Thermal Expansion Property of U-Zr Alloys and U-Zr-Ce 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, Chan-Bock Lee

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

1. Introduction

Metal fuels was selected for fueling many of the first reactors in the US, including the Experimental Breeder Reactor-I (EBR-I) and the Experimental Breeder Reactor-II (EBR-II) in Idaho, the FERMI-I reactor, and the Dounreay Fast Reactor (DFR) in the UK [1, 2]. Metallic U–Pu–Zr alloys were the reference fuel for the US Integral Fast Reactor (IFR) program. An extensive database on the performance of advanced metal fuels was generated as a result of the operation of these reactors and the IFR program.

In this study, the U-Zr binary alloys and U-Zr-Ce ternary alloys as surrogate metallic fuel were fabricated in lower pressure Ar environment by gravity casting. The melt temperature was approximately 1,500°C. Thermal expansion of the fuel during normal operation is related with fuel performance in a reactor. Therefore, it is necessary to investigate the thermal expansion of the fuel in order to warrant a good prediction the fuel performance.

2. Experimental Part

U-XZr binary alloys(X=5, 10, 15, wt.%) and U-Zr-YCe ternary alloys(Y=2, 6, wt.%) were employed as the surrogate metallic fuel specimens for thermal expansion measurement. The specimens are cylindrically-shaped with a length of 10 mm. Al_2O_3 with a length of 10 mm was used as a reference specimen. The standard specimen was Thermal expansion was measured by dilatometer.

3. Results and Discussions

Thermal expansion was measured for U-Zr binary alloys in the temperature range from ~50 to ~700°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 expansion behaviors of U-Zr binary alloys and U-Zr-Ce ternary alloys as a function of temperature, respectively. Linear thermal expansion of U-XZr binary alloys(X=5, 10, 15, wt.%) ranges from 0.5~1.0% at 650°C, and it was steadily increased with increasing temperature. Thermal expansion of U-Zr-Ce ternary alloys ranges from 1.1~1.2% at 650°C, and also it was steadily increased with increasing temperature.

The linear thermal expansion increases almost linearly with increasing temperature for both U-Zr binary alloys and U-Zr-Ce ternary alloys. It was also confirmed that addition of the Zr element in the metallic fuel decreases thermal expansion of the U-Zr binary metallic fuel, but addition of the Ce element in the metallic fuel does not vary significantly the thermal expansion of the U-Zr-Ce ternary alloys.

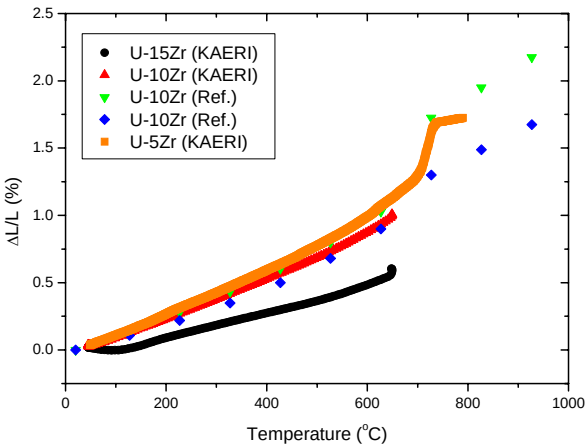

Figure 1. Thermal expansions of U-Zr binary alloys as a function of temperature

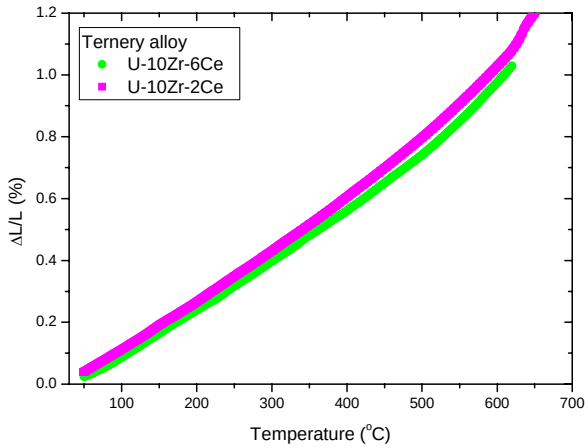

Figure 2. Thermal expansions of U-Zr-Ce ternary alloys as a function of temperature

4. Conclusion

On the basis of thermal expansion measurement results of U-XZr binary alloys(X=5, 10, 15, wt.%) and U-Zr-YCe ternary alloys(Y=2, 6, wt.%), the following conclusions were drawn.

First, thermal expansions of U-XZr binary alloys(X=5, 10, 15, wt.%) range from 0.5~1.0% at 650°C, and those of U-Zr-Ce ternary alloys range from 1.1~1.2% at 650°C.
Second, addition of Zr element in the U-Zr binary alloy decreases thermal diffusivity of the alloy.

Second, addition of the Zr element in the metallic fuel decreases thermal expansion of the U-Zr binary metallic fuel, but addition of the Ce element in the metallic fuel does not vary significantly the thermal expansion of the U-Zr-Ce ternary alloys.

References

[1] L. C. Walters, B. R. Seidel, J. H. Kittel, *Nuclear Technology, 65,* p. 179, 1984.

[2] J. H. Kittel, B. R. T. Frost, J. P. Mustellier, K. Q. Bagley, G. C. Crittenden, J. Van Dievoet, *Journal of Nuclear Materials, 204,* p.1, 1993.