



Friction Stir Welding European Qualifications

**CU03 – FSW Process Operation**

FSW Specialist and Engineer



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# 3. Supervision of the Welding Process Operation

- 3.1. Navigation auxiliary equipment
- 3.2. Hybrid auxiliary equipment
- 3.3. Problems occurring in FSW

# Supervision of the Welding Process Operation

- ✓ For achieving a sound welded joint, the supervision during entire time of welding process is necessary
- ✓ One of possibilities how to avoid the occurrence of defects consists in application of the so-called supplementary/auxiliary equipment
- ✓ The auxiliary equipment may be classified to two basic groups: navigation and hybrid ones

## 3.1 Navigation auxiliary equipment

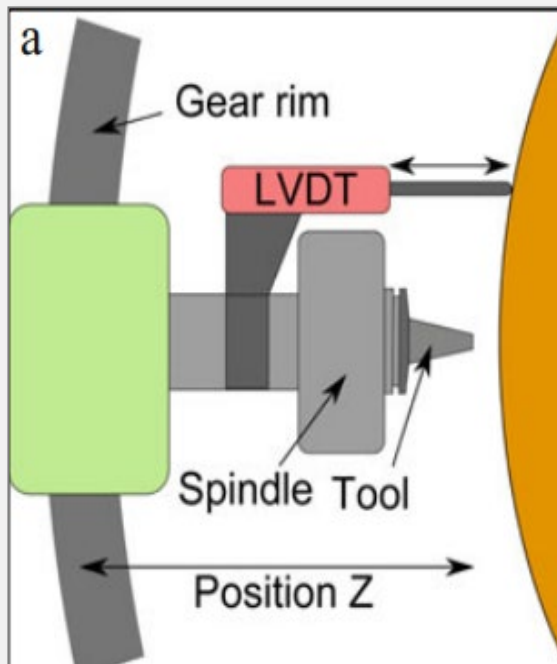
Navigation equipment allows to control:

- Correct position/plunge **depth** of welding tool
- **Temperature** during welding process

## 3.1.1 Depth control (welding tool plunge)

- The depth sensor makes use of axial force for manipulation with the depth of welding tool plunge
- The laser sensors are used as the feedback signals for the controllers
- Experimental results have proven that at application of auxiliary devices (sensors, probes) and a correct setting of plunge depth of welding tool the occurrence of defects like lack of root fusion and excessive flash has drastically reduced

### 3.1.1. Depth control (welding tool plunge)



Configuration of depth sensor



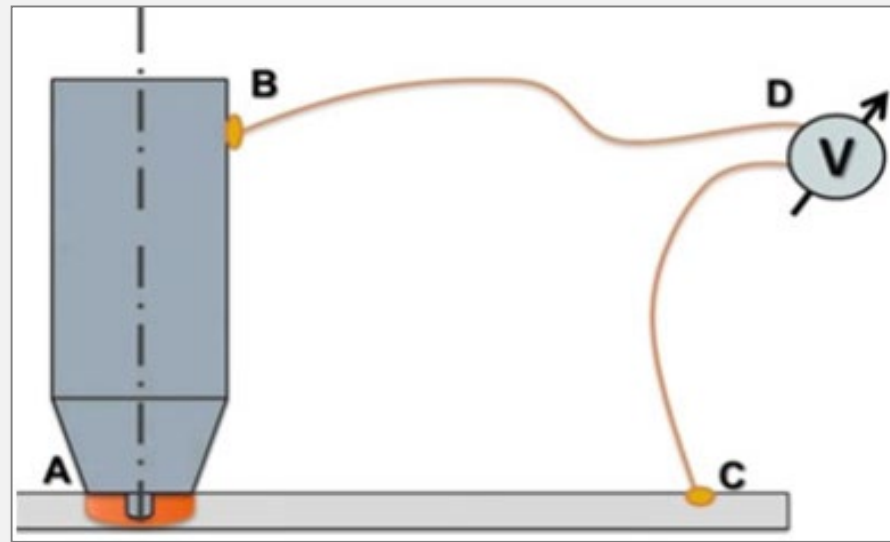
2 Linear differential transformers

## 3.1.2 Temperature control in welding by FSW process

- The temperature is measured by use of a thermo-electric signal between the tool and material welded.
- The TWT method offers an accurate temperature measurement under the tool shoulder and in the vicinity of tool fringe.

