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**INVESTIGATION OF CORROSION BEHAVIOR IN FRICTION STIR  
WELDED DISSIMILAR MAGNESIUM ALLOYS AZ80A-T5 AND  
AZ91C-T6**

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**Abstract**

This study aims to evaluate the bending strength, fatigue strength, corrosion behavior, and wear characteristics of friction stir welded (FSW) magnesium alloys in the as-welded condition. Magnesium alloy 7075 is widely used in applications where high strength is critical and moderate corrosion resistance is required. It is classified as a very high-strength aerospace magnesium alloy with excellent stress corrosion resistance. Depending on its temper, 7075 can achieve a maximum yield strength of 465 MPa and a maximum tensile strength of approximately 540 MPa.

**Keywords:** *FSW, Magnesium Alloys, Tool speed, AZ80A - T5, AZ91C – T6*

**1. Introduction**

The primary objective of this chapter is to investigate the corrosion resistance behavior of the parent metals—AZ80A-T5 wrought magnesium alloy and AZ91C-T6 cast magnesium alloy—as well as their FSW welded combination. For this study, the FSW specimen was prepared under the following conditions: tool rotational speed of 680 rpm, axial load of 6.8 kN, and welding speed of 35 mm/min, which resulted in a minimum ultimate tensile strength (UTS) of 246.33 MPa. The intergranular corrosion (IGC) test was conducted following IGC-Practice ‘C’ and in accordance with ASTM A262:2015.

Corrosion is the deterioration of materials resulting from chemical reactions with their environment. While the term is most commonly associated with metals, it can also refer to the degradation of plastics, concrete, and wood. Corrosion can lead to a loss of strength, increased downtime, leakage of fluids, degradation of surface properties, and a reduction in overall value.

In the 7xxx series of the wrought magnesium alloy, zinc is the major alloying element. These alloys are combined with a smaller amount of magnesium; it is heat treatable and has high strength and excellent corrosion resistance. It has naturally very good weldability. Due to these reasons, these alloys are mostly used in manufacturing the Aircraft structures, Gears, shafts and many more Automotive components.

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F. C. Liu & Dong (2021) The lubricating impact of annealed Fe78Si9B13 glass particles in the FSW method of the metal AA6061 was researched, and it was discovered that the particles played a significant role in enhancing wear resistance. The corrosion and fatigue strength of FSP samples has been enhanced when contrasted to the base metal, which may be related to the minimization of grain width and the CTE imbalance between the base material and reinforced materials by FSP, as well as the lubricating effect of Fe78Si9B13 particles. Due to its unusual metastable structure, the FSP specimen with strengthened particles in an unstructured form displayed superior corrosion and wear resilience.

Heidarzadeh et al. (2020) In T34 and T84 conditions, we tested the susceptibility of Aluminum-Copper-Lithium alloy 2050 to corrosion in chloride solution. They concluded that fatigue-corrosion had the greatest impact on the T34 state's fatigue life. This discovery can be understood by the cyclic solicitation's accelerated spread of intergranular corrosion.

Pitting corrosion of metal alloys was described by C. Zhang et al. (2020) as a highly localized kind of corrosion in the context of aggressive chloride ions. He discovered that pits formed in the insulating oxide when its depth was compromised by chloride assaults. The following are the reactions to the pits spreading.

Bocchi et al. (2018) It was demonstrated that intermetallic particles in the Al matrix, such as iron, altered the corrosion rate of metal alloys. These nanoparticles were found in the microstructure, reducing localized resistance to corrosion. The functionality of these intermetallic phases was affected by the voltage differential for the substrate in the liquid, i.e. the matrix experienced corrosion rate if the particles were electrochemical reaction more exquisite than the matrix, resulting in localized corrosion.

Rajesh et al. (2020) By subjecting 1 cm<sup>2</sup> of the weld zone, TMAZ, and base material separately to 3.5 percent NaCl solution with pH regulated to 10, the corrosion rate of friction stir welded AA7075 metal alloy was investigated, where the change from passive to the active region was quite sharp. Using a BES potentiostat with 352 SoftCorr III corrosion detection software, a potential static scan was done at a scan rate of 0.166mV/s. The standard and supplementary electrodes were SCE and graphite electrodes, correspondingly. Critical pitting capability was defined as the potential for the current to rapidly grow (Epit). Specimens having a higher positive potential were thought to be more resistant to pitting corrosion. The results revealed that weld metal has better cracking resistance to corrosion than TMAZ and BM.

