Friction Stir Welding

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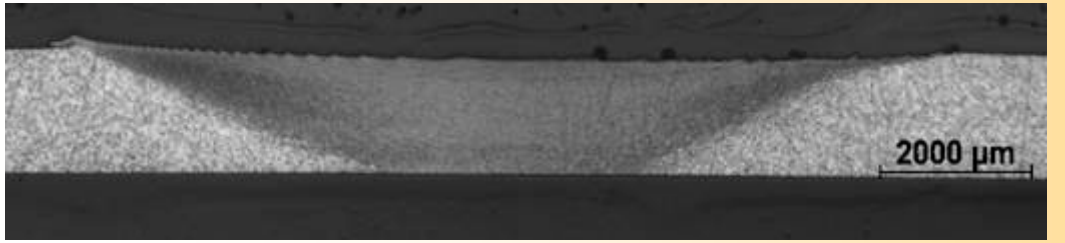
Overview

- What is Friction Stir Welding (FSW)
- Benefits
- Drawbacks
- Weld geometries
- Equipment
- Applications

What is FSW?

- Process invented in 1991 by Wayne Thomas, TWI
- Utilizes a rotating, non-consuming tool, consisting of a « pin » and a « shoulder »
- **At each instance, the joint is formed in a solid state!**

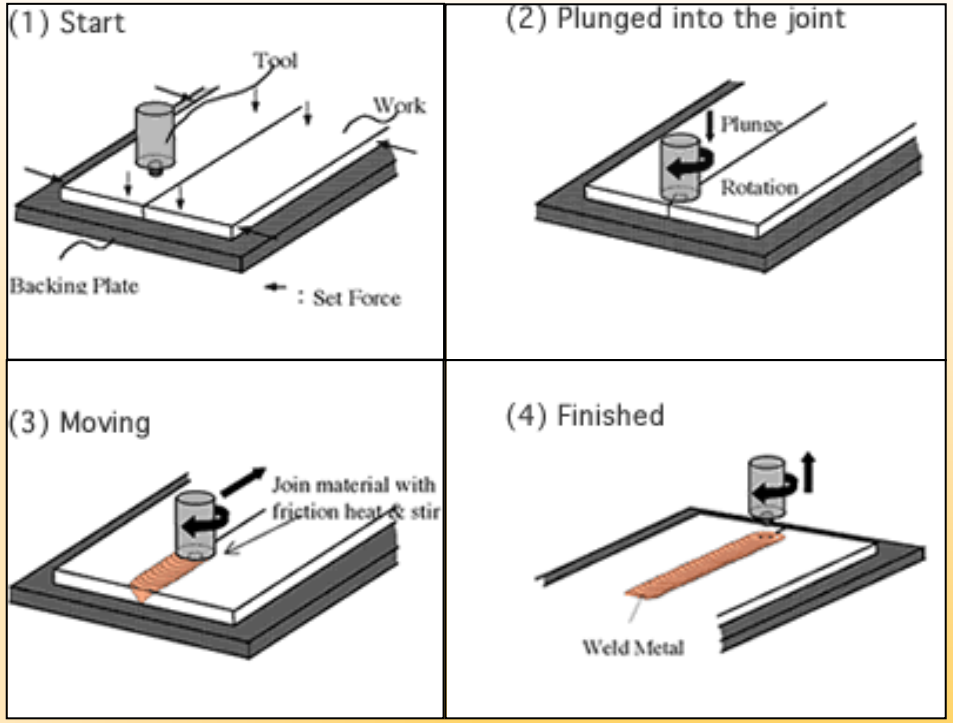
Source:
UCL-PRM



Friction stir weld in 1,5 mm 5182-H111

Principle

- rotating pin is pushed into the material until shoulder meets the workpiece surface; after a while, this causes the material to plasticize due to heating by frictional contact of the tool shoulder and the workpiece (1-2)
- tool is moved forward, and the joint is formed behind the tool (3)
- process is finished when the tool is retracted from the workpiece; a hole remains in the workpiece (4)



Source: Hitachi

Benefits of FSW (1)

