Characterization of U-Zr System Fuel Melt Residue for Recycle of Metallic Fuel Scrap

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1. Introduction

Sodium-cooled Fast Reactor (SFR) is a promising reactor among Gen-IV reactors for future. Metallic fuel slugs for SRF have conventionally been fabricated by injection casting method since 1950s. The injection casting method has the advantages of high productivity and excellent remote control, but the drawback of low yield of about 50%.

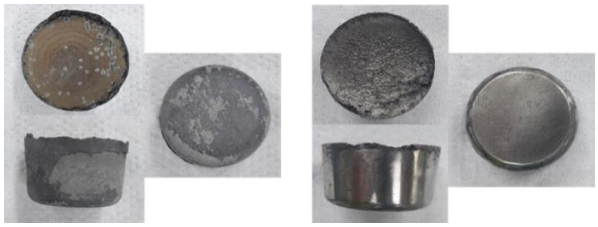
In this study, the characteristics of the residue scraps of U-Zr alloy system fuel in as-cast state and after surface treatment such as mechanical and chemical treatment have been examined to evaluate the feasibility the recycle of the fuel scraps, in order to improve the yield during the fuel fabrication process. In further, metallic fuel slugs were re-fabricated using recycled metallic fuel scraps by injection casting method.

2. Methods and Results

2.1 Experimental Methods

U-10wt.%Zr and U-10wt.%Zr-5wt.%RE fuel slugs have been fabricated using pure depleted uranium and zirconium metal, and RE mother alloy with injection casting method. RE is a rare-earth alloy consisting of 53wt%Nd, 25wt%Ce, 16wt%Pr, and 6wt%La. After injection casting, the melt residue scraps have been obtained and treated on the impurity layer of the surface by either chemical or mechanical method. The metallic fuel slugs were also fabricated using recycled metallic fuel scraps by injection casting method. The microstructure and the composition of the melt residue scraps and metallic fuel slugs were analyzed using using inductively coupled plasma atomic emission spectroscopy (ICP), elemental analysis (EA). scanning electron microscopy (SEM) and energy-dispersive spectroscopy (EDS).

2.2 Experimental Results



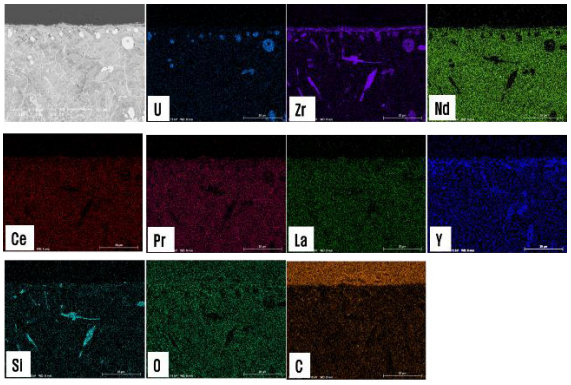
(a) (b)

Fig. 1. The surface states of U-10Zr-5RE melt residue in as-cast state (a) and after (b) mechanical treatment.

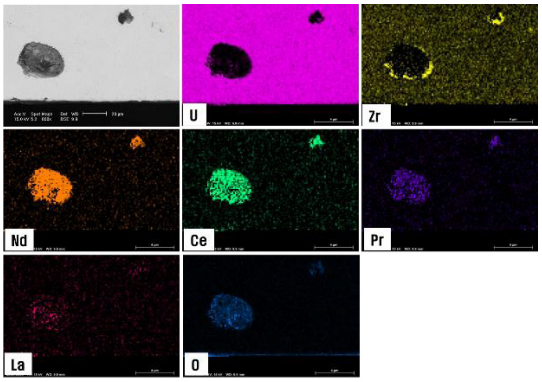
The surface states of U-10Zr-5RE melt residue before (a) and after (b) mechanical treatment are shown in Fig. 1. The U-10Zr-5RE melt residue in the top surface with as-cast state showed RE-compounds ranging from 5 to 30 μm in thickness as the first impurity layer on the top surface and RE-rich layer ranging from 1 to 2 mm in thickness as the second impurity layer, according to the integrated results of SEM, EDS and XRD analyses. The U-10Zr-5RE melt residue in the bottom surface showed Y_2O_3

plasma-spray coating layer of about 20 μm in thickness as the first impurity layer on the bottom surface and RE-rich layer of about 40 μm in thickness as the second impurity layer.

RE-compound layer as the first impurity layer on the top surface in the U-10Zr-5RE melt residue have been removed on the whole in the top surface after mechanical treatment. Y_2O_3 plasma-spray coating layer as the first impurity layer on the bottom surface and RE-rich layer as the second impurity layer have



(a)



(b)

Fig. 2. Scanning electron micrograph and energy-dispersive X-ray spectroscopic mapping showing the surface layer of U-10Zr-5RE melt residue after mechanical treatment; (a) top, (b) bottom.

been generally cleaned in the top surface after mechanical treatment. U-10Zr-5RE fuel slugs with a diameter of about 5.5 mm and a length of about 300 mm were fabricated soundly without cracks or thin sections, recycling metallic fuel scrap of melt residue.

3. Conclusion

The characteristics of the melt residue scraps of U-Zr alloy system fuel in as-cast state and after surface treatment have been examined to evaluate the feasibility the recycle of the fuel scraps. Surface impurity layers on the surface have been removed on the whole after mechanical treatment. Metallic fuel slugs were also re-fabricated soundly with mold length of 300 mm. The feasibility of the recycling of the fuel slug scraps has been demonstrated by the re-fabrication of the metallic fuel slugs.

ACKNOWLEDGEMENT

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