COMUNICAÇÃO TÉCNICA

Nº 178546

Effects of FSW welding on the microstruxture and mechanical properties of alloy AA6005A-T6

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Palestra apresentada no CONGRESSO ANUAL DA ABM, 76., 2023, São Paulo 14 slides

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EFFECTS OF FSW WELDING ON THE MIOCROSTRUCTURE AND MECHANICAL PROPERTIES OF ALLOY AA6005A-T6

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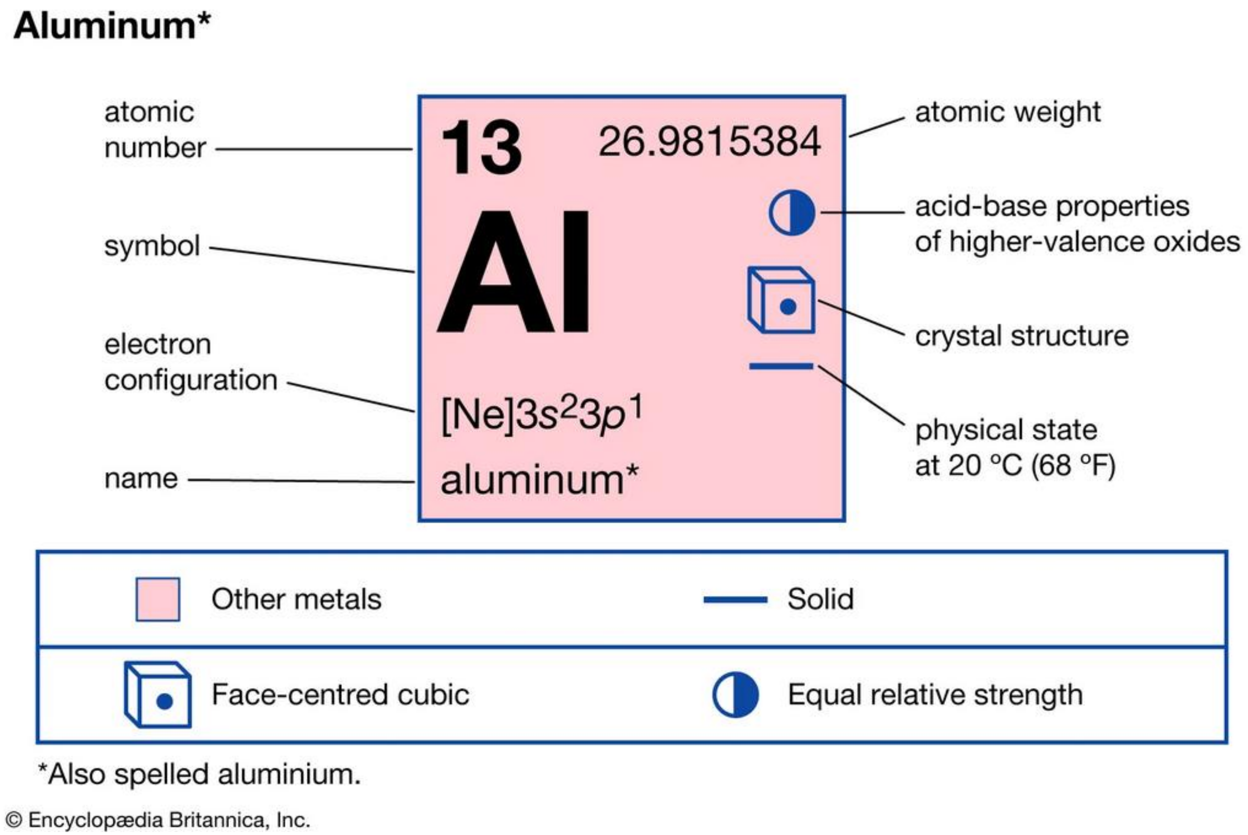
August 3, 2023

Introduction

- Why use aluminium alloys for structural applications?
  - Mechanical Properties
  - Low Density
  - Corrosion resistance

- Possible problems when welding aluminium:
  - Defects
  - Distortions
  - Overaging



