Friction Stir Welding European Qualifications

CU09 – Parts Design

FSW Engineer

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

9. Joint Definition

9.1 Types of Friction Stir Welds

9.2 Technical specifications for the final products

9.3 Guidance's for Design in FSW

9.4 References

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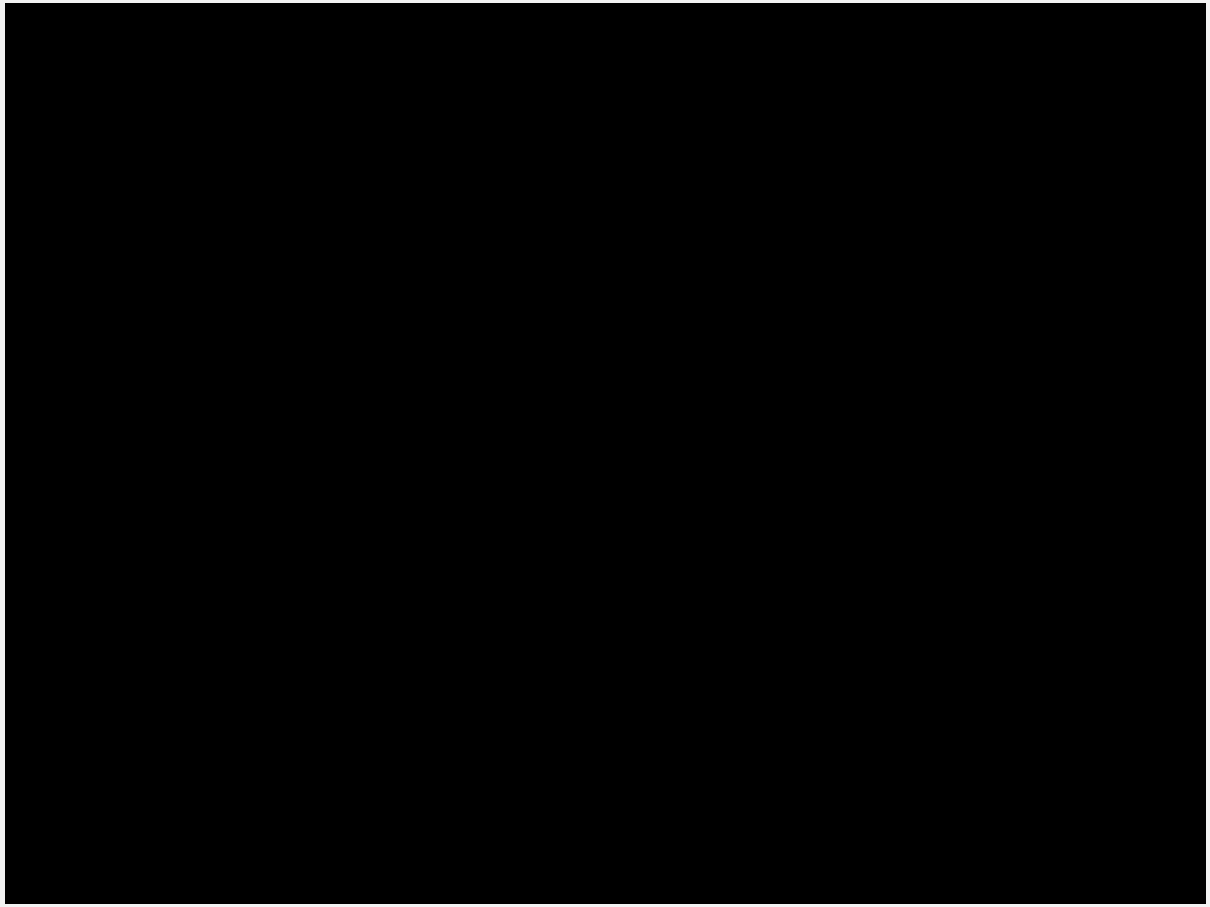
9.1 Types of Friction Stir Welds

- There is a variety of friction welding techniques :
- Rotary Friction Welding — most popular type of friction welding and used for parts where at least one piece is rotationally-symmetrical such as tube or bar.
- Linear Friction Welding — used for jet engine components, near-net shapes, and more where the limitation on the parts is only based upon the mass of the moving part; not the geometry of the interface.
- Friction Stir Welding — often used for aluminum plates, extrusions, and sheets where seam or butt welds are made between thin components without a restriction on the component length.



