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Experimental study of 2024-T3 Al alloy welding using traditional TIG-HF process

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II ENCUENTRO DE INVESTIGACIÓN DESARROLLO E INNOVACIÓN EN EL SECTOR AERONÁUTICO

OUTLINE

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1. Summary.
2. Introduction.
3. Experimental study.
4. Results.
5. Discussion.
6. Conclusion and recommendations.
7. References.

SUMMARY

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- ✓ The weldability of aluminum alloy 2024-T3 using gas tungsten arc welding with high frequency (GTAW-HF) is presented in this article.
- ✓ The objective of this research is to take a first approximation to the weldability of a heat treatable aluminum alloy, using commercial welding rod Harris ER4043 and argon as blending gas.
- ✓ The weld quality was evaluated using metallographic inspection with optical microscopy and by mean of non-destructive radiographic testing.

SUMMARY

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- ✓ The softening of the weldment was inspected using microhardness testing.
- ✓ The strength of the weld was evaluated by means of cross-tension tests and guided root and face bend tests.
- ✓ It is concluded that an increasing in the welding heat input generates a decay in such mechanical properties

INTRODUCTION

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The 2024-T3 alloy with high damage tolerance, has a combination of high fracture toughness, low cycle fatigue strength and resistance to fatigue crack growth and corrosion, making it suitable for fuselage structures, where good static strength, fatigue and fracture resistance are required (Ahn et al., 2017)

EXPERIMENTAL STUDY

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- ✓ Heat treatable aluminum alloy (Al-Cu-Mg) alloy 2024 sheets of 7 inch and 10 inch in the T3 temper condition (solution heat-treated, cold worked and naturally aged) of 1,6 mm thickness were used.

Al	Si	Fe	Cu	Mn	Mg	Cr
Balance	0,5	0,5	3,8-4,9	0,3-0,9	1,2-1,8	0,1

Chemical composition of aluminum alloy 2024-T3

EXPERIMENTAL STUDY

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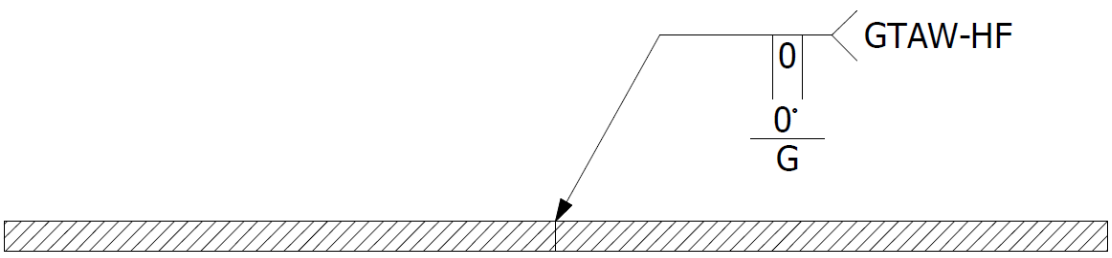
Alloy and temper	UTS		Tensile yield strength		Elongation in 50 mm, %	Hardness HB
	MPa	ksi	MPa	ksi		
2024-T3	485	70	345	50	18	120
Alclad 2024-T3	450	65	310	45	18	120