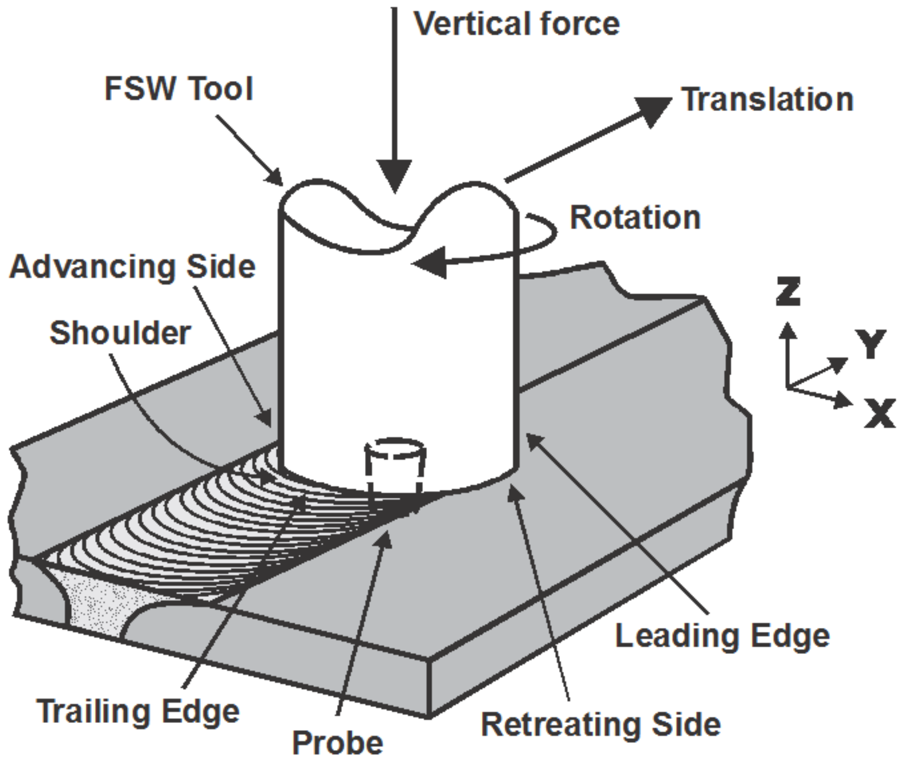
Introduction

- Al-Mg-Si alloys
  - Excellent mechanical properties
  - Good weldability
  - Good extrusion formability
  - Heat treatable alloy → precipitation hardening

SSSS → Cluster of Mg and Si → Co-Cluster Mg-Si → GPZ → β" → β' → β (Mg_2Si)

Introduction

- What's FSW? What are your advantages?
  - Solid state welding technique
  - Heat and plastic deformation lead to joint consolidation
  - Lower heat input → Reduction of deleterious effects
  - Plastic deformation → Microstructural refinement in NZ
- The present study aims to evaluate the microstructural and mechanical properties impacts of the FSW process on a wrought Al-Mg-Si alloy (AA6005A-T6) and compare with literature results



http://dx.doi.org/10.2139/ssrn.3104223

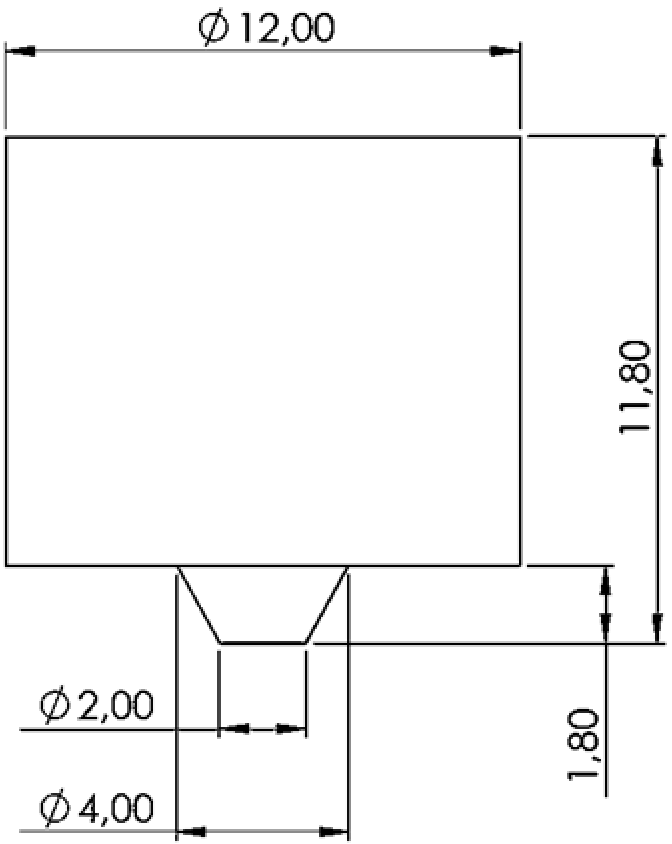
Experimental procedure

1. Welding procedure

- Sheets 300 mm long, 100 mm wide and 2 mm thick of AA6005A-T6
- Equipment: GG7-326 Friction Stir Welder (LEL/IPT)

