



Welding Research Institute (WRI)

Using modern friction stir welding (FSW) in
the railway industry and other innovative
processes

Marek Slovák, slovacem@vuz.sk



Railway industry – new trends

Using of new materials

Safety welded construction

High strength steels

MC type
QL type
N type

Lighter welded construction

Aluminium alloys

5 row
6 row

Big demands for joining – welding

Complicated welding
Demands for high productivity
Demands for automatization/robotisation



Railway industry – FSW

Gantry



- Welding of high thickness, approximately up to 40 mm
- Long weld joints
- Movement of welded components

Robot



- Welding of medium thickness, approximately up to 10 mm
- Welding also of weld joint with complicated trajectory
- Movement of welding head and welded components

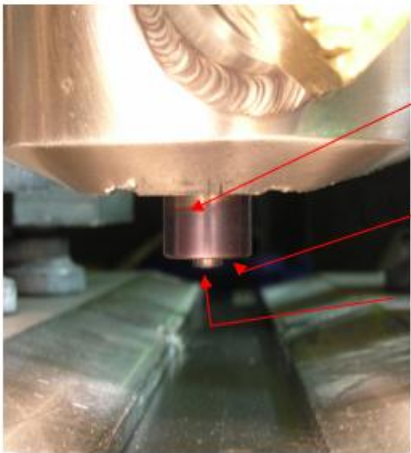
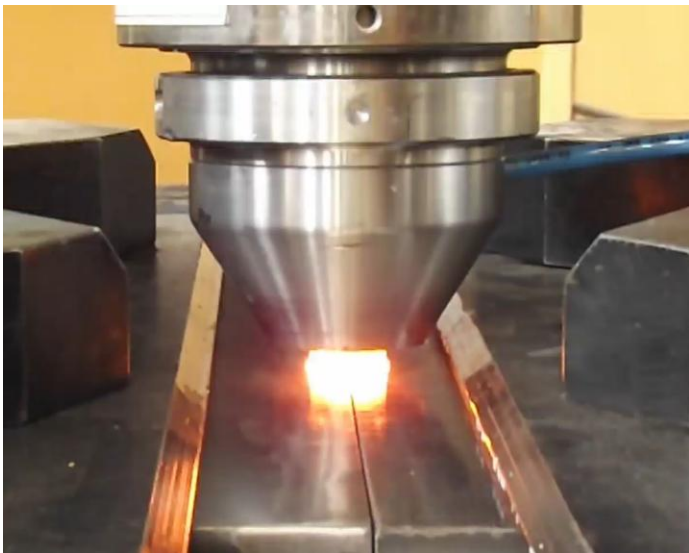
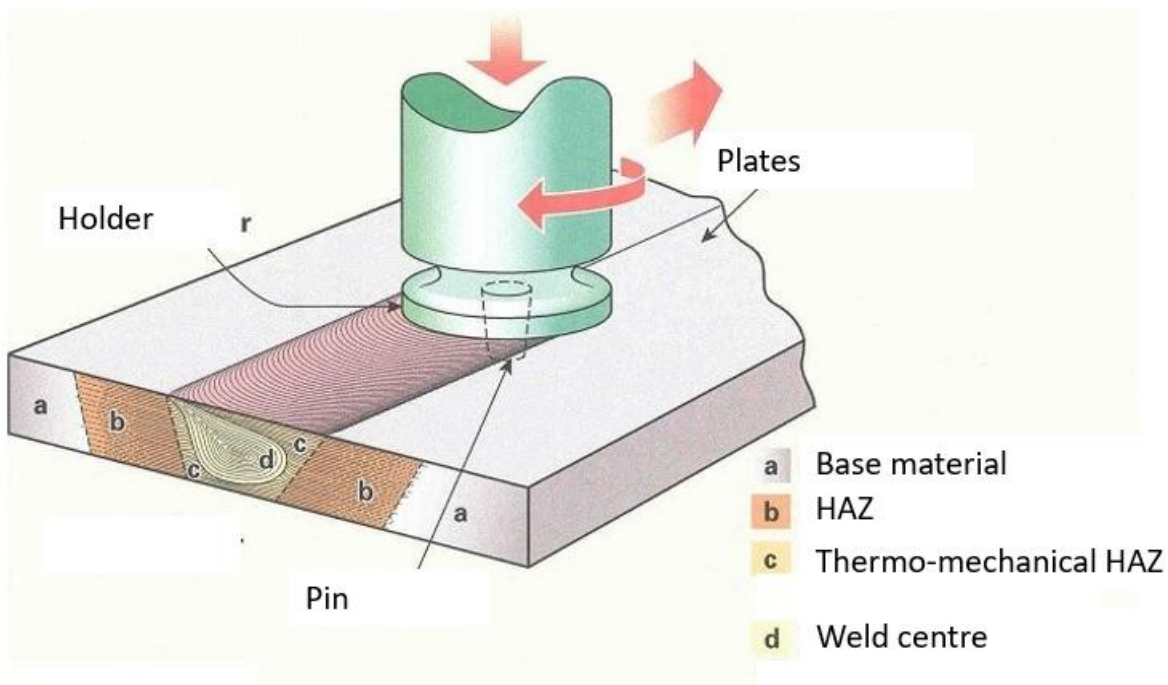
CNC machine tool



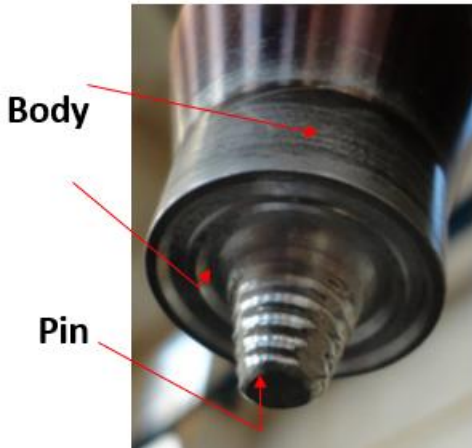
- Welding of small thickness, approximately up to 5 mm
- Welding also of weld joint with complicated trajectory
- Movement of welded components



Friction Stir Welding FSW



Body
Holder
Pin



Body
Pin



Source : TWI

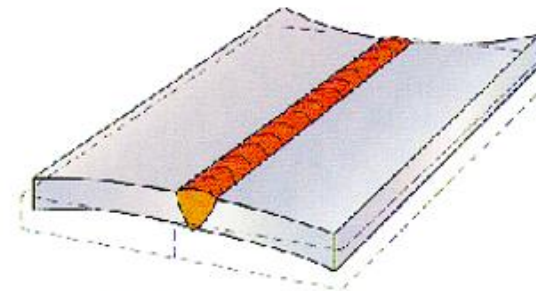
It was born at The Welding Institute in 1992.

Advantages

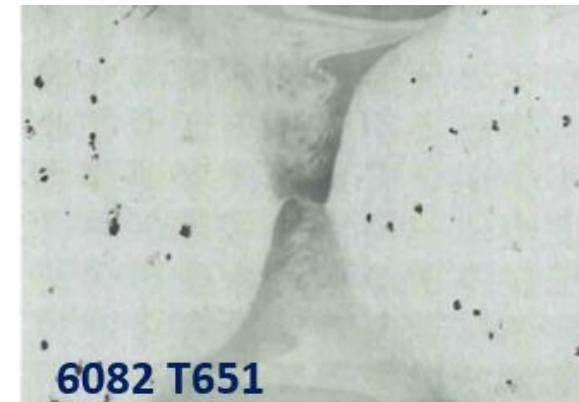
1. Welding under solid temperature, without hot tearing and porosity
2. It need not chamfer/bevel preparation
3. Minimal shrinkage and deformation
4. Without filler material and shielded gas
5. Energetic requirement is lower than arc welding
6. No spatter, no UV radiation
7. Various position
8. Mechanical properties of weld joints are higher than for arc welding
9. It is possible to join materials which cannot be joined by arc welding as heterogenous joints (Al – Cu, Al – Fe)
10. There is existing standard ČSN EN ISO 25239-1 to 5

Disadvantages

1. Expensive welding machine/equipment
2. Need complicated clamping tools
3. The welding construction have to be design based on FSW requirements
4. Only automatised/robotised process



Deformation



6082 T651



FSW –WRI-equipments



- Maximal force 12 tons
- Maximal rotation 1500 round/min
- Velocity max.1500 mm/min
- Possible angle 5°
- Working area 6 000 mm x 1 000 mm
- High 700 mm



