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Microstructural and Electrochemical Characterization of Friction Stir Welded Alloy 625

Alberto Zanesco Fatichi[1,2](IC), Eduardo Bertoni da Fonseca[2](PG), Johnnatan Rodriguez[2](PG), Antonio José Ramirez[1,2](PQ)*

[1]Universidade Estadual de Campinas, [2]Laboratório Nacional de Nanotecnologia

e-mail: alberto.fatichi@lnnano.cnpem.br

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Introduction

Ni alloys are used in chemical, oil, gas, energy and aerospace industries due to the fact that they have good resistance to oxidation and corrosion under severe conditions, and excellent mechanical properties at elevated temperatures [1]. In particular, the nickel alloy 625 is used mainly as a coating material in the oil and gas industry [2]. In most of these applications, we use the fusion welding for joining these components, however, when this type of welding is used in nickel alloys, a microstructure as-cast coarse remains in the melting zone. Additionally, the heat affected zone (HAZ) usually undergoes precipitation of Cr-rich carbides and grain growth during the fusion welding, which reduces corrosion resistance in the heat affected zone (HAZ) and ductility respectively. As most of these problems are attributed to solidification, a solid state joining process as FSW is an option to effectively avoid them.

To evaluate, in a quantitative manner the sensitivity to intergranular corrosion, the electrochemical technique DL-EPR was used.

Results and Discussion

As the grain size is refined during the FSW process, the area of grain boundaries per unit volume increases and the degree of sensitization decreases consequently. This conclusion can be confirmed by the DL-EPR test, whose curves for the base metal and for the stir zone of friction stir welded joints are represented in a single graph in Figure 1 for comparison purpose.

As intergranular corrosion is caused by the precipitation of carbides in grain boundaries, corrosion rate is affected by the volume fraction of the precipitated carbides per unit area of the grain boundaries. The FSW process, to occur in the solid state, has a temperature peak lower than the Alloy 625 melting point moreover the cooling time to room temperature is shorter in comparison to conventional fusion welding methods. Therefore, there is not enough time for significant precipitation of carbides. Thus, the area of grain boundaries has majority influence on sensitization in this case.

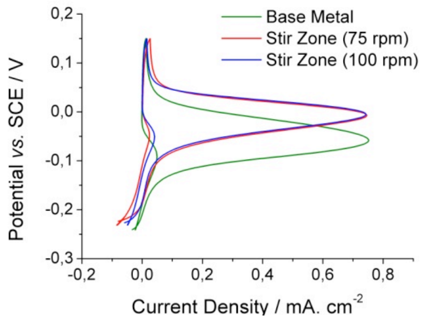

Figure 1. DL-EPR curves for Base Metal and for Stir Zone of friction stir welded Alloy 625.

This is the main reason for the lower current density ratio (Ir/Ia) of the stir zone in comparison with the base metal which curve is shifted toward lower potential, as shown in Figure 1, showing thus a higher corrosion rate with respect to the stir zone.

The stir zone of friction stir welded joints exhibited a lower degree of sensitization (3.53 % and 4.52%) compared to the base metal (6.52%). Thus, sensitization resistance of the fine-grained microstructure is higher compared to the coarse grain microstructure.

Conclusion

The friction stir welded joint exhibited smaller degree of sensitization compared to the base metal, which showed a larger current ratio. The results are mainly due to the strong grain refinement obtained by friction stir welding. The stir zone showed finer grain structure and lower density of twin boundaries than those observed in the base metal, leading to an increase of microhardness.

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