Effect of aluminium tempering on explosive welding quality

XIII International Symposium on Explosive Production of New Materials: Science, Technology, Business, and Innovations

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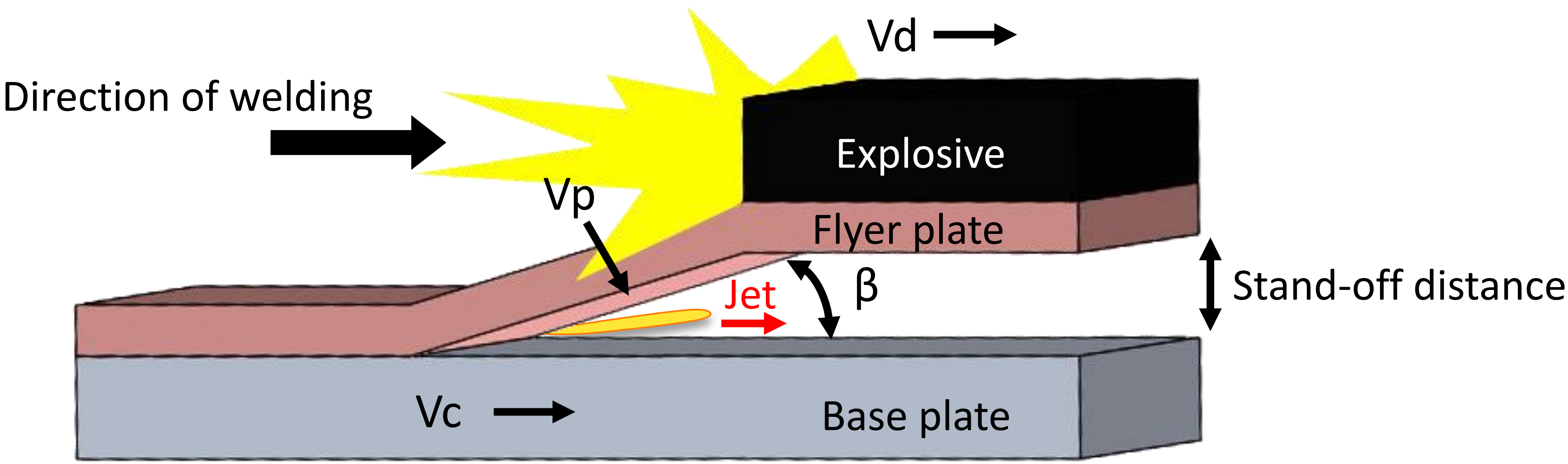
Explosive Welding - EXW

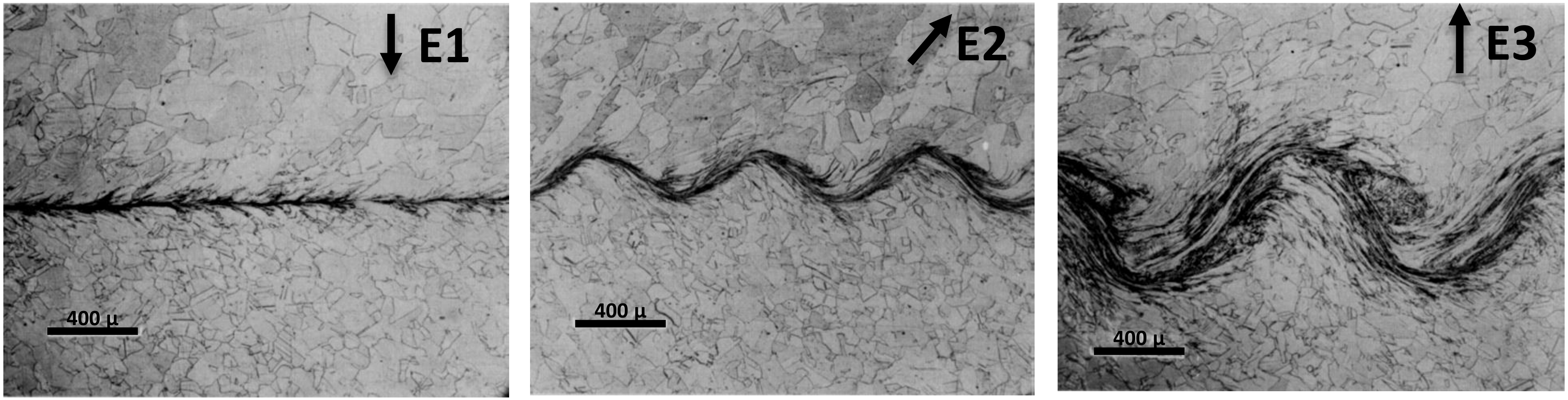
Explosion welding is a solid-state process characterized by a high-velocity impact between two materials as the result of controlled detonation of an explosive.