## 3.1.2 Temperature control in welding by FSW process

### Setup for calibration of the temperature measurement method

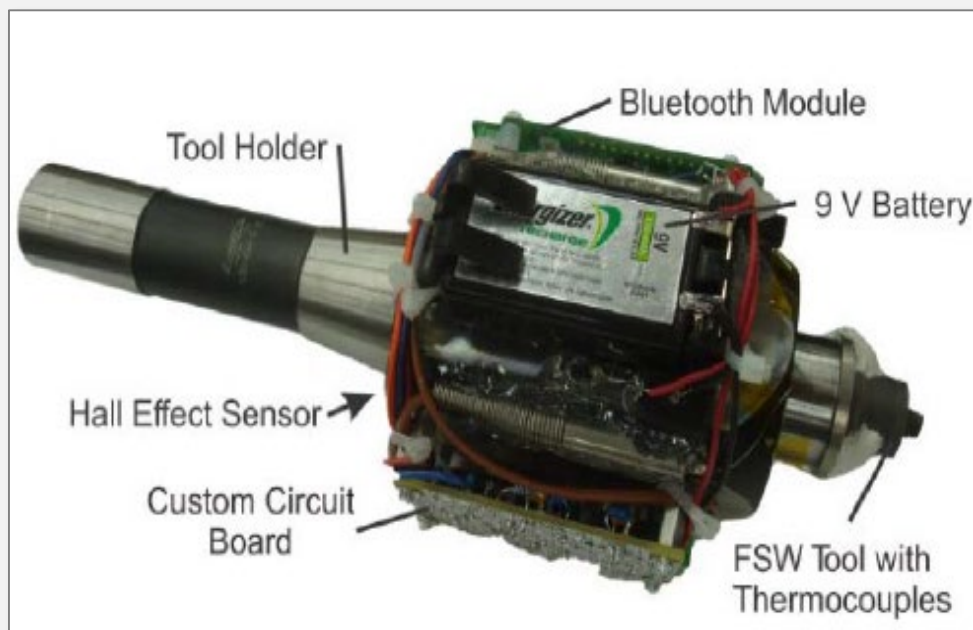


- (A) The thermal boundary between the welding tool made of steel and welded materials of Al alloy
- (B, C) Thermo-electric potentials between the tool and welded material
- (D) The recorded difference in voltage

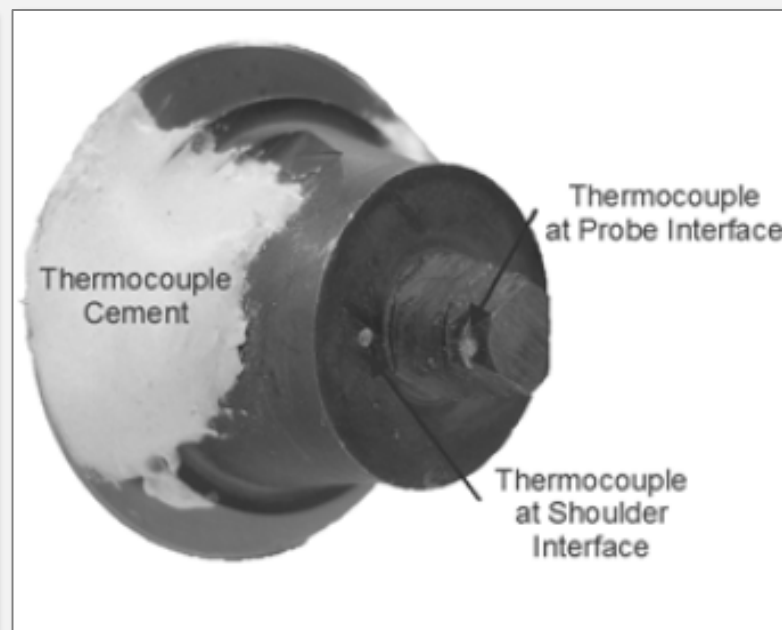
## 3.1.2 Temperature control in welding by FSW process

