FSW-Tech

Friction Stir Welding European Qualifications

EUROPEAN FRICTION STIR WELDING SPECIALIST (EFSW-S) AND ENGINEER (EFSW-E)

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

INSTITUT ZA VARILSTVO
Welding Institute

ISQ

VÚZ

EWF

ASR

6. Maintenance

Scope:

6.1 Backing plate conditions

6.2 Tolerances for backing plate

6.3 Tool conditions

6.4 Tolerances for pin/tool

6.5 Clamping/positioning devices conditions

6.6 Tolerances for clamping/positioning devices

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

6.1 Backing plate conditions

- For carrying out a proper FSW process, the material diffusivity of backing plate material is an important factor.
- The high thermal diffusivity materials such as pure copper, aluminium alloy results in increased heat extraction rate.
- Lower thermal diffusivity materials such as asbestos, ceramic floor tile, granite etc. result in lower heat transfer rate.

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

Level of thermal diffusivities for different backing plates for FSW

Material of backing plate	Thermal diffusivity at room temperature [m^2/s]	Level
copper	$1{,}1\times10^{-4}$	high
aluminium	$0{,}9\times10^{-4}$	high
asbestos	$4{,}1\times10^{-5}$	moderate
non-alloyed steel	$1{,}1\times10^{-5}$	moderate
titanium-commercially pure	7×10^{-6}	low
stainless steel (AISI 304)	4×10^{-6}	low
marble	$1{,}4\times10^{-6}$	low
granite	$1{,}1\times10^{-6}$	low

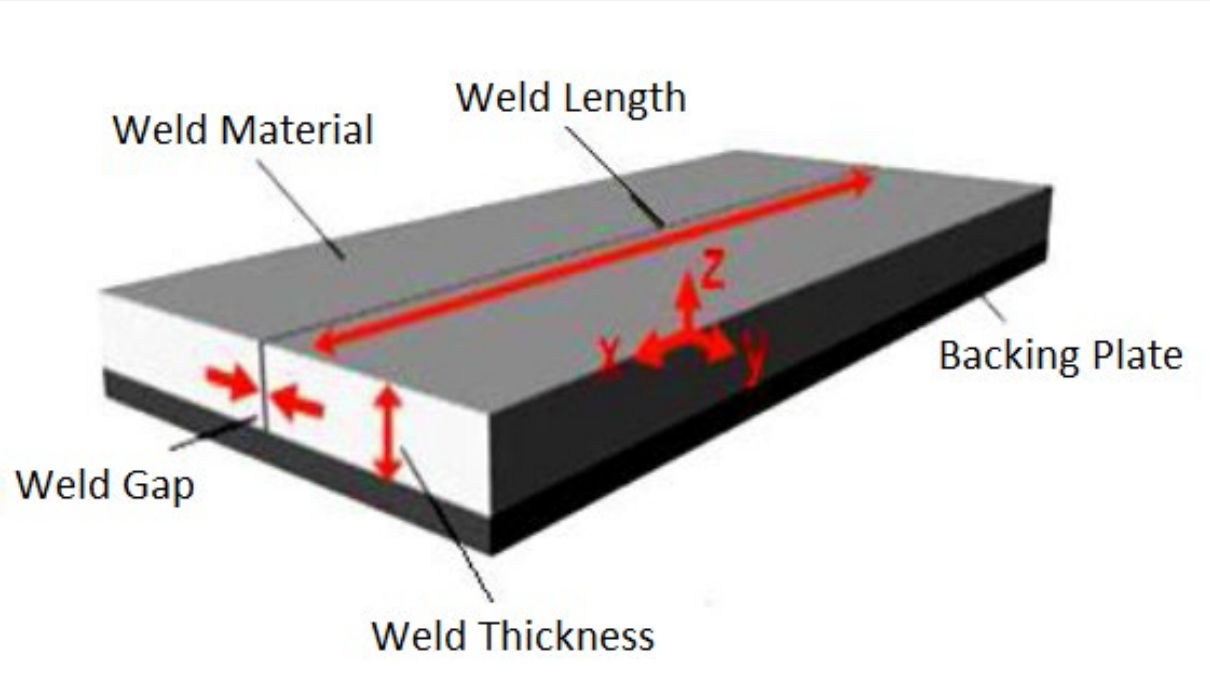
This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein - ERASMUS + KA2: 2017-1-SK01-KA202-035415

Some conclusions for backing plate condition:

- Extremely high thermal diffusivity materials such as copper and aluminium are not suitable as a backing plates because it results in excessive heat transfer rate at bottom of workpieces .
- Low thermal diffusivity back plate is suitable to reduce power requirement and to make FSW process more energy efficient.
- Appropriate choice of backing plate is more important during FSW of thinner sheets/plates.