Explosive Welding - EXW

Most important aspect for a explosive weld

Interface → Weld parameters → Mechanical properties

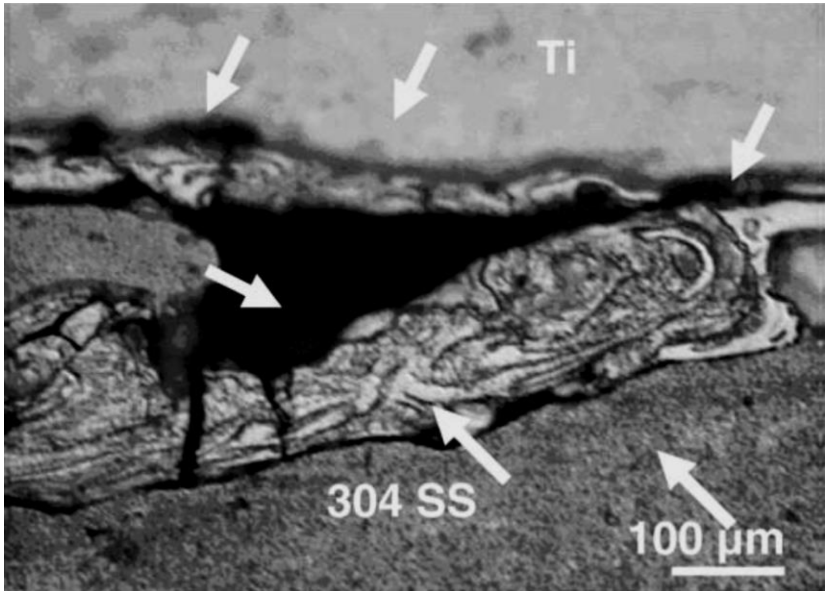


COWAN, G. R., BERGMANN, O. R., HOLTZMAN, A. H. (1971), “Mechanism of bond zone wave formation in explosion-clad metals”. Metallurgical Transactions. v.2, pp. 3145–3155.

Energy1 < Energy 2 < Energy 3

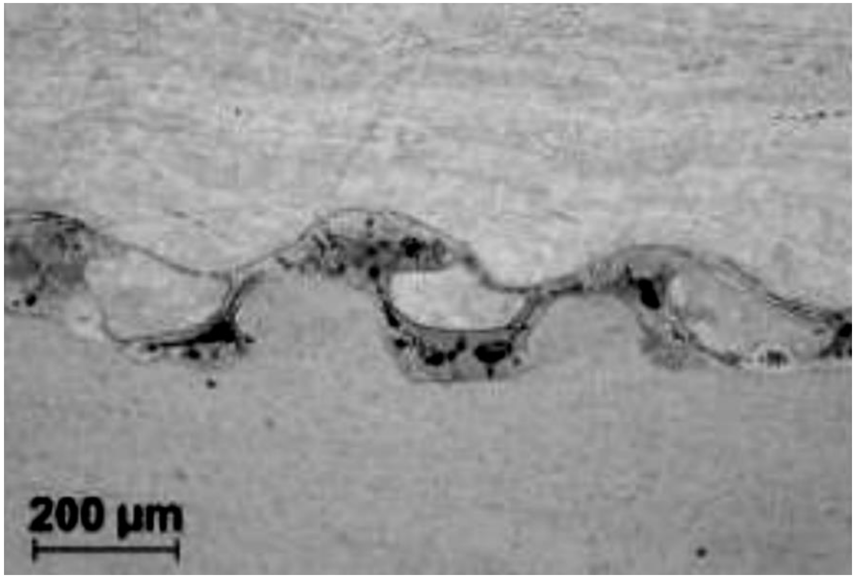
Interface - metallurgical aspects

Defects



Mousavi et Sartangi "Experimental investigation of explosive welding of cp-titanium/AISI 304 stainless steel", Materials and Design v.30 p.459–468