- Maximal force 1 ton
- Maximal rotation 7 000 round/min
- Velocity max. 2 500 mm/min
- All possible angles
- Working area 1700 mm x 1400 mm
- Load capacity 6 tons

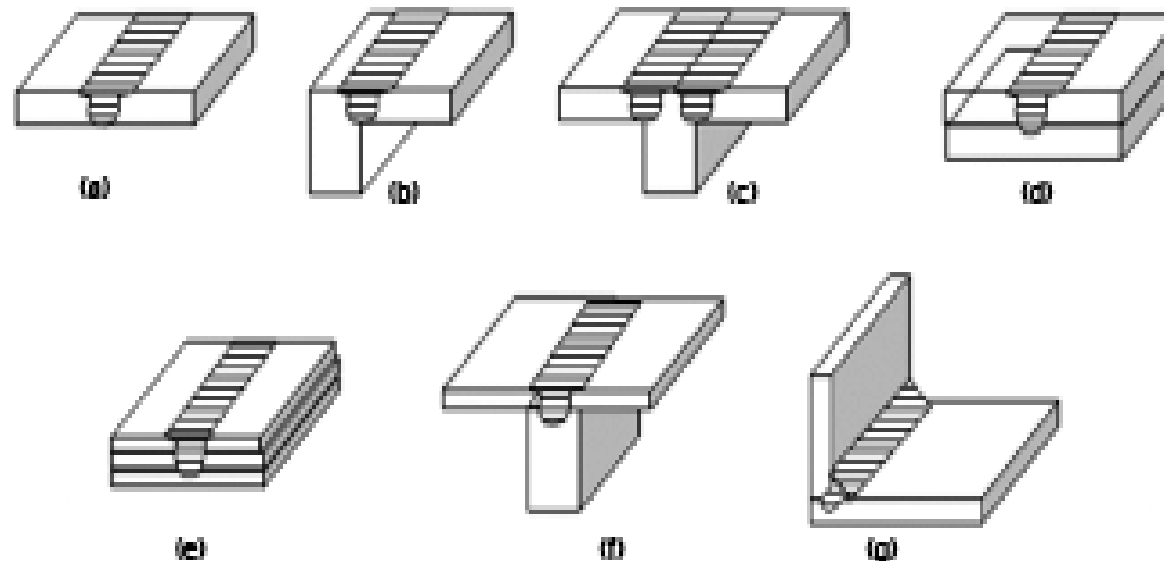
AL materials

Thickness

One side 1-50 mm

Both side up to 100 mm

Velocity 50-2500 mm/min



Steel

Thickness

One side 0.5-10 mm

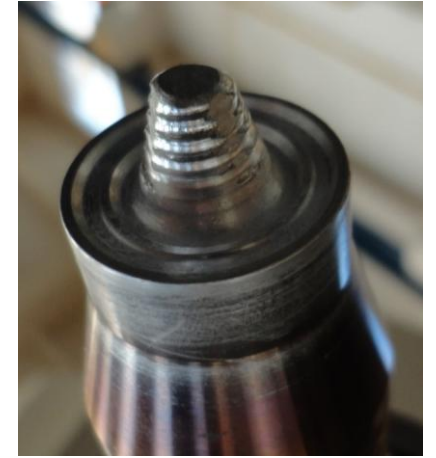
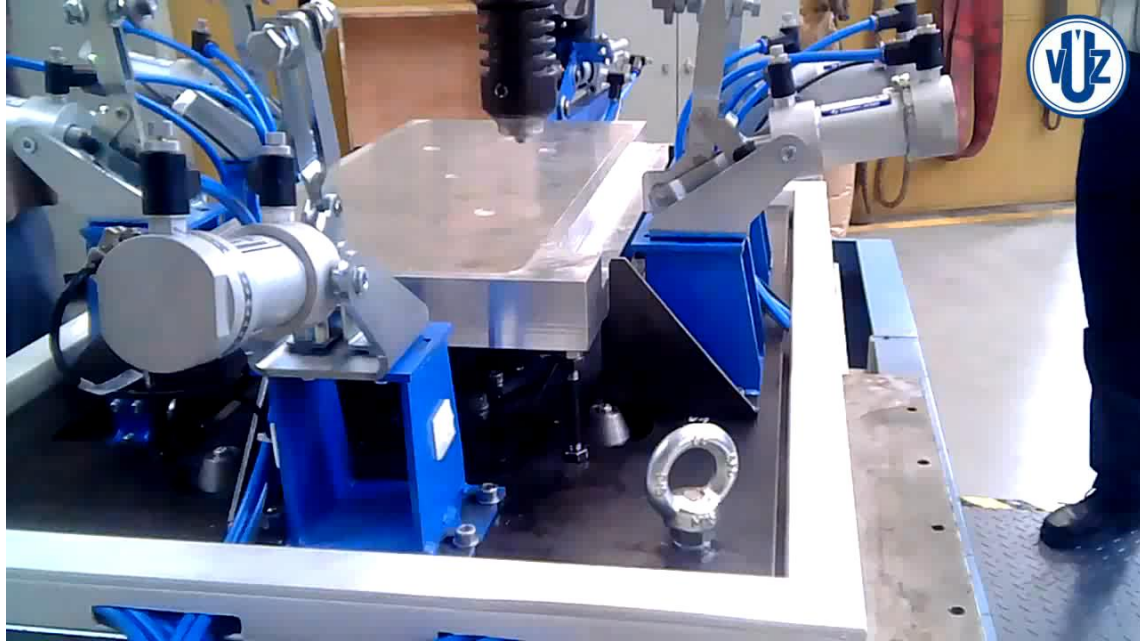
Both side up to 20 mm

Velocity 50-600 mm/min

- **Complete solution in FSW**
 - FSW technology set up
 - Prototype welding
 - Complete material and NDT testing
 - FSW tools development
 - Production with FSW using
 - FSW equipment delivery



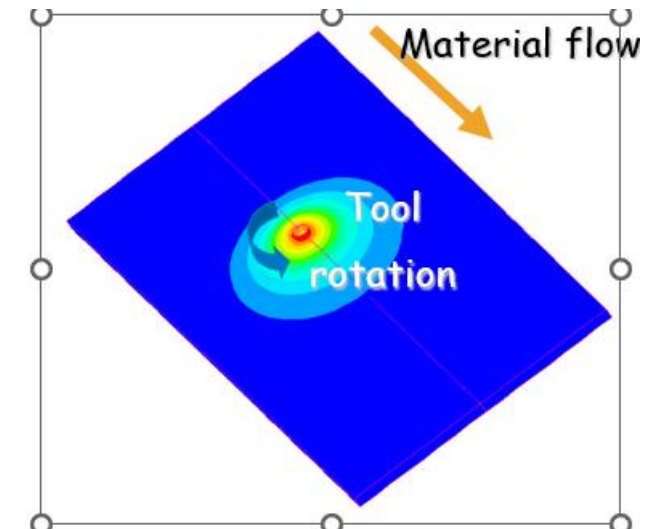
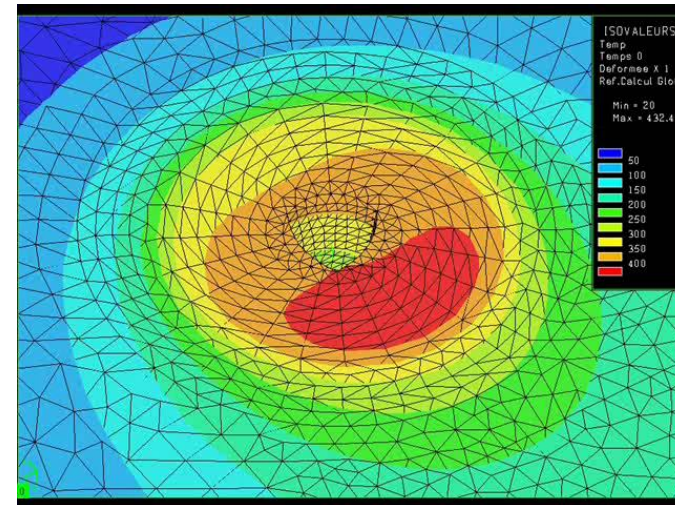
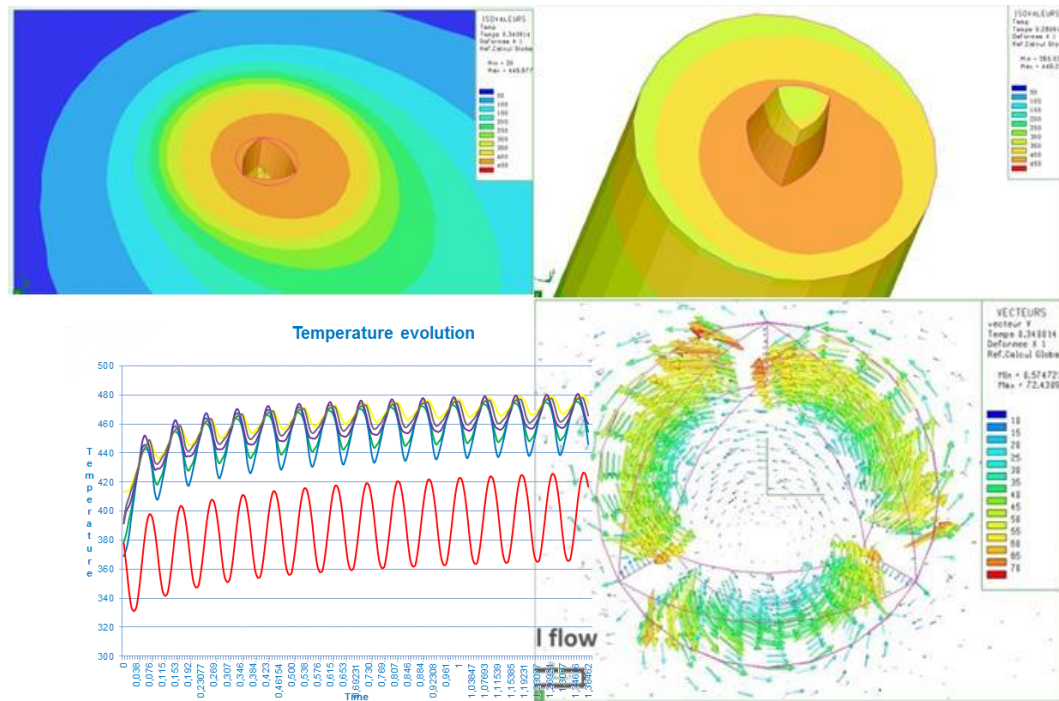
FSW - application





