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Remote Test of Engineering-Scale Injection Casting for SFR

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1. Introduction

To complete the SFR fuel-Pyro fuel recycling, KAERI developed a recycling metal-fuel manufacturing technology for the purpose of developing future PGSFR fuel production manufacturing technology. Manufacturing technology of recycled metal fuel is a technology to produce SFR fuel after Pyro processing of spent nuclear fuel. Because all the manufacturing process is performed in hot cell facility due to high radiation material of recycled nuclear fuel, it is important to develop the remote fabrication technology [1,2]. In this study, a surrogate metal fuel slug was manufactured by performing remotely casting test to verify the feasibility of manufacturing a fuel slug using an remote engineering-scale metal fuel fabrication equipment for the purpose of manufacturing a recycled metal fuel slug in a hot cell.

2. Methods and Results

In this section experimental methods and results are described.

2.1 Experiment Procedure

KAERI(Korea Atomic Energy Research Institute) had prepared the engineering-scale injection casting equipment (Fig. 1). The casting process parameters used in the fabrication test were selected through a series of preliminary process tests performed prior to this test. Melting batch, coating method, melt casting temperature, mold preheating time, and melt deposition time were selected to produce the sound fuel slug. The melt casting temperature which is the principal parameter in the casting operation, depends on the material used for casting. Since the casting quality of the fuel slug is determined by the time of the appropriate casting deposition after the upper raising of mold, the appropriate casting time must be determined. If the molten metal immersion time becomes too long, the molten metal changes from a liquid phase to a solid phase, and there is a possibility that the molten metal and the mold solidified into the solid phase and do not separate and the fuel slug is not produced. On the other hand, if the immersion time in the molten metal is too short, there is a possibility that the fuel slug flows in the mold and the fuel slug is not formed properly. In the case of pressurized pressure, the appropriate pressure to ensure the maximum length of the fuel should be determined with respect to the length of the formed slug. In this case if too large a pressure is applied, the top of the fuel slug receives a lot of pressure, which also affects the quality of the fuel slug. Table 1 shows the selected process variables.

The injection casting method is a method of casting a molten metal into a quartz mold by using the pressure difference between the mold and the casting furnace. Graphite crucibles and quartz molds were used. Before and after casting of cast parts and melting materials, electronic scales were used to measure the difference. For preliminary testing, Cu material with melting temperature similar to uranium was selected as the surrogate fuel slug material. The crucible increased the temperature to 1400 degrees above the liquid temperature of the surrogate material. All work was performed in the argon atmosphere. Vacuum condition was made in the inside of the chamber using a vacuum pump. Melting process was started by induction heating using the power generator. When the desired molten metal injection temperature is reached, the mold assembly is lowered using the mold lifting device and the mold assembly is lowered into the crucible and the end of the mold assembly is inserted into the molten metal. When the molten metal in the mold solidified, the mold assembly was lifted up. After cooling down to room temperature after casting, the NW flange is released using an air locking device and the upper chamber is lifted to the top. The upper chamber is rotated to fix with the mold transfer case, and then the mold assembly is placed on the mold transfer case. The fuel slug was extracted from the mold assembly. Figure 2 shows Cu slugs obtained in the test. The diameter of the Cu slugs was measured at 3 axial points: top, middle, bottom, measured in two perpendicular directions at each axial position. The weight of the slug was measured with an electronic balance. The density of the slug was calculated from the average diameter and weight. The distribution of the slug diameter and density are presented in Fig. 3. As a result of the test, 78 sound fuel slugs which is the maximum number of fuel slug to be fabricated were made.

Table 1. Process variable conditions of the test

Test #	*#1*
Initial charge (kg)	*8.23*
Number of molds	*78*
Length of molds (mm)	*450*
Pressure before injection (Torr)	*400*
Molten metal temp. at injection (℃)	*1,215*

Pressurization rate(bar/sec)	*1.81*

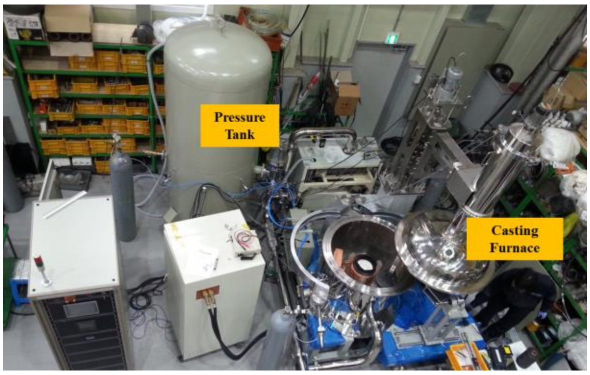

Fig. 1. Engineering-scale injection casting equipment (Max. U-Zr charge: 20kg, installed at KAERI

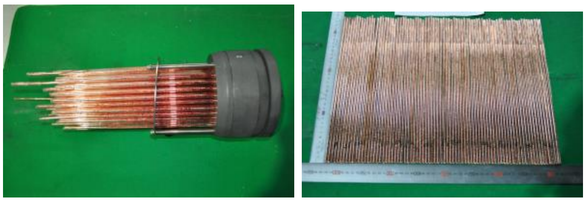

Fig. 2. Mold bundle after casting (left) and Cu slugs after mold removal(right)

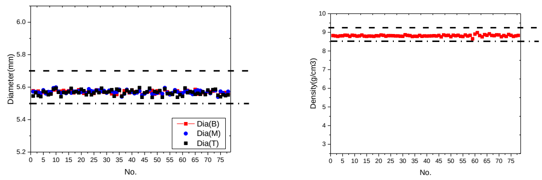

Fig. 3. Distribution of the slug diameter (left) and the slug density (right)

3. Conclusions

Surrogate metal fuel slugs were fabricated by performing remotely casting test to verify the feasibility of manufacturing a fuel slug using remote engineering-scale metal fuel fabrication equipment for the purpose of manufacturing a recycled metal fuel slug in a hot cell. As a result of the casting test, it was confirmed that 78 simulated fuel slug, which is the maximum surrogate fuel slug in the batch, were made remotely and soundly.

REFERENCES

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