Localized melting / molten layer

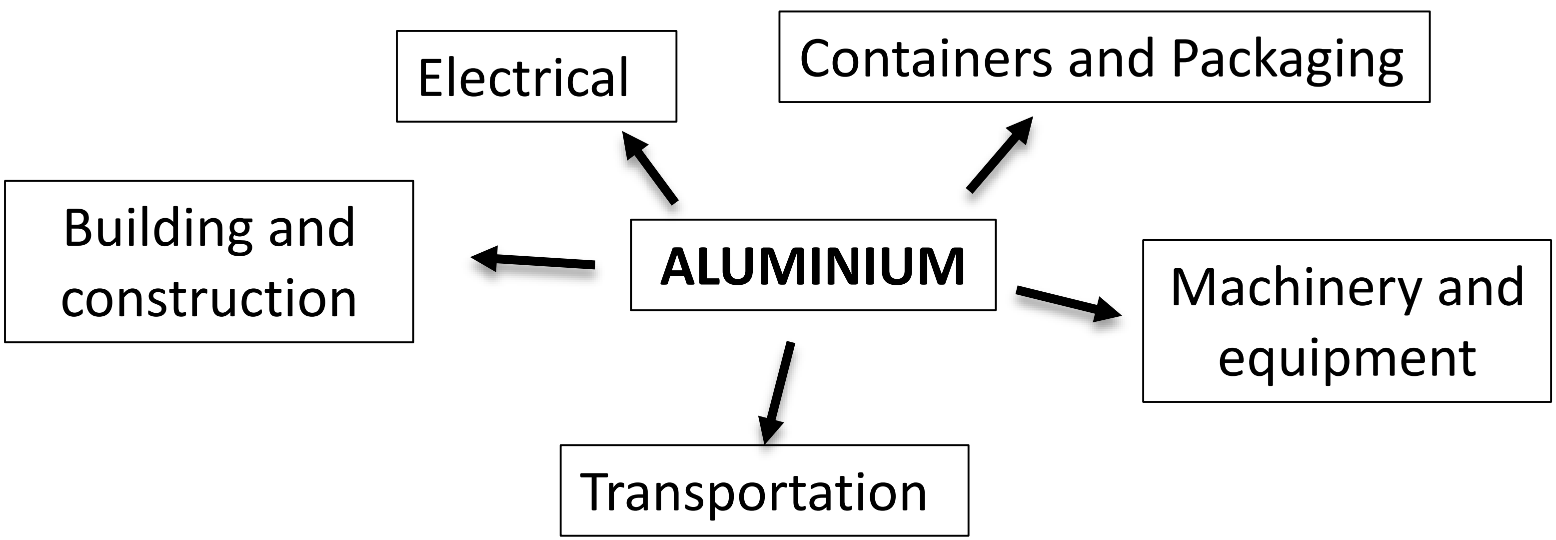


RIBEIRO, J. B., MENDES, R., LOUREIRO, A. (2014), "Review of the weldability window concept and equations for explosive welding". Journal of Physics: Conference Series. v.500, n.5, pp. 1–6.

Aluminium

Second most plentiful metallic element on earth. Interesting properties: light weight, fabricability, physical and mechanical properties, corrosion resistance.

Heat-treatable aluminium alloy provide good strength and toughness while maintaining the low density and corrosion resistance.



Welding aluminium

Aluminium can be joined by most fusion and solid state welding processes, brazing and soldering.

However, when welding heat-treatable aluminium alloy with fusion welding, the HAZ will be softened due the high temperatures.

EXW

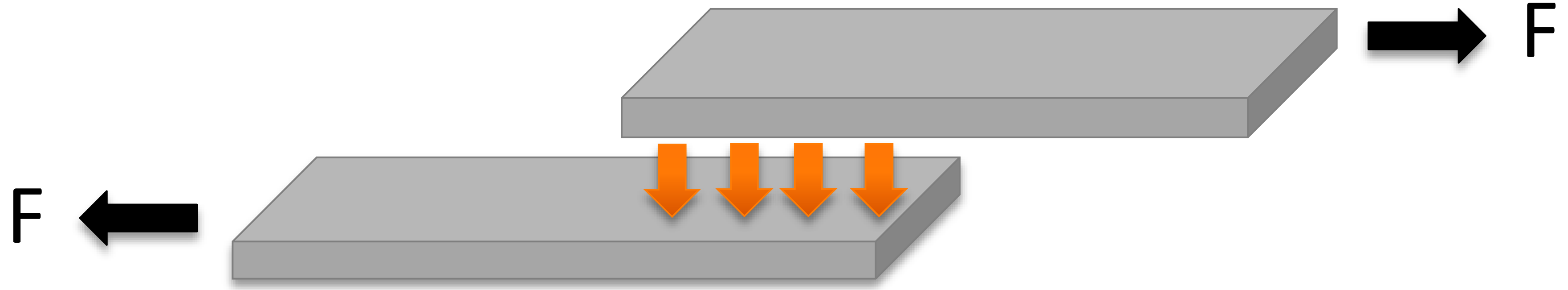
No HAZ, no softening

Dissimilar welding

Large surfaces (cladding)

Objectives

The aim of this research was to study the influence of the material tempering on the final properties of partially overlapped welds of 3mm thick aluminium alloys (AA6082).



Are there differences in the interface morphology and microstructure changing the tempering of the flyer?