Rotary Friction Welding

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Slow motion linear friction welding of Titanium by TWI

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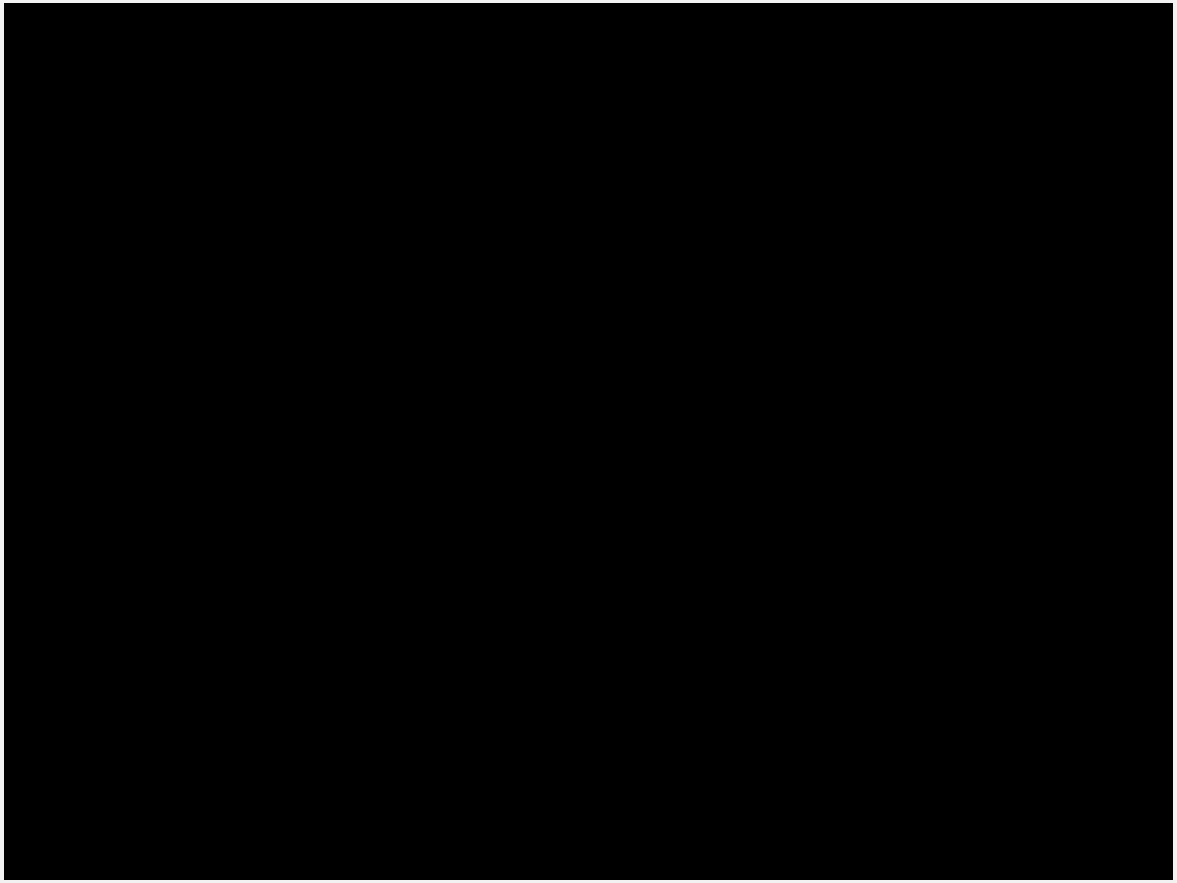

Friction Stir Welding

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9.1 Types of Friction Stir Welds

Advantages

Rotary Friction Welding	Linear Friction Welding	Friction Stir Welding
100% bond at the contact area Ability to join dissimilar materials Minimal joint preparation required Fast weld cycles, allowing more parts to be joined in less time Less inventory required to create part families Eco-friendly since no consumables are used Scalable to any size weld	A rapid, repeatable, and flexible process Ability to join nearly any number of shapes with complex part geometries Ability to join dissimilar metals Minimal joint preparation required; resulting in faster production Eco-friendly since no consumables are used Scalable to any size weld	Affords new joining applications for difficult manufacturing challenges- from extrusions to sheets and more Virtually defect-free bonding Accommodate parts up to 55 feet long Ability to join dissimilar alloys Ability to use dual head feature for fast panel welding Minimal distortion of joined parts, for extremely high-weld strength Eco-friendly since no consumables are used

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9.1 Types of Friction Stir Welds

Top Applications

Rotary Friction Welding	Linear Friction Welding	Friction Stir Welding
Aerospace Agricultural Automotive Construction Consumer products Oil and Gas Military	Aerospace Automotive Military Oil and Gas	Aerospace Electronics Marine Military Transportation

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Types of friction stir welding

- Friction Stir Spot Welding
  - https://www.youtube.com/watch?v=2fldX_Hcaeg
- Double Sided Friction Stir Welding
  - https://www.youtube.com/watch?v=BVhLIv2_cnc
- Stationary Shoulder FSW
  - https://www.youtube.com/watch?v=e_6YS03yulY
  - https://www.youtube.com/watch?v=q0oWjfeVXo8

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9.1.1 Friction Stir Spot Welding

- Friction Stir Spot Welding (FSSW) is a solid-Phase welding process for overlap welding of sheets with similar Joint designs as in resistance spot welding. It generates individual spots instead of continuous welds.
- The process is mainly used in the automotive industry, the railway rolling stock manufacture and in aircraft production. For instance the rear doors of the Mazda RX8 and the boot lid of the Toyota Prius are welded by this process in high-volume production.

