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主 論 文 の 要 旨

論文題目 Effects of Anodizing and Post Sealing on Corrosion Characteristics of Magnesium Alloys (陽極酸化と後処理がマグネシウム合金の腐食特性に及ぼす影響)

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論 文 内 容 の 要 旨

The effect of electrolyte temperature on the corrosion characteristics of wrought AZ31B, AZ61, and as-cast AZ91 Mg alloys in 0.1 M NaCl aqueous solution was analyzed. Systematic studies indicate that AZ91 exhibits higher corrosion resistance than AZ61 at nearly room temperatures. However, at high temperatures of around 55 ° C, we observed contradictory corrosion behavior, as demonstrated by potentiodynamic tests, electrochemical impedance spectroscopy, potentiostatic tests, and cyclic corrosion tests. Of the three different Mg alloys considered in this study, AZ61 shows the highest corrosion potential, lowest corrosion current density, highest polarization resistance, and slowest pitting propagation kinetics at 55 ° C. These results can be attributed to the microstructure of AZ61 which contains nano-scale β-phase particles effectively dispersed within the grains. On the other hand, AZ91 had many grains that did not contain any β-phases, and hence observed lower corrosion behavior than AZ61 at 55 ° C. Of them, AZ31B suffered the severest increase in corrosion kinetics with high uniform corrosion as the electrolyte temperature increased.

In order to improve the corrosion resistance of AZ31B Mg alloy, the surface was anodized with a pulse potential between the anodic oxidation (10 V vs. Ag/AgCl) and active regions (-1.35 V vs. Ag/AgCl) in 2 M NaOH aqueous solution at 30 ° C. Optimal conditions for the pulse anodizing were a duty ratio of 91 %, a frequency of 0.09 Hz, and an anodizing time of 600 s. Pulse anodizing caused a remarkable decrease in the surface porosity (11-fold) and an increase in the film thickness (1.6-fold) from those obtained under a constant potential of 10 V vs. Ag/AgCl. Furthermore, an Al-enriched crystalline oxide layer was formed on the outer surface of MgO, which improves the corrosion resistance of the Mg alloy in neutral solutions. In consequence, the pitting potential for the specimen pulse anodized increased to -1.36 V vs. Ag/AgCl from 10 V of DC anodizing and the corrosion current density decreased to 60 ± 10 uA/cm2, resulting in an approximately 3-fold decrease in the corroded area after anodic breakdown and salt spray tests.

For surface sealing, and therefore, achieving further enhancement in the corrosion resistance of as-anodized AZ31B Mg alloy, stannate post-treatment of as-anodized AZ31B Mg alloy was carried out in 0.4 M sodium stannate 3-hydrate (Na2SnO3 3H2O) at 77 ° C. It effectively leveled the porous anodized coating by depositing a SnO2 superficial layer with a thickness of 0.4 um. After the surface sealing, the mass transport impedance at low frequency was controlled by the ideal capacitance dispersion during the initial immersion; thus, slow corrosion kinetics was achieved. This impedance behavior might account for the ideally polarizable cathodic behavior of the electrode with overpotential. As a consequence, the stannate post-treatment afforded higher polarization resistance, corrosion potential, and pitting potential values throughout the immersion in 0.1 M NaCl.