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Effect of Sodium Chloride on Weight Loss of AA1100 Aluminum Alloy and SGACD Zinc coated Steel Lap Joint

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Abstract

This research aims to study an effect of sodium chloride solution concentration on the corrosion rate of AA1100 aluminium alloy and SGACD zinc coated steel lap joint with a test duration of 30 days and a test temperature of 45^o. The summarized results are as follows. Increase of the NaCl solution concentration increased the weight loss of Al, corrosion rate of Al, weight loss of Fe and also decreased the corrosion rate of Fe. Increase of the test duration affected to increase the weight loss and corrosion rate of Al and also decrease the weight loss and corrosion rate of Fe. The corrosion that was formed in a lap joint consisted of the uniform corrosion on the surface of the metals and the galvanic corrosion in the lap area of the joint. The maximum weight loss of AA 1100 aluminium and SGACD zinc coated steel that was occurred in the sodium chloride with 3.25% was 2.203% and 3.208%, respectively.. The maximum corrosion rate of AA 1100 aluminium and SGACD zinc coated steel that was occurred in 4.00% and 3.5% sodium chloride solution was 0.156 mm/year and 0.479 mm/year, respectively.

***Keywords**: Automotive industries, hot-dip-galvanized steel, lap-joint corrosion, corrosion rate, sodium chloride, aluminium, zinc coated steel, SEM/EDS.*

1. INTRODUCTION

A lap joint is an important joint in an automobile structure and has a number of the application in an automobile structure that is 60% larger than that of other joint such as a butt joint or a T-joint [1]. A lap joint in an automobile structure could be consisted of a similar metal lap joint, such as a similar steel lap joint that was an important metal for producing the automobile structure, or a dissimilar metal lap joint that was increasingly applied in the automobile nowadays. When comparing to the similar metal lap joint, the dissimilar metal lap joint could show flexible properties of the lap joint and show the advantage of each metal that could widely apply to resist the acting force during the service of the lap joint [2]. The lap joint of the dissimilar metal was becoming important when the world faced the energy consumption problem. The

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lightweight metal such as aluminium alloy was introduced to replace the steel part in the structure and showed successfully an energy saving of the automobile [3]. When the dissimilar metal lap joint was applied in the service environment such as liquid solution, natural water, humid air, rain, the corrosion could be developed in the lap joint. This was because these environments showed high electrical conductivity for ion to flow into the joint that was an important factor for corrosion development [4].

By the above discussion, the preparation of the dissimilar aluminium/steel lap joint corrosion data could be conducted for an application of the lap joint in the industries. This paper aims to effect study of sodium chloride solution on the weight loss of the lap joint of AA1100 aluminium alloy and SGACD zinc coated steel. The corrosion behaviour on the surface of the lap joint was also investigated using scanning electron microscopy associated with X-ray energy dispersive spectrometry (SEM/EDS).

2. EXPERIMENTAL PROCEDURE

Materials used in this experiment were the rolled plates of AA1100 Aluminium alloy (hereafter, Al) and AISI1015 steel (hereafter, Fe) that had a chemical composition as shown in Table 1. The 1 mm in thickness of the materials was mechanically cut to be a rectangular coupon that had a width of 20 mm and a length of 40 mm. The cutting edges of the coupon were mechanically polished by the 600 grit number emery paper for preparing the irregular smooth surface. The preparing and cleaning of the coupons in this study was strictly followed ASTM G1-90 [5]. The lap joint between Al and Fe was firmly clamped using a plastic clip [6] and set the overlap distance of 20 mm as shown in Fig. 1.

Table 1. Chemical composition of the experimental materials (%wt).