Friction Stir Spot welding Machine

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9.1.1 Friction Stir Spot Welding

Material	Welding Thickness	Structure	Application Field
All series of AL-alloy	0.5~1 mm	Separate	Aero-space Aero-craft Automobile
Mg-alloy, etc	0.5~4 mm	Separate	Electronic Circuit board Electron, etc.

a) Tool- Spot FSW; (b) Appearance of Spot FSW joint; (c) Spot FSW product for aero-craft

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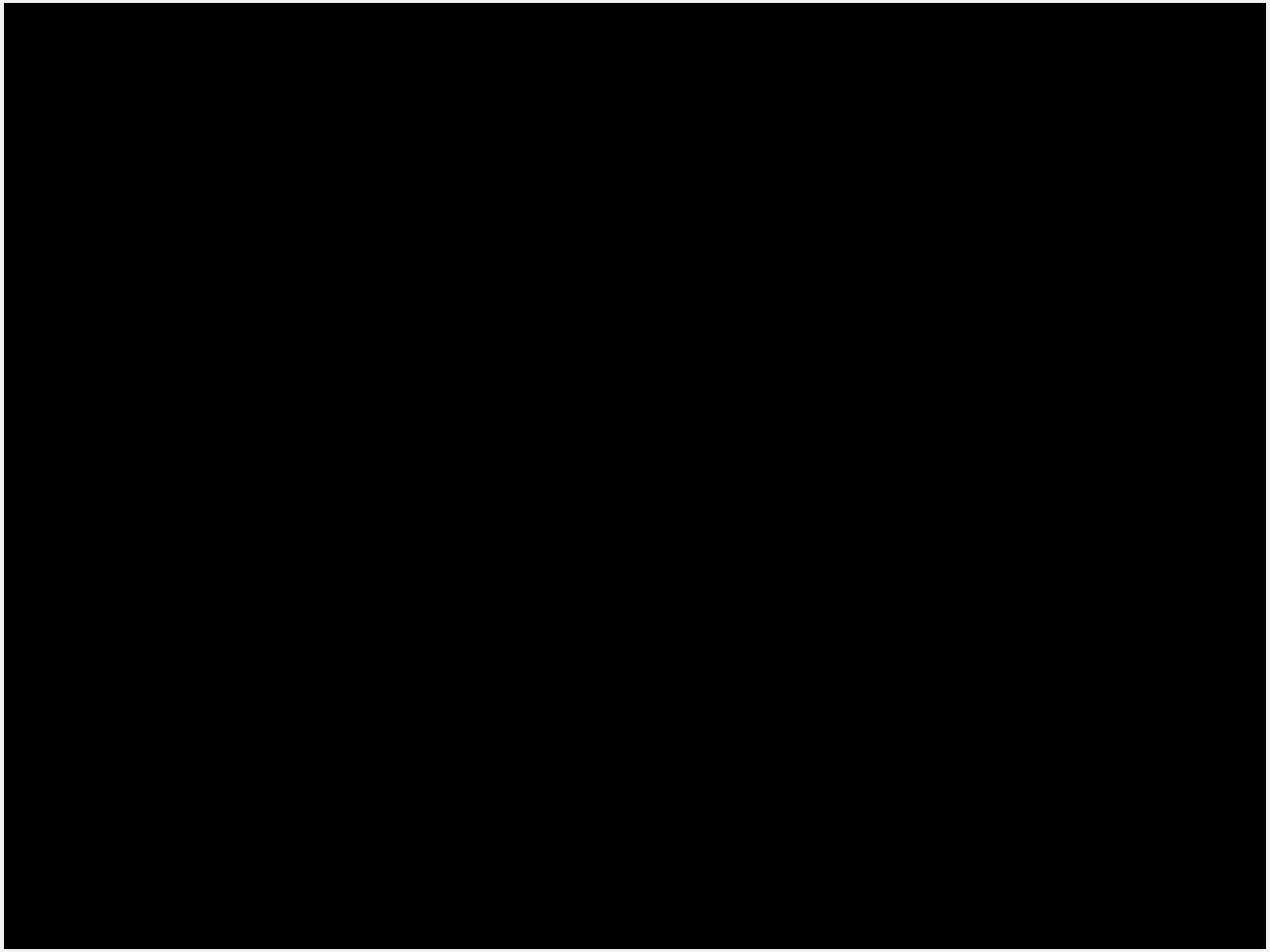

Friction Stir Spot Welding – by TWI Ltd

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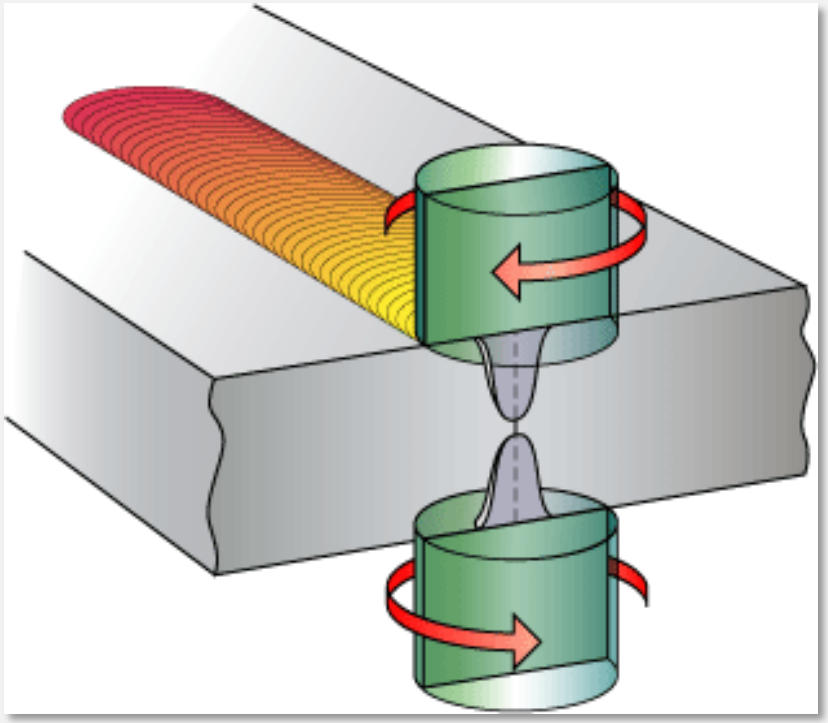
9.1.2 Double Sided Friction Stir Welding