Parameter	Configuration
Welding Speed (v)	600 mm/min
Rotation (ω)	1700 RPM
Pitch (ω/v)	2,8 r/mm
Angle	0,5°
Targeted Force	4,5 kN

Parameters used for FSW welding



Geometry of the h13 tool used for welding. Dimensions in mm

Experimental procedure

2. Joint consolidation and characterization

- Assessment of joint consolidation and presence of internal defects
  - Equipment: TomoScope HV Compact Werth Messtechnik GmbH

- Electrochemical etching with Barker's reagent → reveal grain structure
  - Grain size → ASTM E112

- Hardness profile → 11 different regions

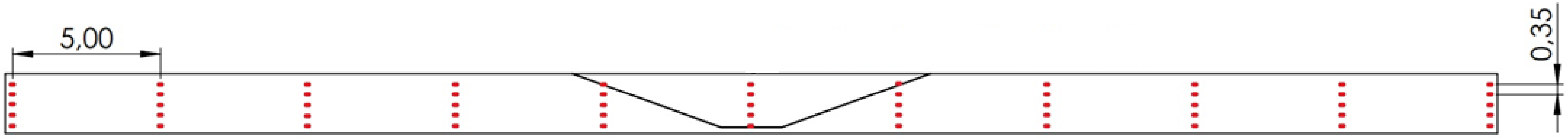
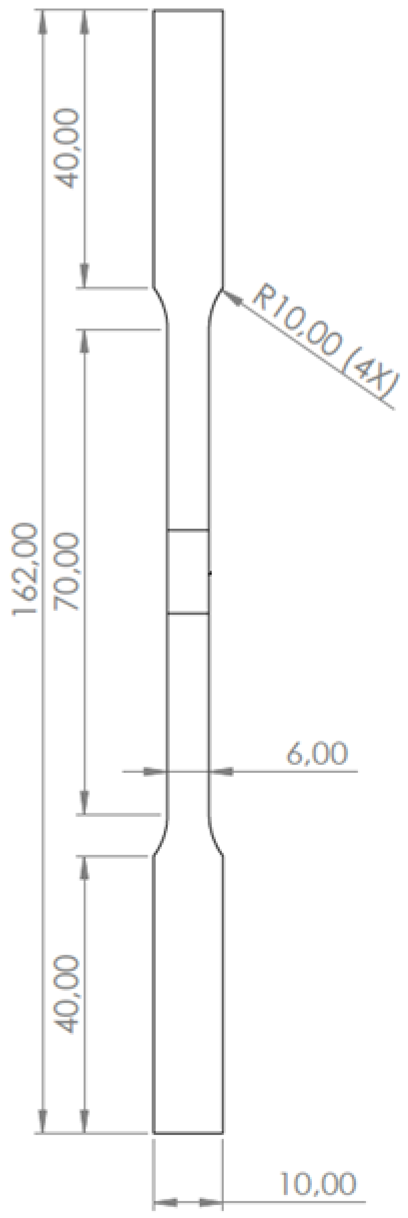


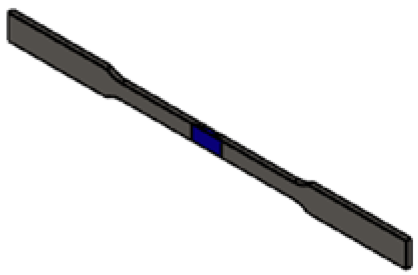
Illustration with measured hardness points (red points) - front view

Experimental procedure

3. Tensile test

- Specimens were obtained by wire erosion
- Performed on a EMIC DL 1000 at room temperature
- Displacement rate: 1,5 mm/min
- 4 sample were tested

