



Friction Stir Welding European Qualifications

CU04 – Post Processing

FSW Specialist and Engineer



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Erasmus+ Programme
of the European Union

4. Post Processing

4.1. Visual Inspections

4.2. Imperfections and Defects

4.3. Cause of imperfections/defects

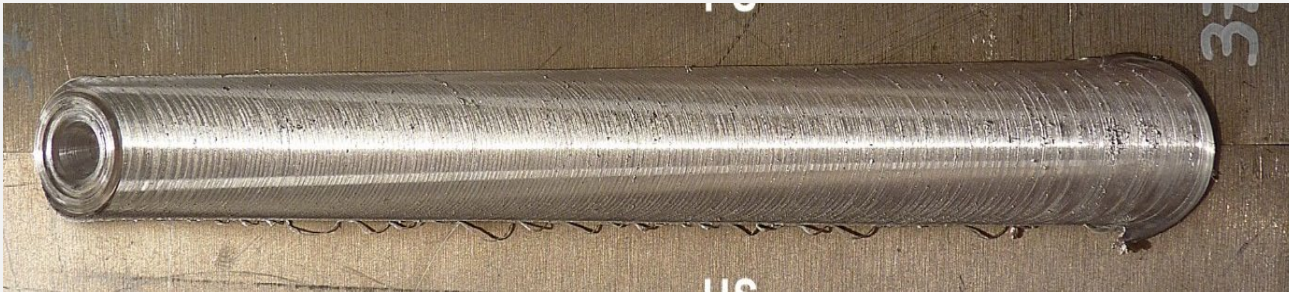
4. Post Processing

- The advantage of FSW process with optimized parameters in comparison to other classical welding processes consists in the fact that after completing the welding process, it is unnecessary to perform the following operations:
 - grinding
 - cleaning
 - heat treatment of welded joints
- For quality inspection of welded joint after welding, the visual inspection is first performed.

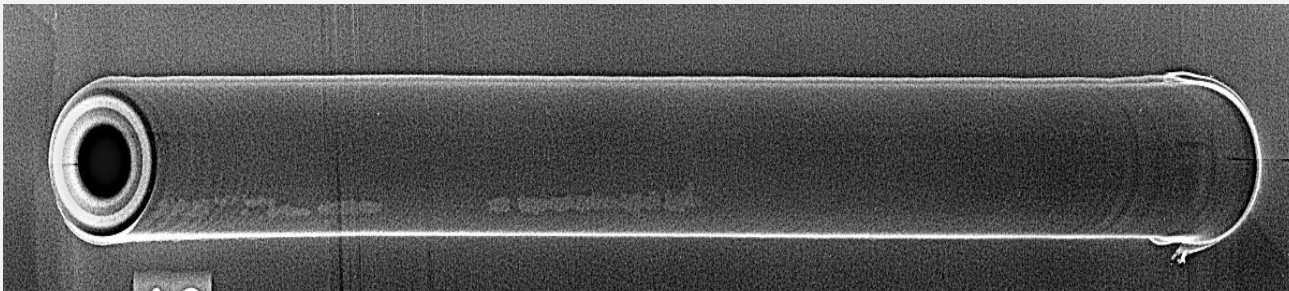
4.1 Visual Inspection

- Visual inspection of welded joint quality is necessary during entire welding process
- Prior to start of welding it also necessary to inspect visually the correct clamping of welded plates and welding tool
- In case of insufficient visual inspection prior to and after welding different imperfections and defects may occur