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

6.2 Tolerances for backing plate



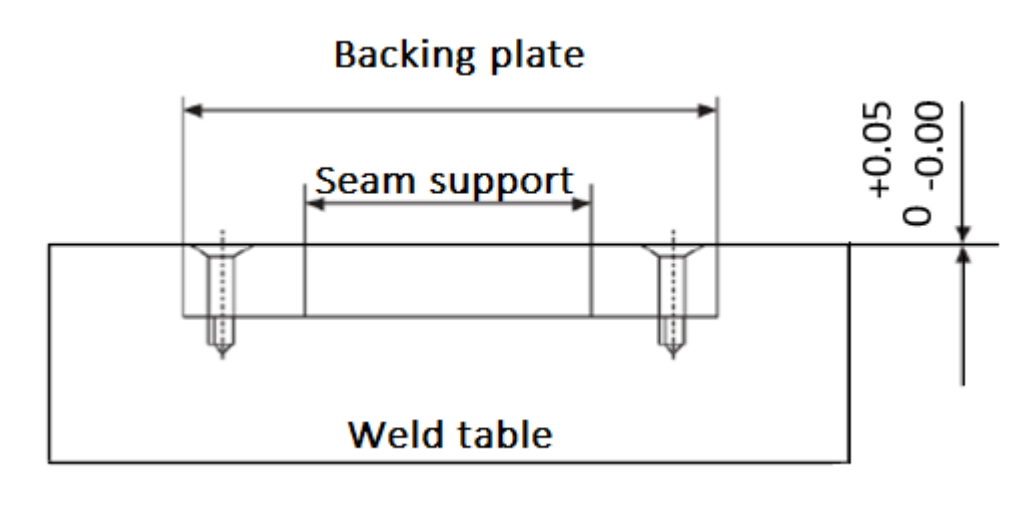
Base material tolerances in FWS

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

- A gap of 10 % of the weld thickness is tolerable before the weld quality is affected (in direction of *y* axis).
- The backing plate receives a proportion of the heat transferred by the weld nugget and so must not warp or deform under the heat applied.
- To make sure there is no deflection or gap between the weldment and the backing plate, a roller can lead the tool applying a constant force to press the material to the backing plate.

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

- Backing plate should be in an absolute plane. Tolerances of the wavy surface of backing plate are limited to 0,1 mm.
- Thermal conductivity of the backing plate λ is important factor to consider tolerances due to heat flow from the weld nugget.



Backing plate tolerance to weld table [mm]

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

6.3 Tool conditions

- Welding tool material selection is important consideration in developing successful FSW process.
- The rotation and translation of tool through the workpiece result in its wear.
- Diffusion and abrasion are the expected wear mechanisms.
- Reaction of the tool material with its environment, including both the workpiece and the surrounding gases, is also expected to contribute to the tool wear.