Element	Al	Fe	Cu	C	Si	Mn	S	Zn	P	other
AA1100	Bal.	-	0.20	0.65	0.05	0.05	-	0.15	-	0.15
SGACD	-	Bal.	-	0.15	-	-	0.24	-	0.01	-

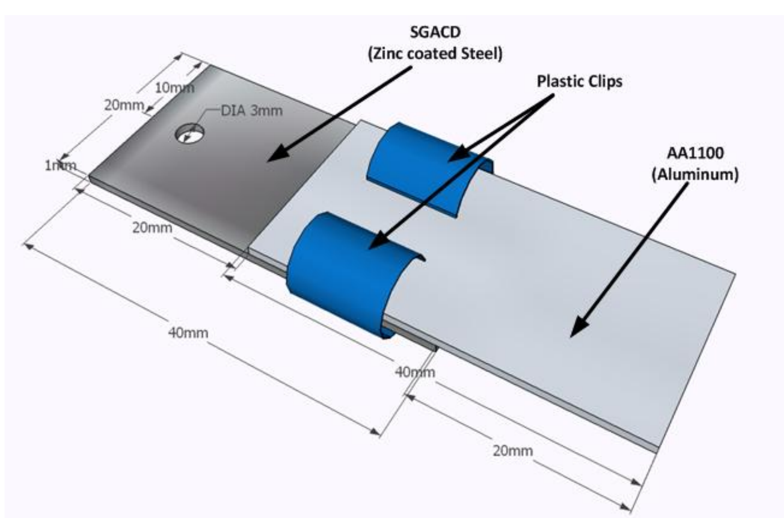
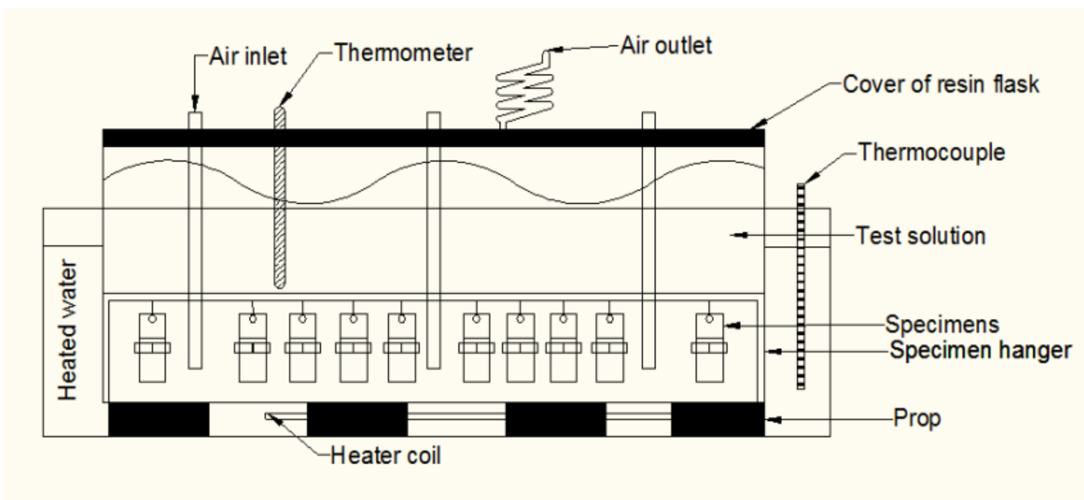


Figure 1. Configuration of the lap joint

The corrosion test equipment was designed and constructed by following ASTM G31-72 [7] as shown in figure 2. The test solution in a test chamber was controlled using a heated water thought a chamber wall using a heating coil as shown in figure 2 (a). The configuration of the constructed immersion test equipment was shown in figure 2 (b). The sodium chloride concentration of this experiment was 3.0-4.0%. The amount of the solution was calculated using the 25 mm^2 of solution for 1 cm^2 of the specimen surface area. Tested duration was 1 – 30 days. The lap joint was taken off from the test chamber in every 3 days for investigation of the weight loss in lap joint. Furthermore, the specimen was mechanically brushed with a plastic brush and was chemically cleaned with the specific solution followed ASTM G1-91. The corrode surface of the lap joint was observed using a scanning electron microscope equipped with an energy dispersive X-ray Spectrometer.