FSW – possible numerical simulation

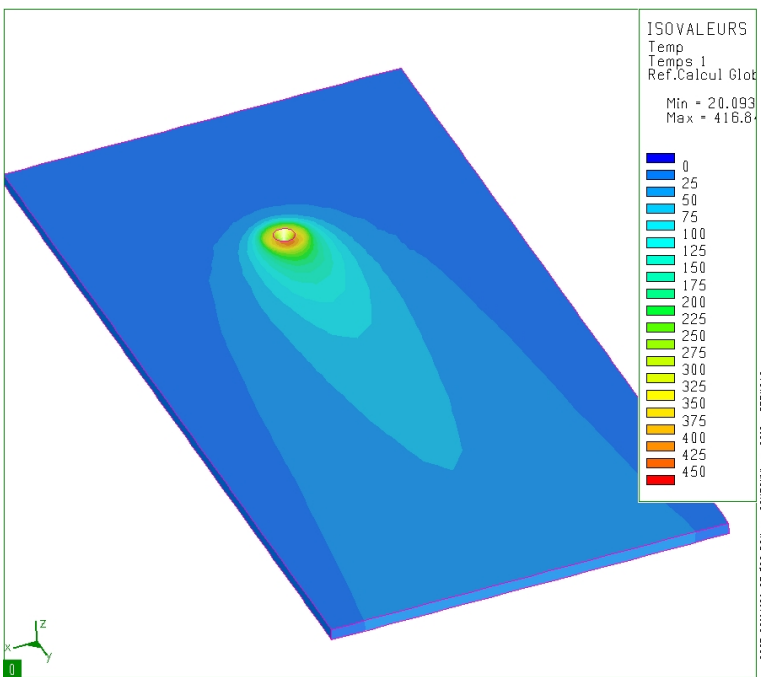
Temperature distribution



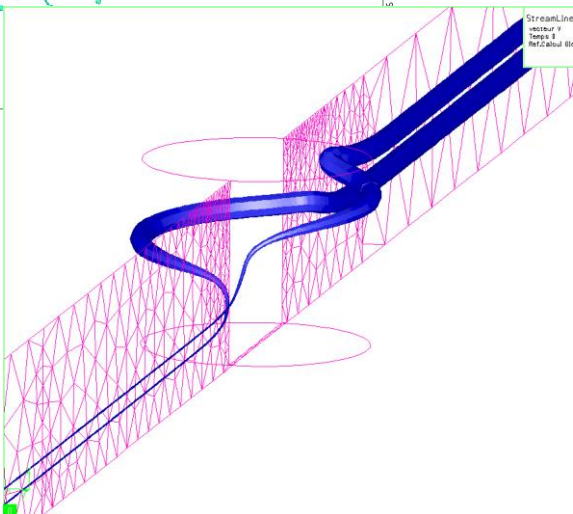
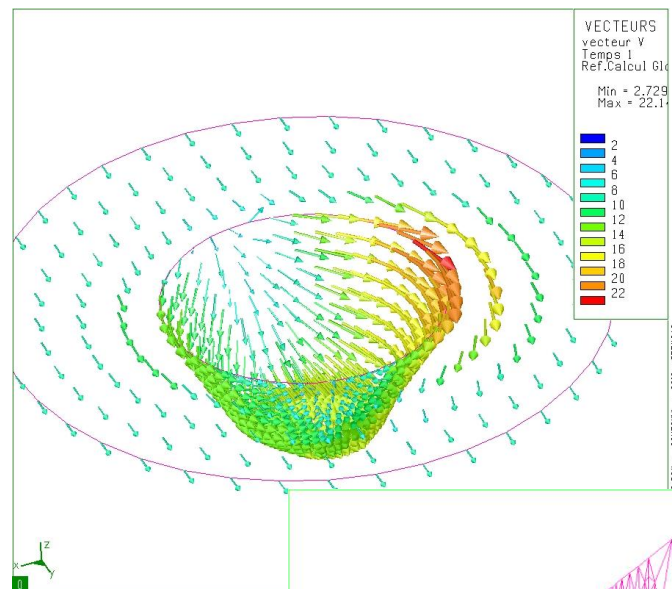