Mechanical properties of aluminum alloy 2024-T3

Al	Si	Fe	Cu	Mn	Mg	Zn
Balance	4,5 - 6	0,8	0,3	0,05	0,05	0,1

Chemical composition of welding rod ER4043

EXPERIMENTAL STUDY



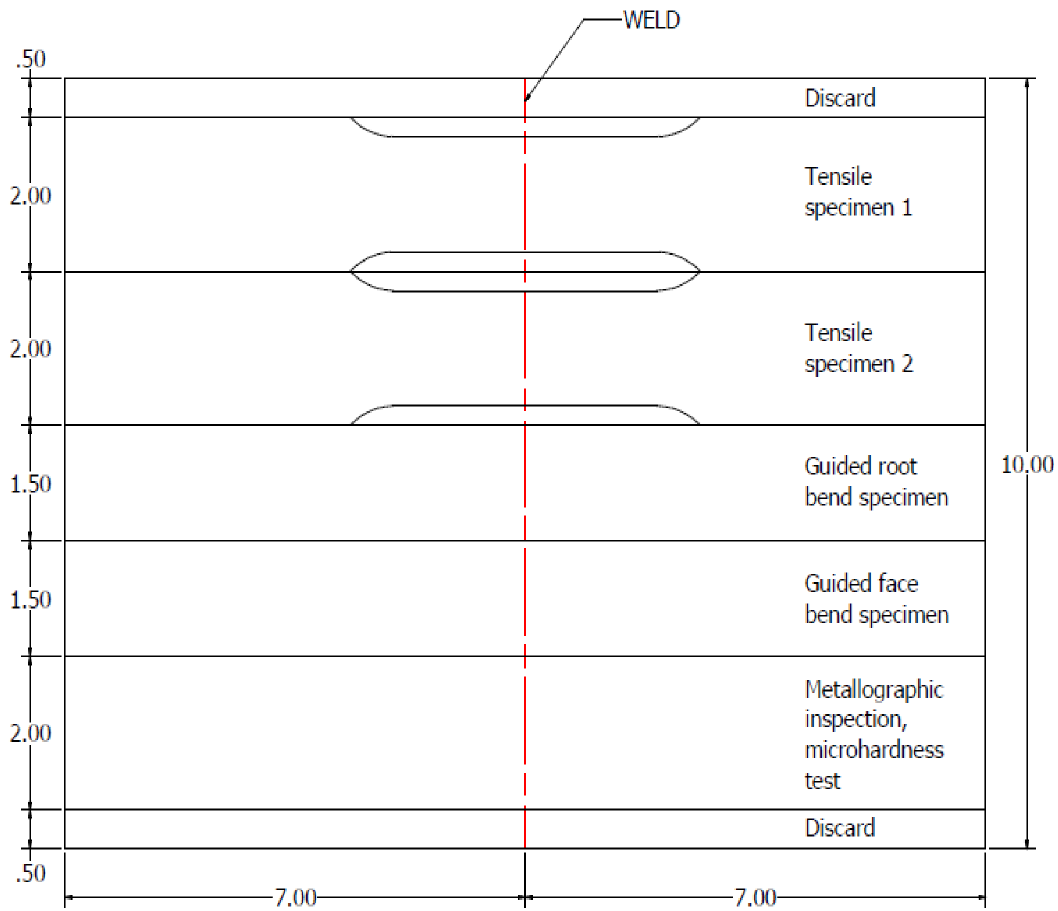
Butt joint designed for the study

#	Welding speed (cm/s)	Welding current (A)	Welding Voltage (V)	Heat Input (J/cm)	Heat Input (kJ/in)	Gas flow (L/min)
1	0,5	50	12,5	1250	3,175	8

$$Q = \frac{V \cdot I}{\vartheta}$$

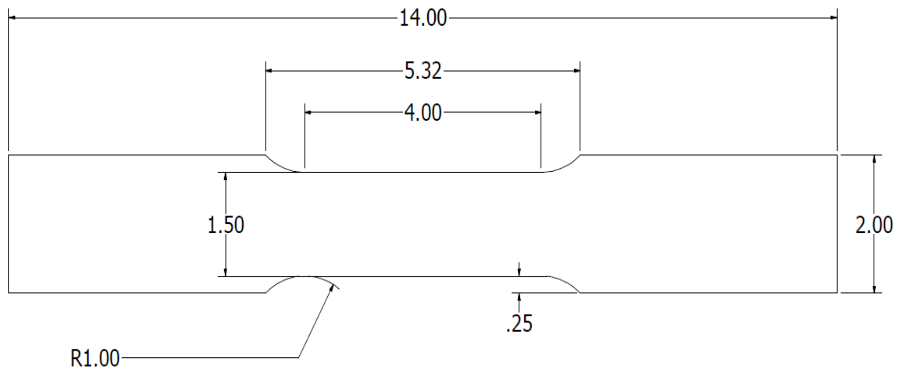
Main welding parameters of experiment.