- Another way for enhancing fabrication of quality welds consists in temperature measurement by the aid of wireless data transfer.
  - The thermocouples are inserted into the welding tool together with the wireless system for data transfer.
  - The thermocouples should be situated in such a manner that they would be as close as possible to the boundary between the welded material and welding tool.

## 3.1.2. Temperature control in welding by FSW process



Tool holder for FSW process and distribution of thermocouples

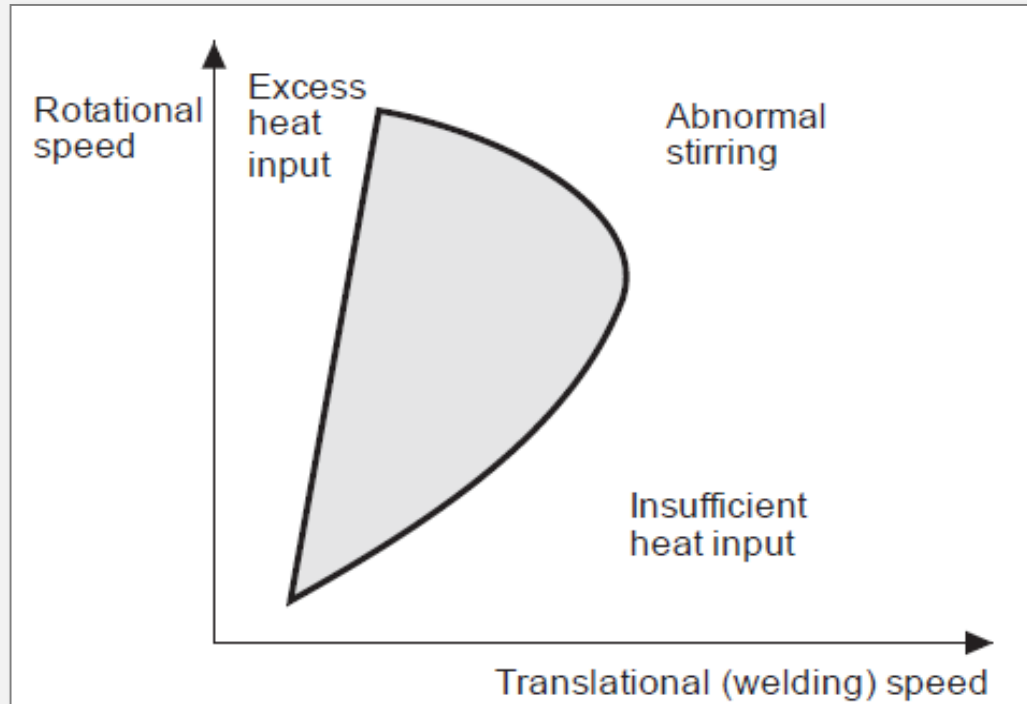


Detailed distribution of thermocouples

## 3.2 Problems occurring in FSW

- The main parameters of FSW process include the welding speed and revolutions of welding tool.
- These main welding parameters will cause either sufficient or insufficient heat supply necessary for plasticizing of material welded.
- The issues occurring during welding process are closely related with selection of suitable welding parameters.