FSW – possible numerical simulation

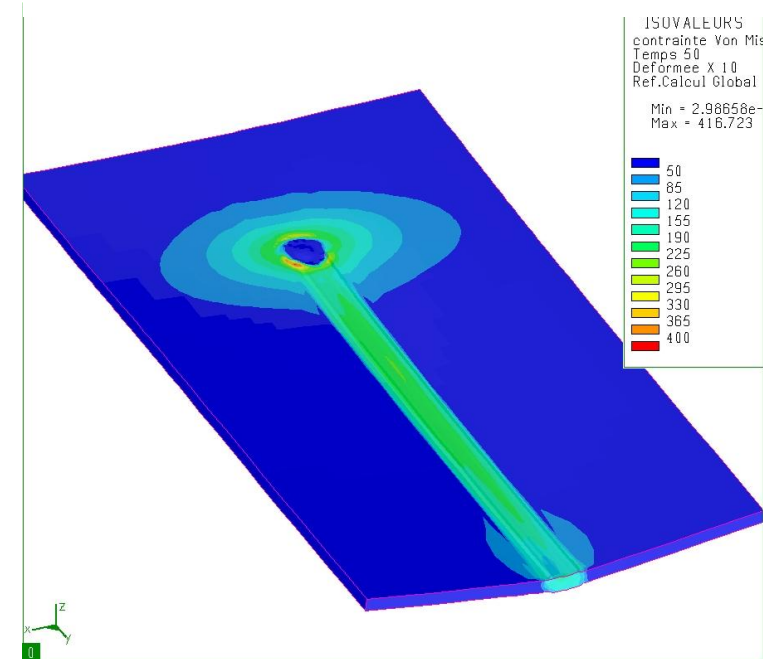
Temperature distribution



Flow around tool



Internal and residual stresses



Flow direction

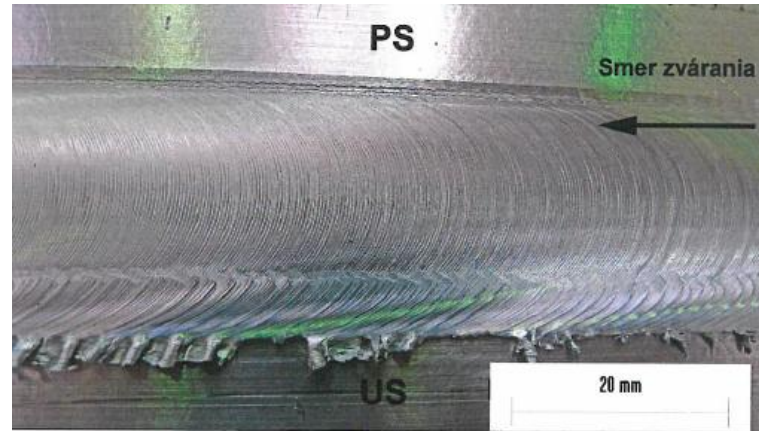
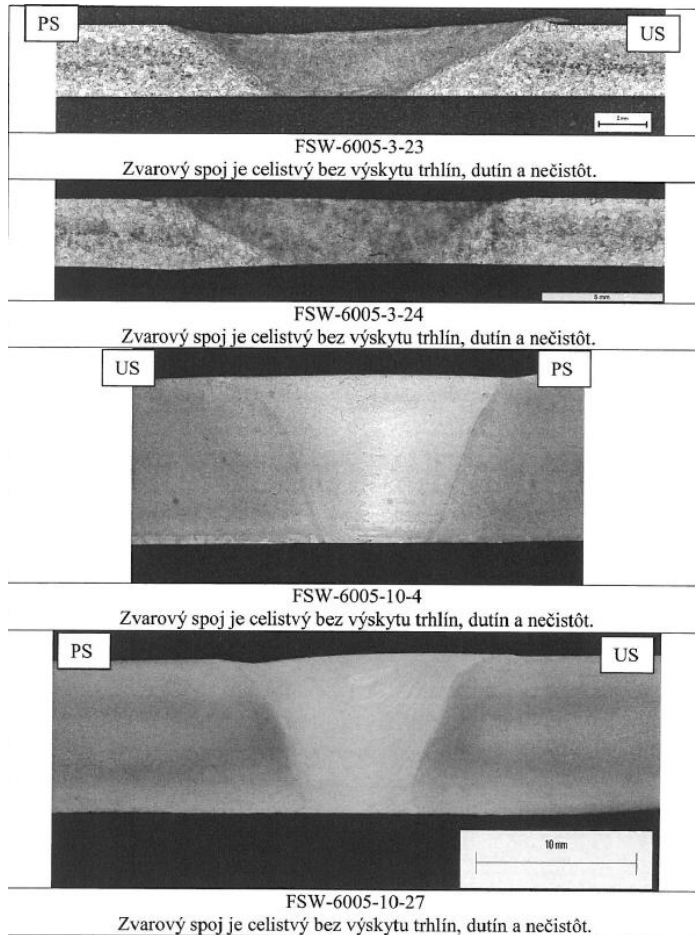
- Tool translation velocity: 500 mm.min⁻¹
- Tool rotation velocity: 1100 r. min⁻¹

Source ESI GROUP

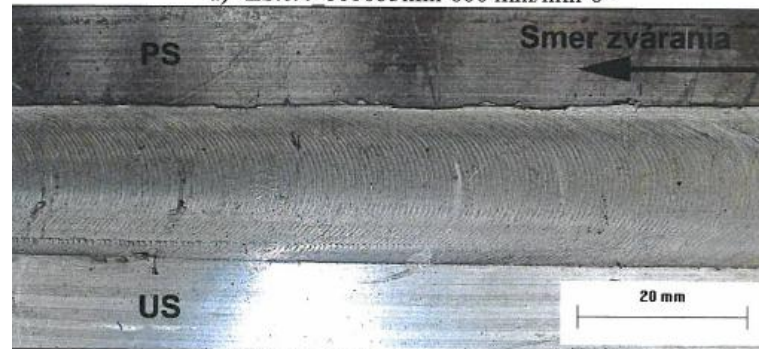


FSW – application in railway industry

- Direction according to thickness and using welding equipment
 - Thickness up to 10 mm – by using robot
 - Thickness between 10- 40 mm - by using gantry equipment
- Test of weldability – welding parameters
- Quality – inspection based on macro section and NDT
- Mechanical testing
 - Tensile tests of base material and weld joints
 - Fatigue tests of base material and weld joints
- Clamping tools development
- Prototype welding
- Used materials
 - AW6005 as extruded
 - AW6082 as plates
 - cast parts AW4xxx
 - Forged parts AW6xxxx
- Thickness
 - 3,5,10,20,30 mm
- Weld joints
 - Homogenous
 - Heterogenous