EXPERIMENTAL STUDY

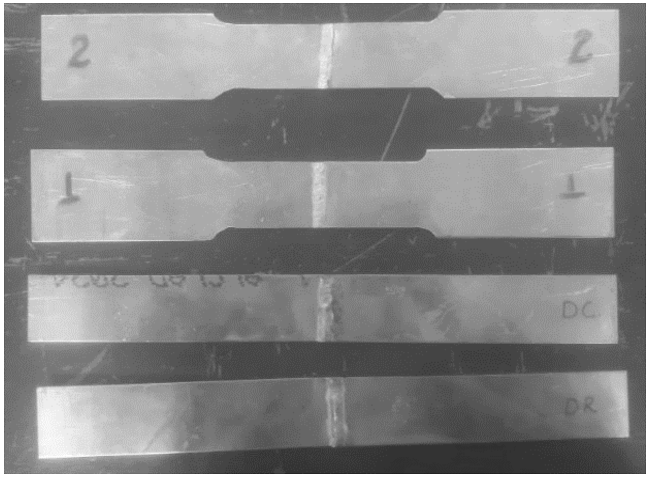


Dimensions of test specimens.

EXPERIMENTAL STUDY



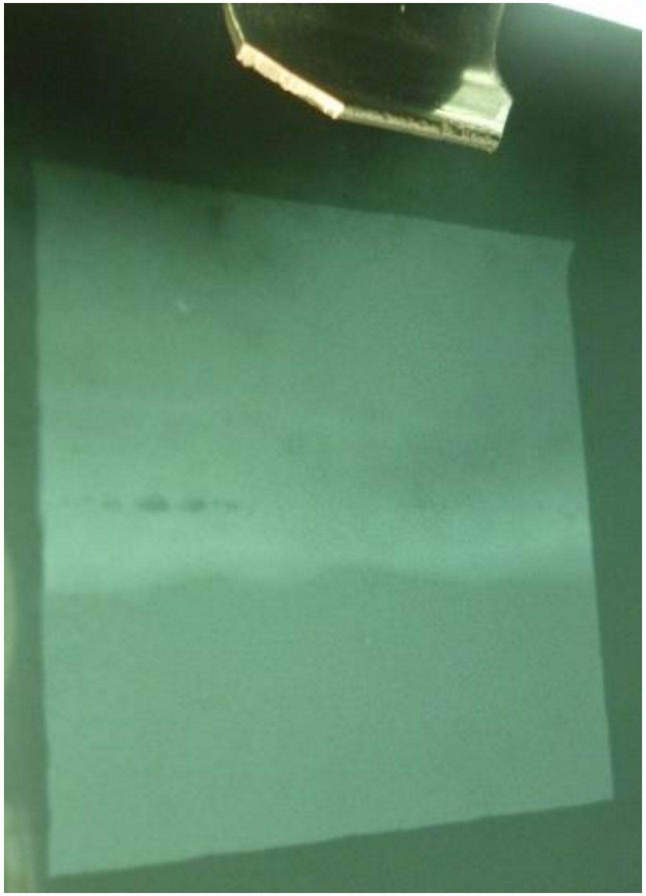
Tensile specimen dimensions.



Dimensions of test specimens.