4.1 Visual Inspection

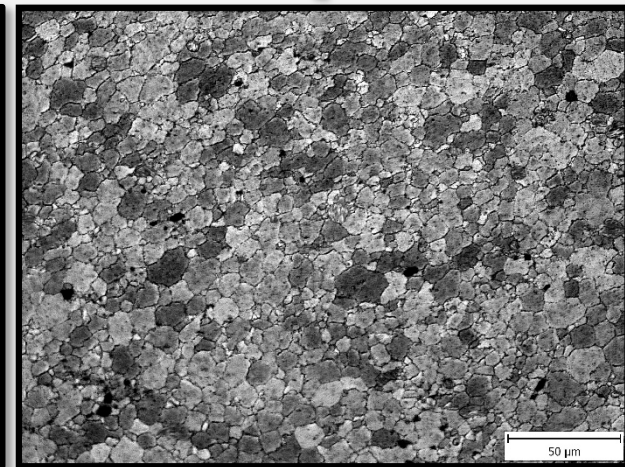
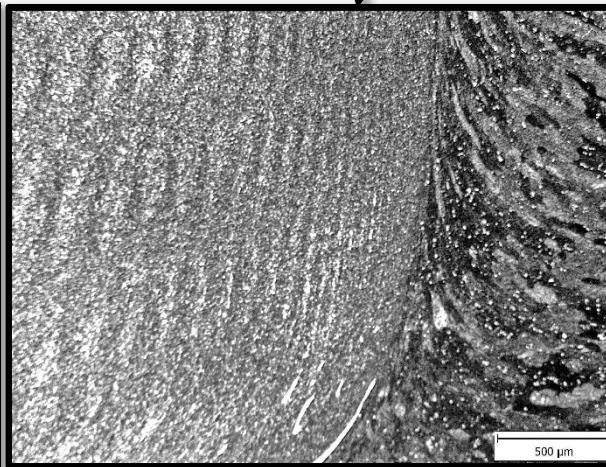
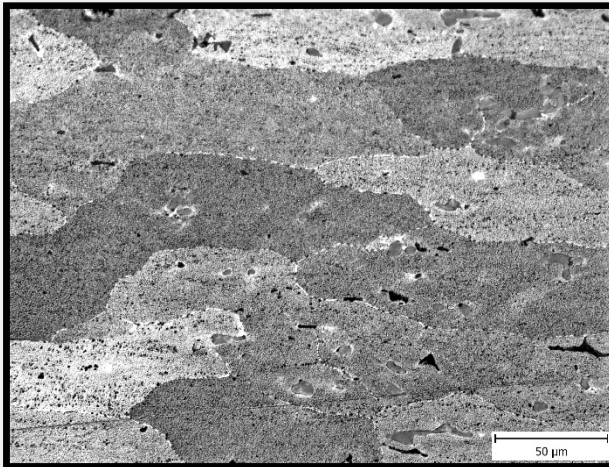
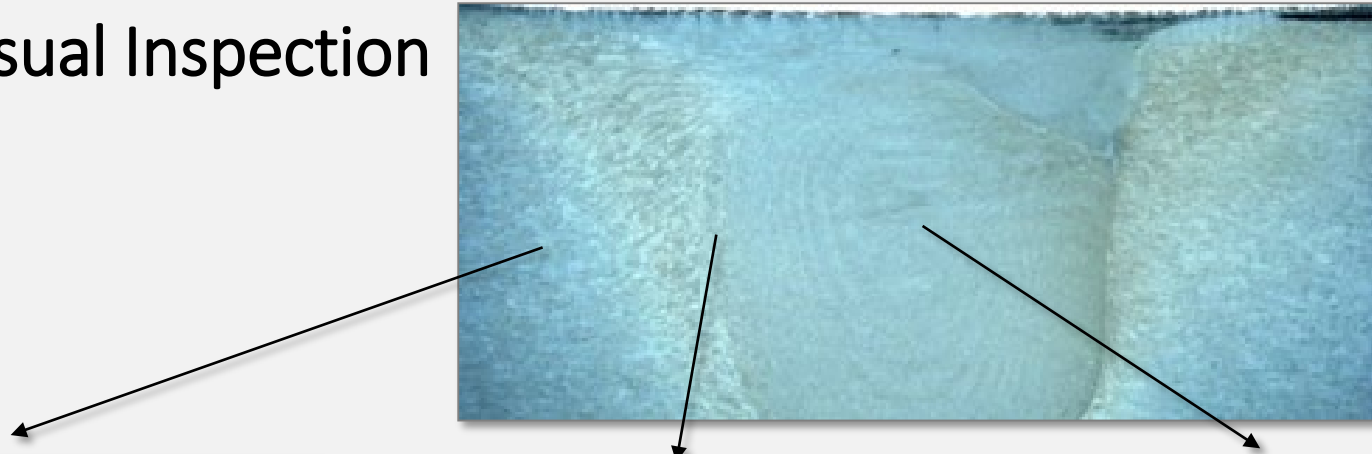


