3.5% NaCl에서 Arc Thermal and Plasma Arc Spray 공법이 적용된 Al- Zn 코팅 강재의 내 식 성능 평가에 관한 연구

Performance of Al-Zn Coating by Arc Thermal and Plasma arc Thermal Spray Processes in 3.5% NaCl Solution

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Abstract

In the present study, Al-Zn coating was deposited by Arc thermal (AT) and plasma arc thermal (PAT) spray processes, and their corrosion characteristics were studied in 3.5% NaCl through electrochemical impedance spectroscopy (EIS), scanning electron microscope (SEM) and mechanical tests. The bond adhesion result showed that plasma arc sprayed coating had a higher value attributed to compact, dense, and less porous coating compared to arc thermal spray coating which contains defects/pores and uneven morphology as revealed by scanning electron microscope analysis. Electrochemical results revealed that the plasma arc sprayed coating had a high polarization resistance at early stage of immersion, suggesting its excellent corrosion protection performance.

키 워 드 : 알루미늄, 징크, 강재, 플라즈마 아크 열, 부착 강도, 부식
Keywords : zinc, aluminum, steel, arc thermal, plasma arc thermal, bond adhesion, corrosion

1. Introduction

Steel is a widely used material in a wide range of industrial applications owing to its remarkable economic and industrial features. However, steel corroded quickly when exposed to a corrosive medium such as marine environment.[1)] Metallic coatings have been used successfully for many years to protect metallic materials against corrosion.[2)] For instance, Zinc coatings have been used as an effective protection method due to its ability to provide cathodic protection to the substrate. However, zinc coatings can suffer from dissolution when exposed to corrosive environments.

In the present work, efforts have been made to combine the corrosion resistant properties of both Zn and Al for protecting carbon steel against corrosion. To this end, Zn-15Al coating was deposited by arc and plasma arc thermal spray processes on mild steel surface. The corrosion protection characteristics of coated steels in 3.5% NaCl solution were investigated using mechanical, electrochemical and surface characterization techniques.

2. Materials and Method

The mild steel composition (in wt.%) is C=0.24, Mn=0.95, Si=0.26, P=0.016, S=0.008, Cu=0.02, Cr=0.04, Ni=0.03, and Fe=balance (wr=t%). The Zn-15Al coating was deposited by arc and plasma arc thermal spray processes on sand blasted carbon steel plate with 1.6mm diameter wires where two wires used in arc thermal, and a single wire used in plasma arc thermal process. Bond strength test was carried out according to KS F4716. The electrochemical impedance spectroscopy (EIS) measurements were carried out in 3.5% NaCl solution at different immersion times using a three-electrode system consisting of coated samples as the working electrode (WE), platinum wire as the counter electrode (CE) and silver-silver chloride (Ag/AgCl) as the reference electrode (RE). A scanning electron microscopy operated at 15 kV was used for surface characterization.

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3. Results and Discussion

The morphology of Zn-15Al coated steel is investigated using scanning electron microscope. SEM images of AT and PAT coated steel are shown in Figure 1(a), and Figure 1(b), respectively. It can be observed that both coatings have some defects, which is a known characteristic of these coatings. However, the surface of PAT coated steel has a morphology more compact and uniform than that obtained by AT spray process. This can be due to the uniform distribution of Al-Zn particles over the steel surface.

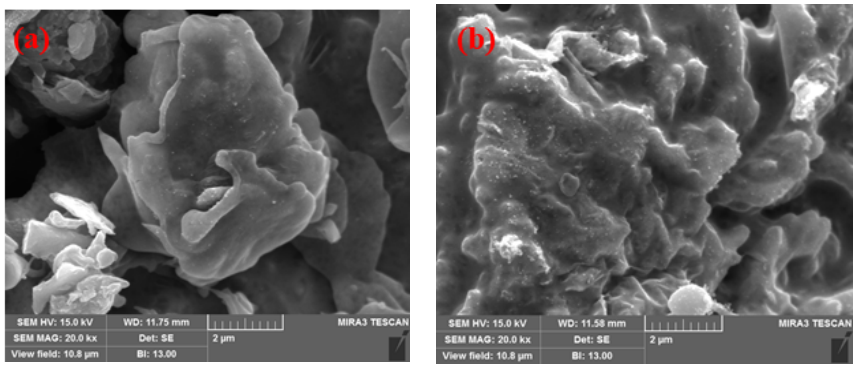

Figure 1. SEM image of Al-Zn coatings deposited by (a) Arc thermal and (b) Plasma Arc thermal spray processess

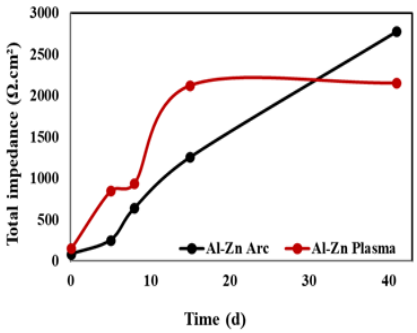

Figure 2. Total impedance of Al-Zn coatings in artificial ocean water with exposure periods

The corrosion protection properties of Zn-15Al coatings are also characterized using electrochemical impedance spectroscopy. Figure 2 shows the total impedance of AT and PAT coated steel. The total impedance reflects the resistance response of the formed layer over the steel. It can be seen from results in Figure 2 that at early stage of immersion in 3.5% NaCl solution, the resistance of both coatings increased with PAT significantly outperforms the AT coated steel. After 15 days of immersion, the PAT coated steel maintain a stable total impedance. In the time interval between 15 and 30 days, the AT coated steel has a lower impedance; however, a sudden increase in observed after day 30. The stability of the PAT coated steel is mainly resulted from the formation of passive layer with high corrosion resistant properties.

4. Conclusion

To sum up, in the present work, the corrosion resistance characteristics of Zn-15Al coatings deposited over steel surface by Arc thermal and plasma arc thermal spray processes were evaluated in 3.5% NaCl using electrochemical and SEM. The surface morphological analysis revealed that Zn-15Al coatings deposited by PAT formed a more uniform and homogeneous layer of steel. Electrochemical impedance spectroscopy indicated that PAT coated steel maintained a stable and high polarization resistance, confirming its outstanding anticorrosion properties.

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