Micro-hardness evolution in Friction Stir Processed 7475 aluminium plate

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Key words

Friction Stir Process, Hardness Mapping, Artificial Aging, Aluminium alloys

ABSTRACT

Friction Stir Process (FSP) is an efficient way to refine microstructure of aluminium alloys and improve the damage resistance [1]. The intense plastic deformation driven by the FSP tool leads to smaller and equiaxial recrystallized grains. However, the heat generated during the processing can strongly affect the precipitation state in case of age-hardening aluminium alloys. Considering FSP with 7XXX aluminium series is thus a compromise between grain refinement and hardening precipitation evolution. As-FSPed samples are usually softened due to dissolution and/or coarsening of the hardening phases. Studying Vickers micro-hardness mapping in the thickness of processed 7475 aluminium plates is a way of easily tracking precipitate evolution during FSP for a large number of heat treatment conditions.

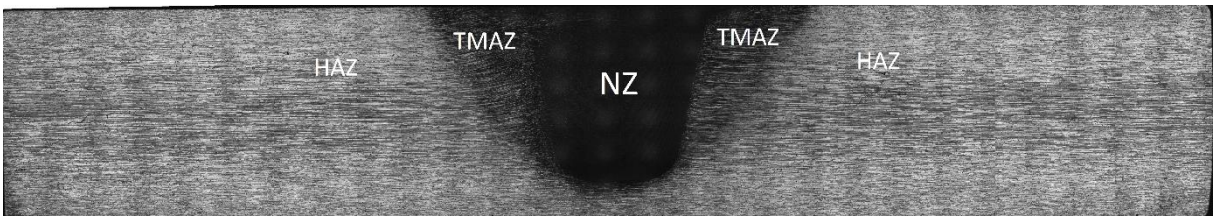

Figure 1: FSPed sample section showing nugget zone (NZ), thermo-mechanically affected zone (TMAZ) and heat affected zone (HAZ)

Due to the shape of the processing tool, FSP generates a nugget zone (NZ) surrounded by a thermos-mechanically affected zone (TMAZ) (Figure 1). Despite a significant grain size difference between these two zones, the hardness (Figure 2) is equivalent inside the NZ and the TMAZ. Severe drop in hardness is observed in the heat-affected zone (HAZ) surrounding the processed region.

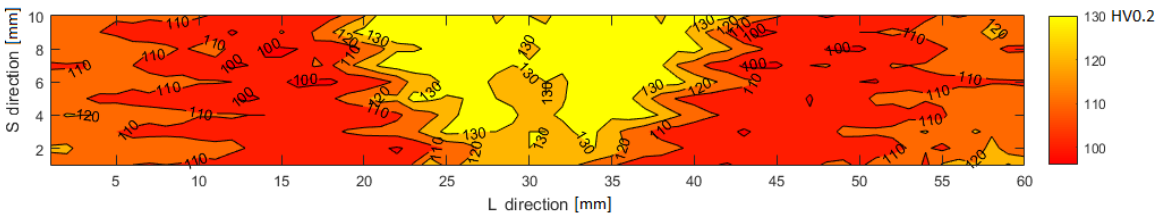

Figure 2: Hardness map through the thickness of the plate

Performing aging treatments is a way of changing the precipitation state without affecting grain size. The small grains of the NZ and the coarser ones of the TMAZ are sensitive to aging, implying some dissolution and re-precipitation of hardening elements during FSP. On the contrary, the HAZ

surrounding the processed zones shows a quasi-constant hardness trough aging time, meaning that FSP has overaged that region by hardening precipitates coarsening.

The goal of this work is to determine the best post-FSP heat treatments to get refined grains at base metal equivalent hardness. In that case, the first order impact on mechanical properties of grain refinement is highlighted. Thermal treatments are based on single artificial aging at 120°C or solution treatment at 510°C followed by quenching in water before artificial aging. The solution treatment dissolves the hardening precipitates and allows the creation of a new fine and homogeneous hardening precipitation. However, the risk of abnormal grain growth of nugget grains is higher with the solution treatment.

References

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