RESULTS

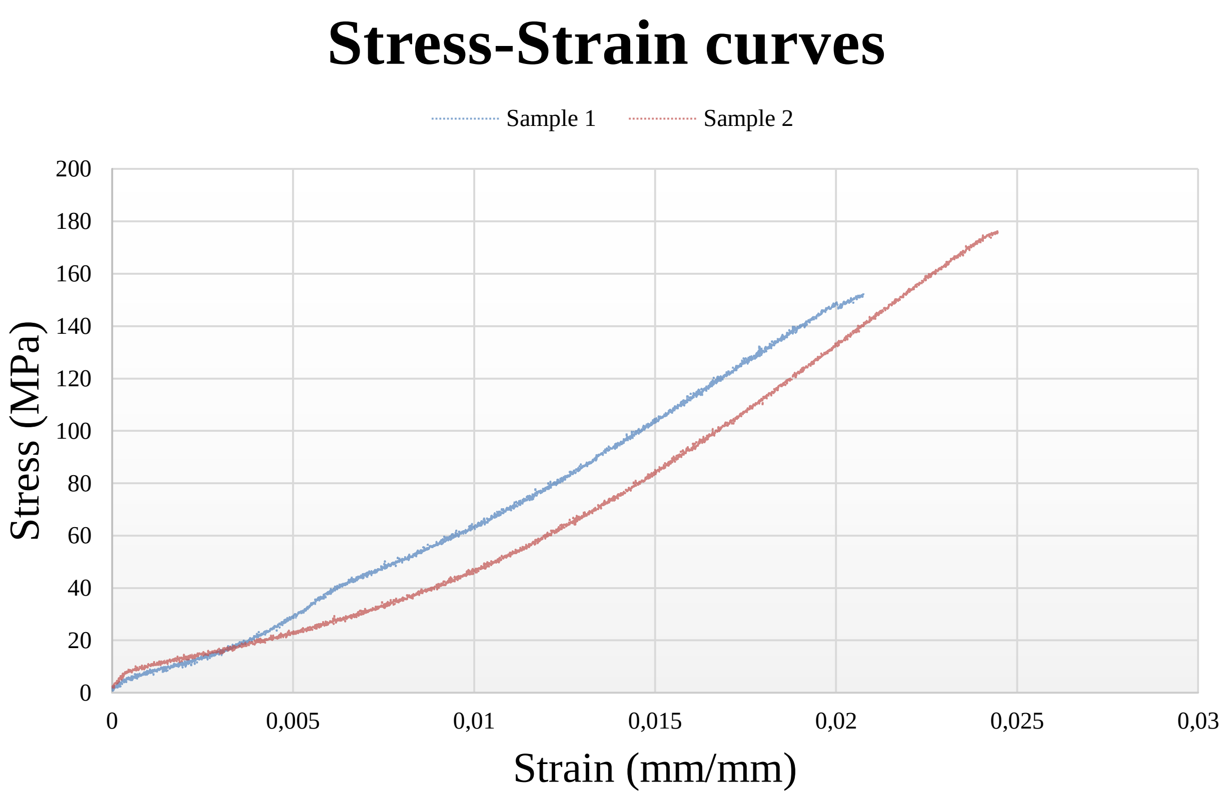
A. Visual and radiographic inspection



Radiographic testing on weld section

RESULTS

B. Tensile test



With a cross-section dimensions of 1,6 mm and 38,3 mm, the UTS for blue curve specimen was 152,73 MPa and 182,64 MPa for red curve.

RESULTS

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C. Bend test

Due to the internal porosity detected in previous tests and fusion problems evidenced, the bend test results are not capable of giving any information regarding the soundness and ductility of the weldment.