Double Sided Friction Stir Welding

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Double-sided friction welding

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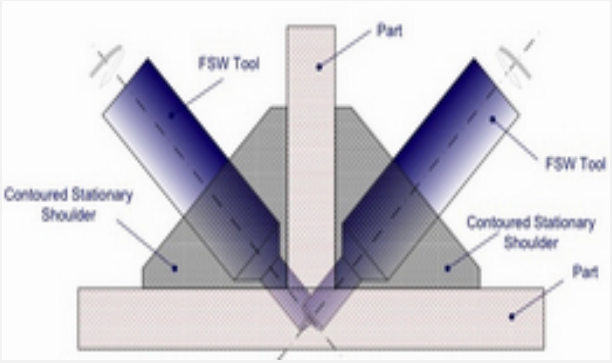
9.1.2 Stationary Shoulder Friction Stir Welding

The stationary shoulder adds no heat to the surface so all of the heat is provided by the probe and the weld is made with an essentially linear heat input profile. The key welding mechanism consists of a rotating pin running through a non-rotating shoulder component, which slides over the surface of the material during welding. The weld surface is very smooth, almost polished, with no or minimal reduction in cross-section.

Using the SSFSW technique on a robot can reduce issues associated with controlling the depth of the tool during welding. The robot structure is prone to deflection as it holds the FSW tool on the material's weld line, meaning changes in the material's softness and subsequent resistance can alter the depth at which the tool operates, producing flaws and defects.



Corner SSFSW joint

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9.1.2 Stationary Shoulder Friction Stir Welding

Material	Welding Thickness	Structure	Application Field
All serials of Al-alloy, Mg-alloy, etc	8~15mm	Separate	Aero-space Automobile
	15.1~30 mm	Separate	Railway Aero-craft
	30.1~45 mm	Separate	Electronic Electron, etc

Corner stationary shoulder FSW tool model type

8 mm thickness Al-alloy Corner Seam Sample welded by stationary shoulder FSW

Corner Stationary Shoulder FSW Tool Application in shipping

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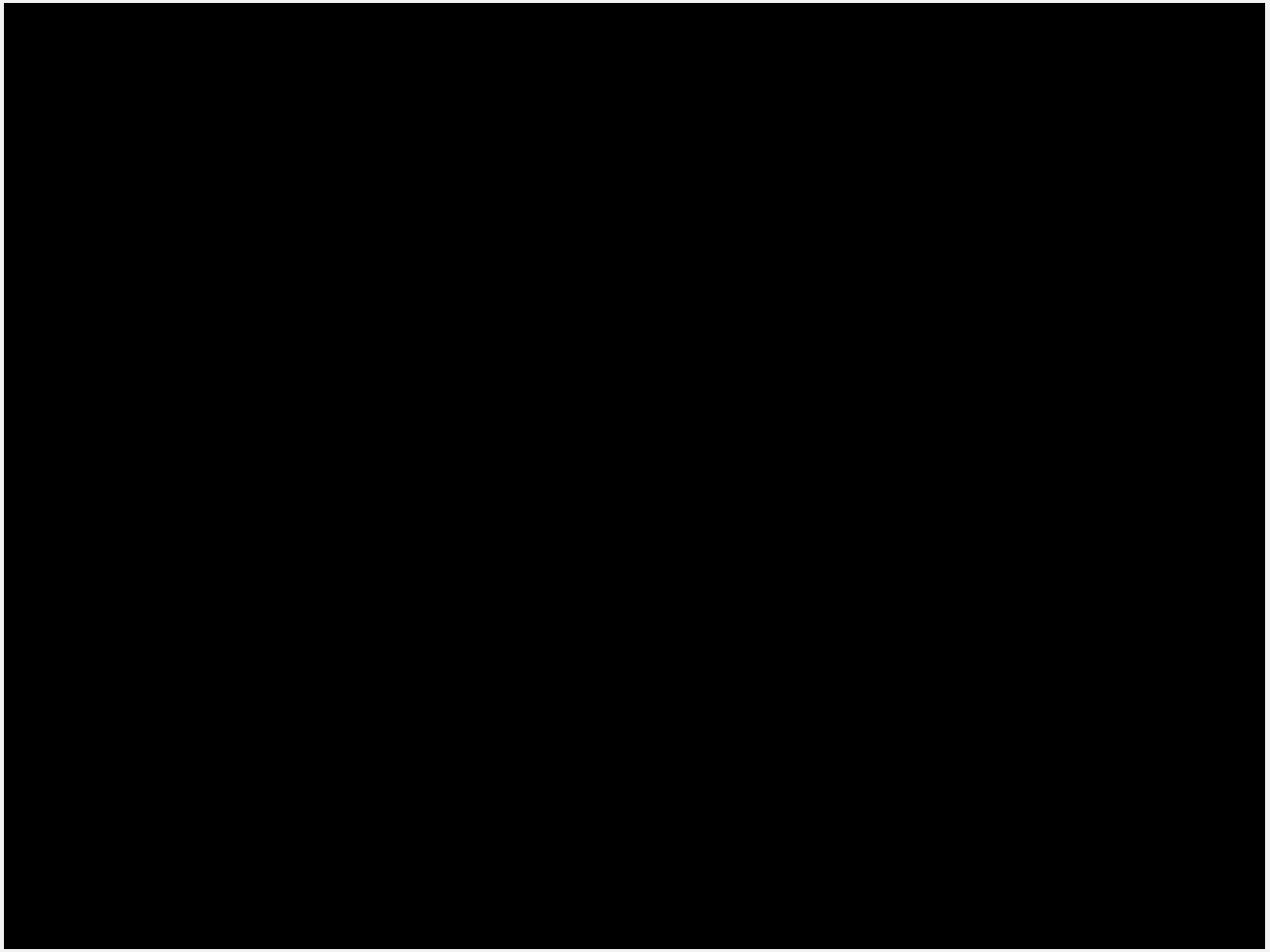