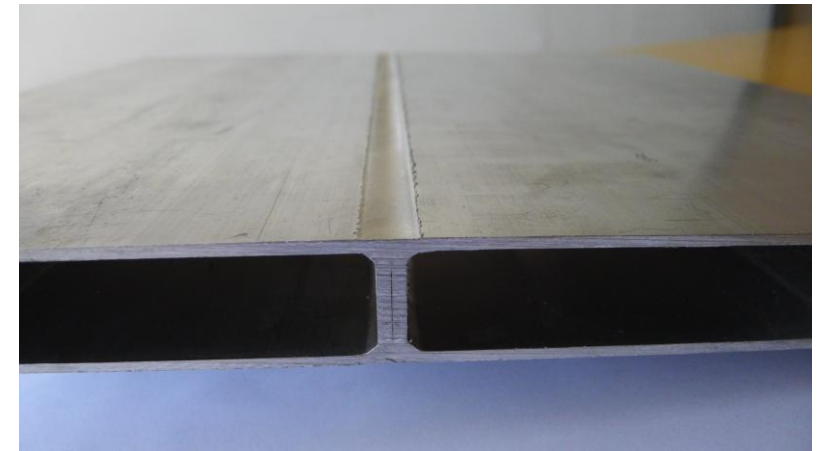


a) ZS.č.4 1000ot/min-600 mm/min-0°

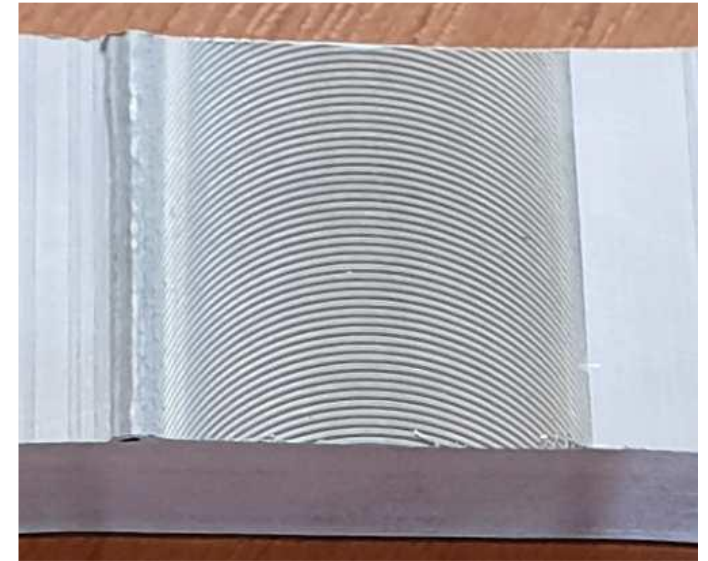


b) ZS.č.27 1500ot/min-1000 mm/min-3°

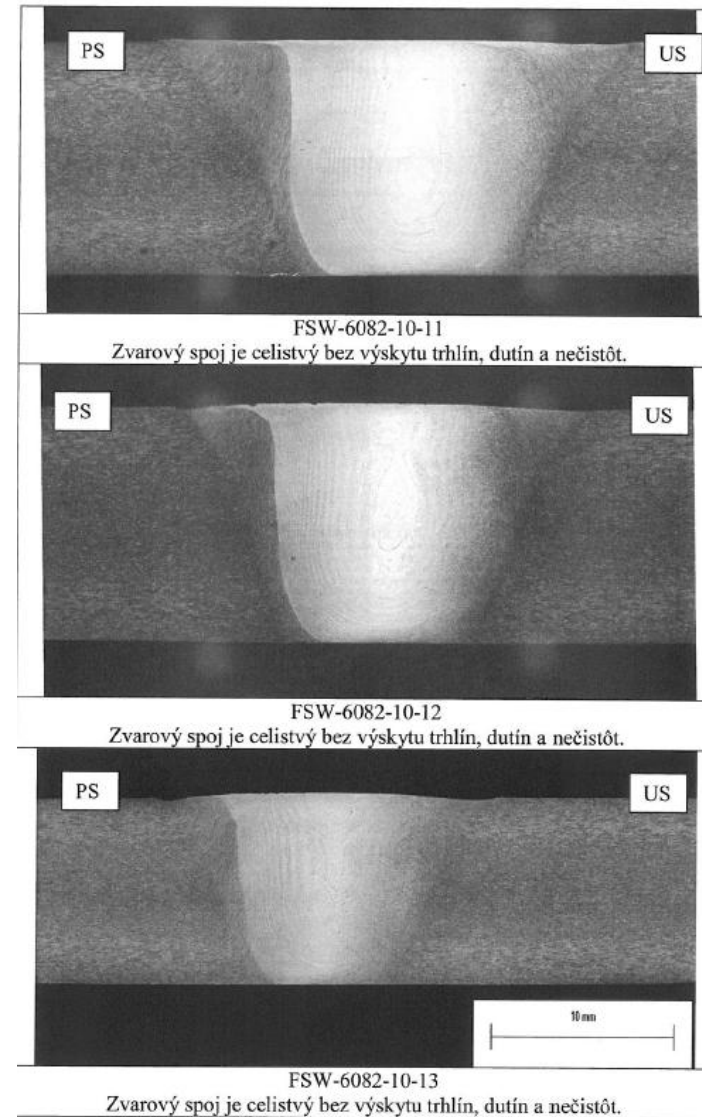
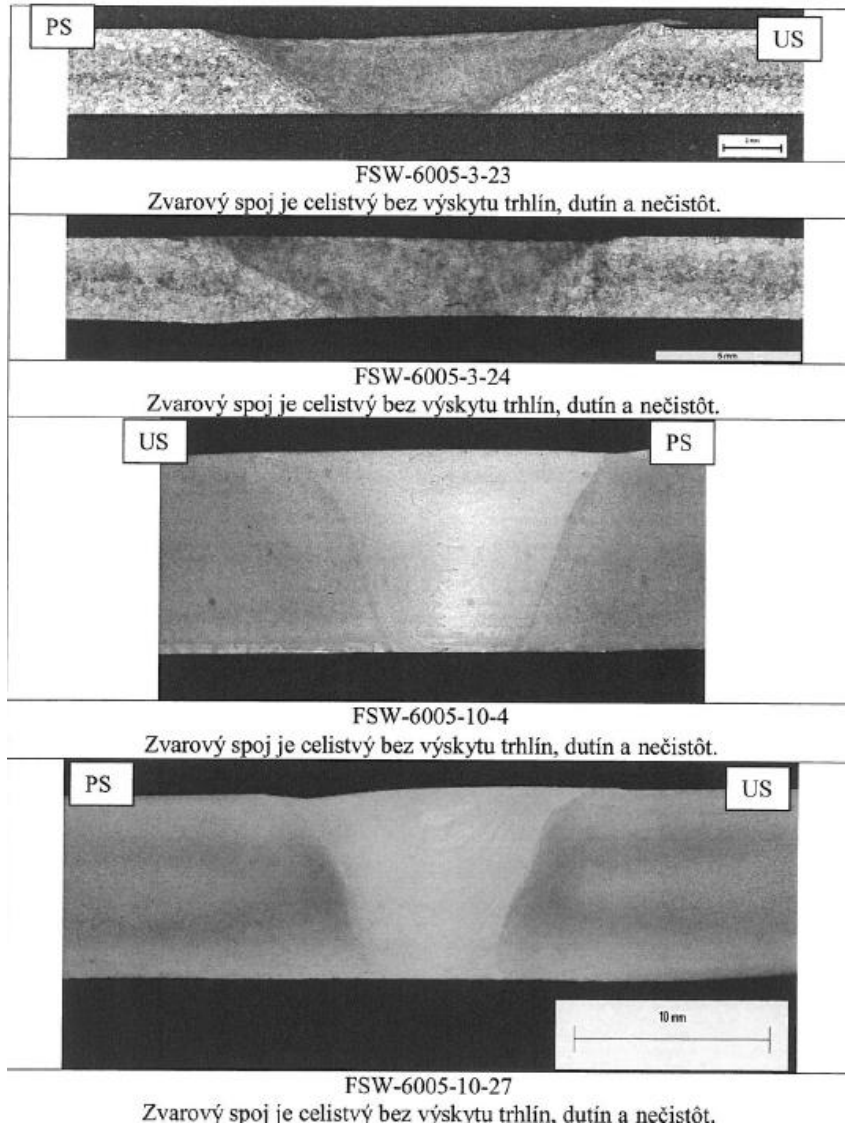
Welding of extruded materials AW 6005



FSW – WRI - FSW and railway industry



AW 6005
3 and 10 mm

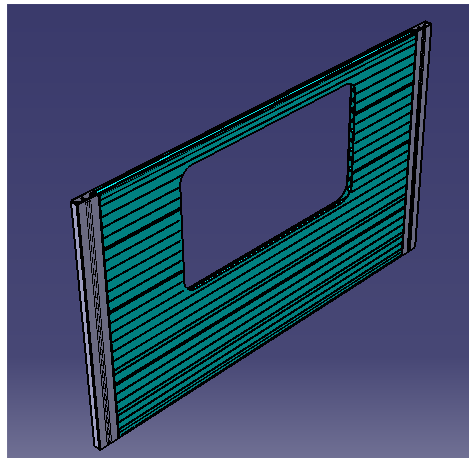
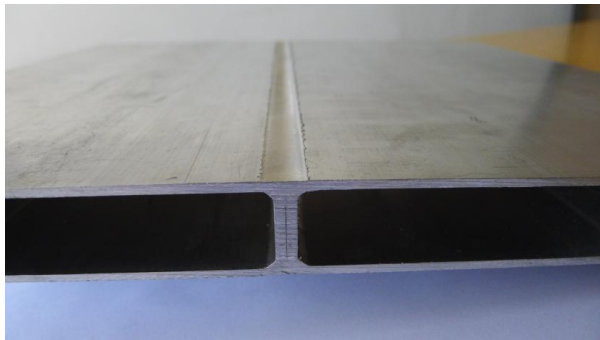
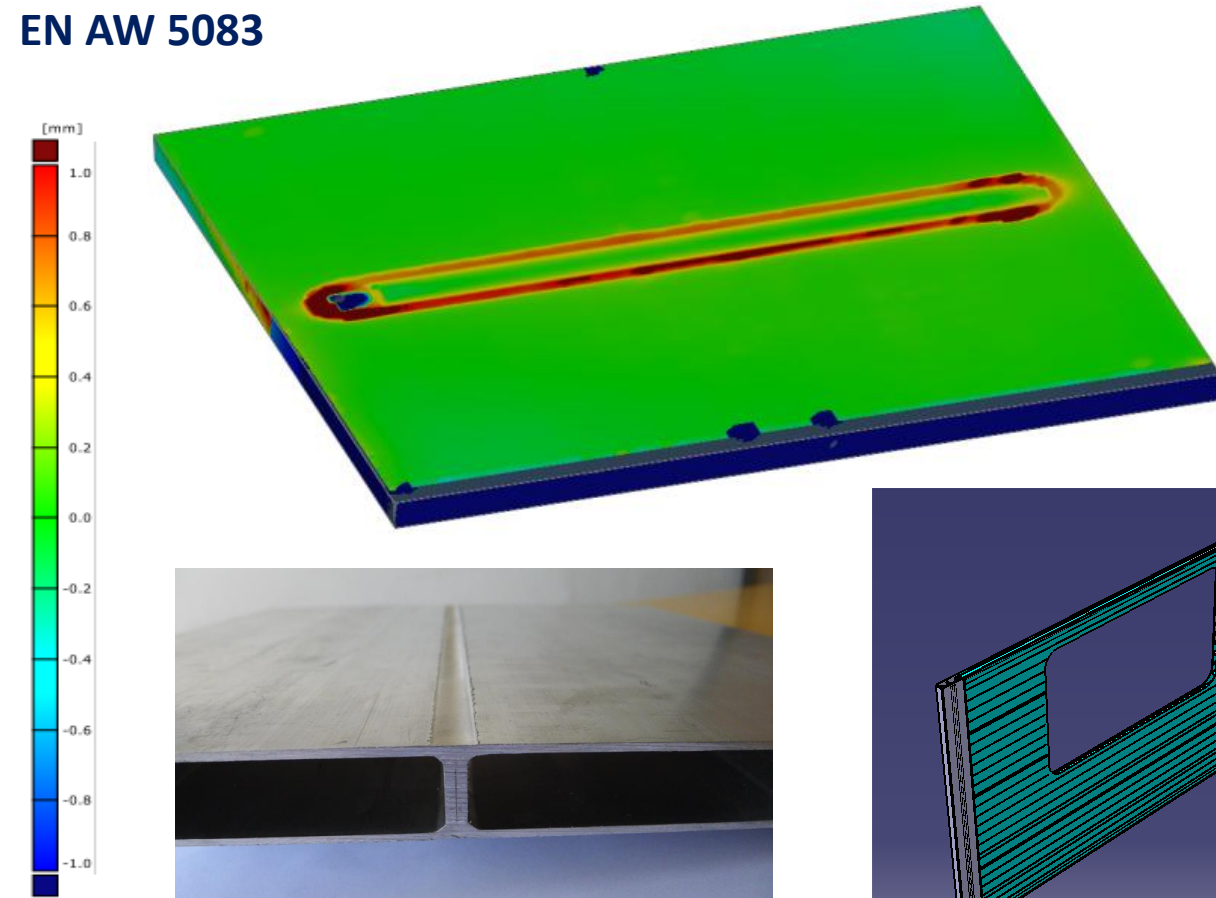