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

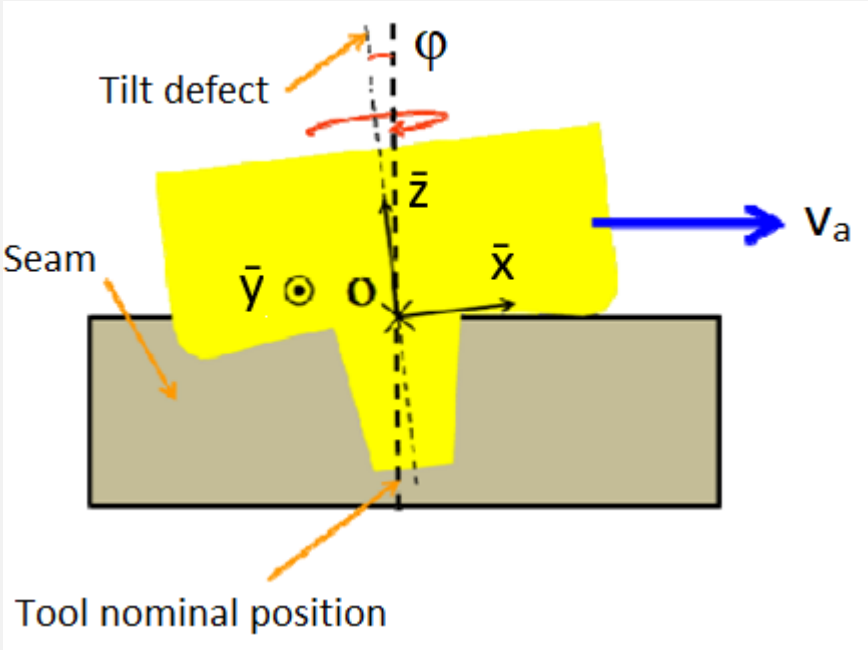
- Tool materials selection is more challenging for FSW of high temperature alloys (steels, nickel alloys, titanium alloys).
- For all high temperature tool materials wear and reactivity to oxygen are the most important.
- Abrasion wear is significant in the presence of harder secondary phase in base material, like in aluminium metal matrix composites.
- Compared with the tool shoulder, the tool pin suffers much more severe wear and deformation, and the tool failures almost always occur in the pin.
- Lower welding speed, preheating of the base material and use of sufficient inert gas shielding can reduce tool wear.

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

6.4 Tolerances for pin/tool

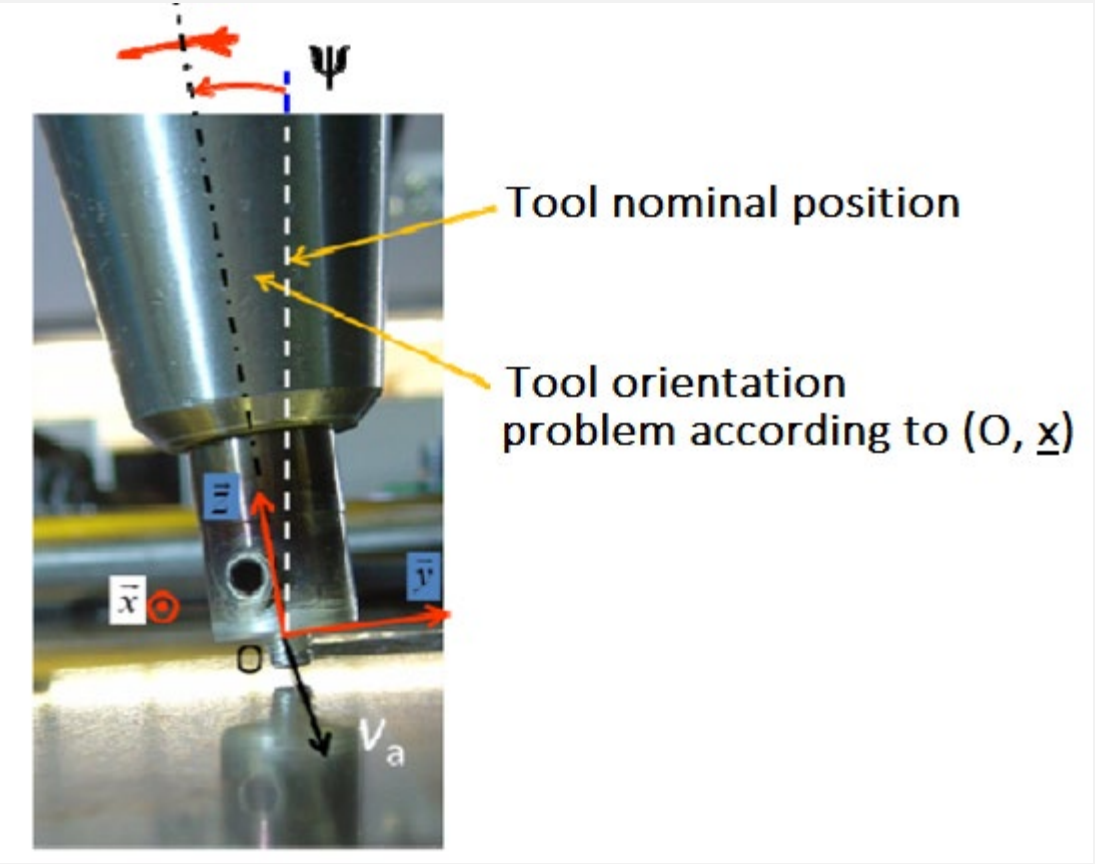
In general, three different tolerances are possible for FSW tool:

- Main tilt angle φ between the ideal vertical axis of tool rotation z and actual axis of rotation (this angle shall be nominal > 0°)



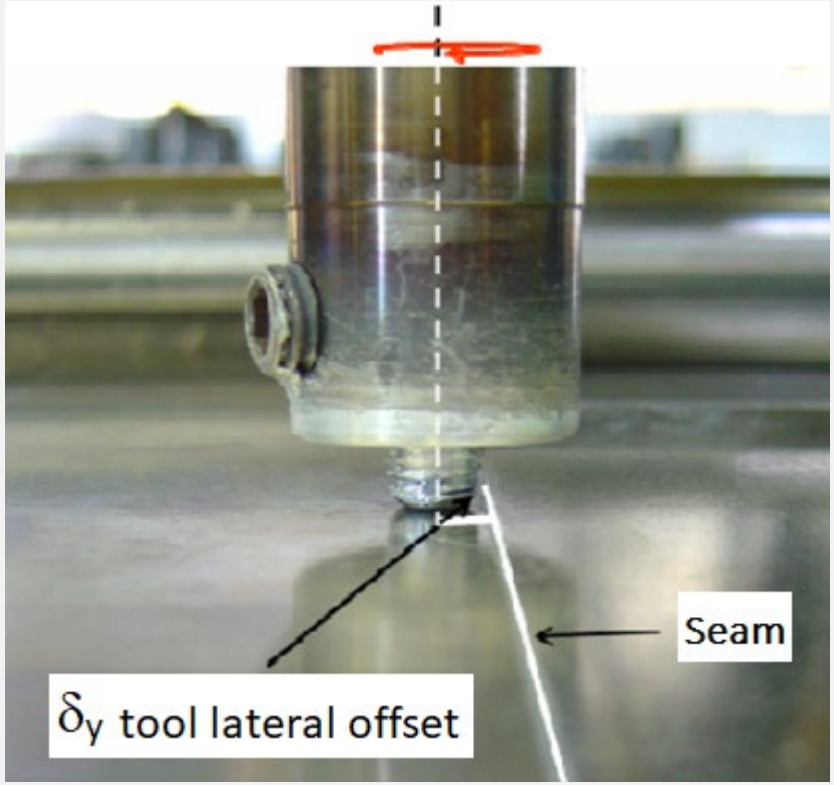
This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein - ERASMUS + KA2: 2017-1-SK01-KA202-035415

- Side tilt angle ψ between the ideal vertical axis of tool rotation z and tool orientation according to x axis (this angle shall be 0°)



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

- Tool lateral offset δ_y between the ideal weld seam (gap) between two workpieces and actual longitudinal path of the tool



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

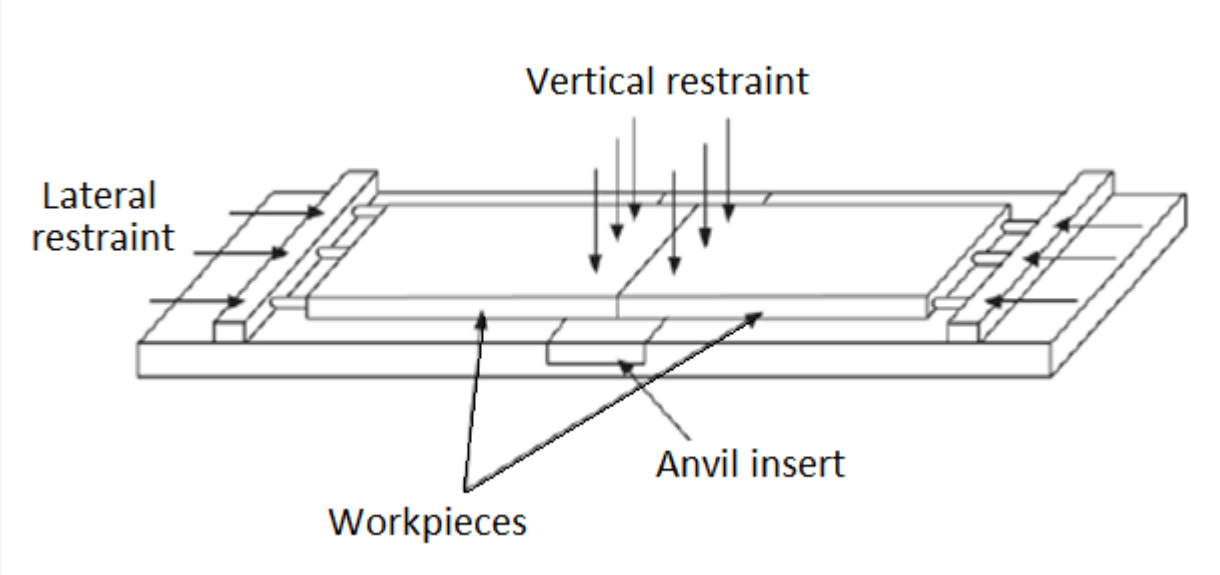
Influences to the FSW weld quality due to improper tool positions:

- Too much tilted tool in the direction of the main tilt angle φ leads to incomplete penetration of the weld, too.
- If the main tilt angle φ is almost 0° (perpendicular to the plane of base material), the tool plunge increases leading to the excessive penetration.
- If the side tilt angle ψ is not equal to 0°, this leads to the thinning of the workpiece at one side and excessive flash at the other side.
- Depending of the FSW process parameters and the tool geometry, sound welds can be obtained by tolerances of main tilt angle ± 1°, side tilt angle ± 2° and lateral offset ± 2 mm.

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

6.5 Clamping/positioning devices conditions

- Exact vertical and lateral clamping forces are dependent on base material, pin tool, workpiece geometry, weld joint type and weld schedule.



Conventional FSW clamping requirements

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

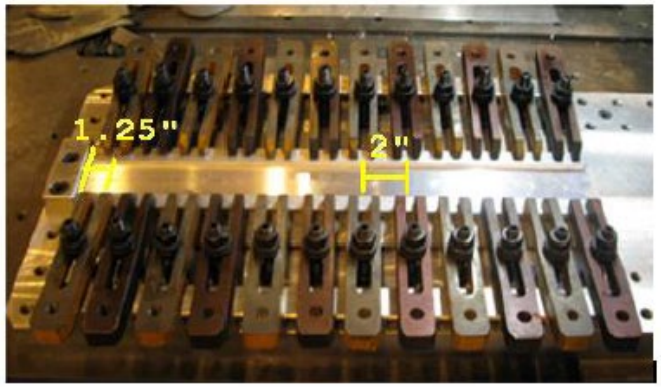
- Requirement to restrain the workpiece against the backing plate (vertical restraint) make it difficult to secure very large and thin workpieces.
- Requirement to restrain lateral separation of the weld joint (lateral restraint) can be difficult for very thick workpieces.

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

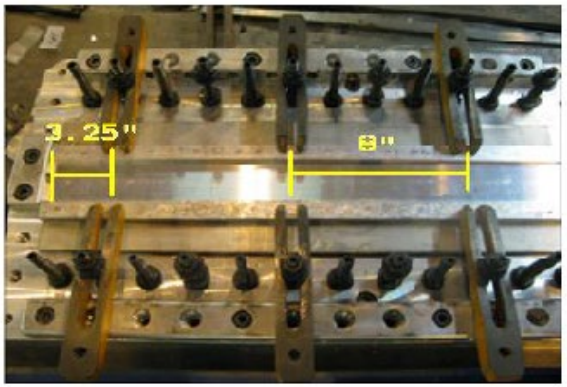
6.6 Tolerances for clamping/positioning devices

- Increasing clamping force limits distortion, but above a certain threshold has diminishing returns.
- Distortion is in close connection with the tolerances of workpiece.
- Three main parameters affects the level of workpiece distortion:
  - rotation speed of the welding tool
  - clamp pitch
  - clamping force

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



high clamping pitch



low clamping pitch

Above: highest distortion (low clamping pitch, low clamping force)

Bottom: lowest distortion (high clamping pitch, high clamping force)

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

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

FSW-Tech

Friction Stir Welding European Qualifications

Thank you for your attention

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