RESULTS

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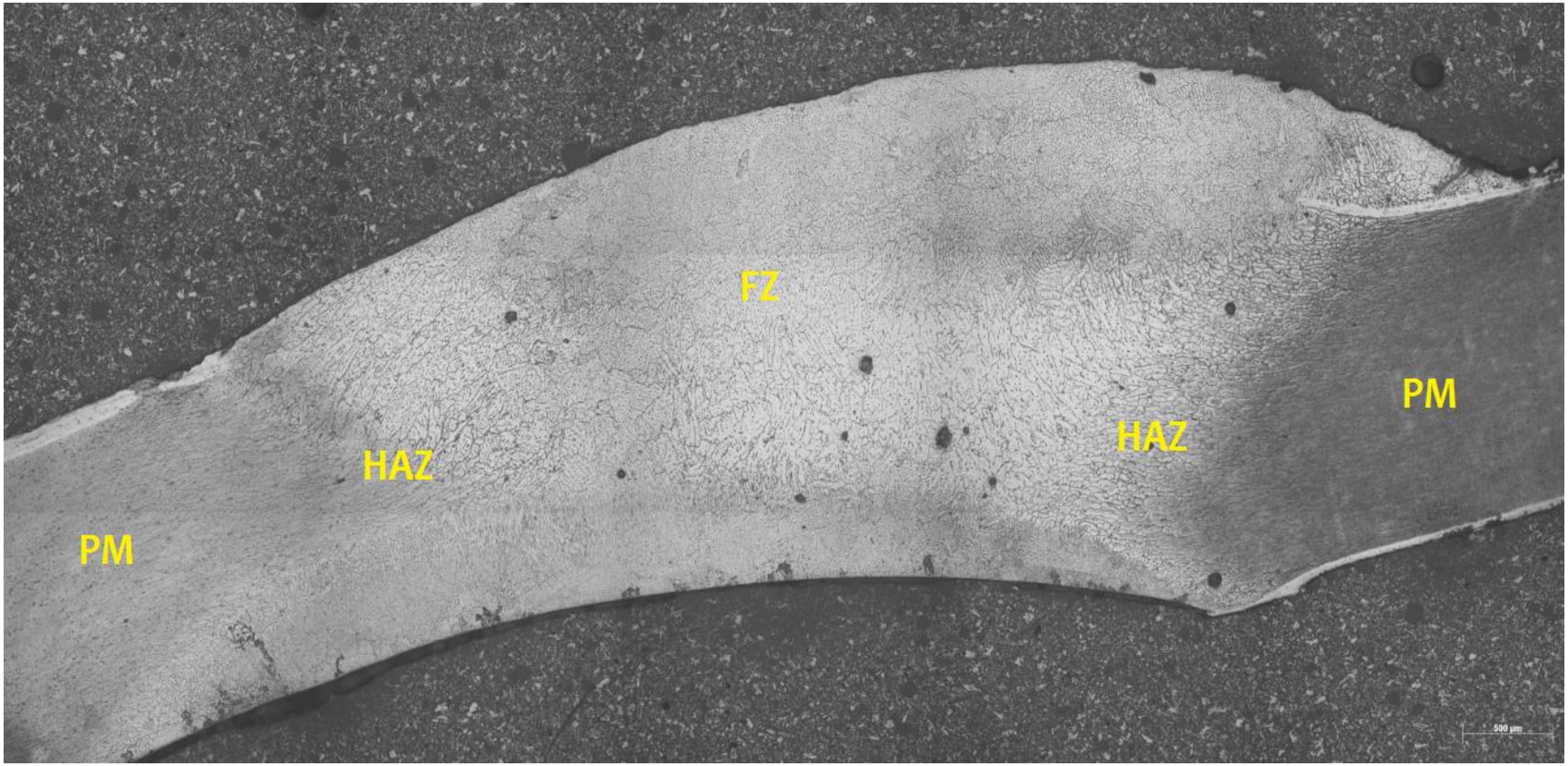
D. Macrostructural and microstructural examination



Macrostructure of weld cross section, showing the zones of parent metal (PM), heat affected zone (HAZ) and fusion zone (FZ)