AW 6082
10 mm

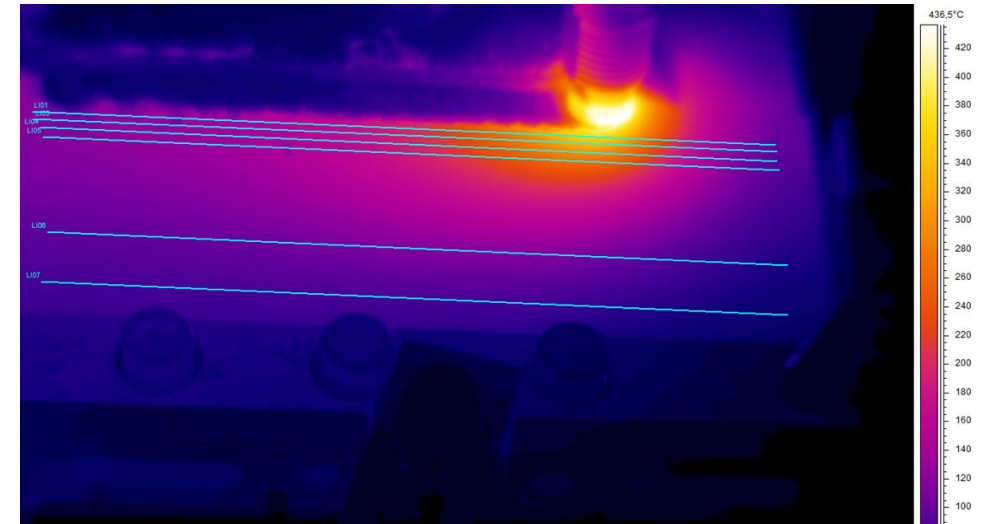
Deformation, optical scanner 3D

Maximal deformation $\pm 0,2\text{mm}$ plate $10 \times 300 \times 450\text{mm}$ s Al

EN AW 5083

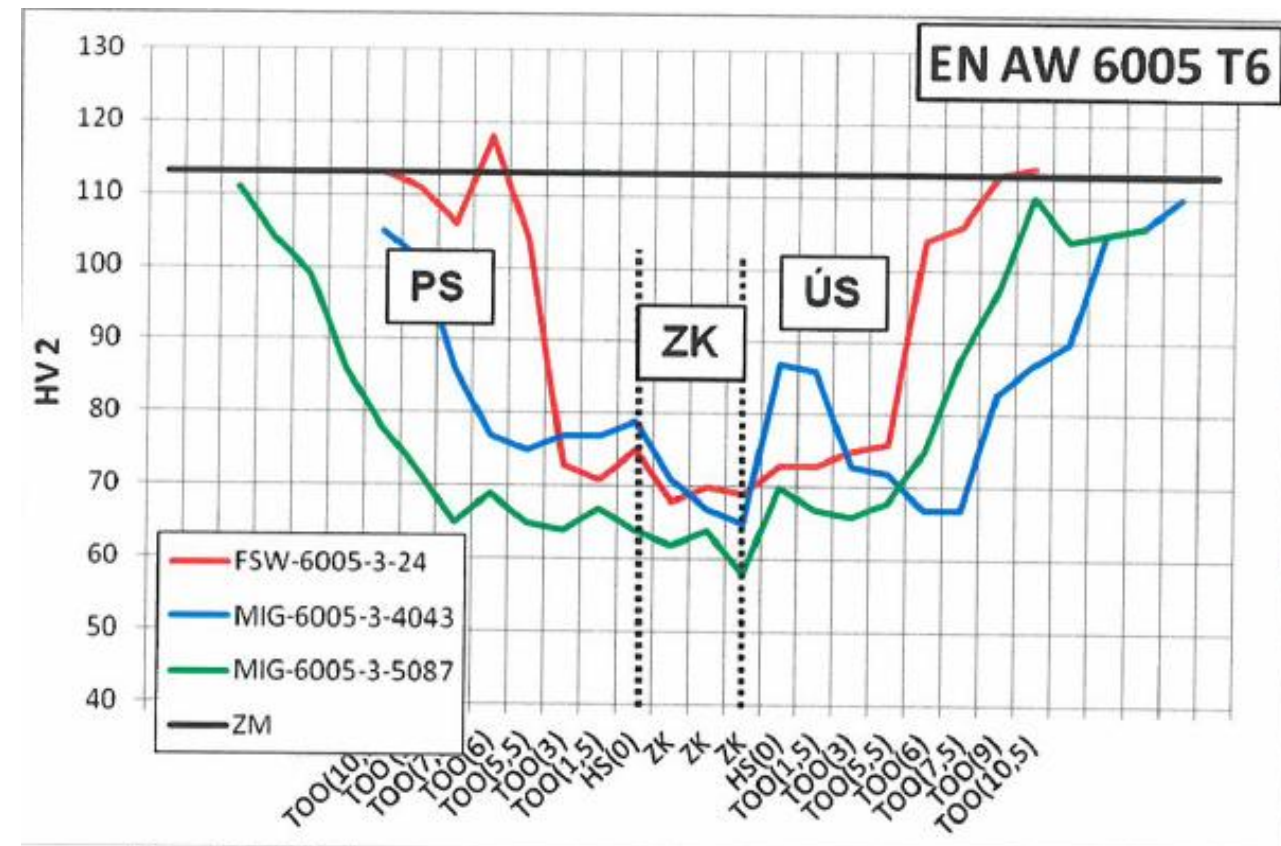
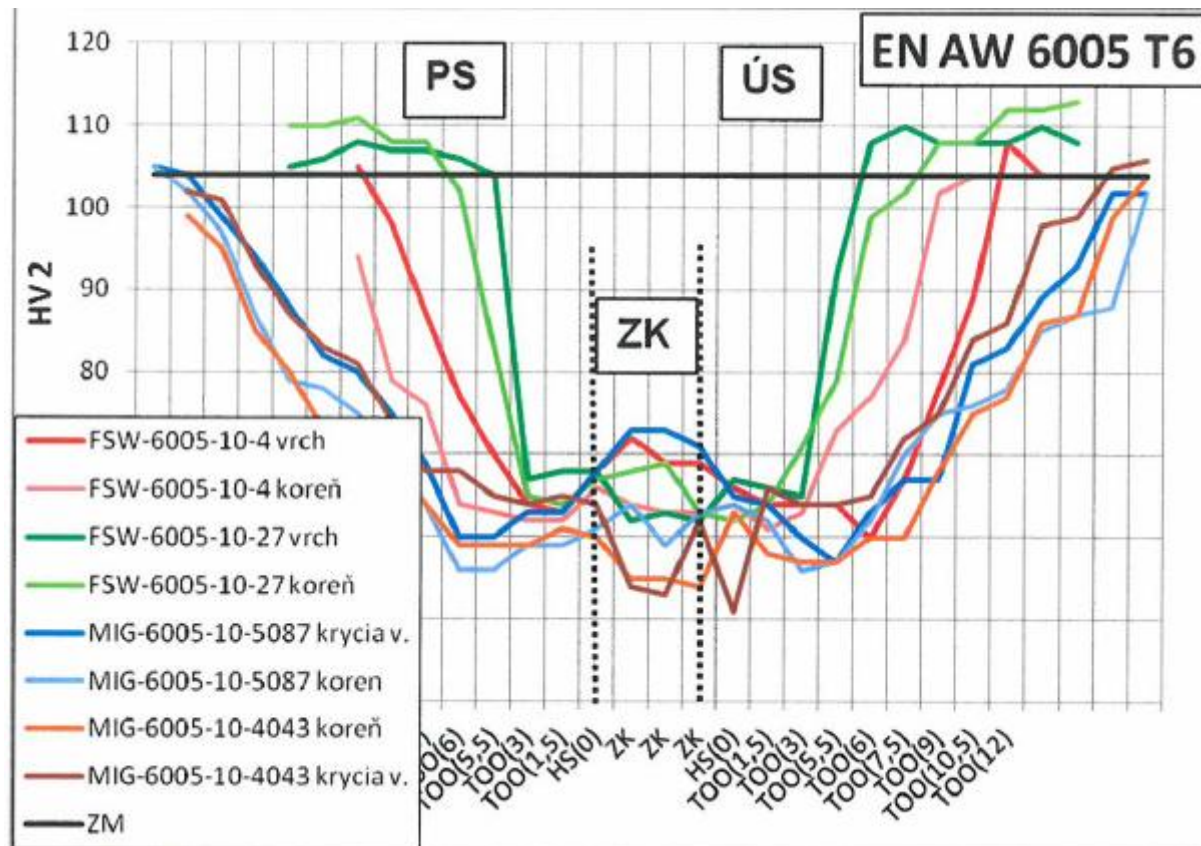