- No hot cracks, no gas pores
- No shielding gases or consumables
- Possibility of joining dissimilar alloys/materials
- Welding possible in all positions
- Limited weld seam preparation (degreasing)
- Few softening or deformation

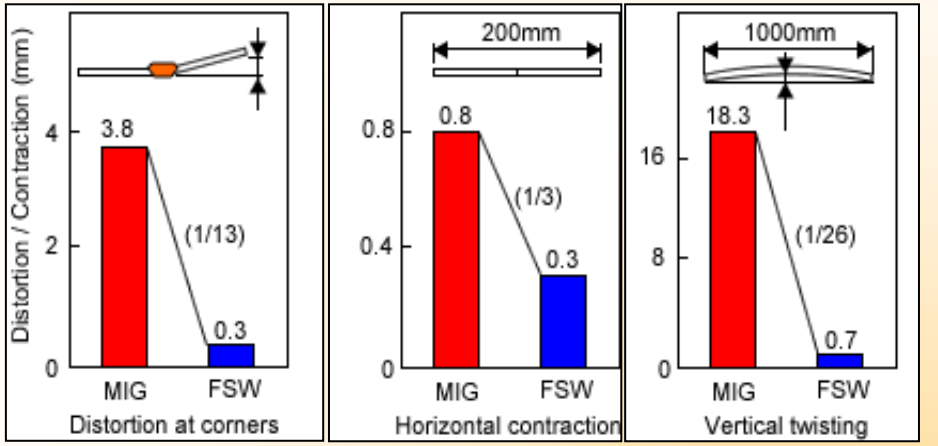
No fusion

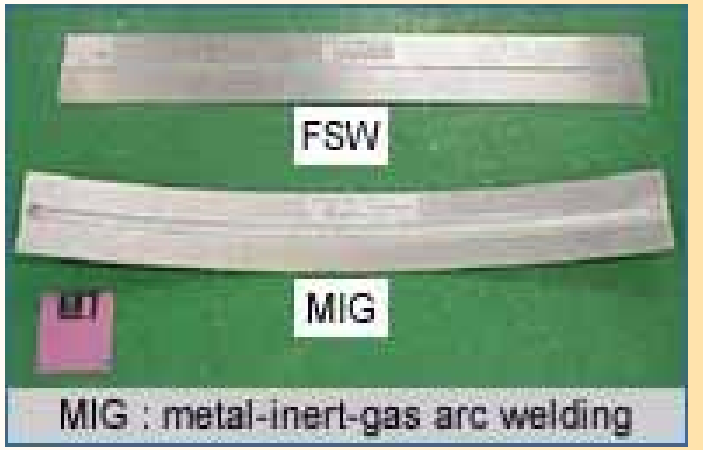
Low heat-input

Benefits of FSW (2)

- Constant weld quality achieved together with high productivity
- Safety:
  - no UV-radiation
  - no welding fume
  - no spattering
- 6xxx series Al alloys: possibility to weld 1,2 mm up to > 65 mm (upper limit determined by maximum power)
- Fully automatic
- Little maintenance
- Flat welding surface without reinforcement

Deformation: MIG vs. FSW





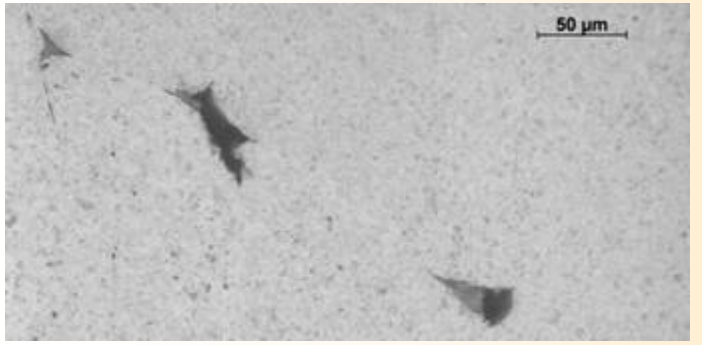
Source: Hitachi

Drawsbacks of FSW

- Large forces: order of magnitude 10 kN (backing plate required!)
- Rigid clamping system needed
- « Hole » at the end of the weld
- Problems if weld gap > 10% material thickness
- Investment cost (equipment with high stiffness)
- License cost: £ 28.000/year (up to 2012/2017)
- Other weld flaws are possible

