

Self-Healing Corrosion Protective Treatment of Aluminum for Seawater Heat Exchangers

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Summary

Aluminum is used in heat exchangers in various fields, because of the high specific strength and the high heat conduction, and the use in seawater is required. The surface of aluminum is oxidized in the air, and it is effective to prevent corrosion. The oxide film can be thick by electrochemical anodizing. Anodized oxide film has anti-corrosion property and high hardness, however, when aluminum substrate is exposed corrosive environment by defect of the film, corrosion proceeds. In order to prevent the corrosion, self-healing corrosion protective treatment is useful. Anodized oxide film has a lot of nanopores in the perpendicular direction to aluminum surface. The anodized oxide film with self-healing property is developed by insertion of healing agent in the nanopores.

In the present research, anodizing of aluminum as surface treatment was conducted to generate nanopores, and corrosion inhibitor as healing agent was inserted in the nanopores, and then anti-corrosion property was evaluated. Pure aluminum was used as a specimen, and the pore size was controlled by changing the voltage to 10-20 V. Then a sodium benzoate as corrosion inhibitor was inserted in the nanopores, and epoxy coating was applied. In order to increase the amount of corrosion inhibitor in the nanopores, the pore widening treatment of anodized aluminum was conducted. To evaluate self-healing property of the treatment, a scratch exposing substrate was generated on specimen, then polarization resistance of the specimen in corrosive solution was measured by electrochemical impedance method for 24 h.

The following results were obtained. The anodized oxide film was generated by applying voltage. Uniform nanopores were generated at 12 V or higher, and it was found that pore size decreased with increasing the voltage. Corrosion inhibitor was inserted in the nanopores. A scratch was given to specimen, and polarization resistance was measured in corrosive solution. Specimen prepared at 12 V for 60 minutes showed the highest resistance. Zeta potential of anodized film was measured for the mechanism of self-healing. The positive potential was indicated at low pH, and the potential was indicated negative at higher pH than 9. Hydroxide ion is generated around the defective part by cathodic reaction of corrosion, and pH increase. Anodized oxide film is negatively charged by pH increasing, then corrosion inhibitor is desorbed, and it diffused to defective part, resulting in the formation of healing film. Amount of corrosion inhibitor in nanopores increased by pore widening treatment, and the polarization resistance increased. Thus, the improvement of a self-healing property of anodized oxide film was confirmed.