## 3.2 Problems occurring in FSW



Range of suitable welding parameters for FSW process

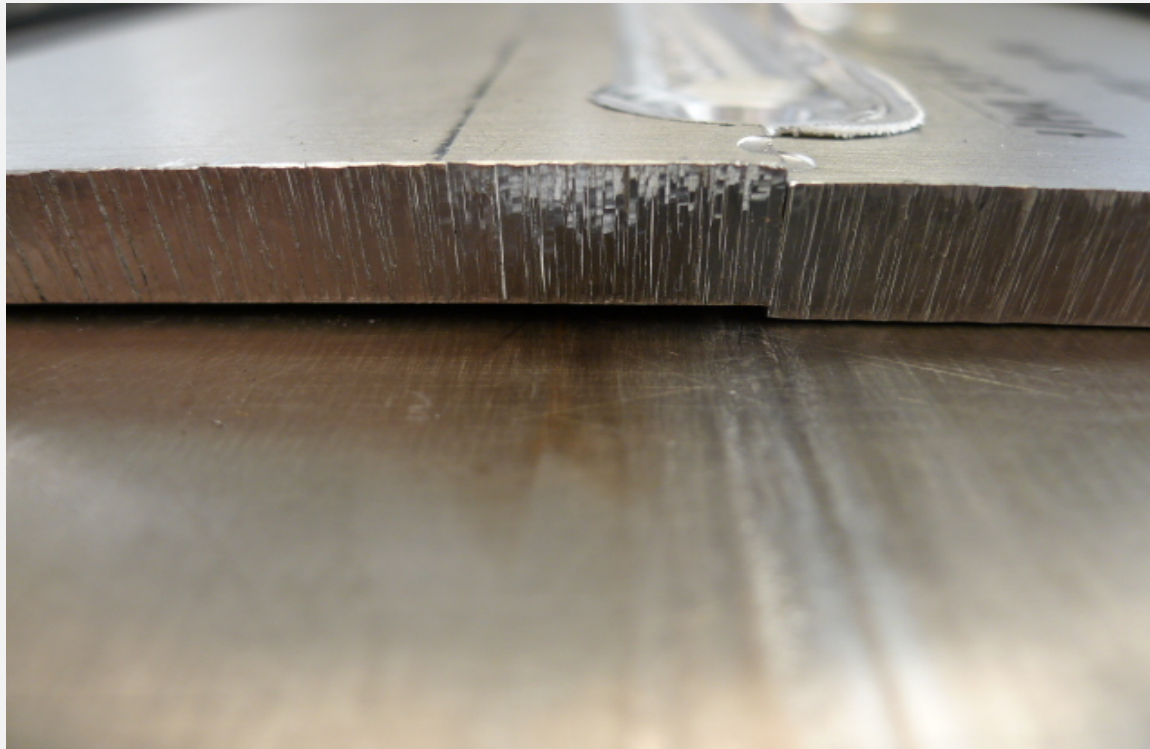
## 3.2.1 Most common basic problems and actions to solve them

- The defects formed in welding process are classified to: **Surface** or **Inner** defects
- The surface defects which may be observed by a naked eye include:
  - Excessive material flash
  - Surface groove along the weld line
  - Worn-out/damaged welding tool.
- The inner defects which cannot be observed by a naked eye (during welding process) as poorly stirred root – kissing bond, subsurface voids and cracks can be defected just by the destructive techniques after the end of welding operation.