Self-retractable pin tool
Source: NASA

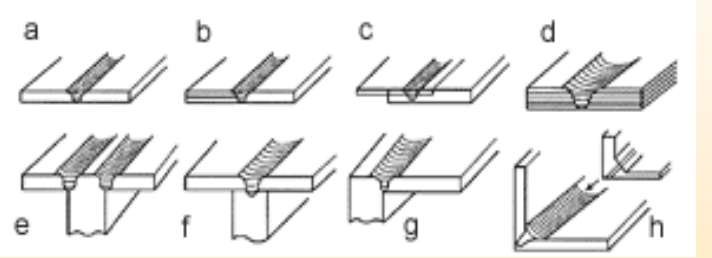
« Tunnel defects » or « wormholes »



« Joint line remnant »

Possible welding geometries

Source: ESAB



a) Square butt
b) Combined butt and lap
c) Single lap
d) Multiple lap
e) 3 piece T butt
f) 2 piece T butt
g) Edge butt
h) Possible corner fillet weld

Source: FPE & Gatwick Fusion Ltd

Equipment

Source: UCL-PRM
Milling machine adapted for FSW

Source: ESAB (Legio)
Small FSW machine

Source: Institut de Soudure
MTS machine, 20 m length!

Current FSW applications: aluminium

Source: Eclipse Aviation
7000 mechanical joints (rivets) replaced by 263 FSWs

Source: Hitachi
Skin panels for rolling stock

Bron: PDC Teknik
Bang&Olufsen loudspeaker housings

Current applications: aluminium (2)

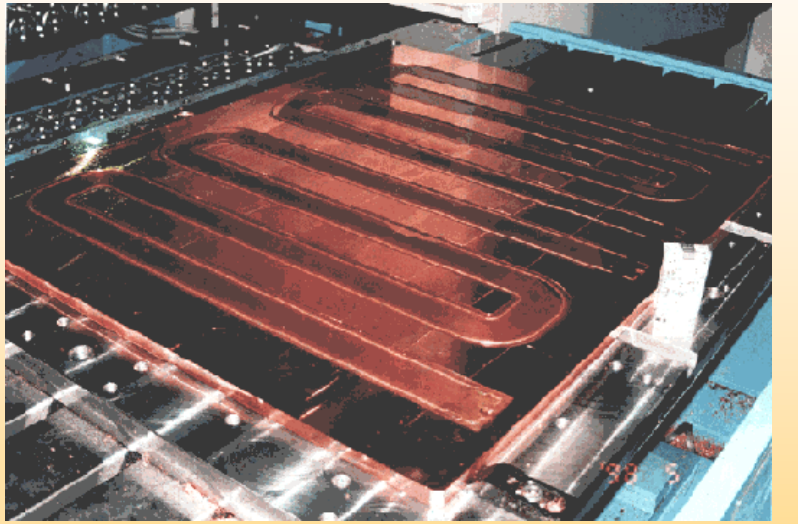
Source: ESAB
Welding relatively simple extrusion profiles together for shipbuilding

Source: ESAB
Fuel tanks for Delta II rockets

Source: Hydro Aluminium
Chassis of the new Ford GT
(Build up with FSW and MIG)

Current applications: copper

Source: TWI
Copper canister for storage of High Level Waste (nuclear), for SKB
Wall thickness: 50 mm!



Source: Hitachi Cable, Ltd
Copper backing plate for sputtering (LCDs, semiconductors)
Material: OFHC copper
Thickness: 10-70 mm!

Furter applications?

- Friction stir welding of:
  - Zn for roofings (welding speeds up to 1,8 m/min at thicknesses of 0,8 mm!)
  - Mg alloys
  - Thermoplastics
  - Titanium, steel and stainless steel (still challenging with respect to the tool material due to the higher temperatures and forces)
  - …