

Evaluation of Corrosion Resistance of Aluminum Components by Low-Temperature Sealing

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KEY WORDS: materials, aluminum alloy, surface treatment, sealing, corrosion resistance [D3]

INTRODUCTION

Aluminum components are widely used in outboard motors for weight reduction. However, their cooling channels are exposed to harsh corrosive seawater environments. While anodizing is a promising alternative to conventional coatings that degrade under thermal stress, anodic films require sealing to address their inherent porosity. Conventional nickel-salt sealing is known to lose corrosion resistance after thermal exposure. This study investigates a low-temperature sealing process, evaluating its corrosion resistance, morphology, and electrochemical properties via Salt Spray Test (SST), Scanning Electron Microscope (SEM), and Electrochemical Impedance Spectroscopy (EIS) in comparison with conventional nickel-salt sealing.

RESULTS AND DISCUSSION

ADC12 aluminum alloy specimens were anodized and sealed under the conditions listed in Table 1. Following thermal treatment, corrosion resistance was evaluated via SST. The corrosion area ratio for nickel-salt sealed specimens increased from 3.5% to 25.8% after heating, indicating significant degradation. In contrast, low-temperature sealed specimens showed negligible white corrosion products regardless of thermal treatment. SEM observations revealed that cracks formed in both coatings after heating. Nickel-salt sealed specimens exhibited wide cracks that propagated during SST. Conversely, while low-temperature sealed specimens showed numerous micro-cracks before SST, these cracks appeared partially filled after exposure, suggesting a modification of the coating structure during the initial stages of corrosion testing. EIS results (Figs. 1 and 2) demonstrated that nickel-salt sealed specimens showed a decrease in both low-frequency impedance and high-frequency phase angle with increasing SST duration, indicating degradation of the barrier properties. In contrast, low-temperature sealed specimens maintained nearly constant low-frequency impedance throughout the test. The high-frequency phase angle increased during the initial SST stage and subsequently remained stable, suggesting that the film retains its protective performance. These results indicate that low-temperature sealing enables the maintenance of corrosion resistance after thermal exposure, likely by stabilizing the anodic film and inhibiting crack propagation through the filling of cracks during SST, thereby generating a highly insulating film.

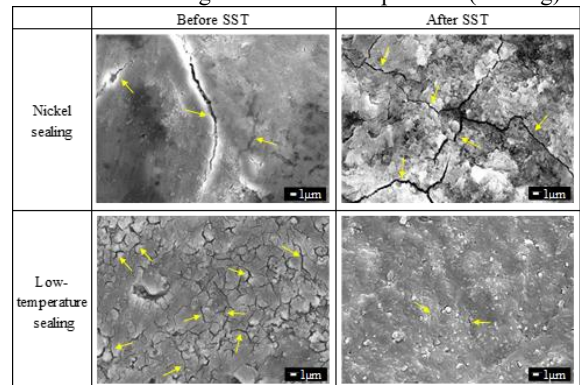
CONCLUSIONS

Conventional nickel-salt sealing showed significant degradation in corrosion resistance due to thermal cracking of the anodic film. In contrast, low-temperature sealing maintained high corrosion resistance despite the formation of cracks. SEM and EIS analyses suggest that these cracks are partially filled during SST, contributing to stable impedance characteristics and the maintenance of protective performance after thermal exposure.

Table1 Surface Treatment Condition

Sealing	Temperature [K]	Time [min]
Nickel sealing	363	10
Low-temperature sealing	313	3

Table2 SEM Images of the Sealed Specimen (Heating)



※Arrows indicate typical crack locations

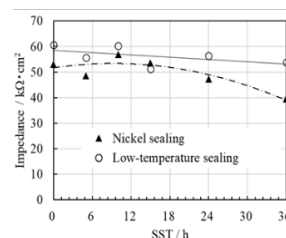


Fig.1 Impedance Value at Low Frequency (1.0Hz)

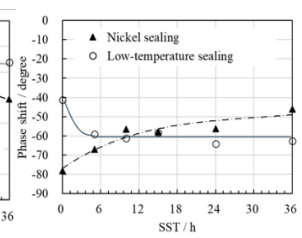


Fig.2 Phase shift Value at High Frequency (10⁵ Hz)