Sound welded joint



Radiogram of welded joint

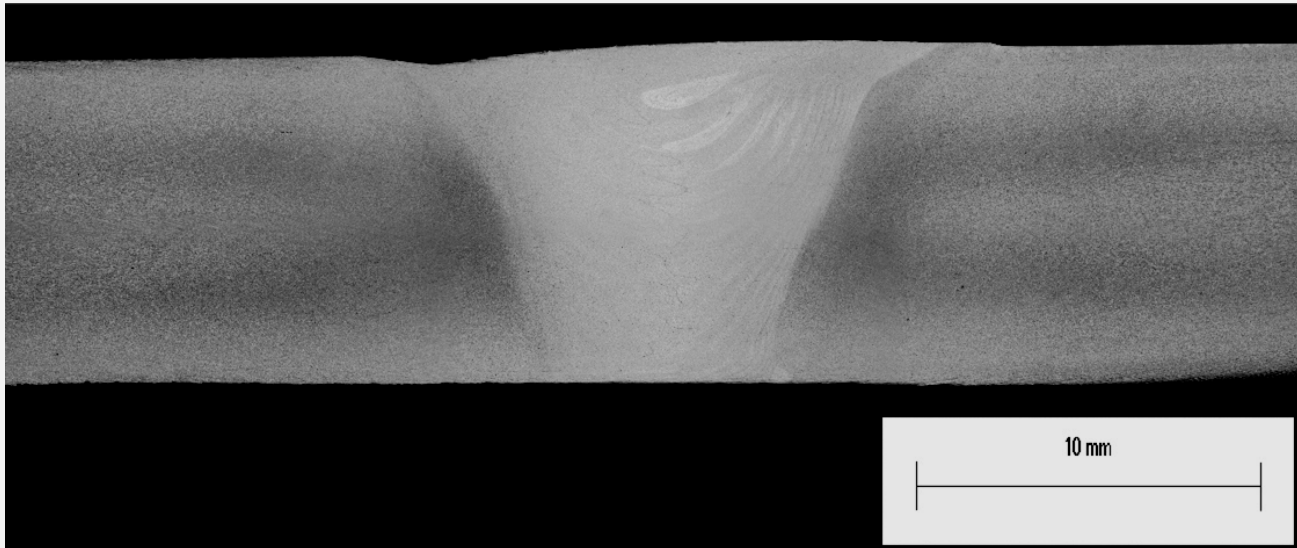
4.1 Visual Inspection



Sound welded joint

Fine-grained polyhedral microstructure of Al alloy (EN AW 5083 H111) with superior strength properties

4.1 Visual Inspection



Sound welded joint – macrostructure of WJ of Al alloy EN AW 6005 T6

Welded with the following parameters:

- ✓ 1500 rev/min
- ✓ 300 mm/min
- ✓ $t=10\text{mm}$

4.2 Imperfections and Defects

- To determine the quality of welded joints regarding the inner imperfections and defects, the application of destructive techniques is necessary.
- The heat supplied during welding by FSW process exerts the tendency to create the conditions causing the microstructural transformations as: recrystallisation, grain growth and dissolution of precipitates.
- Such microstructural transformations take place at different temperatures for different materials and depend on the chemical composition of materials welded.

4.3 Causes of imperfections and defects

The most frequent inner imperfections occurring in FSW may include:

- Voids
- Insufficiently stirred root
- Cracks

In case when insufficient heat needed for plasticizing of welded material is supplied to welding process, the imperfections called the **voids** occur in welded joint.

Though the higher welding speeds enhance the productivity of welded joints, too high speeds lead to formation of **voids under the surface** of welded joint and/or on the advancing side at the fringe of welded joint.