Welding of extruded plates from Al alloys

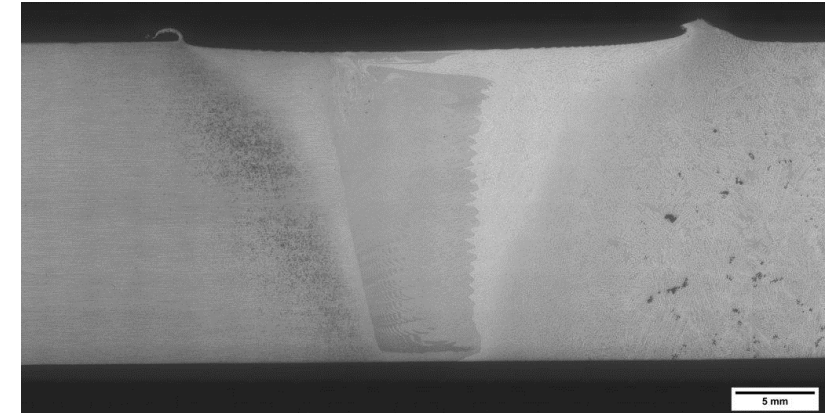
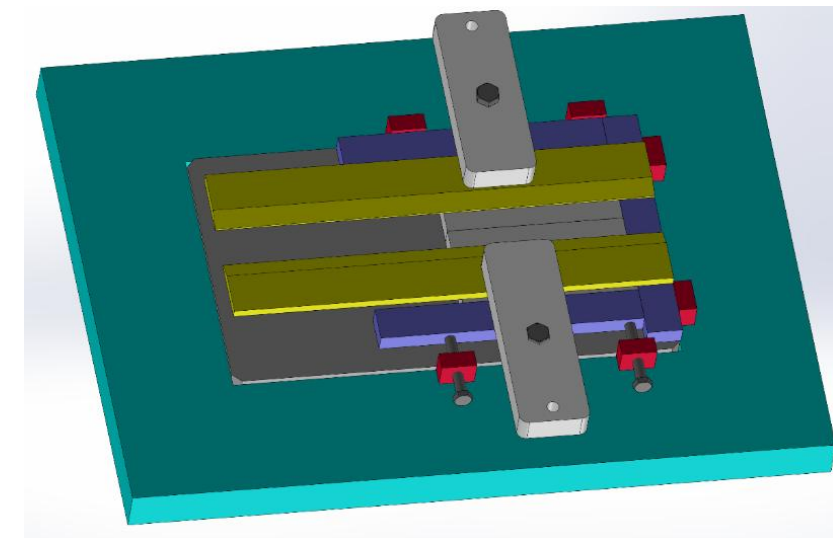
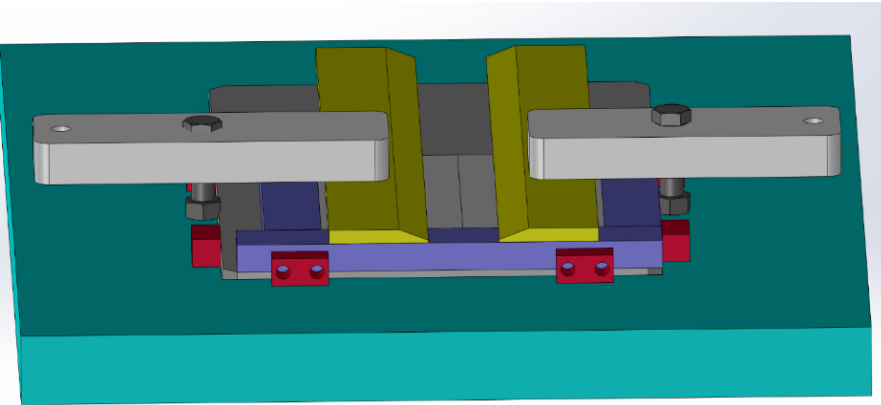


Temperature distribution

Hardness

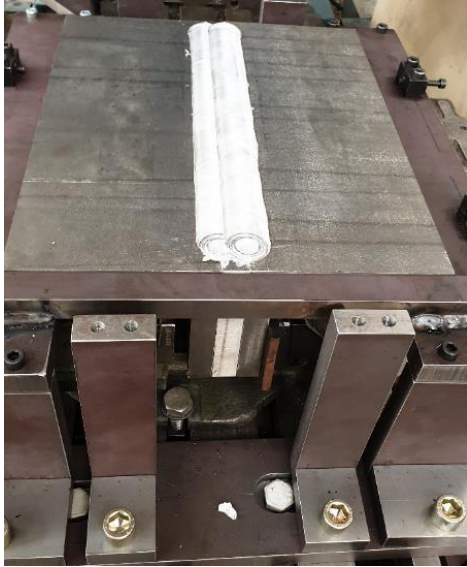


Butt joint 20 mm thickness – AW 6082/AW6082, AW6082/cast part, AW6082/forged part