## 3.2.1 Most common basic problems and actions to solve them

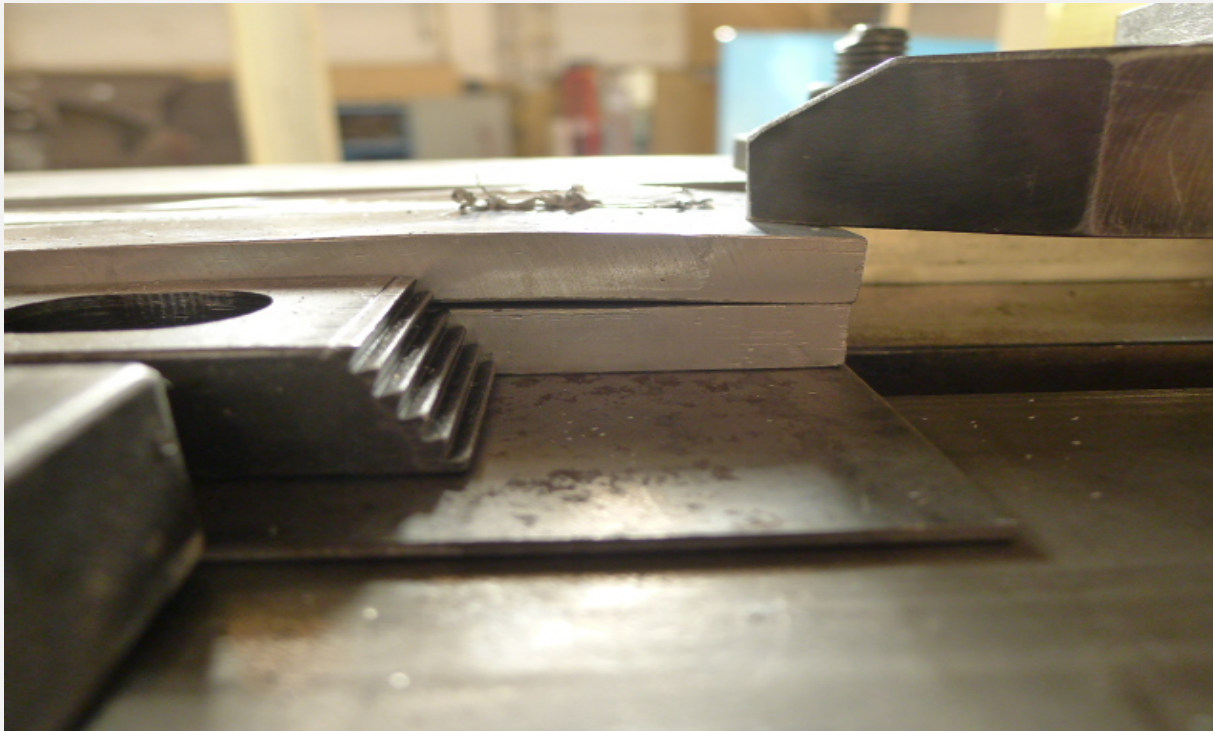
- At the initial penetration of welding tool into welded material, the **forcing out of welded plates** from the clamping mechanism may occur, what results in undesirable gap, causing their non-uniform stirring.
- **Improper clamping** of welded plates may cause the distortion of welded material proper.
- In case of occurrence of such a problem it is necessary to adjust the plunge depth of welding tool and/or the rate of welding tool plunging.
- In most cases, it is sufficient to tighten the loosened clamping bolts, serving for fixing the welded material on welding support (table).

## 3.2.1 Most common basic problems and actions to solve them



Raising-up of welded material due to insufficient clamping force acting on the material – Butt joint