4.3 Causes of imperfections and defects

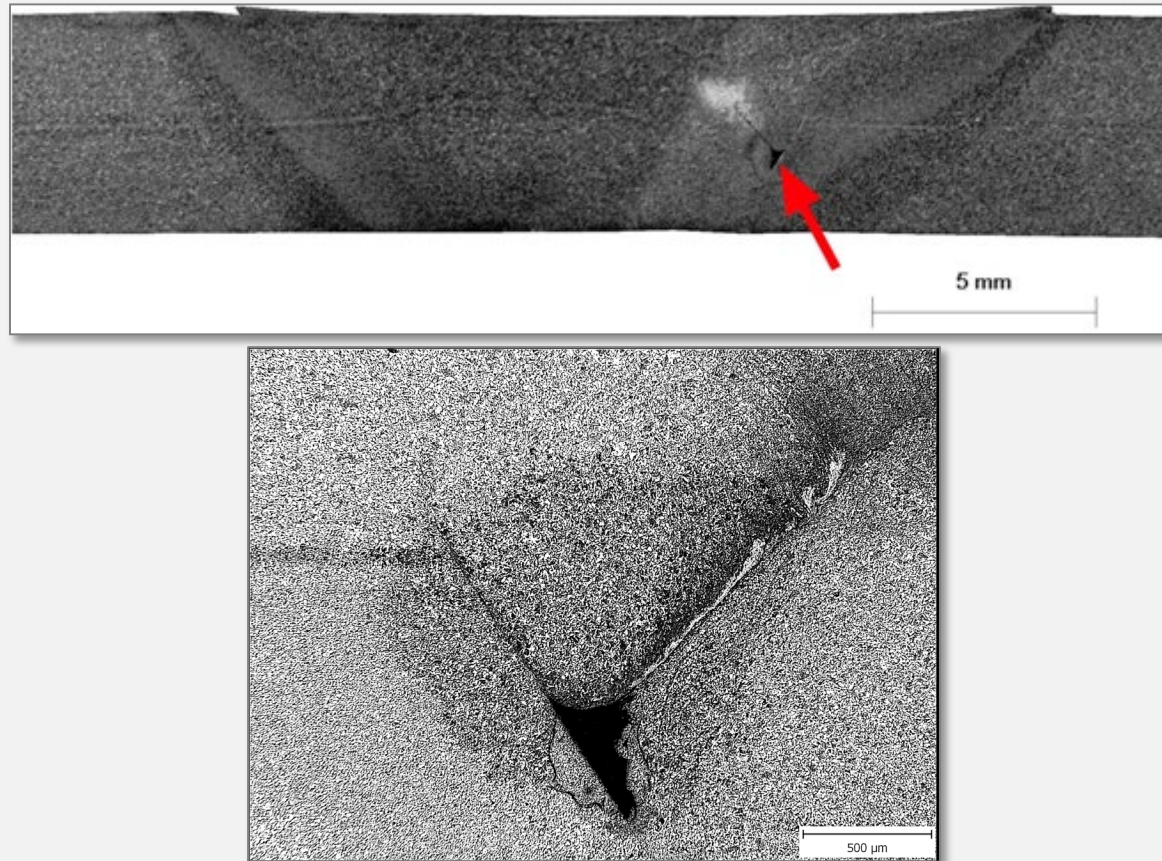
- To maintain **sufficient heat** needed for welding, it is necessary to **reduce the welding speed**, what results in **better plasticizing of material welded**.
 - The experimental results have shown that the zone where voids occurred significantly extended with increasing welding speed.
 - It was also proved that with enlarging diameter of the tool shoulder greater heat volume enters the process, causing better plasticizing of material and thus the **occurrence of voids in welded joint is prevented**.