Sonawane et al. (2020) The impact of welding parameters such as rotation rate and travel velocity on the corrosion rate of friction stir welds in the high-strength metal alloy AA2024-T351 was investigated. The speed of rotation was discovered to play a significant impact in determining the area of corrosion attack. At the low speed of rotation welds, localized intergranular damage was found in the nugget area, but at the higher speed of rotation welds, the attack was primarily in the HAZ.

Sun et al. (2018) When microstructure sensitivity developed in FSW Al alloys, corrosion susceptibility experiments were done. They concluded that similar welding temperature conditions altered the microstructure and reduced corrosion.

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Wang et al. (2020) investigated the effect of pH and chloride density on pitting corrosion of the AA6061 aluminum and discovered that AA6061 has excellent resistance to corrosion insoluble solutions, except for pitting corrosion in the presence of reactive components such as chlorine.

Aliasghari et al. (2020) investigated the corrosion behaviour of friction stir treated high strength deposition hardenable AA2219-T87 alloy using processing variables like the speed of rotation and travel speed. The findings revealed that rotation speed had a significant impact on the rate of deterioration, which was attributable to the intermetallic phases deteriorating and dissolving.

Chen et al. (2020) The corrosion behavior of different cast aluminum alloys A319 and A356 plates bonded by FSW was studied. On corrosion behavior, the impacts of tool rotational and welding rates, and also post-weld thermal treatment, were examined. FSW was used on A319 and A356 plates, with three distinct tool rotational speeds and 2 distinct welding speeds. The post-weld heat treatment consisted of a 12-hour heat-treatment at 540°C, followed by a 6-hour aging period at 155°C. Weld corrosion was studied by immersing them in a solution of sodium chloride (NaCl) and hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) for 6 hours. Both as-welded and post-weld heat processing welds outperformed the A319 and A356 base alloys in terms of corrosion resistance. By raising the tool's rotating speed and/or reducing the welding rate, the corrosion rate of the welded zones was shown to be lowered. In addition, as the spindle speed rose and the welding rate decreased, the average size of the Si particles within the shear zone increased. The hardness at the centre of SZ increased with increasing weld zone and/or decreased tool rotor velocity in both as-welded and post-weld heat treatment situations. In comparison to the base alloys, the stirred zone of FSW samples showed improved resistance to intergranular corrosion behavior. Furthermore, post-weld thermal treatment lowered the agitated zone's resistance to corrosion. Increased tool rotating speed and/or reduced fusing speed were observed to diminish the resistance to corrosion of the shear zone at the centre of the welded zones.

Kangazian & Shamanian (2019) Investigate the resistance to corrosion and stress corrosion rate of AA2219 friction stir welded samples in an experimental setting. In a 3.5 percent NaCl solution, they found that both the source metals and FSW welded samples have good corrosion fracture toughness.

Sabzi et al. (2019) Corrosion research must be regarded as an effective technique of enhancing the resistance to corrosion of metal alloy, which is a superior substitute for steel in the industrial base. In his experiments on the corrosion characteristics of AlMg5 and AlMg1Si1 alloys, Kciuk et al. (2007) generalize that the oxide layer in aluminium constitutes a natural corrosion protective layer due to its nontoxicity. When exposed to a more corrosive atmosphere, however, corrosion was more likely to succeed.

Shi et al. (2018) The corrosion behaviours of different A319 and A356 cast Al alloy plates linked by FSW were investigated utilizing three different tool rotational speeds (usually 1120, 1400, and 1800 rpm) and 2 distinct welding rates (generally 80 and 112 mm/min). On corrosion behaviour, the impacts of tool traverse and welding rates, as well as PWHT, were examined. The PWHT was performed utilizing a 540°C solution heat temperature - controlled for 12 hours, followed by a 155°C aging temp for 6 hours. Weld corrosion was studied by immersing

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them in a solution of (NaCl) and hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) for 6 hours. Both as-welded and post-weld high-temperature welds had good durability than A319 and A356 base alloys, according to the findings.

Vacchi et al. (2020) tested the anti-corrosion capabilities of FSW welds in the aluminium alloys AA 5083 and AA6082. The results showed that the anti-corrosion properties of the dissimilar weld were better than those of the parent materials 5083 and 6082 for specific processing conditions. Antony (2018) tested the corrosion susceptibility of the Aluminium-Copper-Lithium alloy 2050 in chloride solution at T34 and T84 conditions. They concluded that fatigue-corrosion had the greatest impact on the T34 state's fatigue life.

## 2. Materials and Methods

To do the corrosion test, a wide range of corrosion test methods are in practice. This comprises, Intergranular Corrosion Testing (IGC) in accordance with ASTM A – 262 Practice – A – Oxalic Acid Practice – B – Ferric Sulfate – Sulfuric Acid Practice – C – Nitric Acid Practice – E – 16 percent Copper - Copper Sulphate Testing Practice – F – 50% Copper - Copper Sulphate Testing. ASTM G 48 Specification for Pitting and Crevice Corrosion. Method A: Ferric chloride pitting testing

Method B: Ferric chloride crevice testing

Method C: Nickel-base and Chromium-bearing alloys are subjected to a critical pitting temperature test.