## 3.2.1 Most common basic problems and actions to solve them

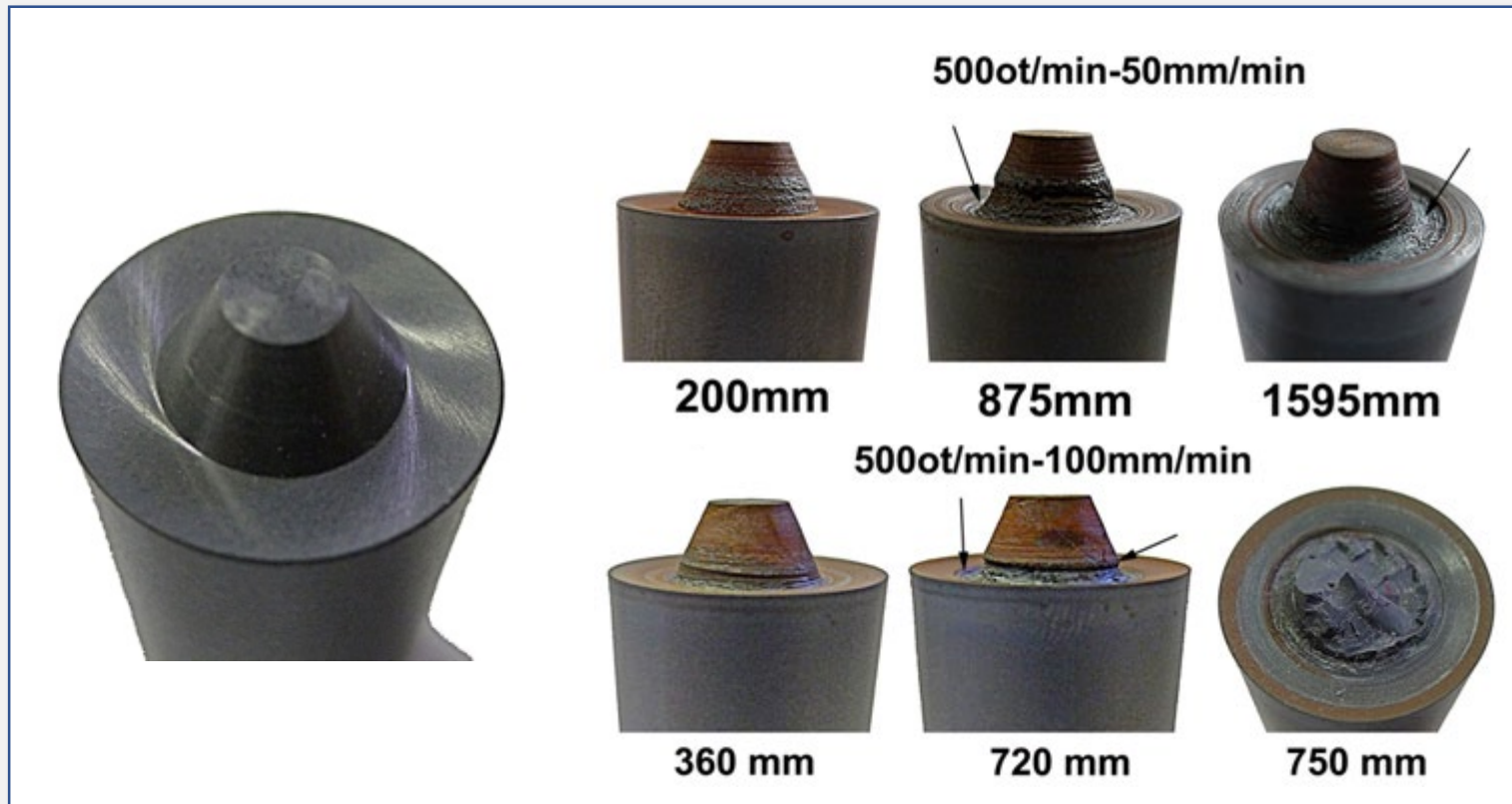


Raising-up of welded material due to insufficient clamping force acting on the material – Overlapped joint

## 3.2.1 Most common basic problems and actions to solve them

- The wear of welding tool can be affected by the plunge depth of welding tool, welding speed and revolutions of welding tool.
- At insufficient welding speed and revolutions of welding tool, the welded material is stuck on the welding tool, what results in insufficiently stirred material welded.
- The only way how to avoid the wear of welding tool consists in optimizing the welding parameters, as the welding speed, revolutions and geometry of welding tool.

