

Corrosion behaviour of physically vapour deposited Al–Zn coatings on 7075 aluminium alloy

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Abstract

Al–Zn coatings applied by physical vapour deposition on 7075 aluminium alloy were investigated from the point of view of their corrosion behaviour. Coatings with two zinc contents (3% and 6%) were tested by d.c. and a.c. impedance measurements. Taking into consideration both the self-dissolution of the coating and the cathodic protection effect conferred to the substrate by the coating, it was concluded that the coating containing 6% zinc is of better value for corrosion protection.

1. Introduction

The protection conferred by a metallic coating to a metal is normally attributed either to superior performance of the coating from the corrosion point of view or to cathodic protection. In the first case the self-dissolution rate of the coating is small, and is usually due to passivation of the coating, whereas in the second case the coating is supposed to dissolve at a certain rate in order to protect sacrificially the substrate. However, the protection current supplied by the coating must be enough to make the substrate cathodic but not so high that it leads to rapid destruction of the protection, *i.e.* of the coating [1].

In the present work the corrosion behaviour of Al–Zn coatings, deposited by physical vapour deposition (PVD) onto 7075 aluminium alloy, was studied. Two contents of zinc in the coatings were used and compared relative to the corrosion protection conferred to the substrate.

Potentiodynamic polarization and a.c. impedance techniques were mainly used to assess the performance of the coatings.

2. Experimental details

The Al–Zn coatings obtained by PVD contained zinc concentrations of approximately 3% and 6%. Polarization plots were obtained for coated specimens and the base aluminium alloy by potentiodynamic experiments. These were taken using a Thompson potentiostat associated with a linear sweep generator. Data acquisition was

via an HP-87 microcomputer and two digital high precision voltmeters.

Potential measurements were performed for the coated aluminium alloy *vs.* a reference calomel electrode by means of a high impedance voltmeter.

A.c. impedance measurements were carried out with a 1250 frequency response analyser connected to a three-electrode system via a Thompson potentiostat. Data acquisition was also via an HP-87 microcomputer.

The solution used in all the tests was 3.5% NaCl.

3. Results and conclusions

Typical anodic polarization plots for the two Al–Zn coatings, as well as the cathodic plot for the uncoated alloy, are shown in Fig. 1.

Table 1, which shows the free corrosion potential of the uncoated and coated alloy after immersion in NaCl solution, makes it apparent that the two coatings are anodic relative to the aluminium alloy; thus, if a galvanic pair is formed between the coating and the substrate the former corrodes, conferring cathodic protection to the substrate.

As a first approximation the cathodic protection current can be envisaged as the current corresponding to the intercept of the anodic and cathodic plots in Fig. 1 [2]. It is apparent that it does not change significantly with coating composition.

The variation of the free corrosion potential of the coated alloy with time is plotted in Fig. 2. The free corrosion potential of the coatings decreases as the zinc content increases and its variation with time shows in

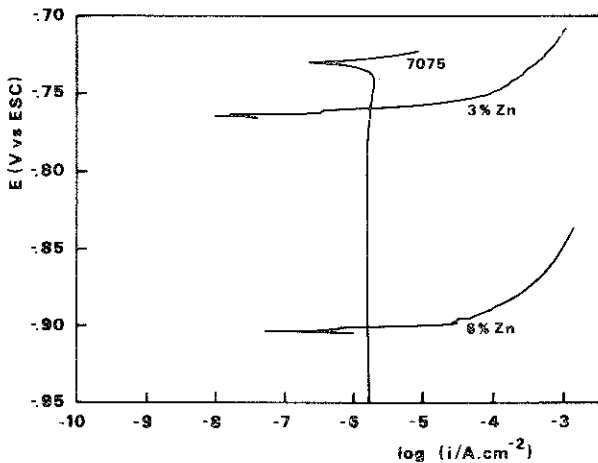


Fig. 1. Anodic polarization plots for the Al-Zn coatings and cathodic polarization plot for uncoated 7075 aluminium alloy.

TABLE 1. Free corrosion potential of the specimens

| Specimen | E_{corr} (mV vs. SCE) |
|----------------|----------------------------|
| 7075 alloy | -729 |
| 7075 + Al-3%Zn | -818 |
| 7075 + Al-6%Zn | -907 |

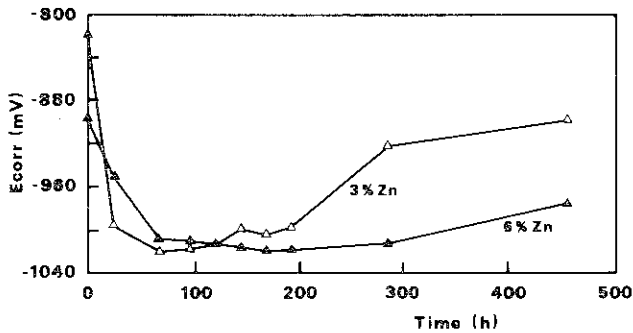


Fig. 2. Variation in potential against time for the two coatings.

both cases an initial decrease, followed in the case of the lower zinc concentration by an increase for times longer than 160 h. In the case of the larger zinc con-

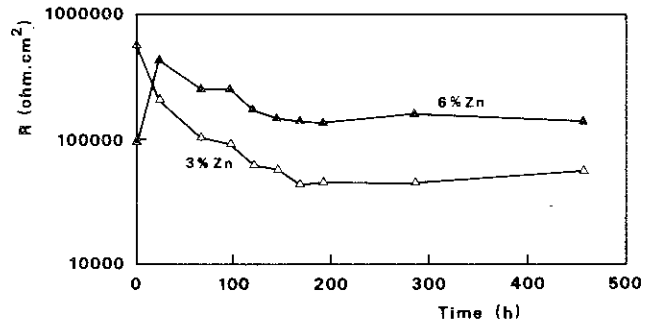


Fig. 3. Variation in charge transfer resistance of the corrosion reaction against time for the two coatings.

centration, the potential remains at a lower level, close to the pure zinc potential.

The study of the coated specimens after 500 h immersion shows that the coating almost disappears completely in the case of the lower zinc concentration, whereas it was hardly attacked in the case of the 6% zinc concentration.

Impedance measurements with time allowed the estimation of the variation in charge transfer resistance with time, Fig. 3. The results show that the coating with the higher zinc content exhibits a lower corrosion rate (larger charge transfer resistance) [3] than the lower zinc content coating.

The above results point to better performance of the Al-Zn coating containing about 6% zinc, since its self-dissolution rate is lower. The coating will be preserved for longer and, if for some reason it becomes faulty and is called to perform as a sacrificial anode, the cathodic protection effect will not be too different from that of the lower zinc content coating, as indicated by Fig. 1.

References

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