Stationary Shoulder Friction Stir Welding

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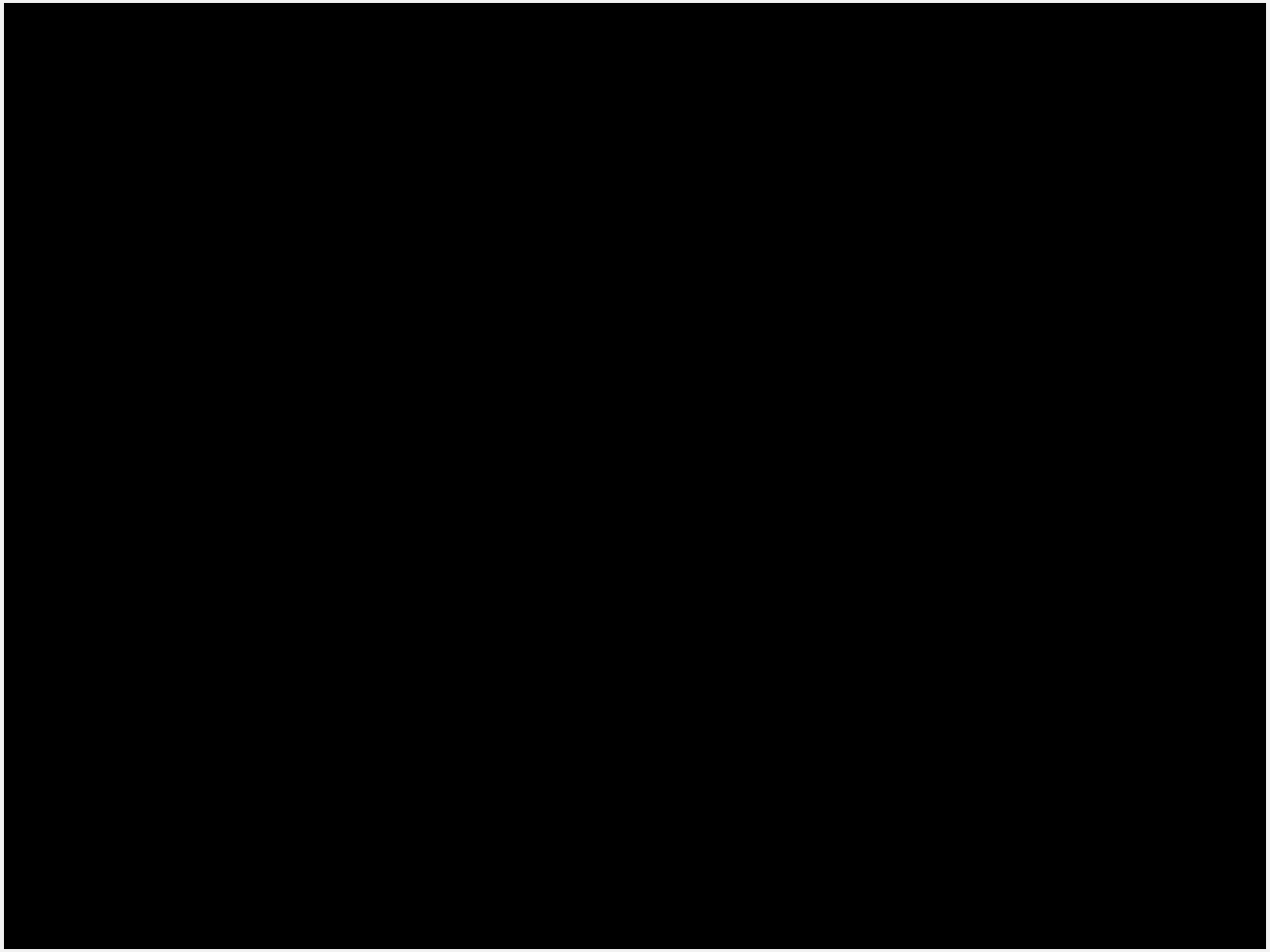