## 3.2.1 Most common basic problems and actions to solve them



Worn-out of welding tool made of Si<sub>3</sub>N<sub>4</sub>

## 3.2.1 Most common basic problems and actions to solve them

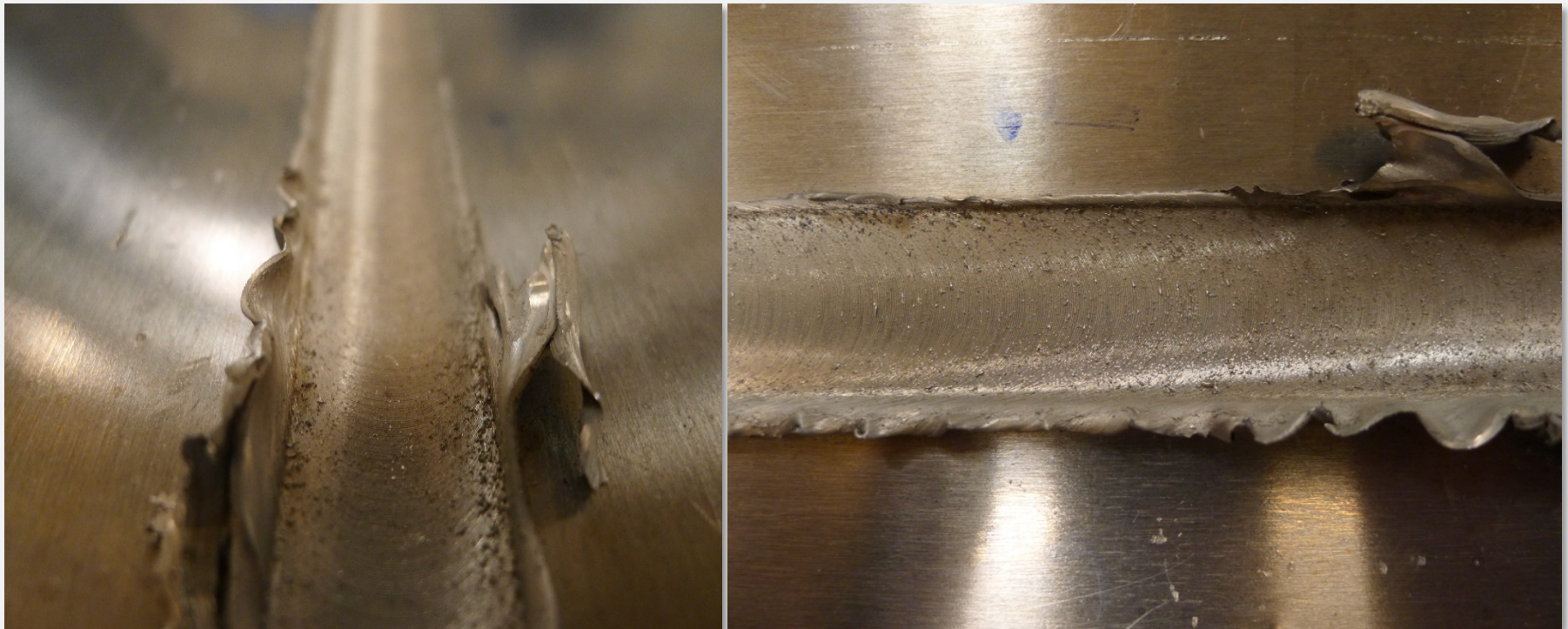


The worn-out welding tools made of steel type 19554 (H13)

## 3.2.1 Most common basic problems and actions to solve them

- A frequent non-conformity (defect) occurring during welding process consists in the fact that the welding tool forces out redundant amount of welded material on the surface, causing thus its certain depleting.
- This defect is designated as excessive flash.
- The main cause of excessive flash formation consists in excessive plunge (plunging) of welding tool in thickness direction of welded material.
- In case when forcing out of welded material on the surface is observed, it is sufficient to shift the welding tool axially in upward direction.
- The welded joint with excessive flush exerts unacceptable appearance, though the strength properties of welded joint may be in several cases acceptable.