4.3 Causes of imperfections and defects



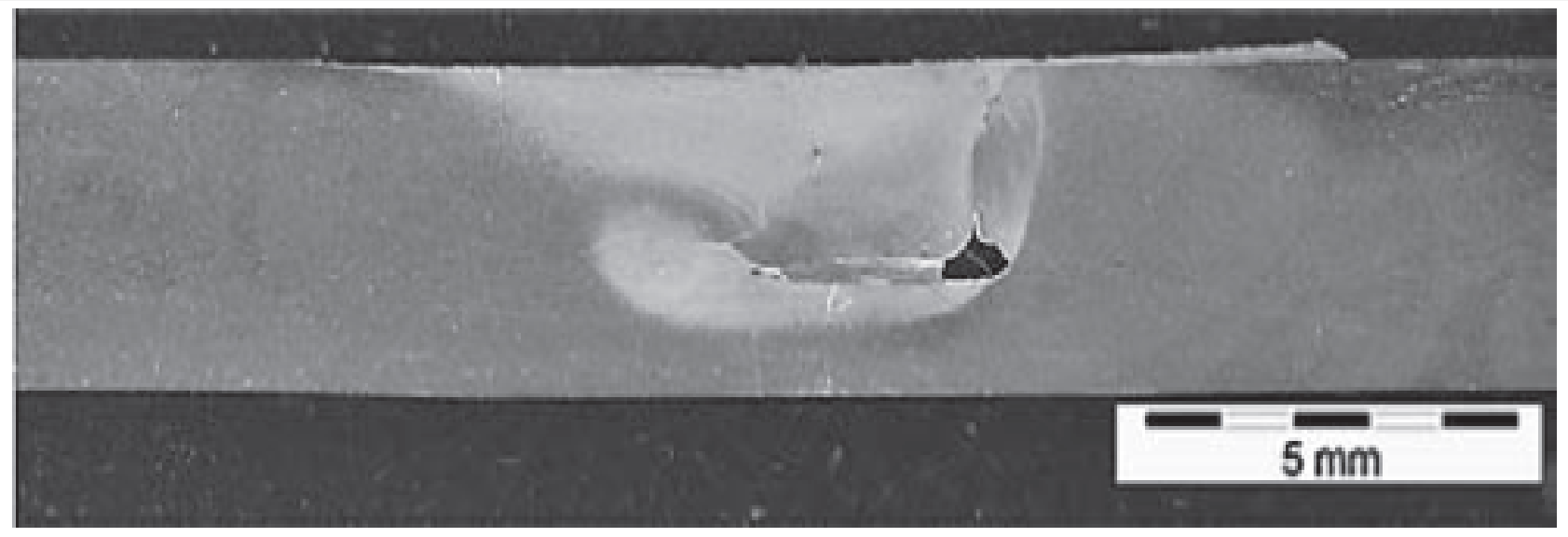
Longitudinal void in WJ made of pure Al
10 mm in thickness

4.3 Causes of imperfections and defects



Macro and microstructure of a void in welded joint

4.3 Causes of imperfections and defects



Macrostructure of a void in welded joint made of AlSi12 alloy

4.3 Causes of imperfections and defects

- Another issue regarding the field of inner defects consists in **insufficiently stirred root**.
- This defect is designated as the kissing bond.
- Such defects are formed due to insufficient heat input and/or due to incomplete disruption of the surface oxide layers.
- Another cause for defect formation may consist in insufficiently selected pin length and the immersion depth of welding tool in relation to welded material thickness.