Materials and Conditions

SAME WELD PARAMETERS

Explosive composition and density	STD	plates dimensions
Ammonium nitrate-based explosive emulsion + with hollow glass microspheres	4 mm	120 x 95 x 3 mm

DIFFERENT FLYER MATERIALS CONDITIONS

Same flyer alloy but different heat treatments

AA6082

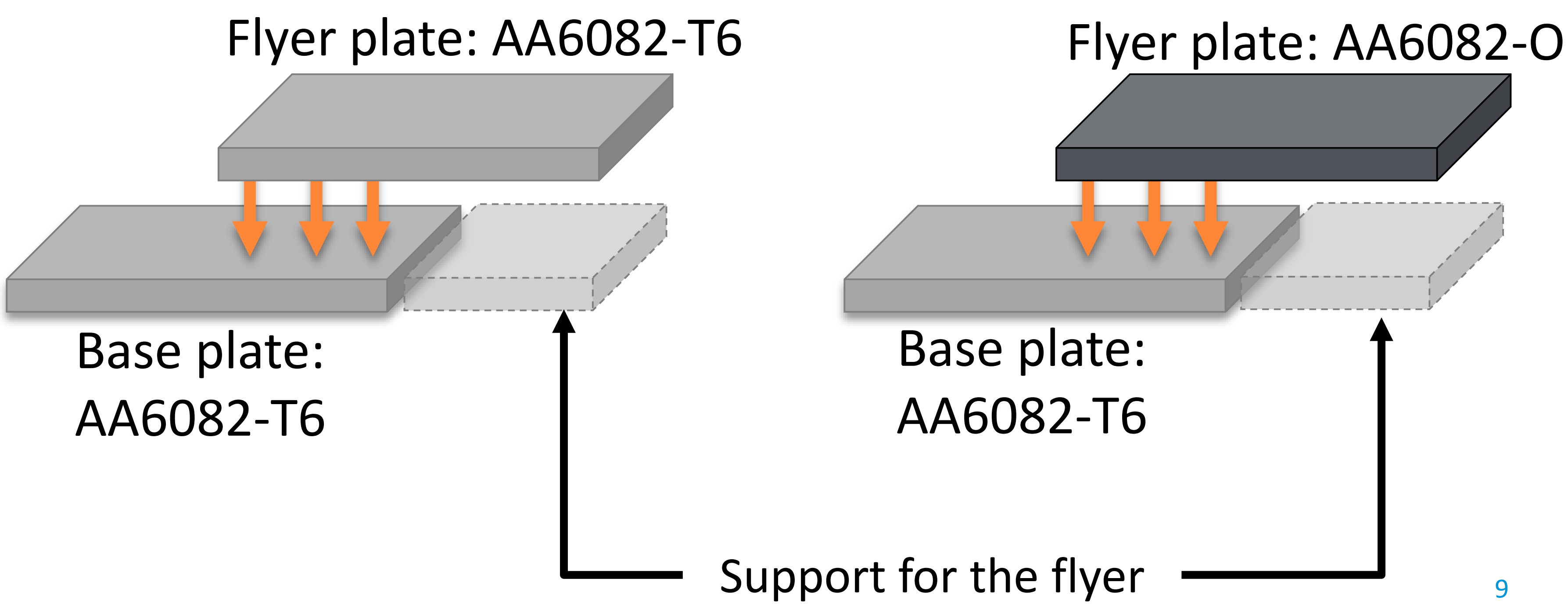
- T6 → ↑ HV ↑ YS