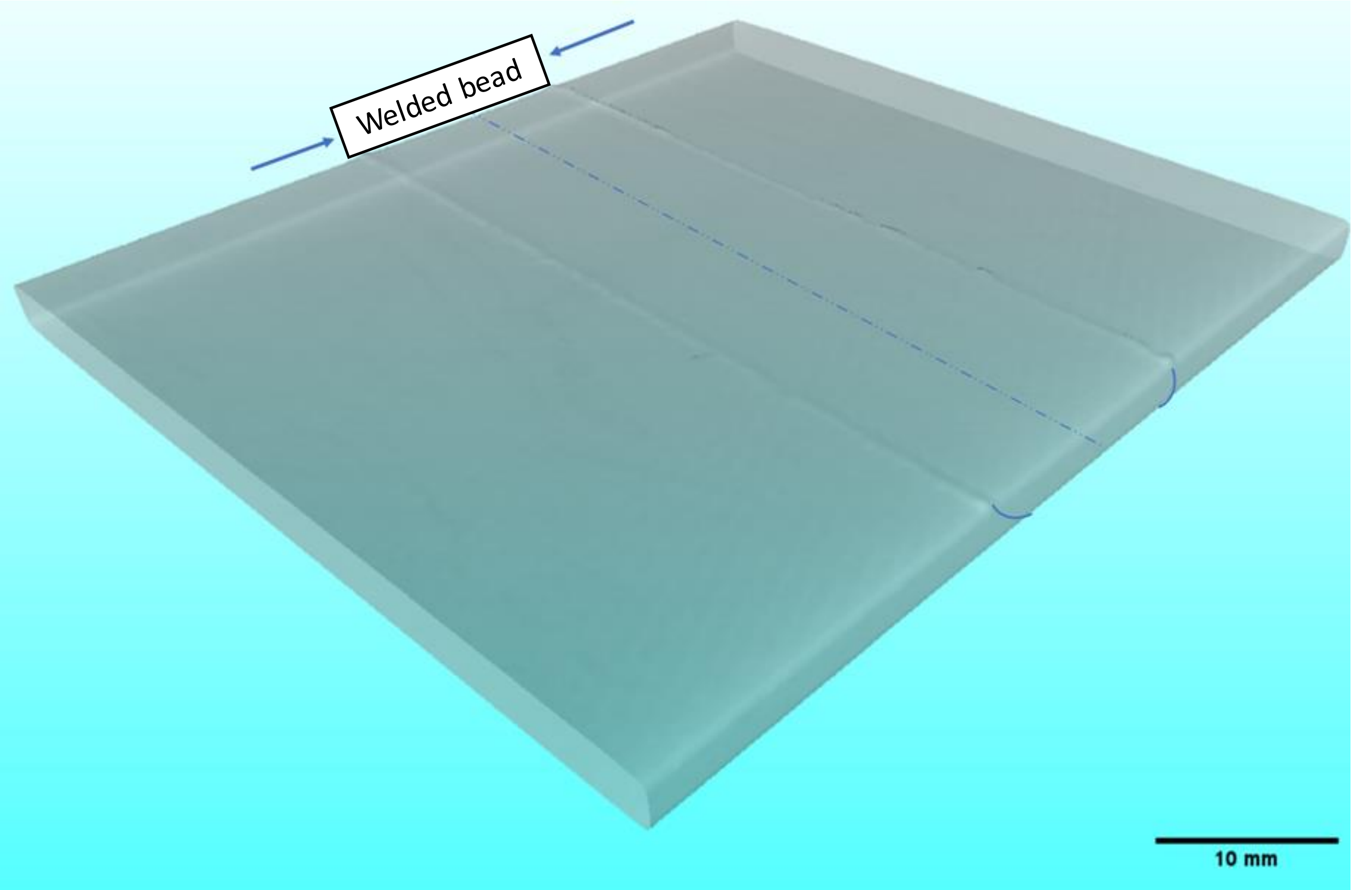




Geometry for the tensile test

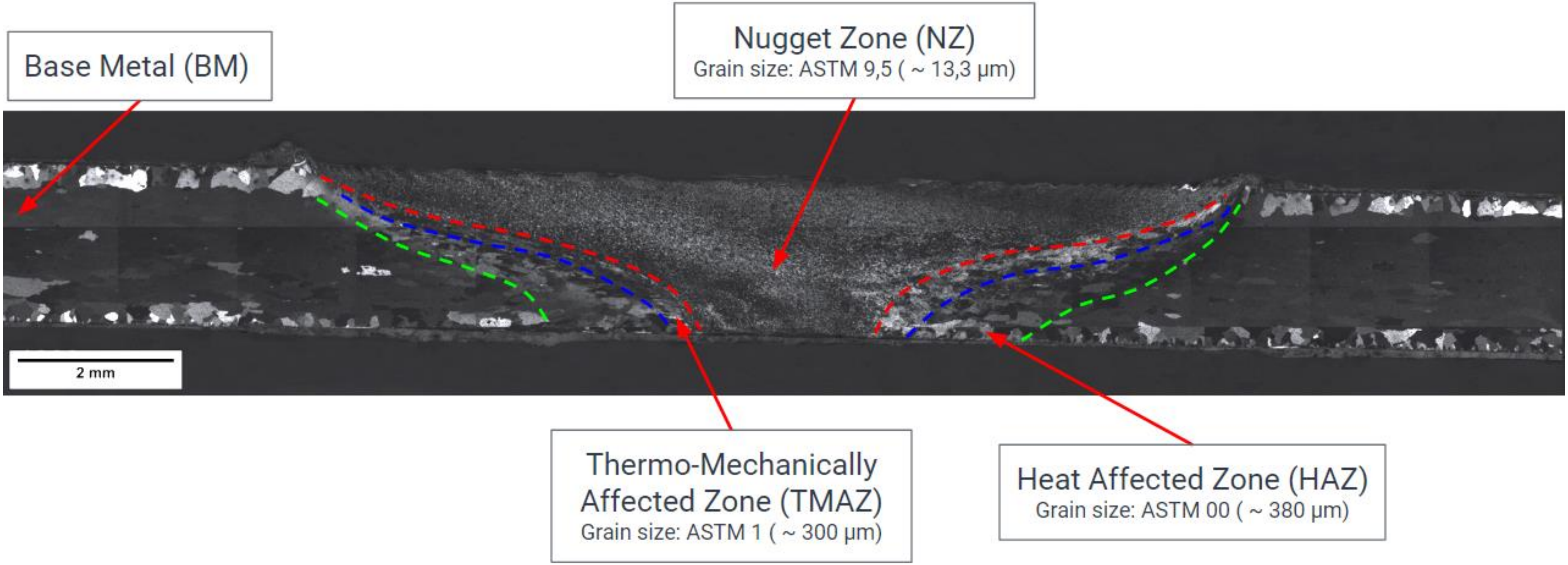
Results and Discussion – Joint Consolidation

- Consolidation of the joint without internal defects