RESULTS

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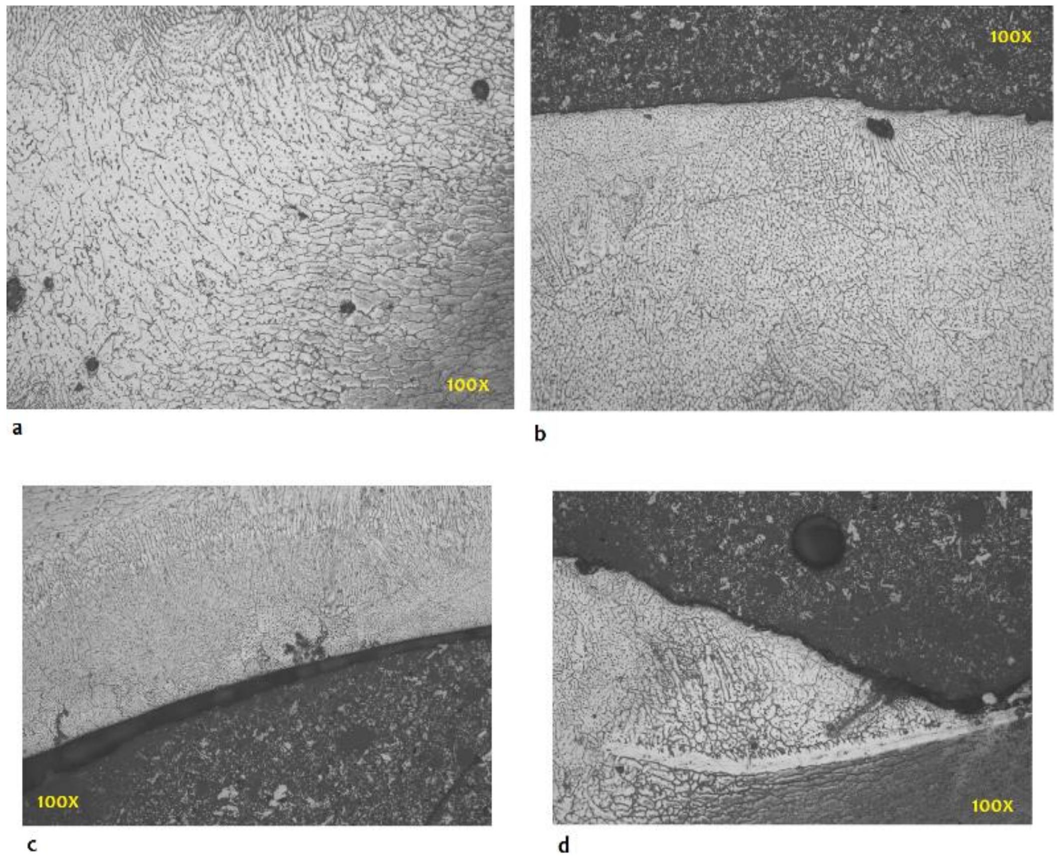
D. Macrostructural and microstructural examination

The dark precipitates observed were supposed to be the intermetallic compounds, varying in size, shape and chemical composition, formed during the solution heat treatment and natural ageing (T3), some of which are $CuMgAl_2$, $CuAl_2$, $Al_{20}Cu_2Mn_3$, Al_7Cu_2Fe, $Al_{10}CuMn$ and $Al_3CuFeMn$ (Ahn et al., 2017)