- O → ↓ HV ↓ YS

Experiments

CONFIGURATIONS

SIMILAR WELD

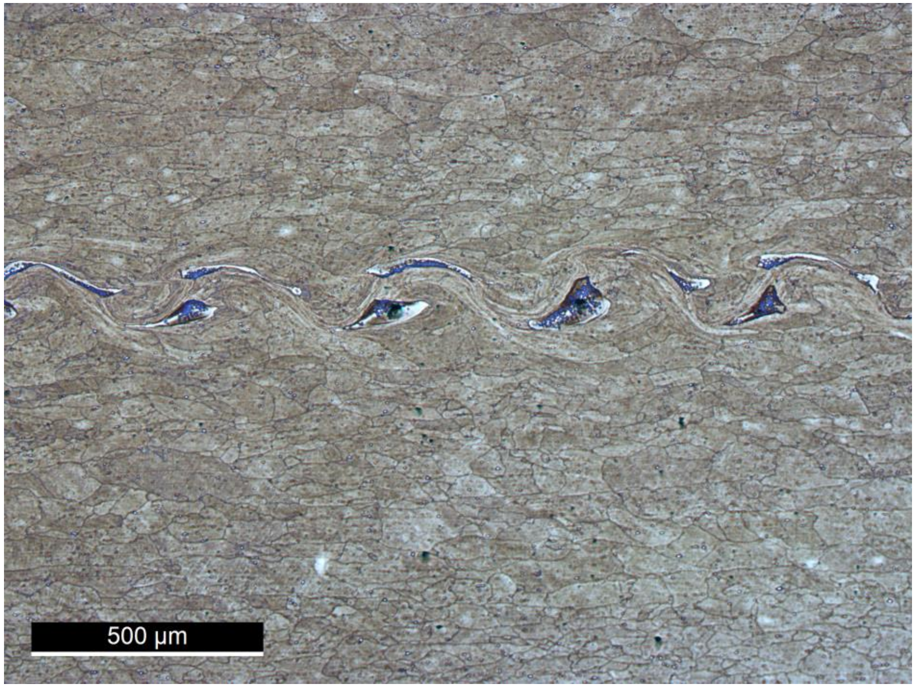
DISSIMILAR WELD

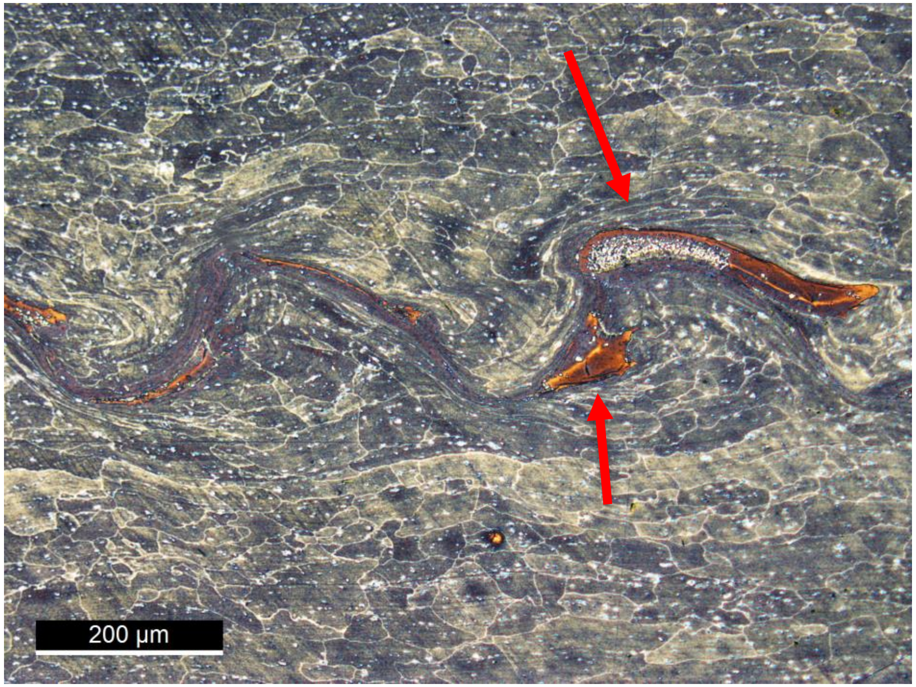


RESULTS

Results – Interface analysis - Microstructure

Similar weld: AA6082-T6 → AA6082-T6

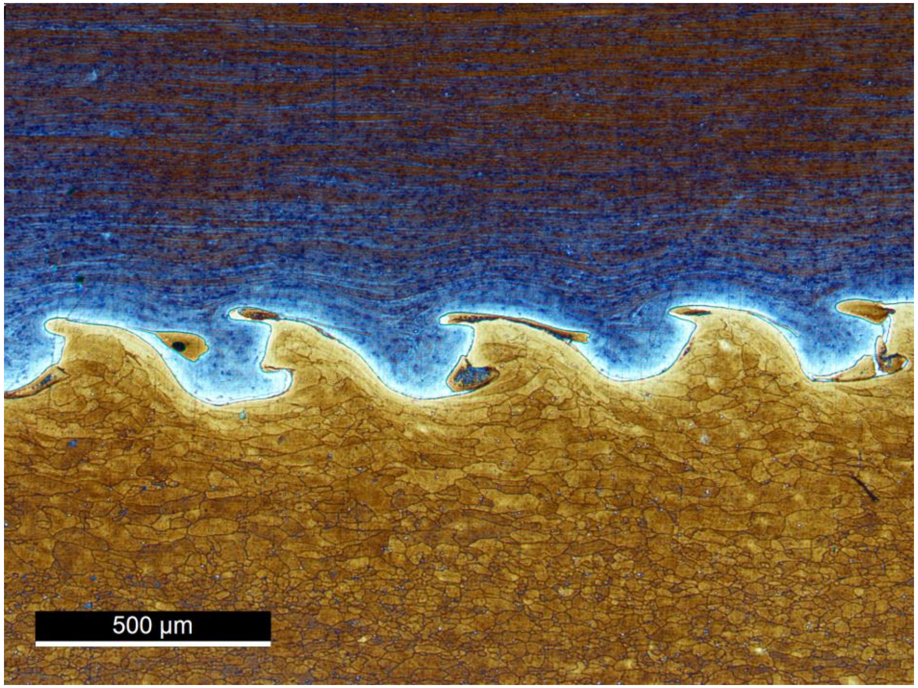


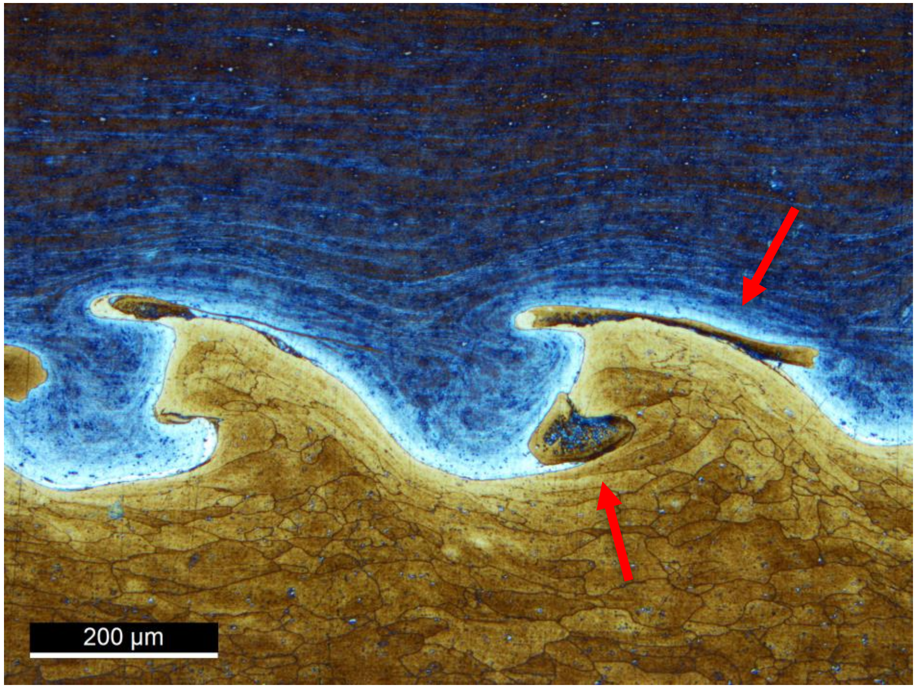