3D reconstruction of the joint analyzed by X-ray computed tomography

Results and Discussion – Microstructure

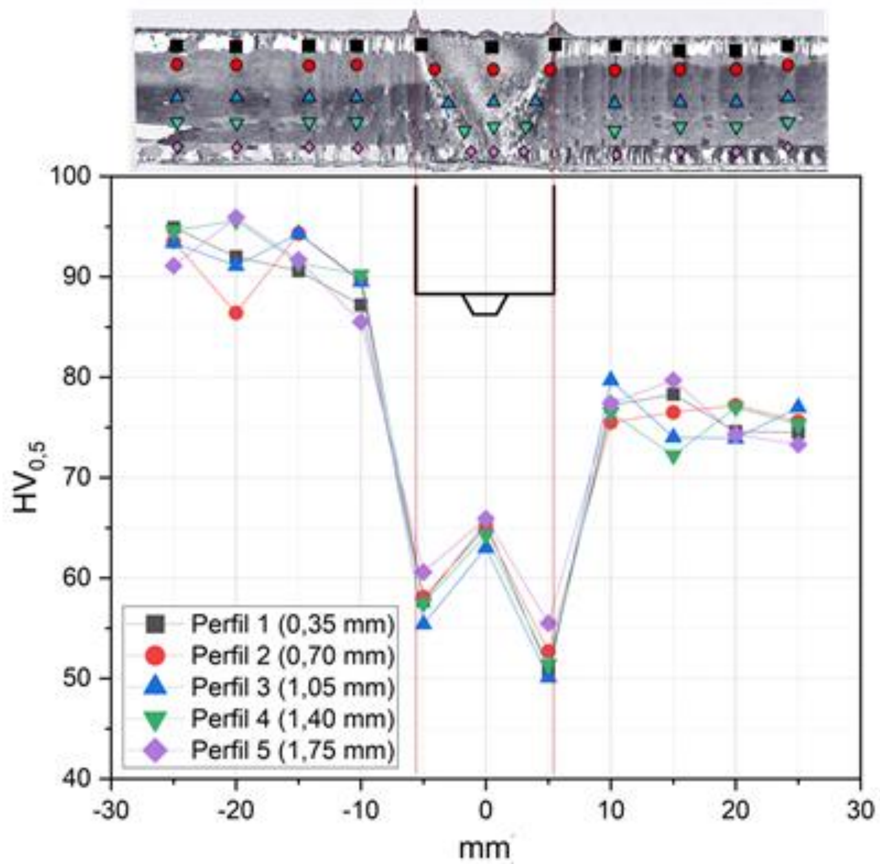


Macrograph of the FSW joint with the four distinct regions identified. Optical microscopy, 50x.