RESULTS

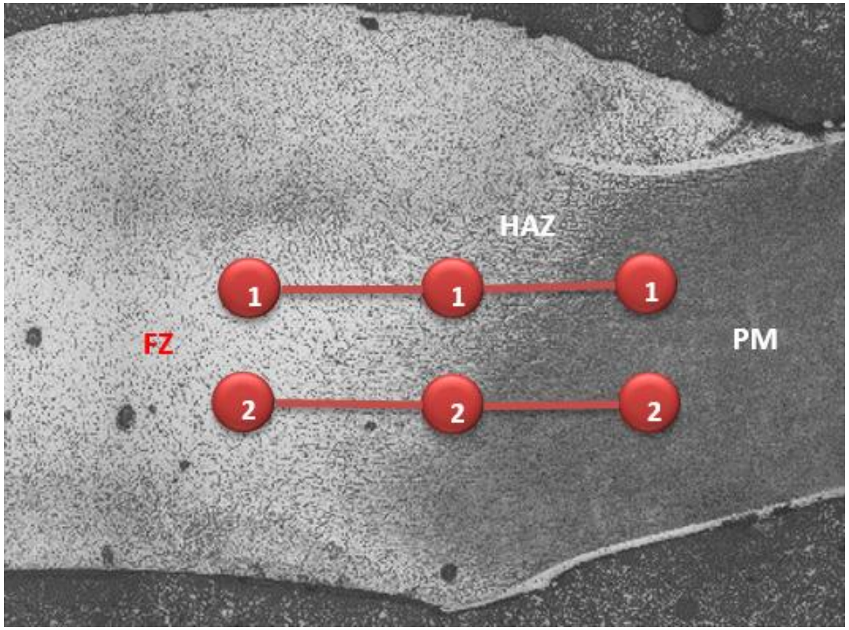
D. Macrostructural and microstructural examination

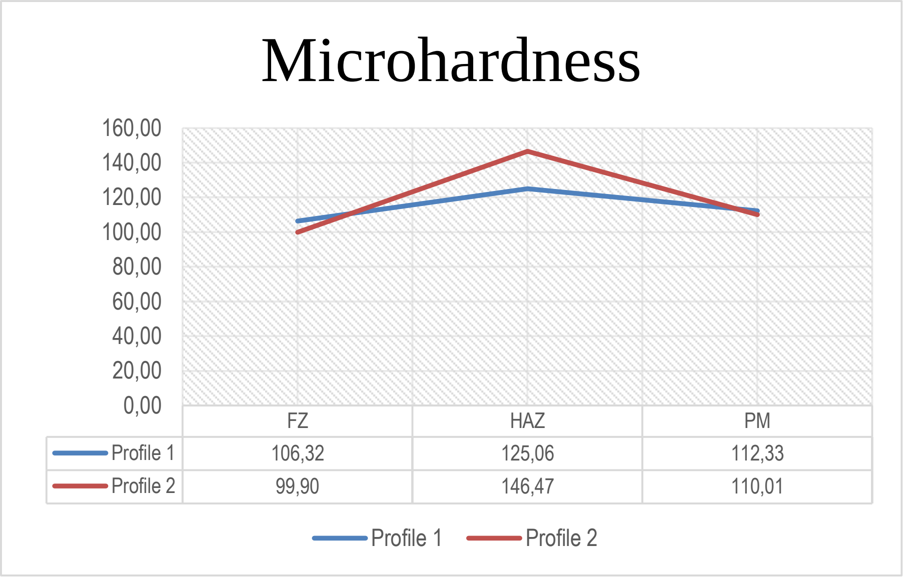


Grain structure of cross section weldment. (a) Planar growth. (b) Dendritic aspect in fusion zone. (c) Columnar-dendritic grains (epitaxial nucleation). (d) Interface weld-Aluminum Layer of Alclad material.

RESULTS

E. Microhardness





DISCUSSION

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- ✓ Is noticeable that there is a decay in mechanical properties during the welding procedure.
- ✓ It would be related to an uncontrolled welding heat input, resulting in an epitaxial dendritic growth, generating a severe size of grains.
- ✓ Also is evidenced a non-uniform distribution of welding interfaces, possibly due to an inadequate technique from the welder.
- ✓ Another detected problem is coming from the aluminum layer, added during Alclad processing,

CONCLUSION/RECOMMENDATION

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- ✓ The experiment gives a great first-step on the future investigation which result indicates potential problems in a traditional welding procedure of heat treatable aluminum alloy.
- ✓ Is mandatory to put special attention in welding parameters that influence the welding heat input, because an uncontrolled grain growth process would be resulting, affecting fundamental mechanical properties.
- ✓ Alclad materials represents a problem in welding operations, so it shall be avoid.

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