강재 표면에 아크 금속 용사된 Al 및 Al-5 % Mg 코팅의 방지 성능

The Corrosion Protection Performance of Al and Al-5%Mg Coatings Deposited on Steel Surface by Arc Thermal Metal Spray

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Abstract

Arc thermal spray process is widely used to protect the steel from corrosion and abrasion. In the present study, two different coatings i.e. Al and Al-5%Mg were used to compare their corrosion resistance performance and the effect of 5% Mg addition in the properties of deposited coating. The SEM results showed the more compact and less porous morphology of Al-5%Mg coating compared to Al. The corrosion resistance performance of both deposited coatings was studied in artificial ocean water with exposure periods and results are compared. The total impedance values of Al-5%Mg at 0.01 Hz exhibited highest with exposure periods might be attributed to the coating and corrosion products nature and morphology compared to Al coating.

키 워 드 : 알류미늄, 알류미늄-마그네슘, 강재, 부식, 부착 강도
Keywords : aluminium, aluminium-magnesium, steel, corrosion, bond adhesion

1. Introduction

Usually different materials such as Al, Zn, Mg are used for steel coating due to their sacrificial characteristics to protect the steel from corrosion in harsh environment. Among them Mg is the most reactive materials in galvanic series. The alloy of Mg plays an important role in corrosion resistance performance. When Mg is added to Al, it enhances the corrosion resistance properties of the alloy. Despite that, the amount of Mg should be moderate i.e. Mg<3 wt.%. If more than this amount is added, it is susceptible to corrosion. Commercially Mg rarely exceeds more than 5wt% in alloys due to the enhancement in pitting corrosion. Therefore, in the present study, we have taken Al and Al-5%Mg wires for deposition of coating to protect the steel structure from corrosion. The 100 μm thick Al and Al-5%Mg coating was deposited by arc thermal spray process and their bond adhesion, morphology and corrosion resistance in artificial ocean water with exposure periods was accessed.

2. Materials and Method

Sand blasted steel plate was used to deposit pure Al (99% purity) and Al-Mg (95% Al and 5% Mg) coating by arc thermal spray process using 1.6 mm diameter of two wires. The bond adhesion test was performed according to KS F 4716. The electrochemical studies, i.e., electrochemical impedance spectroscopy, were performed for determination of coating properties in artificial ocean water solution i.e. ASTM D1141, using Autolab Potentiostat. Alumina with 0.8-1.0 mm was used for sand blasting. For Al and Al-Mg coating processes, two powers (65V and 70V, respectively) were used. A 7.5 kg/cm2 compressed air pressure was used for both materials. The morphology and surface characterization of the deposited coating were carried out by Scanning Electron Microscopy (SEM) coupled with EDS. A SEM (MIRA3, TESCON) operated at 15 kV was used for surface characterization.

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3. Results and Discussion

The average bond adhesion value of 100 μm thick Al and Al-5%Mg alloy coating is found to be 4.86 MPa and 5.28 MPa, respectively. The deposited Al-5%Mg coating exhibited 8.64% higher bond strength compared to Al. The higher bond adhesion of Al-5%Mg coating is attributed to the preferential precipitation of Mg in coating matrix.

Figure 1 (a) and (b), respectively shows the surface morphology of Al and Al-5%Mg coatings deposited by arc thermal spray process. Al coating exhibits globular and splat particles along with defects (Figure 1a) while Al-5%Mg shows compact and uniform morphology (Figure 1b), therefore, this coating exhibited higher bond adhesion values. The presence of defects onto the Al coating leads to make it prone to corrosion where preferential dissolution of coating would start. Figure 1c shows the total impedance of deposited coatings in artificial ocean water with exposure periods at 0.01 Hz. The total impedance value of Al-5%Mg coating significantly increased with exposure periods while Al coating shows consistence in its value owing to the presence of defects onto the surface. Al-5%Mg coating exhibited negligible defects and due to the galvanic coupling between Al and Mg, the corrosion reaction would occur but at the meantime, the corrosion products deposit onto the surface which might be impermeable and protective resulting improvement in total impedance values with exposure periods (Figure 1c).

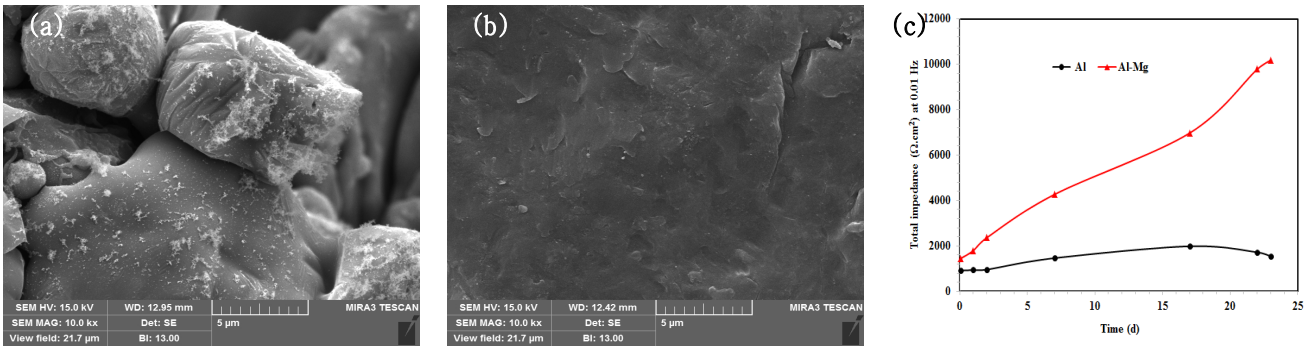

Figure. 1. SEM image of (a) Al, (b) Al-5%Mg coatings and (c) total impedance at 0.01 Hz with time in artificial ocean water.

4. Conclusion

In summary, results from present work indicated that the bond adhesion of Al-5%Mg was 8.64% higher than that of Al coating, due to the preferential precipitation of Mg in coating matrix. The corrosion resistance properties of Al-5%Mg coating were increased with exposure times attributed to the uniform coating morphology as well as deposition of corrosion products. Furthermore, Al coating showed an increased total impedance with exposure periods, which was ascribed to the presence of defects onto the coating surface where solution can easily ingress and enhance the corrosion reaction.

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References

1. Han-Seung Lee, Seoung-Jun Kwon, Jitendra Kumar Singh, Mohamed A. Ismail, Influence of Zn and Mg alloying on the corrosion resistance properties of Al coating applied by arc thermal spray process in simulated weather solution, Acta Metallurgica Sinica (English Letters), 2017
2. Jianfeng Yan, Nathan M. Heckman, Leonardo Velasco, Andrea M. Hodge, Improve sensitization and corrosion resistance of Al-Mg alloy by optimization of grain boundaries, SCIENTIFIC REPORTS, 2016