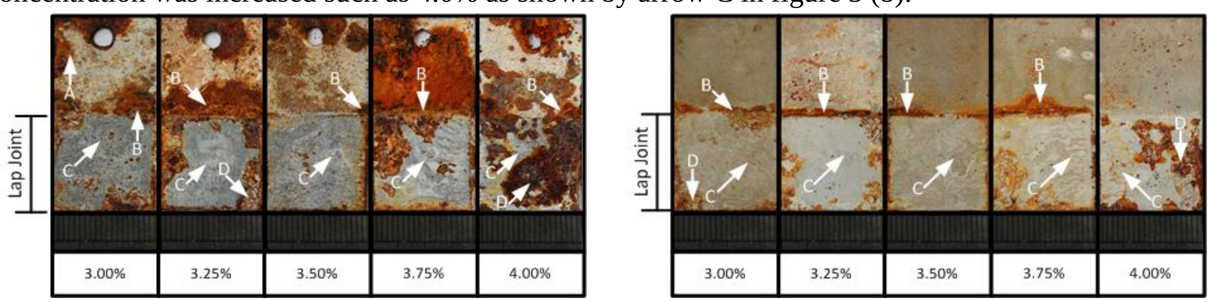
(a) Immersion chamber test design

(b) A constructed immersion test chamber

Figure 2. Constructed immersion corrosion test equipment followed ASTM G31-72

3. RESULTS AND DISCUSION

Figure 3 shows the corroded surface after exposed in various concentration of NaCl solution. The red corrosion product of pitting corrosion was found on the steel and Al surface and tended to increase when the NaCl concentration was increased as shown by the arrow A-D in figure 3. The corrosion of the lap joint was started from a periphery as shown by arrow A, B and D and progressed towards a centre of the joint as shown by arrow C in figure 3 (a). The increase of the corrosion product when the exposed time increased on Fe surface seemed to occur due to zinc coated layer was disappeared from surface of Fe. The increase of the NaCl solution such as 3.75 and 4.0% NaCl, increased the corroded area and affected to corroded seriously the lap joint area in Fe side as shown by arrow D in figure 3 (a). Compare the corroded surface of Al side with Fe side as shown in figure 3 (b), it was found that the corrosion that was taken in Al side was smaller than that of Fe side. Small red corrosion product as shown by arrow A, B and D was from at only a periphery of the surface. However, the corrosion product was increased in the lap joint area when the NaCl concentration was increased such as 4.0% as shown by arrow C in figure 3 (b).



(a) Fe (b) Al

Figure 3. Specimen surface that was tested for 30 days.