Method D: Temperature test in critical crevices for nickel-base and chromium-bearing alloys.

Method E- Critical pitting temperature test for stainless steels

ASTM A – 923 examinations of harmful intermetallic phases in duplex Austenitic/Ferritic stainless steels. ASTM G 28 Method A - Ferric Sulfate - Sulfuric Acid test for intergranular corrosion in Nickel - Rich, Wrought, Chromium - Bearing Alloys. ASTM G 36 Chloride Stress Corrosion Cracking Test. Boiling Magnesium Chloride Solution and Boiling Calcium Chloride Solution are both tested. SSCC (NACE TM 0177) Sulphide Stress.

Corrosion Cracking Test. HIC (Hydrogen Induced Cracking) Test (NACE TM 0284). Mass of Coating and Coating Thickness Measurement • Mercurous Nitrate Test. Neutral Salt Spray Test-NSS (Salt Spray Test). Acetic acid-Salt Spray Test-ASS Acetic acid-Salt Spray Test-CASS Copper Chloride Acetic Spray Test-CASS.

## 3. Result and Discussion

The check was done with the aid of IGC-practice-‘C’ as in step with ASTM A 262:2015. The sensitisation warmness remedy is not required for the magnesium alloys. The test specimen is submerged in a boiling Nitric acid solution for a particular length. The time taken for the pattern boiling within the nitric acid test answer become 24 Hours.

The apparatus consists of a field, specimen helps, heater, stability and a desiccator. The take a look at solution was  $65 \pm 0.2$  % by using weight as nitric acid as decided by evaluation. In practice ‘C’ the full specimen changed into immersed in the nitric acid answer and takes the average weight loss over the whole specimen’s floor. Mechanical deformation, welding, carburization etc, regulate best the unique portion of a specimen.

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With a purpose to calculate the net end result of corrosion, the cloth's response to the acid, in addition to the weight reduction of the specimen, must be measured. The specimen weighed W1 grams before it became immersed inside the Nitric acid solution. Following exposure to Nitric acid answer, the specimen weighs W2 grams.

$$\% \text{ of weight loss} = (W1 - W2) * 100 / W1$$

The weight reduction being expressed in % also. This weight reduction is the Corrosion of that material. The specimens earlier than doing the corrosion take a look at are illustrated in Fig. 3.1 and the specimens after doing the corrosion check are illustrated in Fig.3.2



Figure 3.1 Specimens before corrosion test

Figure 3.2 Shows the specimens after corrosion testing

In Fig3.2, the corrosion specimens display the lifestyles of pores over the floor. Because of the dearth of oxygen in a small pitting, corrosion is fashioned. In other phrases, a place with excess oxygen turns into cathodic and a place with low oxygen becomes anodic. Because diffusion of ions is limited, the corrosion permeates the steel, in addition generating localized oxygen deprivation (Galvele et al., 2005). The corrosion takes a look at consequences of the base substances of A384.Zero-T6, AZ80A - T5, and the Run #5 which changed into recorded to be minimal americaand the equal is proven in table 3.1.

Table 3.1 Corrosion test results

Test Performed		: IGC-Practice C			
Test Method		: ASTM A 262:2015			
Specimen size in mm		: 35 X 20 X 6.35			
Sensitization Heat Treatment		: Not Required			
Sl.No	Sample ID	Initial weight of the sample (W <sub>1</sub> ) in gms	Weight of sample after 24 hrs. boiling in nitric acid solution (W <sub>2</sub> ) in gms	Loss in weight (W <sub>1</sub> -W <sub>2</sub> ) in gms	% of weight loss
1	AZ80A - T5	12.85	12.285	0.565	4.39

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2	AZ91C – T6	11.16	10.269	00.90	8.06
3	R-5	11.98	10.72	01.26	10.51

The burden losses of the determine fabric AZ80A - T5, AZ91C – T6 and Run #5 are calculated and tabulated in table 3.1. This turned into analysed. On this evaluation, the corrosion is less in AZ80A - T5 wrought magnesium alloy, due to its high tensile power. Whereas in AZ91C – T6 forged magnesium base fabric, the corrosion values are in-among the FSW weld of Run #5 and the discern cloth of AZ91C – T6 magnesium alloy. Inside the examined specimens, the existence of pores over the floor changed into without problems recognized by using the naked eye that is shown in Fig 3.2. The Run #5 has extra corrosion in comparison to the two determine materials.

