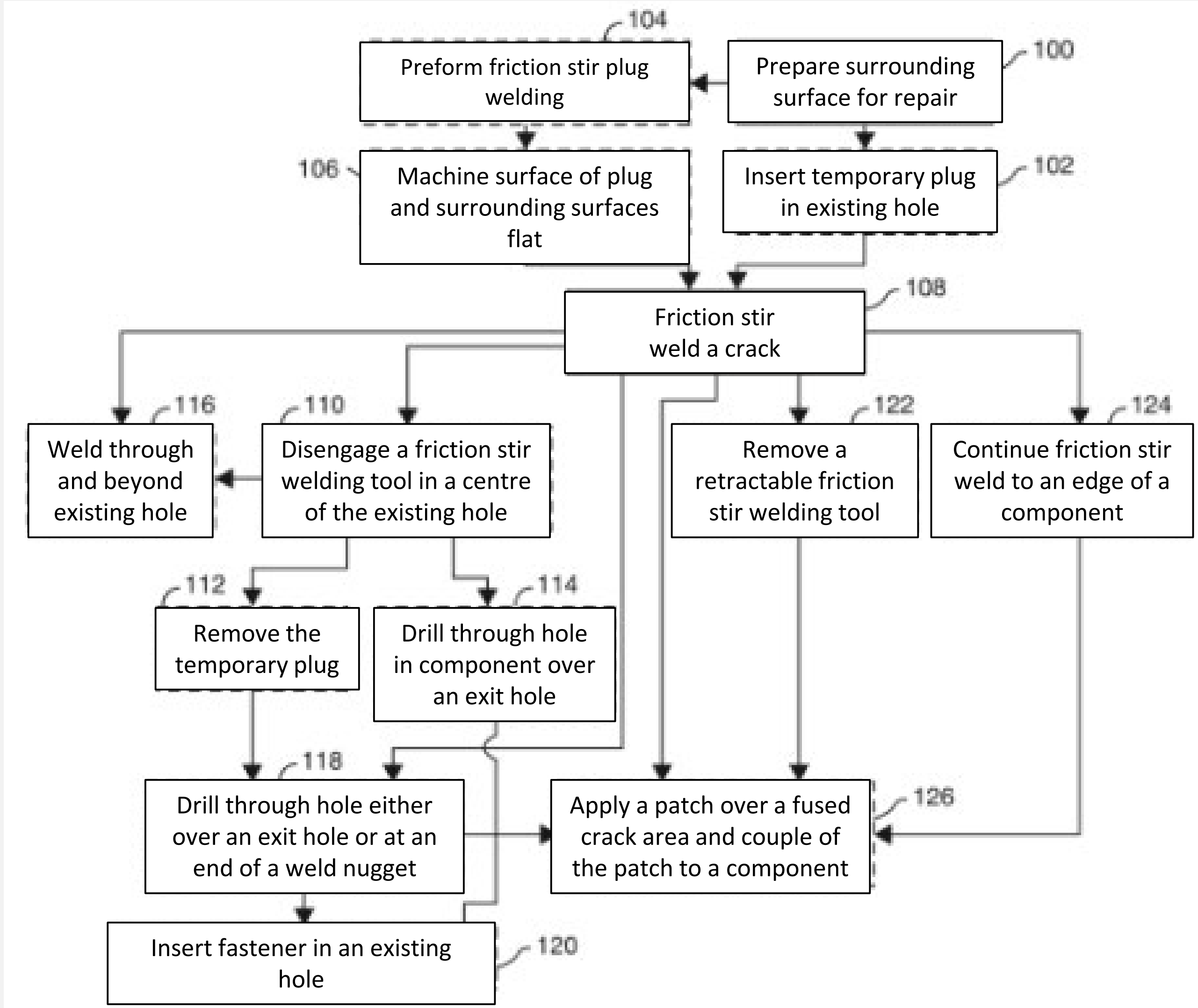
The method:

1. Preparing a surrounding surface of the crack for repairing
2. Welding a first portion of the component on a first side of the crack
3. Welding second portion of component on a second side of the crack to form a fused crack area.

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein - ERASMUS + KA2: 2017-1-SK01-KA202-035415

FSW Engineer

Co-funded by the Erasmus+ Programme of the European Union



This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein - ERASMUS + KA2: 2017-1-SK01-KA202-035415

12.4 – CS4: Underground vehicles

Bombardier use FSW to join stiff longitudinal extrusions, which constitute the car body's sidewalls. Vehicles were used to upgrade Victoria Lane, which is a London Underground line

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein - ERASMUS + KA2: 2017-1-SK01-KA202-035415

12.5 – CS5: Solar panels

The thin parts can be joined with minimal distortion. FSW reduce risk of leakage, because the welds are free from defects like porosity and heat cracks

Solar roof collector before painting

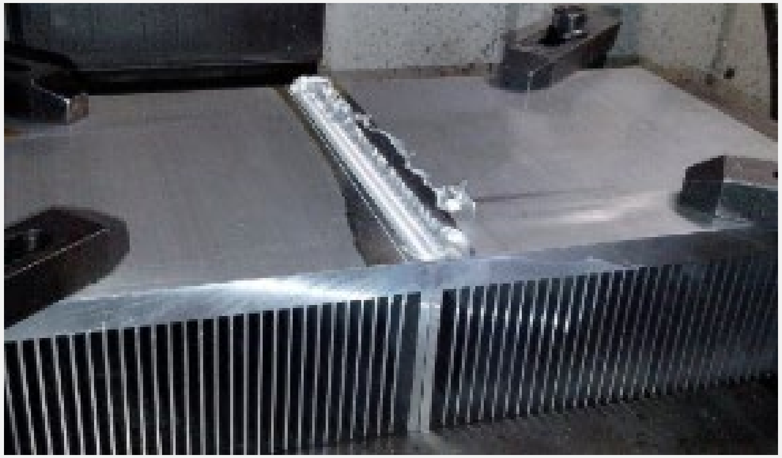
Roof made with solar roof collectors

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein - ERASMUS + KA2: 2017-1-SK01-KA202-035415

12.5 – CS5: Solar panels

FSW is also used to join heat sinks with high density fins by Walmate.

