A Study on Electrochemical Characteristics Aluminum Multi Matrix Compound (Al-MMC) of Neutron Absorber Material

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1. Introduction

In a Spent Nuclear Fuel (SNF) pool, a neutron absorber has been used to inhibit neutronic coupling between fuel assemblies and to maintain fuels in a subcritical condition. Among them, a composite of aluminum-boron carbide is used because it's the compatibility in radiation and elevated temperature environment. [1] However, it has been reported that neutron absorber materials suffer from pitting corrosion and galvanic corrosion in SNF pool, 2500 ppm boron, as boric acid environment, which is like that of SNF pool [2]. Therefore, to investigate the degradation behavior of Al/B_4C corrosion behavior of the composite is investigated by exploiting electrochemical techniques. And its microstructure and chemistry are analyzed by electron microscopy.

2. Experimental

2.1 Materials Preparation

To geometry of specimen is presented in the Fig 1., and the dimension of specimen was 2.54 cm * 5.1 cm * 0.7 cm. It consists of Al 5052 outer clad tightly bound to an inner core of Al 1070 with boron carbide. For the electrochemical tests, the cross section of specimen is prepared to investigate the galvanic corrosion between the outer clad and the inner core. The cross section of the composite was polished with 320, 400, 600, and 800 grit Si-C papers and 0.25 μm diamond suspension.

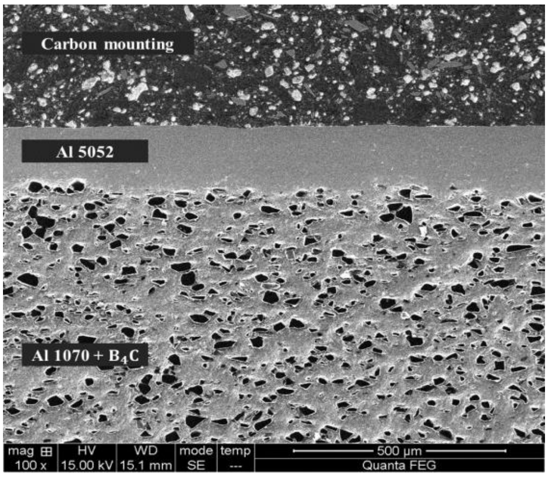

Fig. 1. Cross section results about Al – MMC.

2.2 Electrochemical Test

In electrochemical test, combined measurement of potential and current relationships for an operating corrosion cell over a wide range of oxidizing conditions results in polarization curves that describe the electrochemical reactions. The specimens for electrochemical test were positioned into an electrochemical cell with 1.0 cm^2 surface immersed in air saturated and 3.5wt. % NaCl solution for 3600 seconds to measure open circuit potential (OCP).

Potentiodynamic Electropolarization (PE) was conducted by the potential at open-circuit with a scan rate of 0.1667 mV s^{-1} from -0.5 V to 1.5 V (vs SCE). The potentiodynamic curves were plotted with potential vs current density. The electrochemical tests (OCP, PE) were performed in Al - MMC's cross section and surface respectively.

3. Results and Discussion

3.1 OCP and PE results of Al – MMC

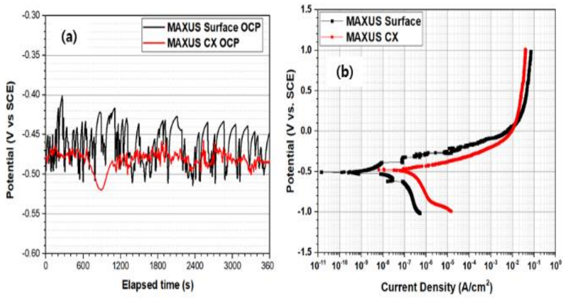

Fig. 2. OCP and PE result of Al – MMC.

Experiments were performed at 3.5wt.% NaCl solution. Unstable OCP curve appears to be related to pit formation and galvanic corrosion. [3] Some passive regions appear to be short. Passivity is lost due to the pitting corrosion of the surface Al cladding.

3.2 Cross section of Al - MMC after electrochemical test

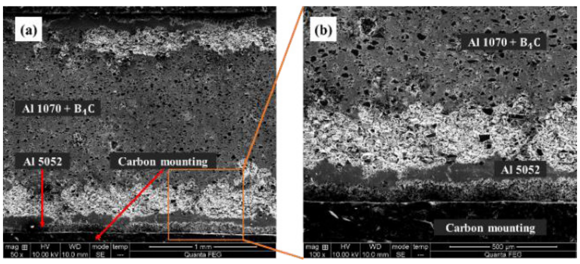

Fig. 3. After electrochemical test cross section (a) and bottom (b).

In Fig 3., Al/B_4C corrosion has been actively occurred near Al cladding. Mainly Al was oxidized, B_4C was not oxidized. It can be seemed occurrence galvanic corrosion between Al 1070 and Al 5052.

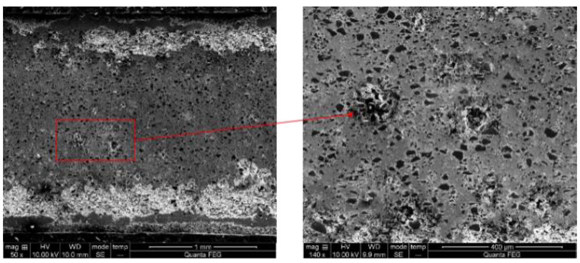

Fig. 4. Possible pitting corrosion on material's edge.

In Fig 4., the SEM image shows a site that is believed to have caused pitting corrosion. [4] The diameter of the corrosion estimated by pitting corrosion is 50 μm.

4. Summary

Al - MMC, used as a neutron absorber, shows pitting corrosion and/or galvanic corrosion in 3.5wt.% NaCl solution. If pitting corrosion penetrates the core, neutron absorption performance could be affected. Galvanic corrosion was observed between Al 5052 and Al 1070, and pitting corrosion was observed around B_4C.

ACKNOWLEDGEMENT

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REFERENCES

[1] W. Emma, (2009) Degradation of Neutron Absorbing Materials in Spent Fuel Pool, Nuclear Regulatory Commission, NRC, 2009-2026.

[2] Description, E., & Amendment, P. L. (2015). Material Qualification Report of MAXUS® for Spent Fuel Storage.

[3] Sori Won, et al (2018), Corrosion behaviors of friction welded dissimilar aluminum alloys, *Materials Characterization, 144, 652-660.*

[4] F. LOCKWOOD, et al (1985), PITTING CORROSION OF 5052 ALUMINUM ALLOY. *Application of Surface Science, 20, 339-346.*