Evaluation of Injection Casting Process Parameter for Fabricated SFR Metallic Fuel

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1. Introduction

TRU fast reactor metal fuels are recycled as nuclear fuel material from pyro-processing of spent fuel and it is necessary to develop recycling SFR metal fuel fabricating technology to complete the SFR-Pyro recycle. The recycling metal fuel fabrication technology is a technology to manufacture SFR fuel slug from spent nuclear fuel of Pyro process by injection casting method, and the whole manufacturing process is carried out in hot cell facility by handling of radiation material. The production of fuel slug by injection molding method is simple and can be mass-produced. It is also known as a technology that is advantageous for remote operation. Since the fuel slugs are manufactured in a short time with various process parameters and the quality of the fuel slug is determined, fuel slug manufacturing with the right process parameters is important [1,2]. In this study, the injection casting test of the fuel slug was carried out to evaluate the manufacturing performance and the soundness of the fuel slug according to the process parameters for the injection casting metal fuel slug selected as the SFR fuel.

2. Method and Results

In this section experimental methods and results are described.

2.1 Experiment Procedure

We evaluated the soundness of the fuel slug after melting and casting the Cu slug and DU slug fuel rods by using the small injection casting device and recently developed engineering scale remote injection casting device in the Korea Atomic Energy Research Institute (Fig. 1). Remote engineering-scale injection casting system can melt and cast up to 79 fuel slugs. A small injection casting machine can melt and cast up to 13 fuel slugs. The casting method used in the experiment is an injection casting method. The 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 crucible and quartz mold were used. Before and after casting of cast parts and charging materials, electronic scales were used to measure the difference. After casting, the fuel slug was extracted from the mold after cooling to room temperature. A total 13 casting test of Cu surrogate fuel slug and 19 casting test of DU surrogate were carried out using a small injection casting machine. A total 8 test of surrogate Cu fuel slug were performed using an engineering scale remote injection casting machine. For the performed test data, the casting process variables were evaluated by the number of fuel slugs, the melting batch, the pressurized pressure and casting temperature. Table 1 shows the selected process variables. Figure 2 shows Cu slugs obtained in the test. The dependence of casting temperature by melting batch is presented in Fig. 3 and Fig. 4. Evaluation result show that the casting temperature of fuel slug was increased from 47 ℃ to 117 ℃, represented by superheating temperature above liquidus temperature, in proportion to the melt batch and the pressure was increased in proportion to the length of the fuel slugs. Injection casting temperature of the fuel slugs was decreased in inverse proportion to the time of immersion in the molten metal.

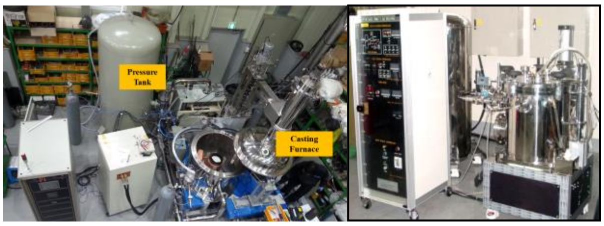

Fig. 1. Engineering-scale injection casting equipment (left) and small scale injection casting equipment (right)

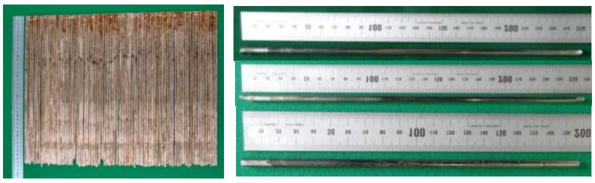

Fig. 2. Cu slugs from engineering-scale injection casting equipment and DU slug from small-scale injection casting equipment

Table 1. Conditions of the tests

No. of test	*Melting material*	*Melting batch (g)*	*Casting Tem. (℃)*	*pressure (bar)*	*Length of slug(mm)*
13-1	*Cu*		*1,160*		*300*
13-2	*Cu*		*1,170*		*300*
13-5	*Cu*		*1,120*		*300*
13-6	*Cu*		*1,120*		*300*
S13-1	*DU*		*1,400*	*1.3*	*50*
S13-2	*DU*		*1,450*	*1.3*	*50*
S13-3	*DU*	*584*	*1,530*	*2.2*	*250*
S13-4	*DU*	*655*	*1,530*	*2.2*	*250*
S15-1	*DU*	*2,833*	*1,430*	*0.8*	*100*
S15-2	*DU*	*3,023*	*1,430*	*2.5*	*350*
S15-3	*DU*	*2,796*	*1,430*	*2.0*	*300*

S15-4	*DU*	*2,786*	*1,550*	*2.2*	*100*
15-1	*Cu*	*8,700*	*1,180*	*1.5*	*350*
15-2	*Cu*	*9,970*	*1,205*	*1.5*	*370*
15-3	*Cu*	*4,700*	*1,196*	*2.19*	*350*

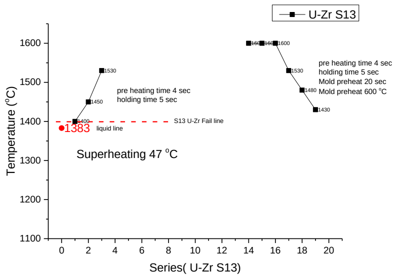

Fig. 3. Dependence of casting temperature(S13)

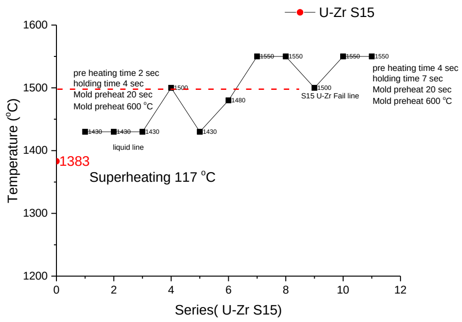

Fig. 4. Dependence of casting temperature(S15)

3. Conclusions

The process parameters were evaluated by the number of fuel slugs, the melting batch, the pressurized pressure, casting temperature and the melt deposition time for the injection casting metal fuel slug. As a result of the evaluation, the casting temperature of fuel slug was increased in proportion to the melt batch and the pressure was increased in proportion to the length of the fuel slugs. Injection casting temperature of the fuel slugs was decreased in inverse proportion to the time of immersion in the molten metal. These results are likely to contribute to inferring the proper process parameters for engineering-scale remote fuel shims using DU in the future.

REFERENCES

[1] M. Tokiwai, A. Kondo, R. Yuda, Journal of Nuclear Science and Technology, Sup. 3, pp.910, 2002.
[2] H.F. Jelinek, G.M. Iverson, Equipment for Remote Injection Casting of EBR-II Fuel, Nucl. Sci. Eng., Vol.12, p.405, 1962.