FlexiFab Demo: Robotic Stationary Shoulder FSW

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9.2 Technical specifications for the final products

- Technical specifications of the final products are imposed by the beneficiary, usually the components that came to be welded in laboratory or industry has some specifications that need to be followed.
- The specifications are imposed by the designer in concordance with standards(ISO, AWS, ABS, etc) because the designer knows the loads and the distribution of the loads in the components. Each component needed to by examine after the weld in concordance with the specification received.

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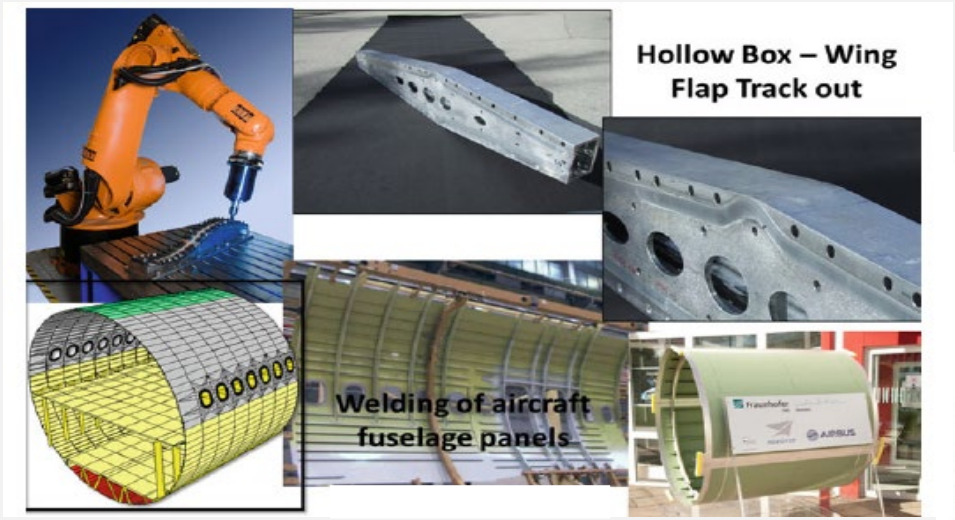
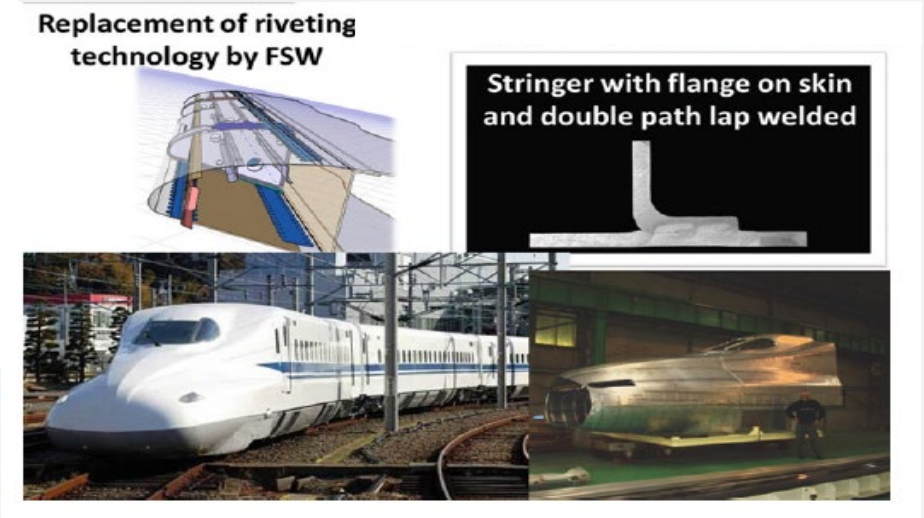
9.2 Technical specifications for the final products

Components of planes and trains





A few illustrative examples of implementation of friction stir welding (all aircraft related photographs courtesy Airbus Group, Ottobrunn, Germany and Shinkansen photographs courtesy Mr. Gilbert Sylva)

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9.3 Guidance's for Design in FSW

- Friction Stir Welding can be used in Aluminium alloys, Titanium Alloys, dissimilar materials and this process is used predominant for Aerospace.
- Recent research lied that now can be welded using FSW titanium in thicknesses of 3mm and 8mm (HZG- Hamburg). Excellent results have also been achieved with exotic aluminium alloys from 2mm – 35mm in a range of challenging configurations.

Table Friction Stir Welding

Moving Table

FSW Machine

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Probes Shapes

The pin/tool can produce deformational and frictional heating. Ideally, it is designed to combine the two surfaces of the pieces by milling, mixing the material in front of the pin/tool and moved the material behind the pin/tool.

