Defect characteristic for metallic fuel slug by casting parameters

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1. Introduction

The recycling metal fuel manufacturing technique required to complete the SFR fuel-pyro cycle is a technology to reprocess the spent fuel and then to SFR fuel. Since the entire process performs in a hot cell facility due to the high radiation content of the recycled fuel, it is important to develop a process for remotely manufacturing. Up to now, we have acquired lab-scale injection casting technology and engineering-scale injection casting technology. In this study, to improve the casting integrity of metal fuel slug manufacturing technology, casting defects evaluated according to the manufacturing process parameters of metal fuel slug [1, 2].

2. Methods and Results

In this section, experimental methods and results described.

2.1 Experimental methods

To simulate the manufacturing recycling metal fuel slugs in hot cells, casting tests carried out using engineering-scale metal fuel slug remote casting equipment. The casting process parameters used in the manufacturing test selected through a series of preliminary process experiments performed prior to this test. The casting process parameters selected to fabricate the fuel slug such as melt size, coating method, melt casting temperature, mold preheating time, and melt deposition time.

The injection casting method is a method of casting molten metal into a mold by using the pressure difference between the mold and the casting furnace. Graphite crucibles and quartz molds used as components. Cast parts and melt materials measured with electronic scales before and after dissolution. All work performed in Argon atmosphere. The vacuum pump used to make the inside of the chamber vacuum, and then the melting process started using a generator. When the desired molten metal injection temperature reaches, the mold drift device lowered and the mold assembly lowered into the crucible and the end of the mold assembly inserted into the molten metal. When the molten metal in the mold solidified, the mold assembly lifted up. After cooling to room temperature, the NW flange opened using an air lock device to release the chamber and lift the upper chamber to the top. The upper chamber rotated to position the mold transfer case, and the mold assembly placed on the mold transfer case. The fuel slug extracted from the mold assembly. Fig. 1 shows the engineering-scale injection casting equipment.

Table 1 shows the detailed manufacturing process parameters for the production of the fuel slugs and shows the shape of the fuel slug produced in Fig. 2. The length of the prepared metal fuel slug was 250 ~ 450 mm and the diameter was 5.54 mm ± 0.1, and the surface condition was generally good from a visual observation. Density measurement specimens were prepared by cutting to 40 ~ 50 mm length to evaluate the overall homogeneity of the manufactured metal fuel slug.

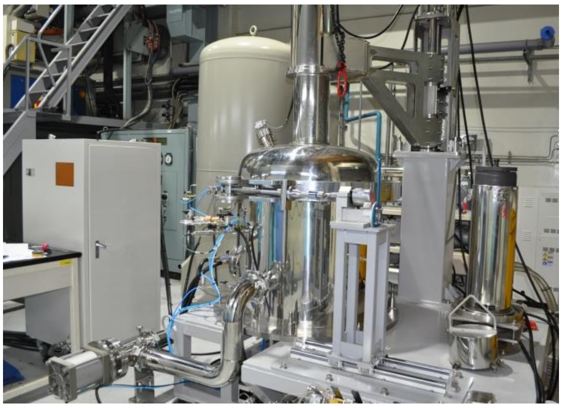

Fig. 1. Engineering-scale injection casting equipment (Max. U-Zr charge: 20kg, installed at KAERI

Table 1. Casting parameters

Parameters	
Initial charge (kg)	*8.70*
Number of molds	*~78*
Length of molds (mm)	*200~450*
Pressure before injection (Torr)	*200~400*
Molten metal temp. at injection (℃)	*1,000~1,600*
Pressurization rate(bar/sec)	*0.5~1.5*
Casting ratio (%)	*20~72*

2.2 Results

From the casted fuel slugs, it observed that as the casting temperature increased, the shrinkage hole and porosity of the fuel padding increased. It seems that the casting temperature affected the flow of molten metal and the solidification temperature. The melt casting temperature depends on the material used in the casting but belongs to the main factor determining the melt temperature. It is also depends that the appropriate molten metal immersion time must be determined, since the quality of the fuel slug is determined by the appropriate molten metal immersion time after the upper mold of the injection casting descends.

If the molten metal immersion time is too long, the molten metal is changed from the liquid phase to the solid phase, and the molten metal and the molten metal that are changed into the solid phase do not fall off and solidify, so that the fuel slug may not be produced. On the other hand, if the immersion time of the molten metal is too short, there is a possibility that the fuel core flows in the mold and the main surface not formed properly. In the case of pressurized pressure, a suitable pressure to ensure the maximum length of the fuel slug should be determined as a value related to the length of the formed fuel slug. If too large a pressure is applied, the top of the fuel slug will receive too much pressure, which also affects the quality of the fuel slug. A various defects produced during casting shown in Fig. 3.

The shapes and defects formed on the surface of the fuel slug occurred in pressurized argon gas injected during the melting process and gas remained in the mold during pressurization and the casting defects related to injection were minimized by adding the vacuum process.

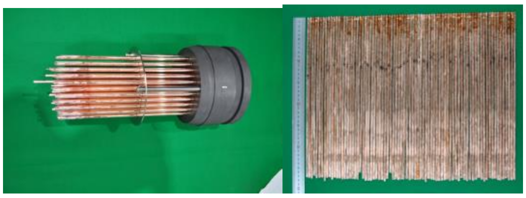

Fig. 2. Mold bundle after casting (left) and Cu slug after mold removal (right)

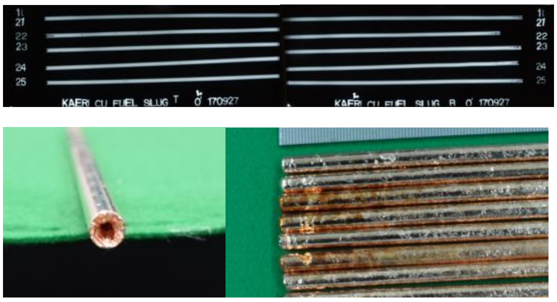

Fig. 3. Radiography image (top), hollow casting (left) and shrinkage void (right)

3. Conclusions

In order to improve the casting integrity of the metal fuel slug manufacturing technology, casting defects evaluated according to the manufacturing process parameters of the metal fuel slug. As the result of the melt-casting test using the fabrication equipment, the shrinkage cavity and pore increased with increasing pressure and casting temperature. It seems that the casting temperature affected the flow of molten metal and the solidification temperature. The shapes and defects formed on the surface of the fuel slug occurred in pressurized argon gas injected during the melting process and gas remained in the mold during pressurization and the casting defects related to injection were minimized by adding the vacuum process.

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