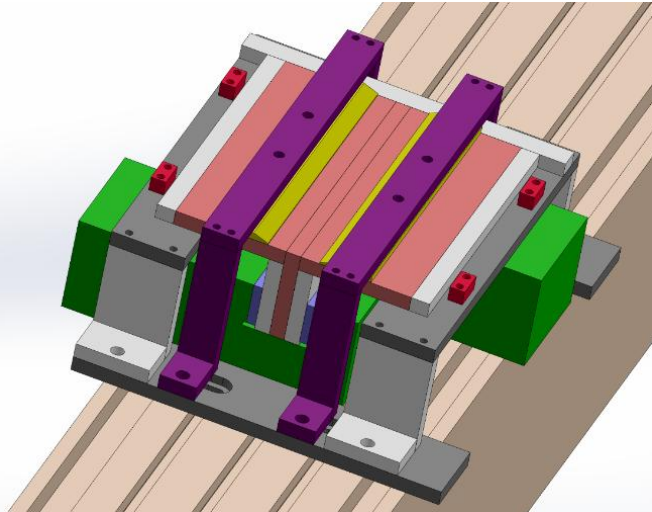
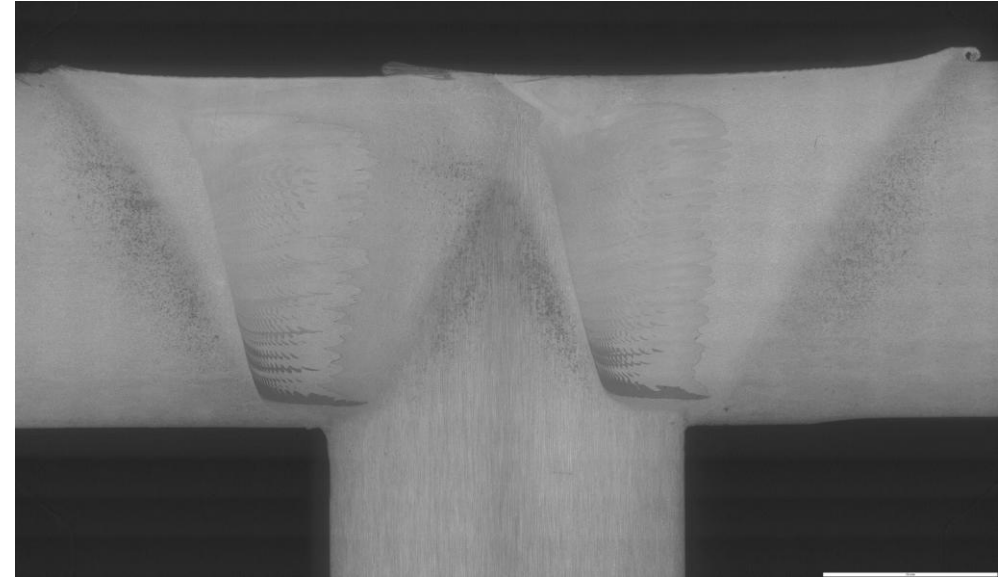


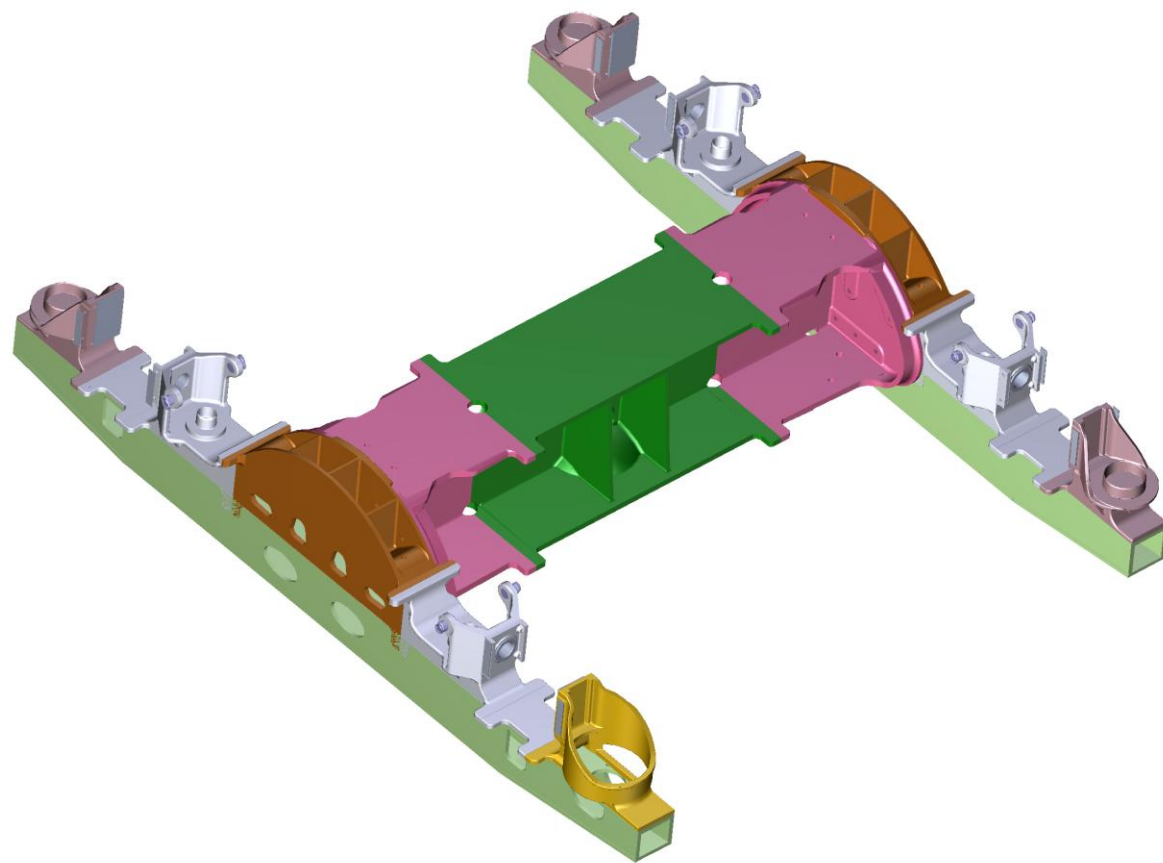
AW 6082/cast part
20 mm

FSW – WRI - FSW and railway industry



T joint 20 mm thickness – AW 6082/AW6082, two variants



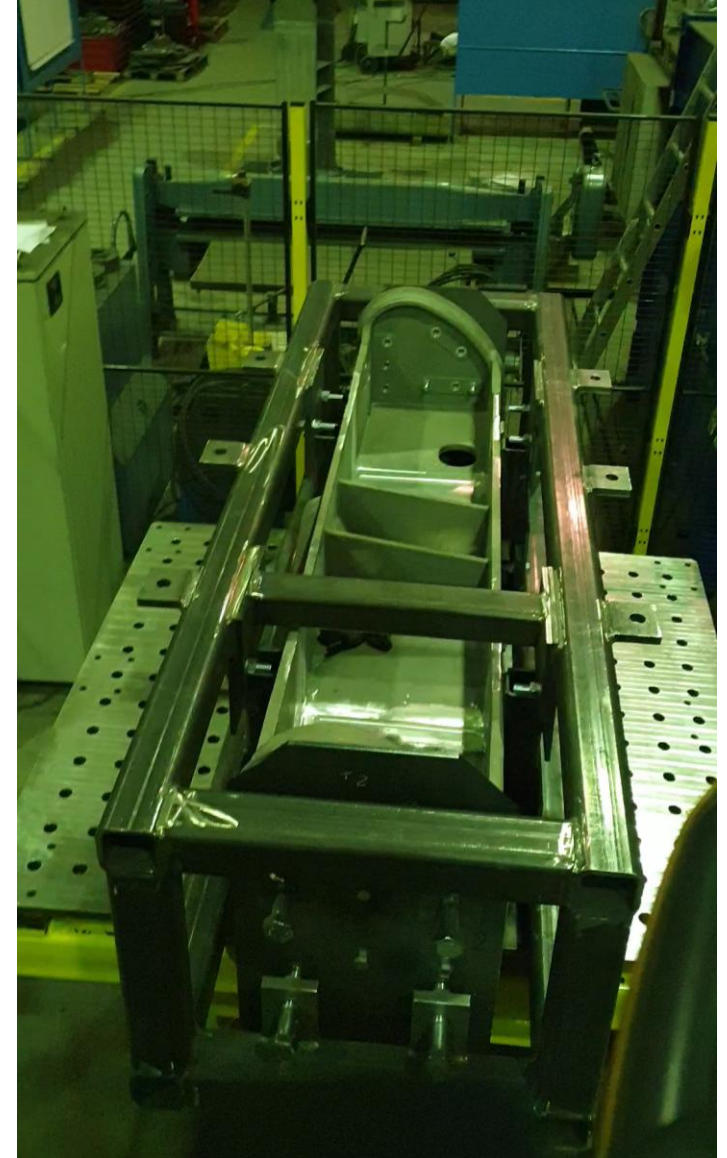


Prototype of freight wagon bogie

- New construction design
- Maximal mechanisation
- Joining cast parts and extruded parts
- Higher mechanical properties
- First prototype
- Complete from Al alloys
- Complete joined by FSW



FSW – application





FSW – application



The world premiere:
InnoTrans Berlin 20-23.10 2022
3 000 exhibitors





FSW – conclusion

- FSW is very modern and effective method
- Using mainly for Al alloys – low stiffness (Youngs modulus) and low yield stress
- Possibility to weld Al cast parts and forged parts and extruded parts
- Complete technology set up and material testing including fatigue test (it is missing in FAT construction curves)
- Complete prototype welding
- Delivering complete technologies and also machine and clamping tools