Thermal Diffusivity Evaluation of U-Zr Alloys as a Surrogate Metallic Fuel for SFR

Sun-Ki Kim, Jong-Tak Lee, Seok-Jin Oh, Young-Mo Ko, Ki-Hwan Kim, Youn-Myung Woo, Ho-Jin Ryu, Chan-Bock Lee, Jong-Hun Kim

Korea Atomic Energy Research Institute, 150 Deokjin-dong Yuseong-gu, Daejeon 305-353, Korea
kimsk@kaeri.re.kr

1. Introduction

Metallic fuel of U-Zr-Pu alloys has been used for sodium-cooled fast reactor (SFR) related to the closed fuel cycle for managing minor actinides and reducing a high radioactivity levels since the 1980s. In this study, the U-Zr binary alloys (dia. 10mm and dia. 6mm) as surrogate metallic fuel were fabricated in lower pressure Ar environment by gravity casting. The melt temperature was approximately 1,500°C. Thermal conductivity of the fuel during normal operation is related with fuel performance in a reactor. Therefore, it is necessary to investigate the thermal conductivity of the fuel in order to predict the fuel performance.

Even if thermal conductivity data for metallic fuels in SFR are very important, few experimental dada is available [1, 2]. To evaluate thermal conductivity, thermal diffusivity data are needed.

$$\lambda = \alpha c_p \rho \quad \text{……………..……………….(1)}$$

where,
λ : Thermal conductivity
α : Thermal diffusivity
c_p : Specific heat
ρ : Density

In this paper, some experimental data on thermal diffusivity are presented. This measuring principle has been well established [3].

2. Experimental Part

U-XZr binary alloys(X=10, 15, wt.%) were employed as the surrogate metallic fuel specimens for thermal diffusivity measurement. The specimens are disk-type shaped with a thickness of 2 mm. Thermal diffusivity was measured by laser-flash method.

3. Results and Discussions

Thermal diffusivity was measured for U-Zr binary alloys in the temperature range from 50 to 600°C to characterize the thermal properties of SFR fuel. The experimental results are shown in the Fig. 1and Fig. 2. Fig. 1 and 2 show thermal diffusivity variation of U-10Zr alloy and U-15Zr alloy, respectively, with increasing temperature. Thermal diffusivity of U-10Zr ranges from 9.2~10.5mm^2/s, and it was steadily increased with increasing temperature. Thermal diffusivity of U-15Zr ranges from 8.7~10.0 mm^2/s, and also it was steadily increased with increasing temperature.

The thermal diffusivity increases almost linearly with increasing temperature for both U-10Zr and U-10Zr alloys, but the increasing rate is somewhat mitigated beyond about 500 °C. It was also confirmed that addition of the Zr element in the metallic fuel decreases thermal diffusivity of the U-Zr binary metallic fuel.

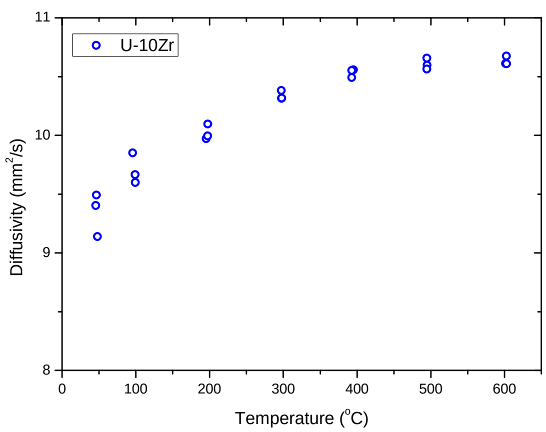

Figure 1. Thermal diffusivity of U-10Zr alloy

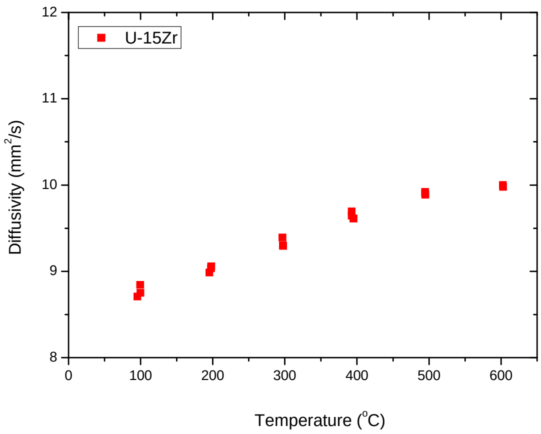

Figure 2. Thermal diffusivity of U-15Zr alloy

4. Conclusion

On the basis of thermal diffusivity measurement results of U-Zr binary alloys, the following conclusions were drawn.

First, thermal diffusivity of U-Zr binary alloys increases with increasing temperature in the temperature range from ~50°C to 600°C.

Second, addition of Zr element in the U-Zr binary alloy decreases thermal diffusivity of the alloy.

Reference

[1] D. C. Crawford *et al*., “Fuels for sodium-cooled fast reactor : US perspective”, *Journal of Nuclear Materials*, 371, 2007.

[2] J. Carmack *et al*., “Advanced Sodium Fast Reactor (SFR) Fuel Comparison”, *GEN IV International Forum*, April, 2008.

[3] Y. Takahashi, *Int. J. Thermophys*. 5, p. 41, 1984.