4.3 Causes of imperfections and defects

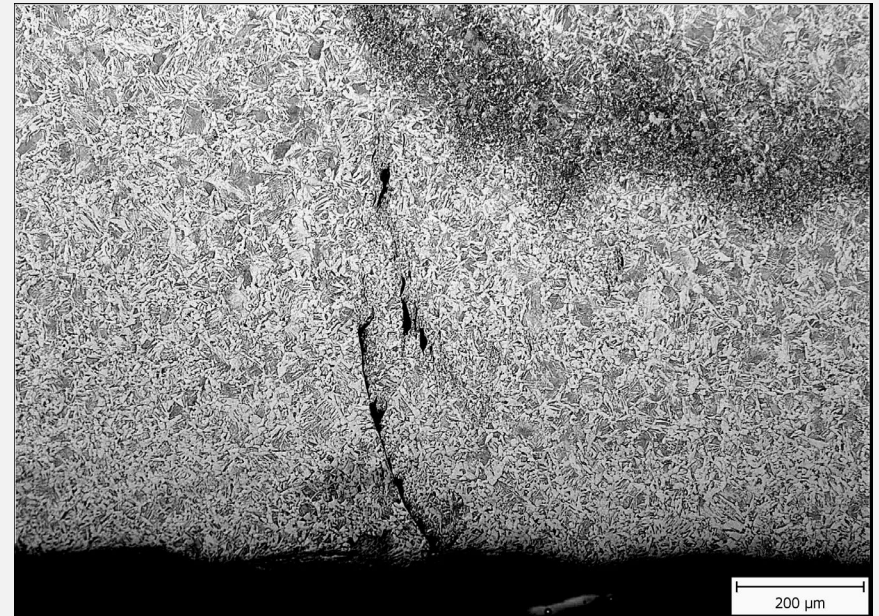
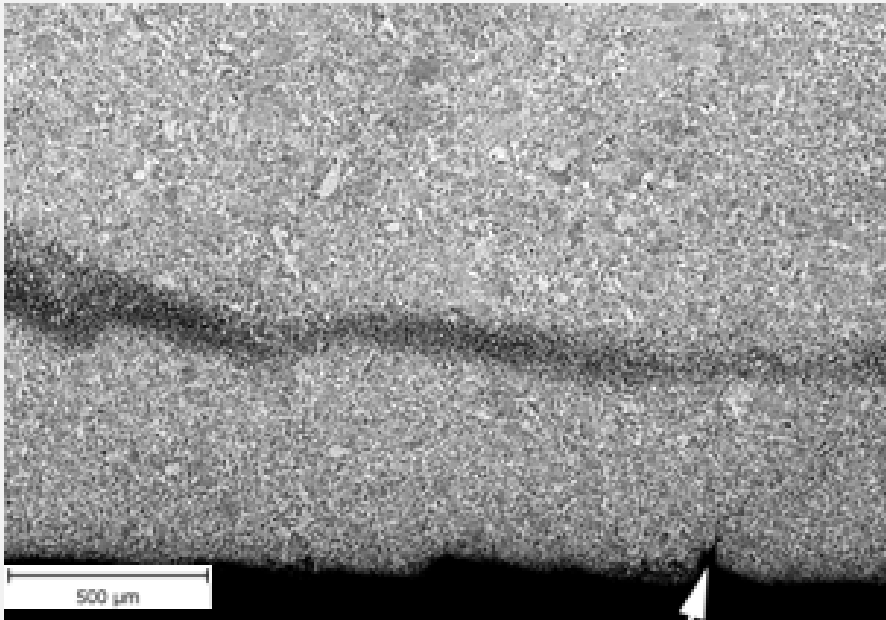
- At appropriately high revolutions of welding tool sufficient heat input is supplied to the joint which supports a correct stirring of welded material with a wide and dissipated distribution of particles.
- The average grain size in the stir zone is reduced with increasing welding speed and/or speed of revolutions of welding tool.
- The control of revolution speed of welding tool allows a significant suppression of defect occurrence.

4.3 Causes of imperfections and defects



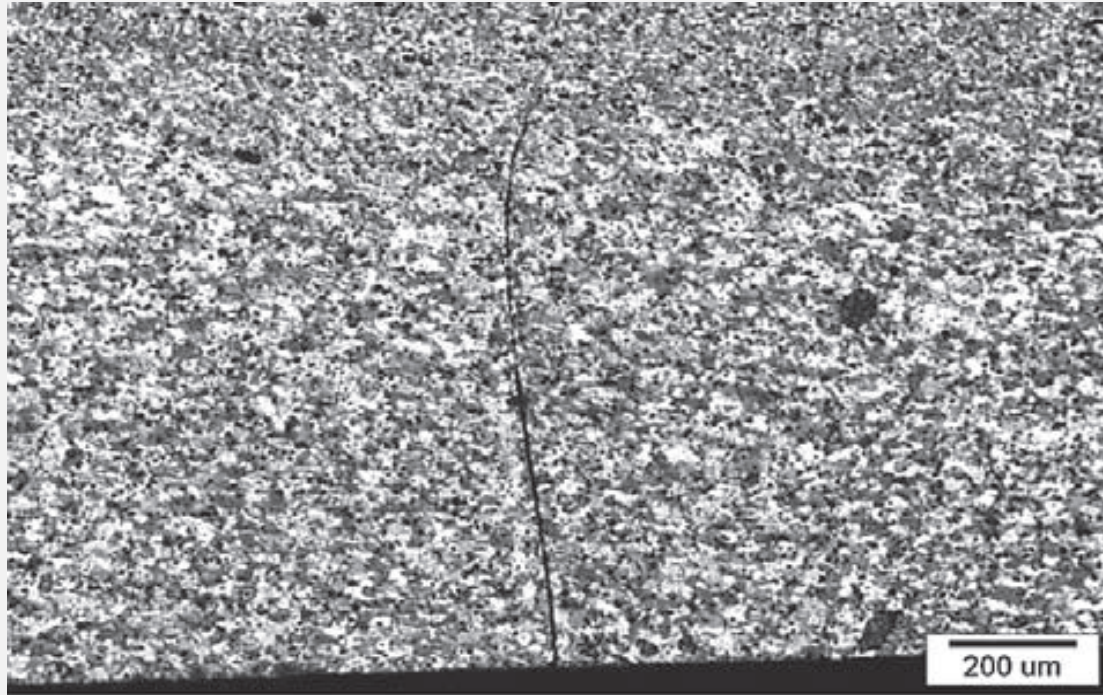
Insufficiently stirred root of welded joint

