Microstructure and Corrosion Properties of Zirlo-Inconel718-SS304-NM Metal Waste Form Alloys for Improving Stability of Metal Waste Generated by Pyro-Process and Long-term Disposal Stability

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1. Introduction

Pyroprocessing has been studied based on the electrochemical separation technology in molten salts for the recycling of spent fuel (SF). In the pretreatment and electrorefining processes, various metal wastes including cladding hull tubes, NFBC (Non-Fuel Bearing Components), and NMs (noble metals) in the anode sludge are generated as a process waste in the pyroprocess [1]. Among them, Zirlo cladding hulls have the highest weight ratio, which reaches about 62wt.%, excluding the SF, whereas NFBC has the highest volume ratio. Many researchers are studying technologies for the treatment of the metal wastes by melting or compaction, followed by a solidification process. The metal waste solidified by the melting process can easily be alloyed with other elements to improve the corrosion resistance and stability for long-term disposal. However, most of the studies have focused on the alloys based on stainless steel (SS) cladding materials and NM, which are generated from the fast breed reactors [2]. Since the pyroprocessing studying at KAERI is targeting the SF from PWRs (Pressurized Light Water Reactors), it is essential to develop waste form alloys that include Zr-based cladding hull wastes with NMs. In particular, by recycling the cladding hull waste and NFBC as a solidification medium for immobilizing the NMs, we can have a great advantage not only in the volumetric reduction effect but also in the reduction of the waste amount, and in the simplification of the waste treatment process.

In this study, Zirlo-Inconel 718-SS304-NM based alloys including all the metal waste components were fabricated by the induction melting process to evaluate the long-term disposal stability of the metal wastes generated from pyroprocess using microstructure analysis and corrosion tests.

2. Experiments

The induction melting process was performed using a Y-coated silica crucible with 99.9% pure Zr, Inconel718, SS304, and NM samples mounted in a vacuum induction melting furnace.

The metal waste form of about 3 x 3 cm^2 in size based on 100 g of the specimen was produced by melting at the temperature range of 1200^oC to 1400 ^oC and by slowly cooling down. The various Zr-Inconel-SS-NM alloys were produced by controlling the content of Inconel and SS304. The prepared specimens were evaluated for soundness and long-term stability of the waste form by examining the microstructure and by corrosion tests.

3. Results and discussion

We fabricated six waste form specimens including three different Zr-Inconel-NM alloys by controlling the content of Inconel718 and three Zr-Inconel-SS403-NM alloys added with Cu and Cr based on the composition of NFBC (Fig. 1). All the waste form specimens were fabricated in almost uniform size and shape without any apparent cracks due to a slow cooling rate.

	ZIN 195	ZIN 245	ZIN 295	ZINS5_#9	#10	#11
Top						
Side						
Crack	X	X	X	X	X	X

Fig. 1. Pictures of metal waste forms at various compositions.

In the result of SEM observation, the microstructures of representative samples were shown to consist of three different colors; bright grey, grey, and dark grey (Fig. 2).

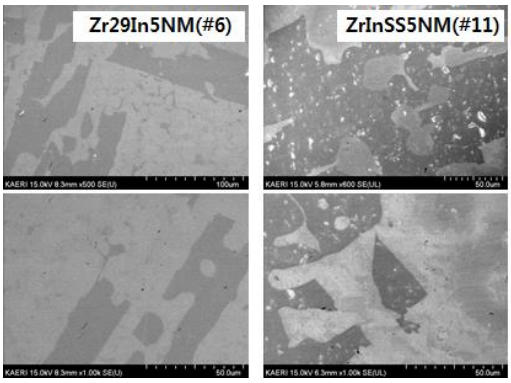

Fig. 2. SEM images of the microstructure for Zr-29Inconel-5NM and Zr-Inconel718-SS304-5NM.

For the two different kind of alloys, Cr and Ni were distributed in the regions of Fe and Zr, respectively, while NMs were evenly distributed over the entire surface. From the corrosion tests, E_{corr} and i_{corr} depending on the composition of specimens were shown in Fig. 3. Relatively higher E_{corr} were evident for all the compositions of Zr-Inconel-NM alloy specimens and a lowest i_{corr} was found at the lowest concentration of Inconel718, showing a superior resistance to corrosion. On the other hand, for the NFBC composition, both E_{corr} and i_{corr} were measured to be relatively low. The addition of Cu and Cr enhanced the resistance to corrosion of the waste forms based on NFBC composition.

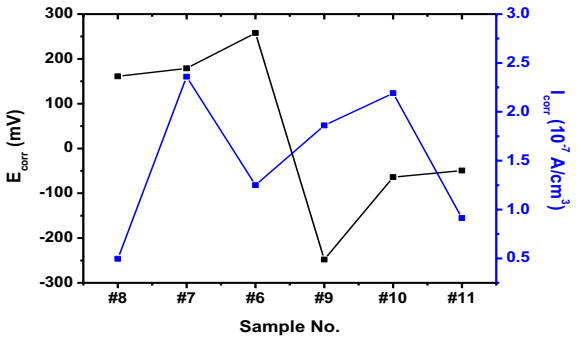

Fig. 3. E_{corr} and i_{corr} for the specimens with various compositions.

4. Conclusion

In this study, we fabricated metal waste forms using an induction melting process and evaluated the performance thereof to recycle the cladding hull and NFBC wastes generated from pyroprocess thereby reducing the volume of the waste.

REFERENCES

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