Wavy interface and melted zones

Results – Interface analysis - Microstructure

Dissimilar weld: AA6082-O → AA6082-T6





Wavy interface and melted zones

Results – Interface analysis - Microstructure

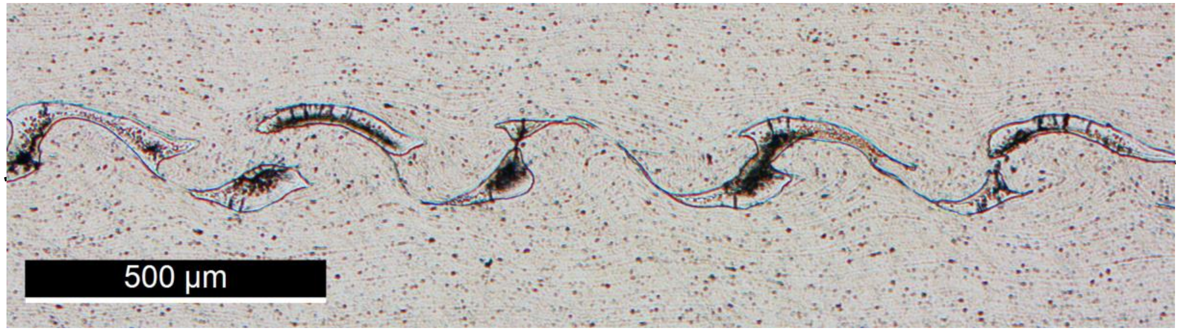
Both welds presented a wavy interface, with presence of small portions of molten material next to the waves.