The depth of deformation and tool travel speed are mainly governed by the probe. The end shape of the probe is either flat or domed. The flat bottom probe design that emphasizes ease of manufacture is currently the most commonly used form.

The main disadvantage of the flat probe is the high force during plunging. In contrast, a round or domed end shape can reduce the force and tool wear upon plunging, increase tool life by eliminating local stress concentration and improve the quality of the weld root directly at the bottom of the probe

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Design of Joint Configuration

- The specimens that need to be welded in solid phase don't need special preparation
- Usually are butt welds and the surface of the specimens are only fixed in the clamping system
- It is desirable to perform a small number of preparations before and after welding.

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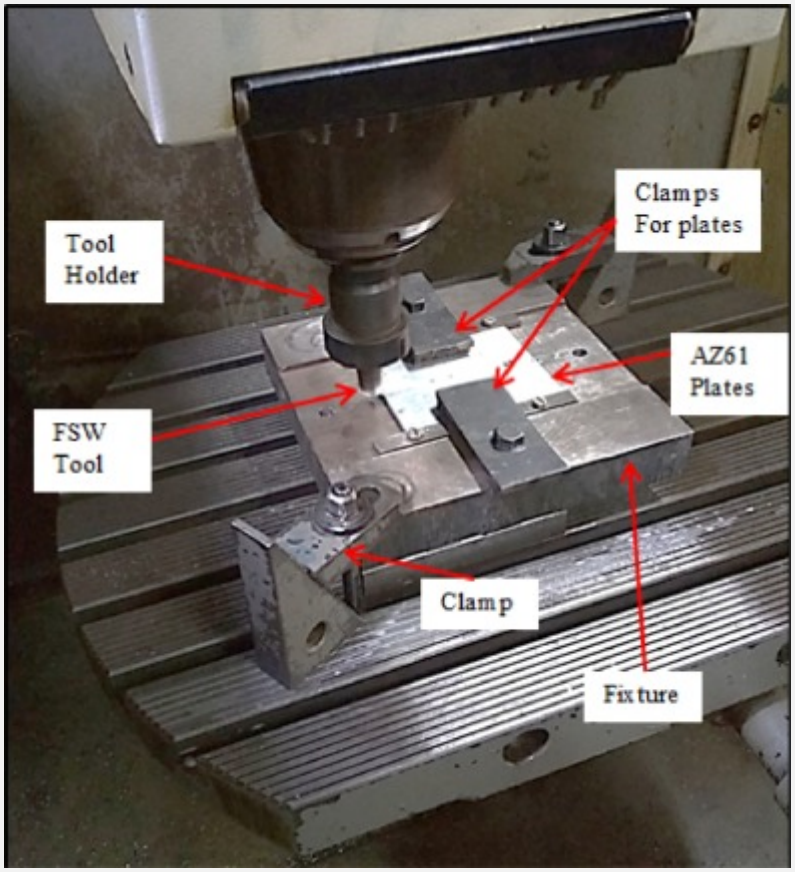
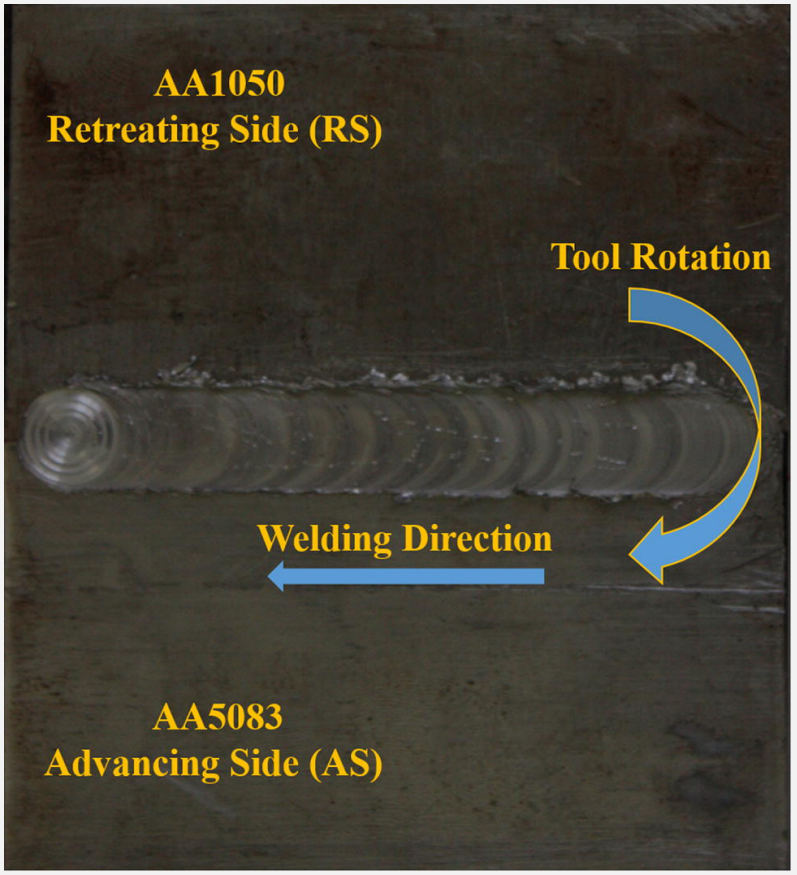