Results and Discussion – Hardeness Profile

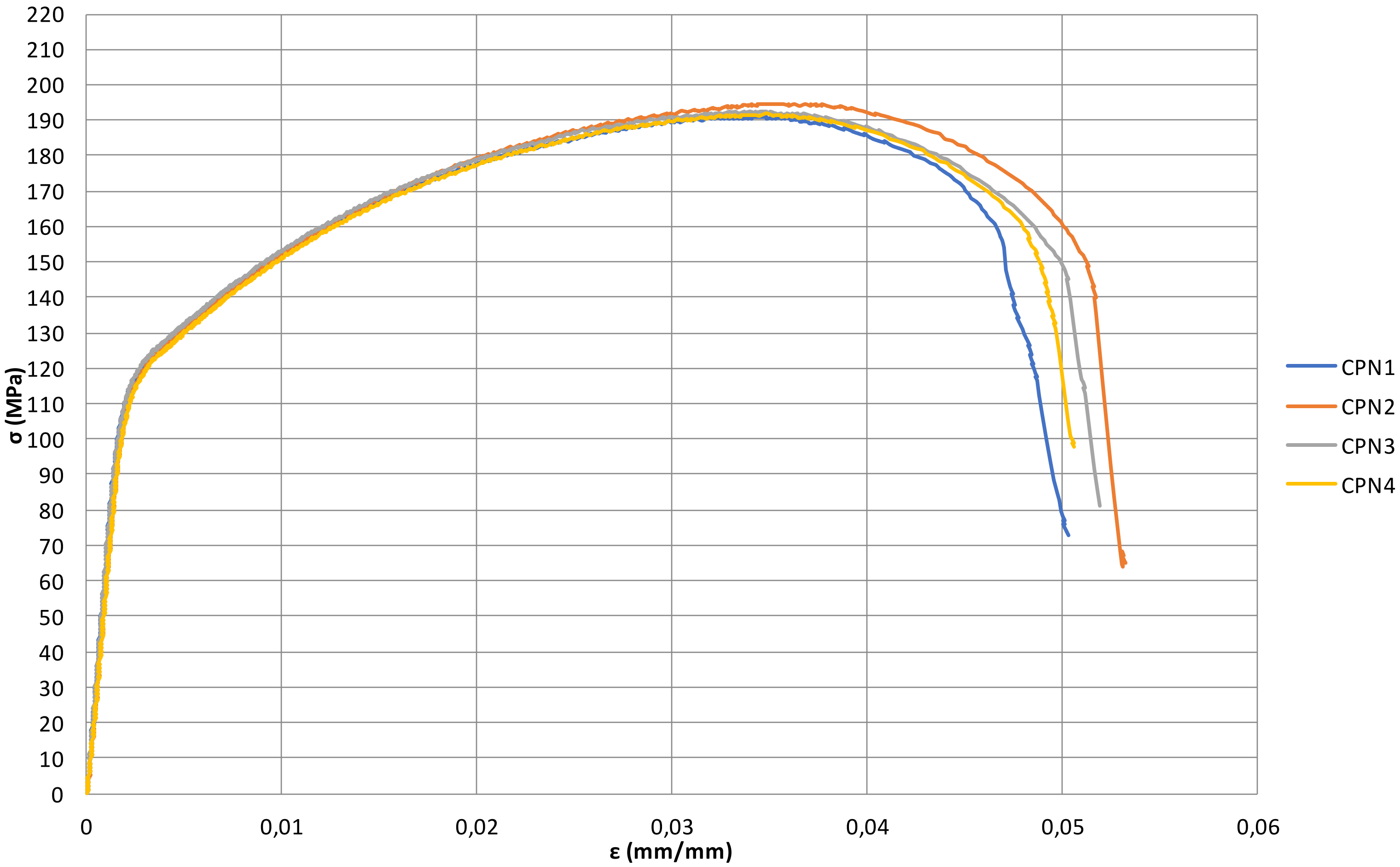
- Typical "W" profile
  - NZ → Microstructural refinement
  - Hardness reduction in TMAZ and HAZ
    - 96 HV → 55 HV

