Study on the damage of core internals in nuclear reactor during severe accident

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Abstract: To assess the access route to the fuel debris in nuclear power plant, corrosion of the structural stainless steel by the corium should be clarified. By immersion experiment, the dissolution behavior of corium into the stainless steel was estimated. The influence of zirconium on the dissolution behavior was investigated.

Keywords: Severe accident, Fuel debris, Dissolution, Diffusion coefficient, Stainless steel, zirconium.

1. Introduction

The severe accident that broke out at Fukushima Daiichi Nuclear Power Plant has led to an eventual catastrophic. During the accident, the control rods (B_4C) dissolved into the cladding tube (stainless steel) at high temperature and melt into the corium.[1] It would flow down to the bottom of the plant and react with the supported stainless steel. To treat the fuel debris in reactor, it is necessary to understand the dissolution behavior between the stainless steel and the corium. In this study, the diffusion behavior of corium into stainless steel was estimated by the diffusion coefficient of boron. The influence of zirconium added into the melt corium was also investigated.

2. Experiment

The corium was simulated by the stainless steel, B_4C and zirconium powder. Protected by the Ar-H_2 gas, they were synthesized at 1723 K in an alumina crucible. After adjusting the immersion temperature in furnace, a stainless steel rod was immersed into the molten alloy for one minute. Then, the rod together with the crucible was taken out of the furnace and quenched immediately by water. The rod surrounded by the alloy was cut and the chemical composition around the interface between steel and alloy were analyzed by EPMA.

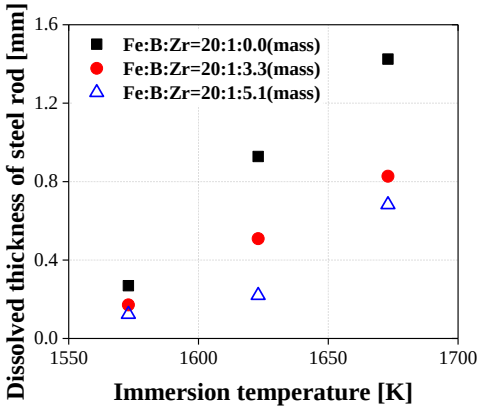

Fig.1 Dissolved thickness of steel rod

3. Results and discussion

After immersion, the dissolved thickness of steel rod was measured and the result was shown in Fig.1. It can be seen that the dissolved thickness increased with the increasing immersion temperature. In addition, as the concentration of zirconium in the corium increased, this dissolved thickness decreased significantly. It indicates that zirconium may suppress the diffusion of elements into the liquid corium. The diffusion coefficient of boron was estimated on the basis of the Fick`s second law and the result was shown in Fig.2. It was found that the diffusion coefficient increased with increasing immersion temperature. Compared with the corium with 16.4wt% zirconium, this coefficient in the corium with 22wt% zirconium was smaller. However, when temperature was higher than 1673K, this coefficient in corium without zirconium became the largest. It implied that the zirconium decreased the diffusion activation energy of boron. In the future, the diffusion coefficient of zirconium will be studied.

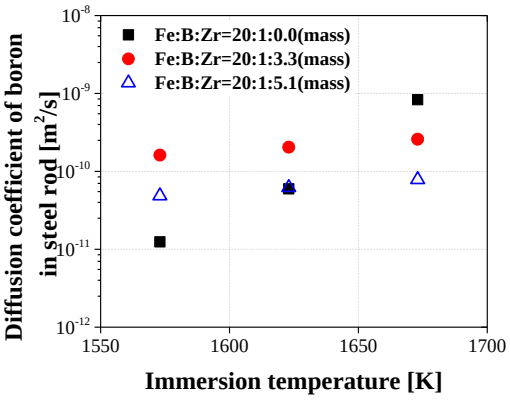

Fig.2 The diffusion coefficient of boron

References

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