Similar weld

Dissimilar weld

Results – Interface analysis - Microstructure

Similar interface (wavy), but with differences in morphology

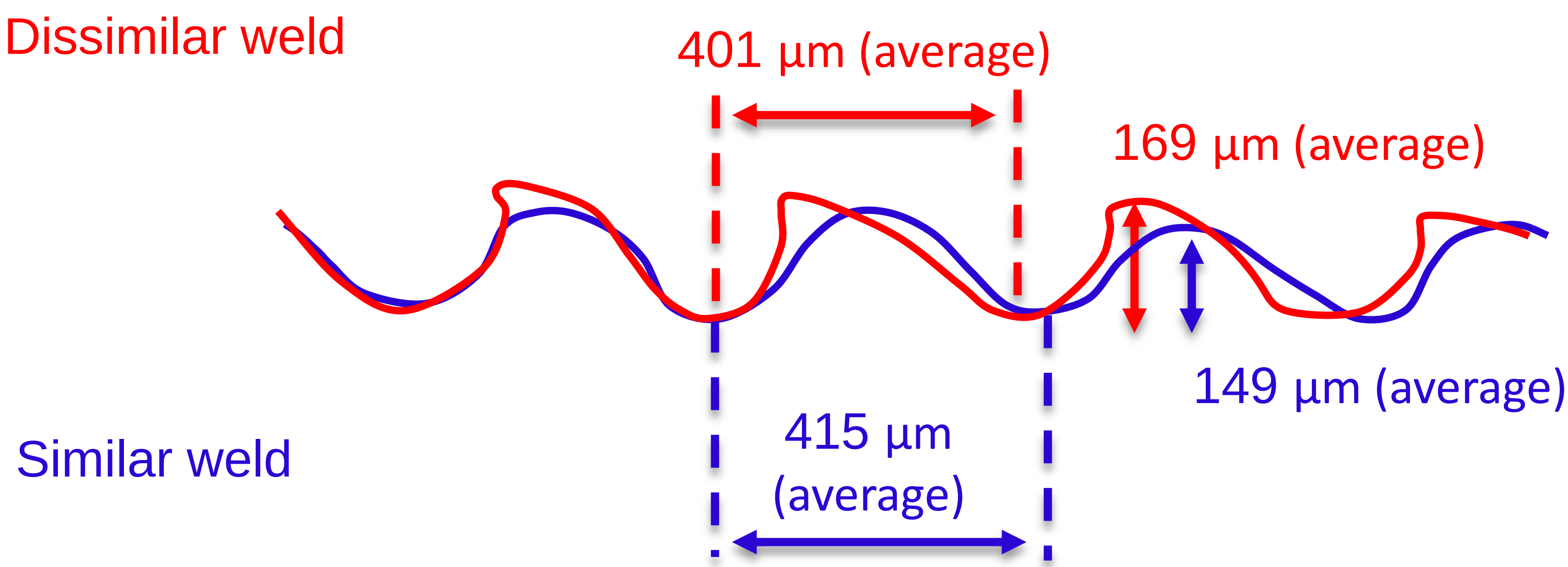


Similar weld

Dissimilar weld

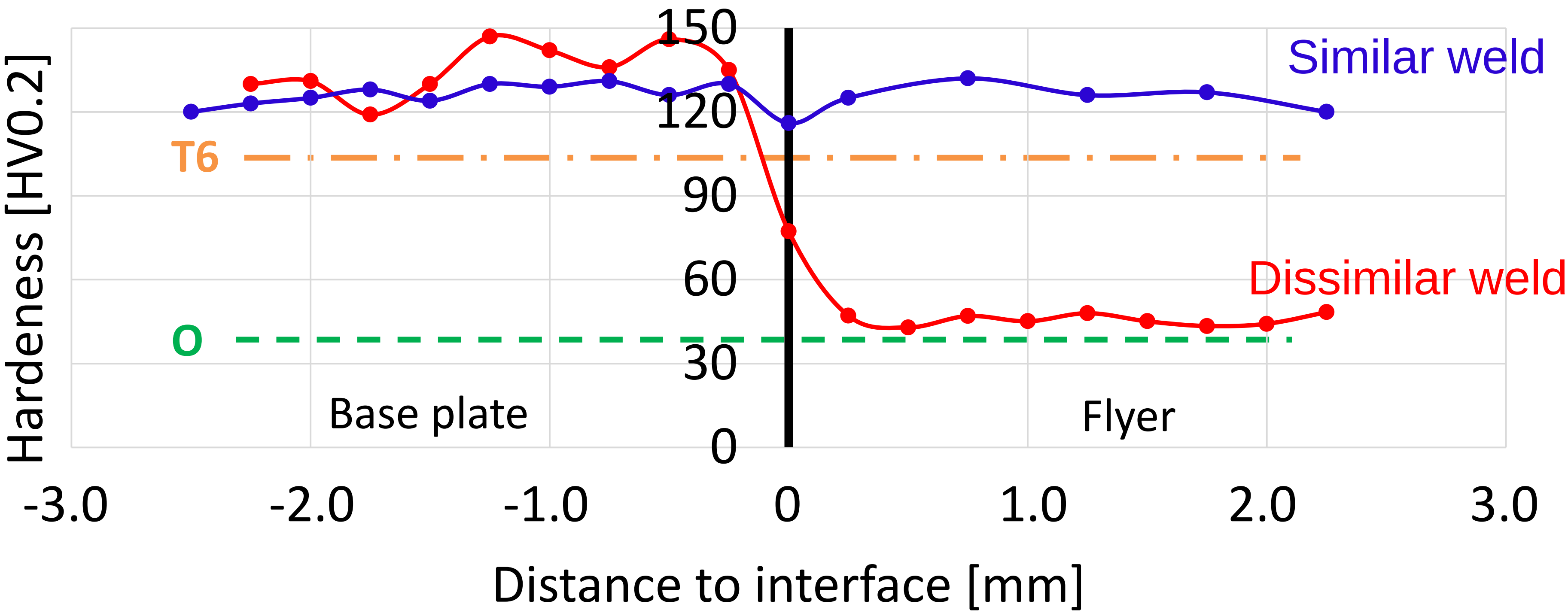
Results – Interface analysis - Waves

Waves with differences in size and shape.