#### 4. Conclusion

On this Inter Granular Corrosion take a look at analysis, the following conclusions are made through the discussion of the corrosion take a look at outcomes.

- All of the tested specimens are subjected to inter granular corrosion and pitting.
- The combination of AZ80A - T5 and AZ91C – T6 FSW welded joints at 680 rpm, feed rate of 35 mm and an axial force of 6 kN, corrosion of 10.51% was recorded.
- This 10.51% of corrosion is obtained in the specimen of the lowest UTS of 246.33 MPa.
- The base alloys of AZ91C – T6 and AZ80A - T5 have less corrosion percentage comparing to the FSW run #5 weld.
- The percentage of weight loss is 10.51 % at the lowest UTS in mixture of AZ91C – T6 and AZ80A - T5 FSW welded joints. So, all other FSW welds have less % of corrosion comparing to the Run #5.

#### Reference

- Abdelatif, A. O., Ožbolt, J., & Gambarelli, S. (2018). 3D finite element modelling of corrosion of lap splice joints in concrete. *Construction and Building Materials*, 169, 124–131.
- Alcantara, A. S., Fábíán, E. R., Furkó, M., Fazakas, É., Dobránszky, J., & Berecz, T. (2017). Corrosion resistance of TIG welded joints of stainless steels. *Materials Science Forum*, 885, 190–195.
- Bocchi, S., Cabrini, M., D'Urso, G., Giardini, C., Lorenzi, S., & Pastore, T. (2018). The influence of process parameters on mechanical properties and corrosion behavior of friction stir welded aluminum joints. *Journal of Manufacturing Processes*, 35, 1–15.
- Chenyan, Z., ZHANG, J., & others. (2021). Fatigue strength analysis of aluminum alloy trimaran considering corrosion effects. *中国舰船研究*, 1–8.
- DeSantis, M. K., Triantafyllidou, S., Schock, M. R., & Lytle, D. A. (2018). Mineralogical evidence of galvanic corrosion in drinking water lead pipe joints. *Environmental Science & Technology*, 52(6), 3365–3374.
- Jegdić, B., Bobić, B., Radojković, B., Alić, B., & Radovanović, L. (2019). Corrosion resistance of welded joints of X5CrNi18-10 stainless steel. *Journal of Materials Processing Technology*, 266, 579–587.

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7. Kangazian, J., & Shamanian, M. (2019). Micro-texture and corrosion behavior of dissimilar joints of UNS S32750 stainless steel/UNS N08825 Ni-based superalloy. *Materials Characterization*, 155, 109802.
8. Liu, H., Chen, H., & Chen, Z. (2020). Residual behaviour of welded hollow spherical joints under corrosion and de-rusting. *Journal of Constructional Steel Research*, 167, 105977.
9. Rajesh, S., Saravanan, R., Kamatchi, T., Gnanavel, C., Ajith arul Daniel, S. Evaluation on hardness and percentage of elongation discrepancy by Zinc oxide nanoparticles on AA6070 alloy composites *Materials Today Proceeding*, Volume 62, Part 4, 2022, Pages Pages 1921-1924
10. Saravanan, R., Gnanavel, C., Rajesh, S., Kamatchi, T., Ajith arul Daniel, S. Synthesis of Zinc oxide and CNT in AA7178 aluminium alloy composite impression on characteristics. *Materials Today Proceeding*, Volume 62, Part 4, 2022, Pages 1973-1976.
11. Rajesh, K. V. D., Buddi, T., Kanth, P. R., & Satyanarayana, K. (2020). Microstructural and corrosion resistance study on plasma arc welded joints of AISI 304 and AISI 316. *Advances in Materials and Processing Technologies*, 6(2), 189–205.
12. Sabzi, M., Obeydavi, A., & Mousavi Anijdan, S. H. (2019). The effect of joint shape geometry on the microstructural evolution, fracture toughness, and corrosion behavior of the welded joints of a Hadfield steel. *Mechanics of Advanced Materials and Structures*, 26(12), 1053–1063.
13. Shi, Y., Cui, S., Zhu, T., Gu, S., & Shen, X. (2018). Microstructure and intergranular corrosion behavior of HAZ in DP-TIG welded DSS joints. *Journal of Materials Processing Technology*, 256, 254–261.
14. Sonawane, P. D., Bupesh Raja, V. K., & Gupta, M. (2020). Microstructure, mechanical, and electrical properties and corrosion analysis of lead-free solder CSI joints on Cu substrate using novel concentrated solar energy soldering (CSES) method. *Advances in Materials Science and Engineering*, 2020.