- Role of β” decomposition on the hardness reduction

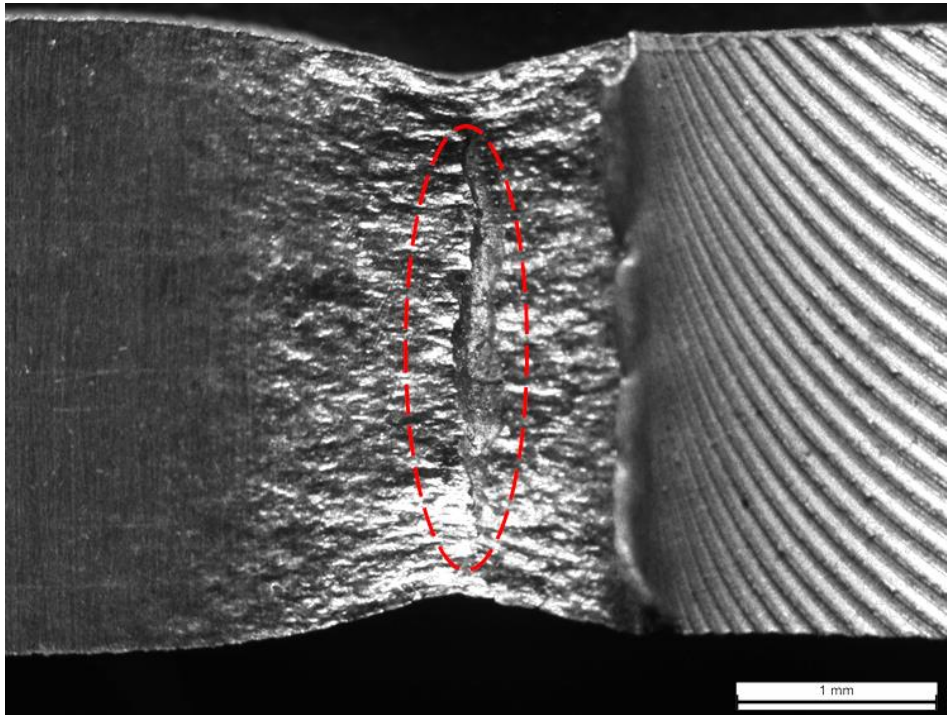


Microhardness profile of the FSW joint. An illustration of the tool geometry indicates the different tool engagement regions.

Results and Discussion – Tensile test



FSW joint stress-strain curve



Macrograph highlighting the region where the crack appeared. On the right, weld bead can be seen

Results and Discussion - Comparison with the literature

Reference	ω	v	Properties			
			Yield Strength	Ultimate Strength	Failure strain	Joint efficiency
FSW Joint	1700 RPM	600 mm/min	126 MPa	193 MPa	5,2%	76%
Dong, P. et al.	1200 RPM	400 mm/min	149 MPa	225 MPa	9,0%	80%
Liu, J. et al	900 RPM	300 mm/min	-	245 MPa	9,5%	80%
Simar, A. et al.	1000 RPM	200 mm/min	114 MPa	193 MPa	7,2%	67%
Hu, W. et al.	1400 RPM	600 mm/min	121 MPa	150 MPa	3,4%	71%

Comparison of the average properties obtained by this work and results obtained from the literature

Conclusion

- After evaluating the results, it can be concluded that:
  - FSW welding produced asymmetrical macrostructural and microhardness profiles.
  - Degradation of the mechanical tensile properties of the welded joint was observed in relation to the base metal, which was attributed to microstructural alterations. However, this reduction in properties measured through joint efficiency is at acceptable levels (76% efficiency) and within the limits reported in the literature (between 67% and 80% efficiency).
  - Despite being the region that suffers the highest heat input, the nugget zone (NZ) has a higher hardness (65 HV) than the TMAZ and HAZ (55 HV), so that it is possible to conclude that the refining microstructure of this region is enough to recover, even partially, the mechanical properties in the region.
  - The fracture of the statically tested samples occurred in the region between the TMAZ/HAZ, coinciding with the region of lower hardness of the welded joint.

Thank you

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