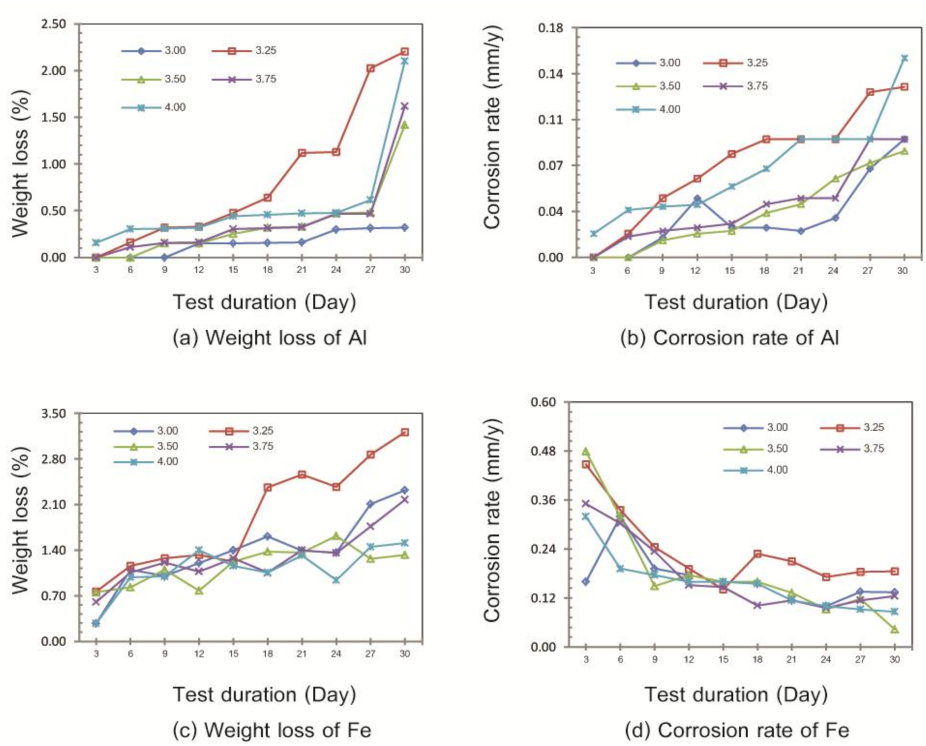


Figure 4. Graphics of corrosion rate and weight loss in SGACD and AA1100

Figure 4 (a) shows the relation between the weight loss of Al, test duration and the NaCl concentration. It was found that the test duration and the NaCl concentration affected directly to increase the weight loss of the lap joint. No weight loss was observed on Al side when the test duration was 1 to 3 days. The weight loss of Al was slightly increased when the test duration was longer for the NaCl of 3.25-4.00% but it was not changed with the NaCl of 3.0%. The corrosion rate of the Al side was increased with the increased of the solution concentration and the test duration as shown in figure 4 (b) due to the formation of the red corrosion product on the surface as shown in figure 3 (a). When compared between 2 test solutions such as 3.75 and 4.00% NaCl solution of the exposed time that was longer than 6 days, it was found that the corrosion rate of Al was 2 time difference. The maximum weight loss of Al was occurred in the sodium chloride with 3.25% was 2.203. Whereas the corrosion rate was occurred in the sodium chloride with 4.00% was 0.156%.

The weight loss of Fe side was slightly increased with increasing of the test duration and the test solution concentration as shown in figure 4 (c). For the test duration that was shorter than 27 days, the weight loss was lower than that of 0.50%. The corrosion rate of Fe showed high corrosion rate when the test duration was 3-9 days as shown in figure 4 (d). This corrosion rate of Fe was dramatically decreased when test duration was increased. The corrosion of Fe was also higher when the test solution concentration was 3.50. The maximum weight loss and the corrosion rate of Fe were 3.208% and 0.479 mm/year, respectively.