They field application include wind and solar energy sectors.



Friction stir welded heat sink

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein - ERASMUS + KA2: 2017-1-SK01-KA202-035415

12.6 – CS 6: Naval shipbuilding panels

- Available extrusions can be joined using FSW.
- Main advantage in comparison to fusion welding, are low heat input, low distortion and reduced thermal stresses.

Super Liner Ogasaware

The choice of tool material includes:

- Properties of the weld metal
- Required quality of the joint
- Strength of the work material, which determines the stresses induced to the tool
- Tool material properties related to heat generation
- Tool material properties related to coefficient of thermal expansion – thermal stress introduced by FSW
- Tool material selection can be also based on hardness, ductility and reactivity of the work materials

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein - ERASMUS + KA2: 2017-1-SK01-KA202-035415

Tools and welding procedures

- FSW – weld procedure specification (WPS) and Welder Performance Qualification Record Requirements (WPQR) shall be developed and qualified prior to production welding.
- Tool is characterised by:
  - Tool and probe material
  - Tool and probe geometry/design, e.g., shoulder diameter, probe diameter, probe length, probe shape (conical, cylindrical, etc)
  - Threads or no threads
  - Number of flats (if applicable)
  - Tool ID
  - Probe ID (if two-piece tool) and shoulder design]
  - Fabrication process (i.e., fixed, bobbin, retractable)

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein - ERASMUS + KA2: 2017-1-SK01-KA202-035415

Tolerances on weld preparation and fit-up

- ✓ The process can accommodate a gap of up to 10% of the material thickness without impairing the quality of the resulting weld.
- ✓ Additional requirements can be found in FSW standards.

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein - ERASMUS + KA2: 2017-1-SK01-KA202-035415

Post weld heat treatment, NDT and quality control

Post weld heat treatment (PWHT) can be deployed successfully with aluminum alloys, especially 2xxx and 7xxx aluminum alloys. Effects of heat treatment depends on type of heat treatment and can include:

- ✓ Uniform hardness distribution
- ✓ Improved or lowered tensile properties of the joint
- ✓ Improved fatigue performance

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein - ERASMUS + KA2: 2017-1-SK01-KA202-035415

General approaches include:

- Leaving the material in the as-welded condition
- Applying a low temperature stabilizing heat treatment (e.g. 25 hours at temperature near 100°C)
- Applying a solution heat treatment to the material after welding and then age to desired temper
- Applying additional post-weld aging to material originally in T6 or earlier temper to arrive at the final desired temper
- Applying a localized post-weld treatment

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein - ERASMUS + KA2: 2017-1-SK01-KA202-035415

Visual Inspection practice

Both top and bottom of each friction stir weld shall be inspected to the maximum extent possible, for attributes include:

- ✓ Exit hole uniformity
- ✓ Flash
- ✓ Chevron markings
- ✓ Dimensional variations in thickness
- ✓ Misalignment
- ✓ Cracks
- ✓ Porosity
- ✓ Lack of penetration

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein - ERASMUS + KA2: 2017-1-SK01-KA202-035415

References

Slide:

[1] https://www.twi-global.com/media-and-events/insights/defect-free-low-distortion-welding-for-autoclave-fabrication-362

[2] www.phase-trans.msm.cam.ac.uk/2003/FSW/aaa.html

[2] https://web.wpi.edu/Pubs/E-project/Available/E-project-102610-103816/unrestricted/Final_Presentation-BuckleyChiang.pdf

[3, 12] http://imv-global.com/news/wp-content/uploads/2017/05/Slip-table%E3%80%80TVH0321.pdf

[3] M.-K. Besharati-Givi, P. Asadi, Advances in Friction-Stir Welding and Processing (Woodhead Publishing Series in Welding and Other Joining Technologies), Woodhead Publishing, 2014

[10] https://www.grenzebach.com/insights/friction-stir-welding-for-energy-revolution/

[8] https://www.twi-global.com/media-and-events/insights/friction-stir-welding-on-the-london-underground-383

[11] https://commons.wikimedia.org/wiki/File:Super_Liner_Ogasawara-1.JPG

[13, 14, 16] https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20090015054.pdf

[13, 16] Mel Schwartz, Innovations in Materials Manufacturing, Fabrication, and Environmental Safety, CRC Press, 2010

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein - ERASMUS + KA2: 2017-1-SK01-KA202-035415

References

Slide:

[13, 16] Chiteka, Kudzanayi. "Friction stir welding/processing tool materials and selection." International Journal of Engineering Research & Technology 2.11 (2013).

[13, 16] Chiteka, Kudzanayi. "Friction stir welding/processing tool materials and selection." International Journal of Engineering Research & Technology 2.11 (2013).

[13, 16] https://ww2.eagle.org/content/dam/eagle/rules-and-guides/current/survey_and_inspection/186_frictweldalum/fsw_guide_e.pdf

[16] http://shodhganga.inflibnet.ac.in/bitstream/10603/8523/9/09_chapter%202.pdf

[16] Rajiv Mishra, Murray Mahoney, Yutaka Sato, Friction Stir Welding and Processing VII, Springer, 2016

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein - ERASMUS + KA2: 2017-1-SK01-KA202-035415