Results – Interface analysis - Hardness

Increase in hardness for both welds

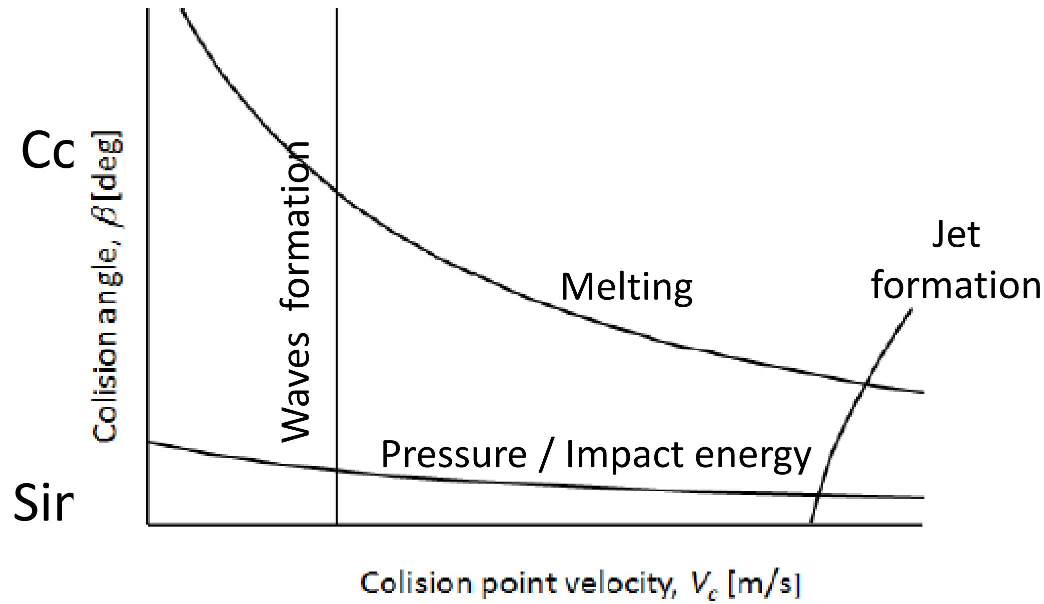


Discussion – interface morphology

Similar weld: smaller amplitude, bigger wavelength, more symmetrical wave

Dissimilar weld: bigger amplitude, smaller wavelength, more asymmetrical wave

Yield strength → Influences plastic deformation → Wave formation



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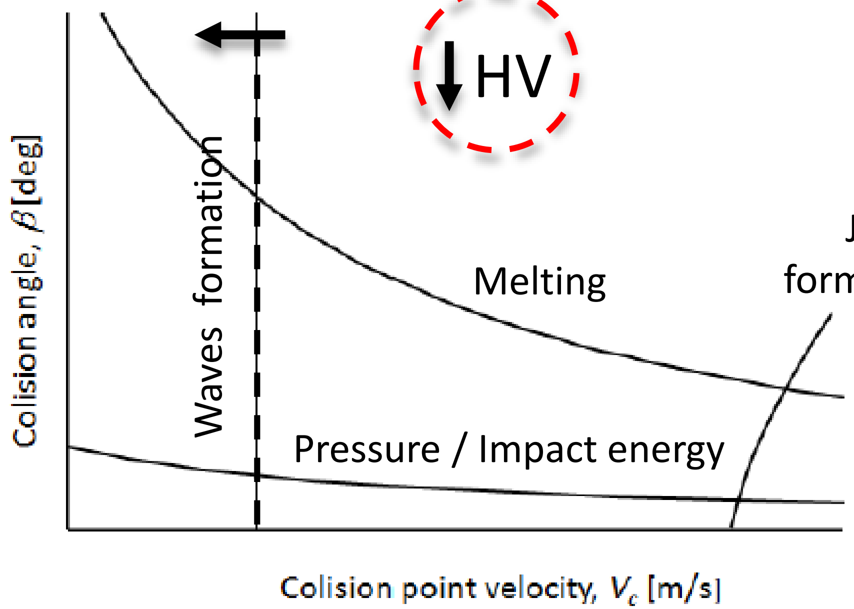
↓HV



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Conclusions

- Both welds could be achieved with the same weld parameters;
- The welds presented an increase in hardness;
- The interface were wavy for both combinations but with different waves morphology;
- For the same alloy, differences in tempering (essentially differences in hardness and mechanical strength) change the waves morphology and the weldability window.

Nevertheless, it was not found <u>significant</u> differences in weld quality between the use of a soft (O) and artificially aged (T6) AA6082 flyer.

THANK YOU! OBRIGADO!