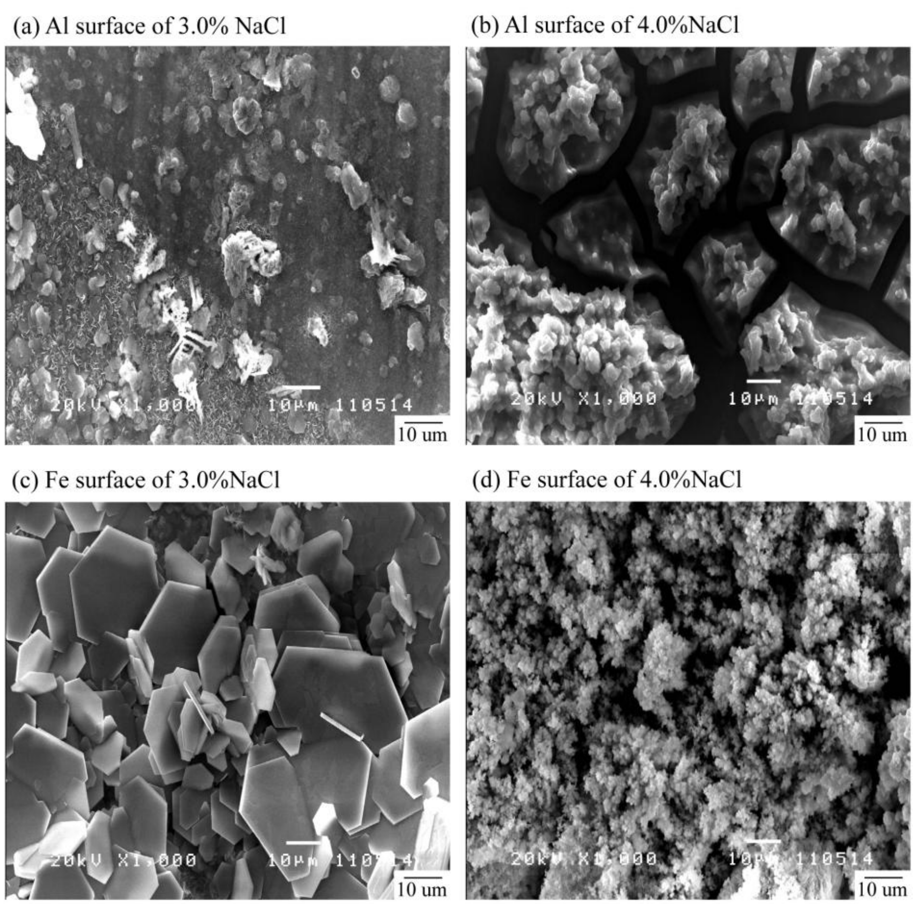


Figure 5. Corroded surface in a lap area.

Figure 5 shows the corroded surface in the lap area as shown in figure 3 that was tested 30 days in 3.00 and 4.00%NaCl solution, respectively. The surface of Al that was tested in 3.00%NaCl solution showed the all locations that were attacked by the solution as shown in figure 5 (a). Small corrosion product was occurring on the surface of Fe during the test and showed high amounts of Al as shown in figure 5 (a). The corrosion product that formed on the Al surface was larger and deeper when the NaCl was increased to be 4.00% in the tested chamber as shown in figure 5 (b). This larger and deeper corrosion product indicated the higher amount of oxygen when compared with the Al side that was tested in 3.0%NaCl solution as shown in figure 5 (b). When compared the Al surface with Fe side, the larger and deeper corrosion product was occurred on the Fe surface when the 3.0%NaCl was applied in the tested chamber as shown in figure 5 (c). When the test solution was increased to be 4.0%, the corrosion product geometries were smaller that that of the Fe surface that was tested in 3.0%NaCl solution. The decrease of the corrosion product geometries on the Fe surface that was tested in 3.00 and 4.00% NaCl solution related to decrease the amount of oxygen as shown in figure 5 (b).