FSW machine with the clamping system



Details regarding tool rotation, welding direction

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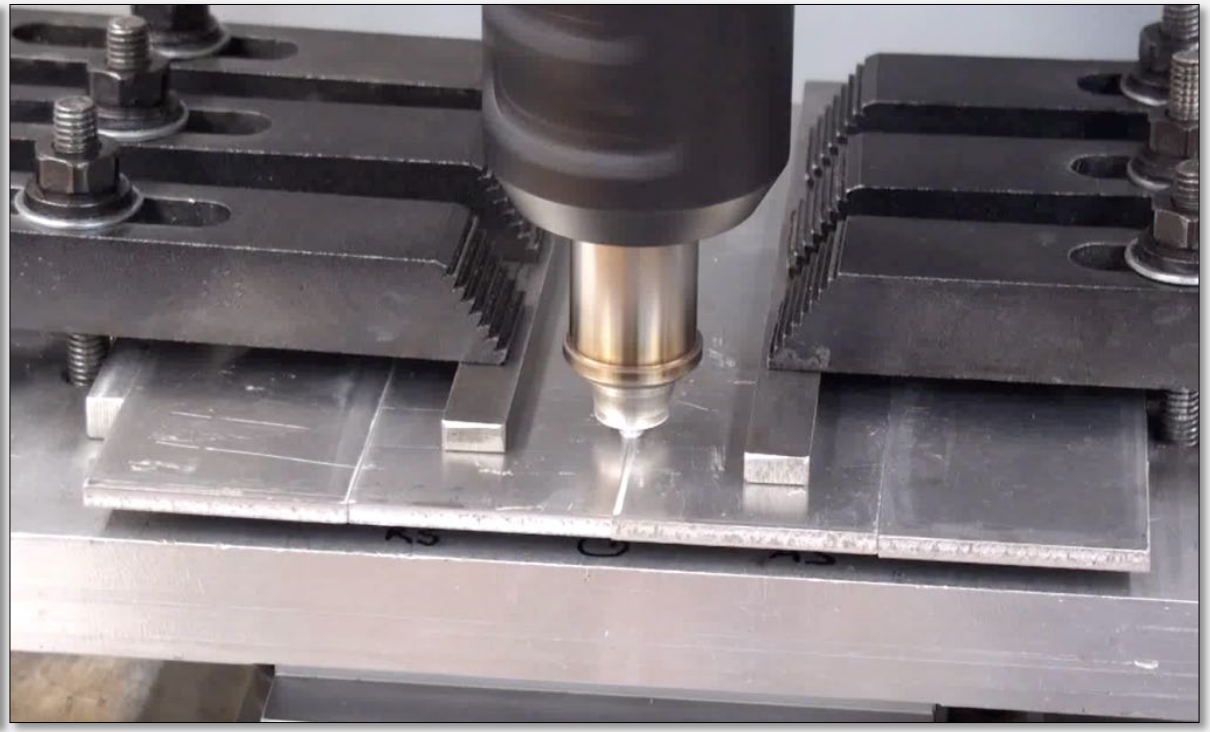

FSW weld – Without edge preparation

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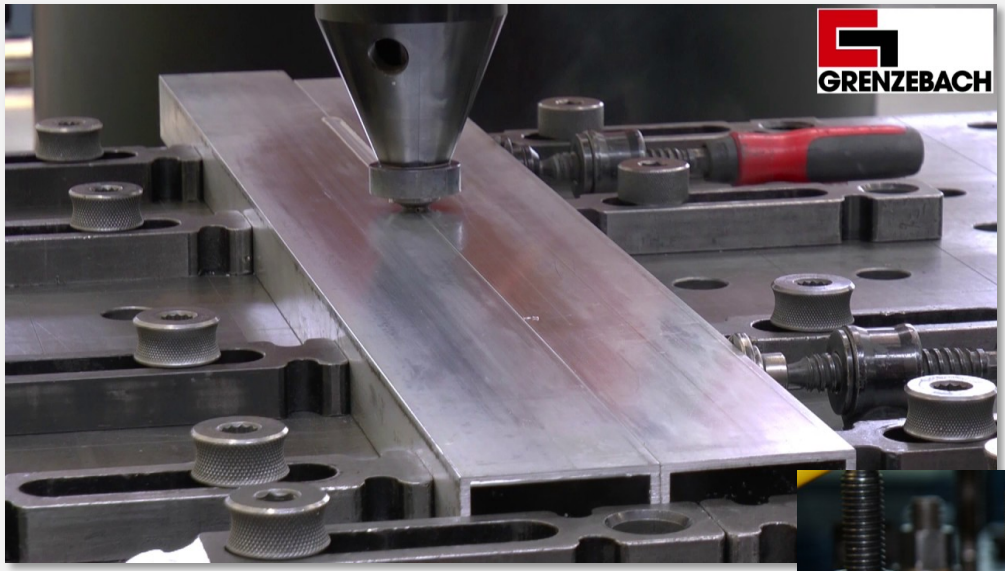

FSW weld – Without edge preparation

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FSW-Tech

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