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Enhancing Corrosion Resistance of Friction Stir Spot Welded AA 6061 Joints by Varying Dwell Time

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Abstract - *Friction Stir Spot Welding is an important solid-state material joining technique which is successfully used in many manufacturing industries for material joining. In this paper, an attempt has been made for enhancing the corrosion resistance of the friction stir spot welded AA 6061 joints by varying the dwell duration. Out of the three important friction stir wpot welding process parameters such as tool rotational speed, plunge depth and dwell time, the duration of dwell was increased from 16 seconds to 30 seconds. The joints were subjected to corrosion testing by using electro dynamic potential pitting testing and immersion tests. The modifications in the surface aspects upon subjecting the joints to corrosion tests were identified by using Scanning Electron Microscopy.*

Key Words: Corrosion, Al6061, Dwell Time, Scanning Electron Microscopy, Pitting Test.

1. INTRODUCTION

The difficulty in joining dissimilar materials arises from the differences in the mechanical and metallurgical properties of the individual materials [1]. However, Friction Stir Spot Welding (FSSW), a linear variant of Friction Stir Welding (FSW), is found to be a prudent option to spot join dissimilar materials at solid state. Compared to resistance spot welding (RSW), FSSW causes very less pollution and consumable free, and thus is widely being used in automotive, marine aerospace and electrical industries [2]. Aluminum and its alloys find importance in various industries and applications owing to its excellent properties such as good density to strength ratio and its dissimilar joints with Copper alloys are required in electrical and electronic applications as they possess good corrosion resistance and better conductivity [3]. FSSW have been preferred to spot join dissimilar materials by researchers. FSSW is a three step process which consists of initial plunge of a high speed rotating non consumable tool into the joint zone. Next is a duration of dwell time in which for a specific span of time the tool is held in that position to produce frictional stir, thereby softening the joint zone. The third is drawing out wherein the tool is withdrawn thereby allowing the joint region to cool to enable FSSW joint to occur [4].

Suhddin et al used FSSW process to spot weld AA5754 aluminum with Magnesium AZ31, and investigated the changes in microstructure caused due to dynamic recrystallization and observed intermetallics such as $Al_{13}Mg_{17}$ at the joint interface. The tensile properties of similar spot joints were compared to that of the dissimilar spot joints and the fatigue life were analyzed [5].

On evaluating the important literatures and previous investigations, no investigation was reported regarding corrosion evaluation on Friction Stir Spot Welded Al 6061 joints. Thus, in this research, an attempt was made for enhancing

On evaluation of the previous literatures and important investigations post weld heat treatment of friction stir spot welded joints was not found. Thus, in this paper, an attempt was made for evaluation of the mechanical properties of friction stir spot welded AA6082 joints by using post weld heat treatment process.

2. MATERIALS AND METHODS

In this research, Al 6061 Aluminium alloy was selected to be the base material. It was procured in rolled form, with a thickness of 2.5 mm. By using abrasive cutting equipment, it was sized to a length of 100 mm and 35 mm in breadth. For performing friction stir spot welding experiments, Friction Stir Spot Welding tool was prepared using H13 material. The friction stir spot welding tool was fabricated with shoulder diameter of 16 mm, pin diameter of 6 mm and pin length of 3.5 mm. For conducting the friction stir spot welding experiments a modified Vertical Milling machine was used. By substituting the cutting tool of the vertical milling machine by friction stir spot welding tool, the experiments were conducted.

By holding the workpieces in lap configuration by using fixtures attached to the bed of the vertical milling machine the experiments were conducted. The friction stir spot welding equipment used in the experiments have been indicated in Figure 1.

Fig -1. Experiments for conducting friction stir spot welding

Corrosion testing was conducted by using potentio dynamic polarization technique. Using a saturated calomel electrode, the pitting corrosion tests were conducted. Using 5% NaCl solution as electrolyte, the experiments were conducted. Immersion tests were conducted for a duration of 20 days.

Fig -2. Pitting corrosion test equipment

The Friction Stir Spot Welding experiments were conducted as per the values of process parameters indicated in Table 1

Table -1: Friction Stir Spot Welding Process Parameters

Tool Rotational Speed	Rpm	1500
Plunge Depth	Mm	5
Dwell time	Seconds	15, 17, 19, 21, 23

By using the vertical milling machine, and by using the friction stir spot welding process parameter values as per Table 1, the experiments were conducted. The Spot welded joints have been indicated in Figure 3

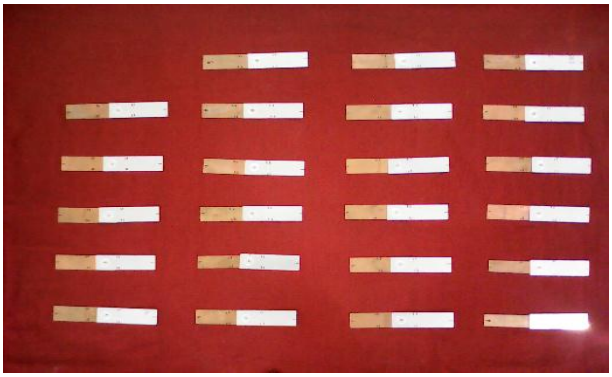


Fig -3. Friction Stir Spot Welded Joints

The joints were subjected to pitting corrosion test and the results has been indicated in Table 2

Table -2: Heat Treatment Process Parameters

S No	Specimen with varying dwell time	E pitt value eV
1	15 s	-316
2	17 s	-309
3	19 s	-301
4	21 s	-291
5	23 s	-297

3. RESULTS AND DISCUSSIONS

The potentio dynamic polarization curves have been indicated in Figure 4.