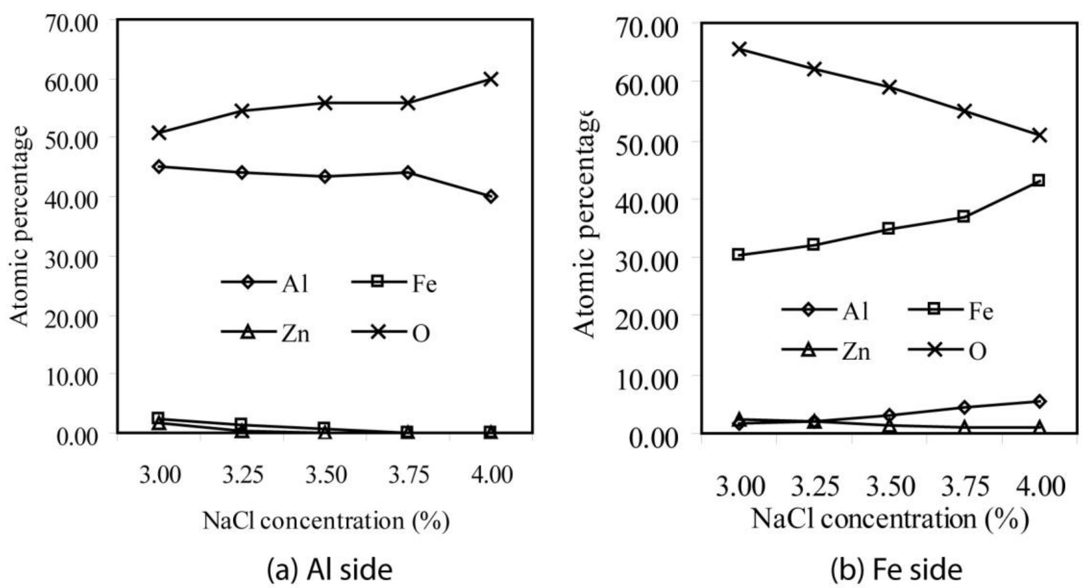


Figure 6. EDS chemical composition analysis of the corrosion product in the lap area

The chemical composition of Al and Fe surfaces in figure 6 also showed some interested results that implied the galvanic corrosion was formed in the lap joint. On Al side, small amount of Fe and Zn was detected in a corrosion product when the test solution was 3.00-3.25%NaCl for 30 days. On Fe side, small amount of Al was also detected in a corrosion product when the test solution was 3.00-4.00%NaCl for 30 days. The detection of Al in Fe corrosion product and Fe and Zn in Al corrosion product implied that the sharing electron and ion between two metals of the lap joint was performed.

4. CONCLUSION

The corrosion test of the lap joint between AA1100 aluminum alloy and SGACD zinc coated steel was performed at the test solution of 3.00-4.00%NaCl, the test duration of 30 days and the test temperature of 45℃. The summarized results are as follows:

4.1 Increase of the NaCl solution concentration increased the weight loss of Al, corrosion rate of Al, weight loss of Fe and also decreased the corrosion rate of Fe.

4.2 Increase of the test duration affected to increase the weight loss and corrosion rate of Al and also decrease the weight loss and corrosion rate of Fe.

4.3 The corrosion that was formed in lap joint consisted of the uniform corrosion on the surface of the metals and the galvanic corrosion in the lap area of the joint.

4.4 The maximum weight loss of AA 1100 aluminium and SGACD zinc coated steel that was occurred in the sodium chloride with 3.25% was 2.203% and 3.208%, respectively.

4.5 The maximum corrosion rate of AA 1100 aluminium and SGACD zinc coated steel that was occurred in 4.00% and 3.5% sodium chloride solution was 0.156 mm/year and 0.479 mm/year, respectively.

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REFERENCES

[1] Branes, T.A., Pashyby, I.R, “Joining Techniques for Aluminium Space frames used in Automobiles Part I-Solid and Liquid Phase Welding.” *J. of Materials Processing Technology*, Vol. 99, pp. 62-71, 2000.

[2] Brandon, D., Kaplan, W.D, Joining Processes, An Introduction, *John Wiley&Sons*, pp. 364, New York, 1997.

[3] Sun, Z.. Karppi, R., “The Application of Electron Beam Welding for the Joining of Dissimilar Metals: An Overview,” J. *of Materials Processing Technology*, Vol. 59, pp. 257-267, 1999.

[4] ASM. ASM Handbook Volume 15 Corrosion. 2000 ASM International. USA. CD-ROM.

[5] Standard Method G1-90, Annual Book of ASTM Standards. Standard Practice for Laboratory Immersion Corrosion Testing of Metals.

[6] Chico, B., Fuente, D., Almeida, E., Morcillo, M., Gonzalez, J.A., Otero., E., “Lap-joint corrosion of precoated materials for building applications,” *Surface and Technology*, Vol. 190, pp. 65-74, 2005.

[7] Standard Practice for Laboratory Immersion Corrosion Testing of Metals, Standard Method G31-72. Annual Book of ASTM Standards.