Study of the corrosion behaviour of friction stir welded AA 2024-T3 using global and local electrochemical techniques

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Friction-stir welding (FSW) is an innovative process to join metals developed by The Welding Institute (TWI) where the parts to be welded do not reach the melting temperature. It avoids several drawbacks involved in welding procedures that are more common, being a major achievement for welding of high strength Al alloys used in the aerospace industry. In the process, a non-consumable rotating tool composed of a shoulder and a threaded pin moves along the butting surfaces of two rigidly clamped plates placed on a backing plate. The heat generated by the tool rotation and displacement along the seam causes severe plastic deformation and flow of the plasticized metal creating the weld, which is typically composed by three different zones. The heat affected zone (HAZ), which is only submitted to a temperature gradient with no mechanical deformation, the thermomechanically affected zone (TMAZ), affected both by heating and plastic deformation, and the nugget, where the parts to be joined reach the highest temperature and deformation. This latter region is characterized by fine equiaxed grains due to recrystallization [1]. These differences in deformation and temperature cycles of the welding zones introduce changes in the microstructures of the parts to be joined and, consequently, affect their corrosion resistance.

In the literature, a number of works devoted to the investigation of the corrosion behaviour in FSW of high strength Al alloys has been published. However, only few of them have used EIS or local techniques to perform the investigation and, to the best of the authors' knowledge, none of them has used both techniques together.

In the present work, the corrosion behaviour of FSW in 2024-T3 Al alloy in 0.001 M NaCl solution was investigated by means of polarization curves, EIS, local electrochemical impedance spectroscopy (LEIS) and SVET. SEM observations of corroded specimens were used to consolidate the interpretation of the electrochemical results.

The study of each weld region individually revealed that the ensemble nugget + TMAZ had the lowest corrosion potential. This sample also presented a defined passive region and did not exhibited localized type of corrosion, at variance with the behaviours observed for the HAZ and the base metal, both showing the classical pitting corrosion morphology associated with 2024 alloys. This sample also displayed the best EIS response, with higher impedance values, even though the diagrams for the three individual samples presented similar shape.

SVET measurements for the nugget + TMAZ zone revealed that the electrochemical activity was mainly concentrated in the TMAZ, with higher activity being observed in the advancing side of the tool. On the other hand, the analyses of the HAZ showed that the temperature gradient plays a major role in the electrochemical activity of the sample.

Results obtained with LEIS and with galvanically coupled samples will also be presented and discussed.

[1] M. Jariyaboon, A.J. Davenport, R. Ambat, B.J. Connolly, S.W. Willians, D.A. Price *Corr. Sci.* 49 (2007) 877.