## 3.2.1 Most common basic problems and actions to solve them

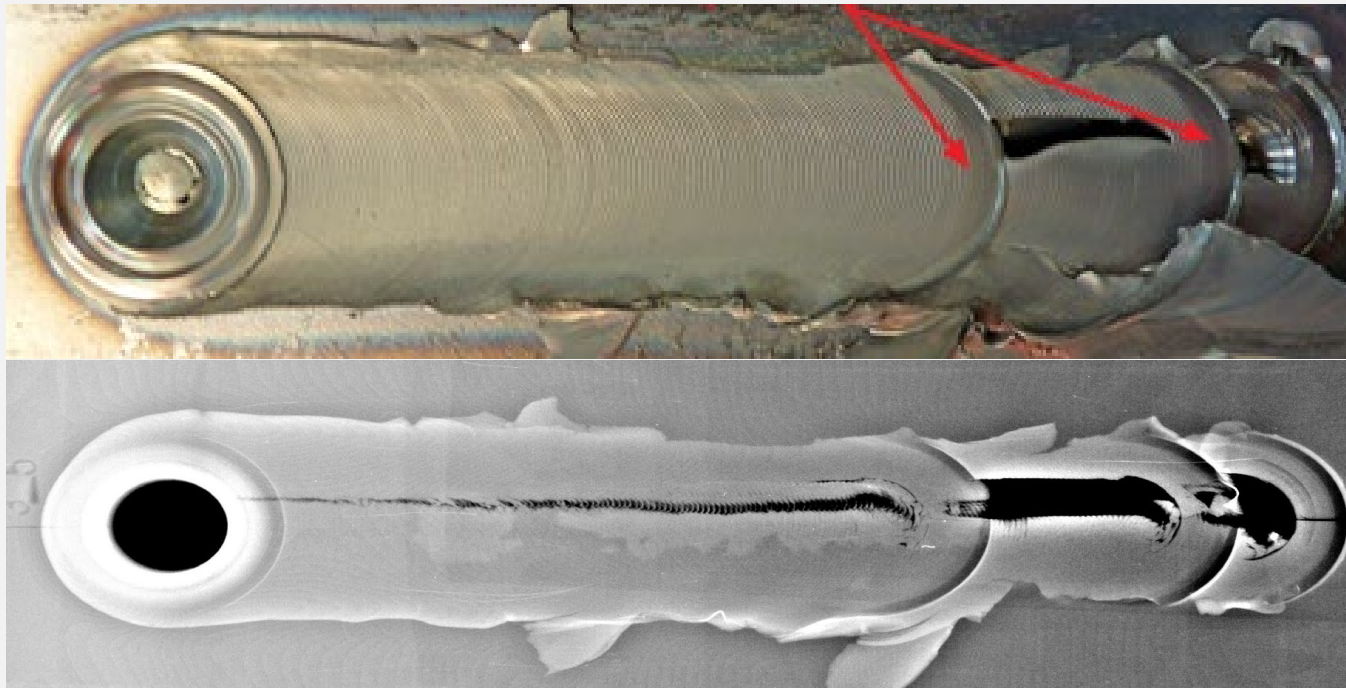


Welded joint with excessive flash

## 3.2.1 Most common basic problems and actions to solve them

- At too high setting of welding speed, the issue with insufficient stirring of welded material occurs.
- At occurrence of such an issue, a longitudinal continuous groove – channel is formed on the surface of material welded.
- In such a case it is necessary to adjust the welding parameters, mainly the welding speed and to apply a suitable geometry of welding tool.

## 3.2.1 Most common basic problems and actions to solve them



The longitudinal continuous groove – channel

## 3.2.1 Most common basic problems and actions to solve them

- Another problem is that at the end of welding process an imprint of welding tool remains on the material welded.
- This issue is solved by adding a splice plate – an additional material on which the welding tool will pass during welding process from the material welded.

## 3.2.1 Most common basic problems and actions to solve them



Run-out of welding tool without a splice plate

## 3.2.1 Most common basic problems and actions to solve them

- During welding of steels, high temperatures occur which may cause the sticking of welded material on the welding support (table).
- To avoid such an issue, a continuous layer of powder (for example the PCBN powder), preventing the adherence, is deposited on the welding support.

## Conclusions

- ✓ As in the case of all welding technologies, also in the case of FSW process the precautions of Health and Safety of Work (HSW) must not be neglected.
- ✓ In case of violating the HSW precautions, the following dangers may threaten: cutting, skin burning, harm to eyes and face.
- ✓ Fabrication of a sound welded joint, either with application of the auxiliary equipment or without and avoiding the mentioned problems is possible only by optimizing the welding parameters.