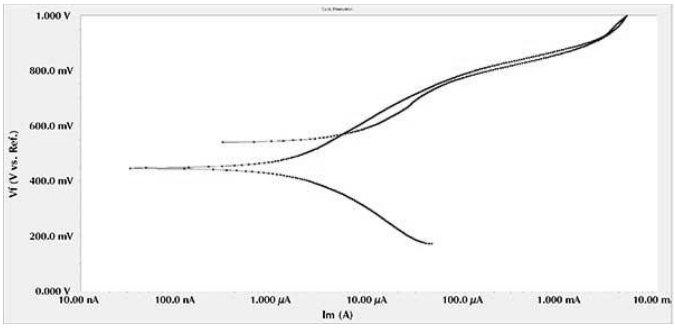


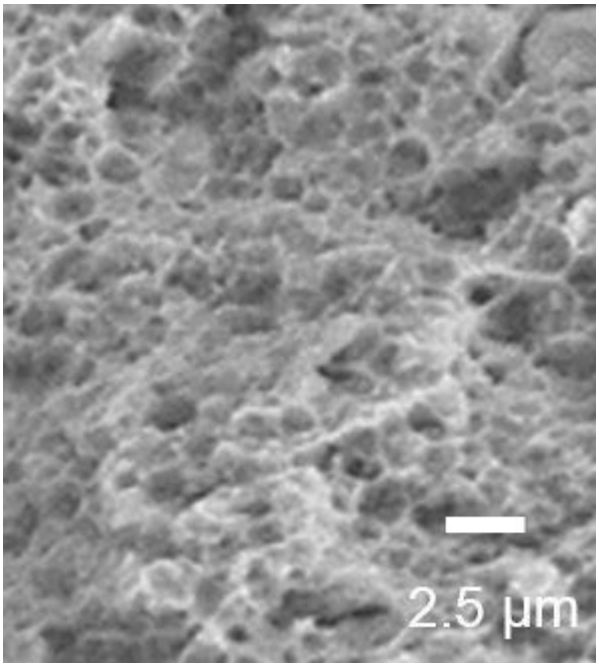
Fig -4 Potentiodynamic curves.

The specimens were subjected to immersion tests for 20 days. The samples were weighed before conducting immersion tests and after conducting immersion tests the mass loss was evaluated. The immersion mass loss in grams has been recorded in Table 3

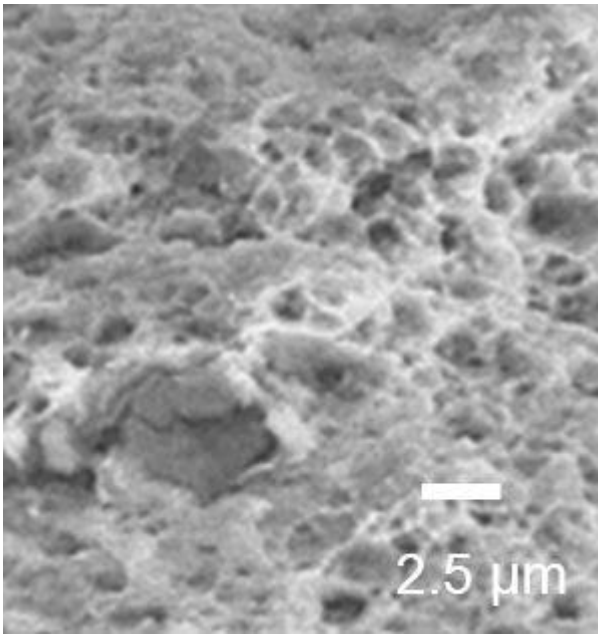
Table -3: Immersion test results

S No	Specimens with different dwell time	Mass loss in g
1	15 s	2.6
2	17 s	2.45
3	19 s	2.13
4	21 s	2.03
5	23 s	2.11

The corroded regions were subjected to microscopic evaluation. The SEM micrographs of the corroded joints have been indicated in Figure 5. Figure 5 (a) indicates corroded region with pits. Figure 5 (b) indicates corroded region with micro cracks.



(a)



(b)

Fig - 5 SEM micrographs of corroded regions

4. CONCLUSION

Thus, in this manuscript, an attempt has been made to enhance the corrosion resistance of friction stir spot welded Al 6061 joints by fluctuating the dwell duration. On conducting pitting corrosion test and immersion test, it was found that increasing dwell duration increased the corrosion resistance.

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