4.3 Causes of imperfections and defects



Microstructure of welded joint – the lack of root fusion in steel type S235JRC+N

4.3 Causes of imperfections and defects

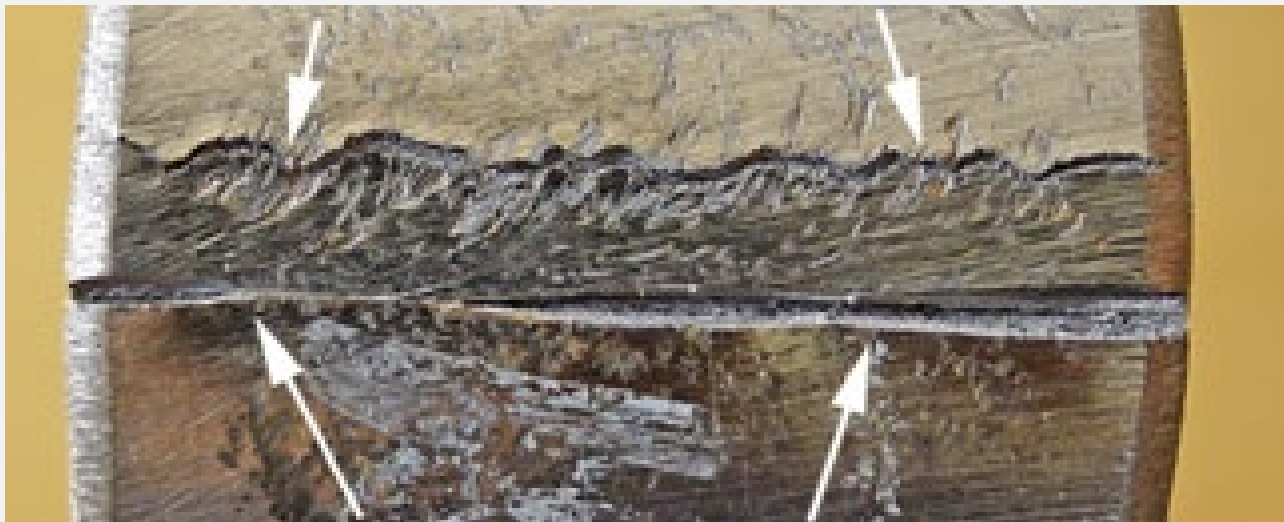


Microstructure of welded joint – the lack of root fusion in Al alloy type 5083

4.3 Causes of imperfections and defects

- Amongst the next basic imperfections and defects, the cracks may be mentioned.
- It was experimentally proved that the crack which initiated from the root of welded joint through the undulated defect line caused the welded joint rupture during tensile test.
- For avoiding the cracks in welded joints, the same is valid as in the case of lack of root fusion. It is necessary to ensure a sufficient heat input, which supports a correct stirring of material welded.

4.3 Causes of imperfections and defect



Identified crack in welded joint after the bend test

Conclusions

- An efficient selection of welding parameters (welding speed and revolutions of welding tool) for FSW process eliminates formation of the mentioned defects, what significantly contributes to improvement of mechanical properties of welded joints.