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Development of gravity casting mold design for annular fuel fabrication

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1. Introduction

The motivation for innovative fuel development is the development of the advanced ultra-high burnup sodium-cooled fast reactor metallic fuel concepts. The fabrication experiment seeks to investigate advanced fuel designs with the following features: decreased fuel smeared density (SD), venting of the fission gas to the sodium coolant, reduce the FCCI (Fuel Cladding Chemical Interaction), and an advanced fabrication method that includes consideration of annular fuel and extrusion method. The one of most attractive advantage of extrusion method is save the process waste by omitting the sodium process. From the previous study, annular fuel shows the possibility of the reduction of swelling effect and then prevention of the FCMI (Fuel Cladding Mechanical Interaction) [1, 2]. However, the extrusion fabrication technology of the annular fuel has not been developed yet. Therefore, KAERI has started to study the annular fuel fabrication method by using gravity casting method.

This research manufactured and evaluated annular metal fuels with a composition of U-10wt.% Zr using injection casting. Based on gravity casting studies conducted by KAERI, process variables were set and new mold design were used to fabricate annular metal fuel. After casting, the final production of annular metal fuel with a 6.40 mm outer diameter, 3.00 mm inner diameter, and a length of over 50 mm were successfully obtained.

2. Methods and Results

In order to manufacture a annular fuel of the target shape, a graphite mold with an inner diameter of 6.4 mm was manufactured by attaching a graphite rod with an outer diameter of 3.0 mm. (Fig. 1) The inside of the mold for casting was spray-coated with Y_2O_3 and then inserted into the flange. Afterwards, the prepared crucible and mold assembly are charged into the induction heating chamber, an argon (99.99%) or vacuum atmosphere (4.0x10-5 torr) is maintained, and the temperature is raised to the melting temperature to form a eutectic molten metal. When DU and Zr were eutectic, the upper mold cap was removed mechanically. After melting, the mold assembly was raised and cooled at room temperature to manufacture a U-10wt.%Zr annular fuel.

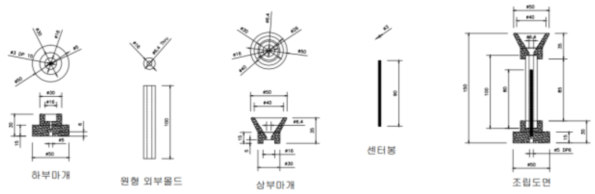

Fig. 1. Design of the gravity mold for annular fuel fabrication.

The length of the annular fuel manufactured using new mold was found to be 200~230 mm, and casting defects were observed at the top ~5 mm and the bottom ~20 mm. Further process development is ongoing to reduce the defect of the annular fuel.

3. Conclusions

This study manufactured and evaluated annular fuel with U-10wt.% Zr composition using gravity casting. Based on the results of the existing gravity casting research conducted at KAERI, process variables such as casting temperature, pressurization pressure, and atmosphere were set, and annular metal fuel were manufactured through new mold design. Annular fuel with an outer diameter of 6.40 mm, an inner diameter of 3.00 mm, and a length of more than 60 mm was manufactured, confirming the feasibility of manufacturing an annular fuel through gravity casting.

Acknowledgments

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