Spent Fuel Temperature Behaviors during Loss-of-coolant-accident in a Spent Fuel Pool Accident Scenario

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1. Introduction

The spent fuel pool accident scenario is classified into two kinds of accident initiators. One is a loss of cooling that leads to a boil-off in the spent fuel pool. The other is a loss of coolant that brings a full or partial drainage in the spent fuel pool. In the boil-off scenario, a coolant water becomes evaporated and a steam would be produced. In the loss of coolant accident either in partially or fully, air would be admitted into the pool. Both steam and air would react with zirconium alloy cladding. The air oxidation of zirconium alloy cladding leads to a higher exothermal heat production and a more severe cladding degradation than the steam oxidation of zirconium alloy cladding [1-3]. In this paper, we investigated the zirconium fire phenomenon which may occur in the spent fuel pool complete loss of coolant accident scenario. If the zirconium fire occurs, the cladding would be severely degraded and it may lead to a massive release of radioactive source terms. Therefore, it is crucial to prevent the zirconium fire phenomenon for the spent fuel pool safety. In the complete loss of coolant accident, the zirconium alloy cladding would be directly reacted with air. However, a main cause to trigger the zirconium fire was not identified. In order to identify a possible mechanism of the zirconium fire, we carefully investigated the integral test data which is a prototypical experimental program of spent fuel pool complete loss of accident. In this study, the fuel temperature behaviors for behaviors for two kinds of spent fuel pool accident scenario are presented.

2. Understanding of OECD-NEA SFP Project

In this section some of the techniques used to model the detector channel are described. The channel model includes a SiC detector, cable, preamplifier, amplifier, and discriminator models. The Spent Fuel Pool Project (hereinafter SFP project) [4-5] is the experimental program to investigate the phenomena of spent fuel pool complete loss of coolant accident using a 17x17 PWR fuel assembly. In this section, the zirconium fire phenomenon which was observed from the SFP project is briefly investigated. Fig. 1 and Fig. 2 show the fuel assembly temperature (i.e. zirconium alloy cladding temperature) and oxygen concentration profile of the SFP project phase-1 ignition test. At around 12.7 hour, the temperature abruptly increased and the oxygen concentration also dramatically decreased. This abrupt temperature escalation is the zirconium fire phenomenon. In order to investigate the mechanism of this zirconium fire phenomenon, behaviors of both temperature and oxygen concentration are carefully compared in the following.

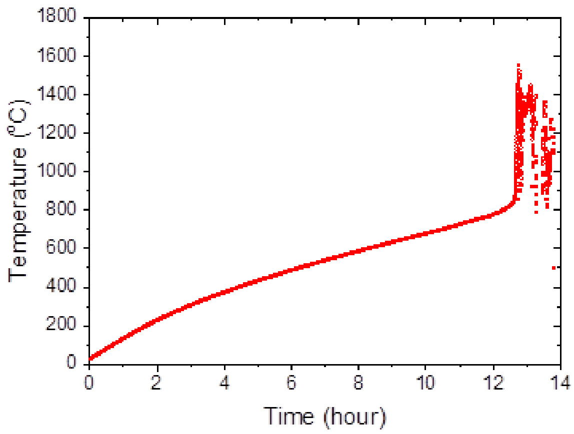

Fig. 1. Fuel assembly temperature behaviors with time of the SFP project phase-1 ignition test

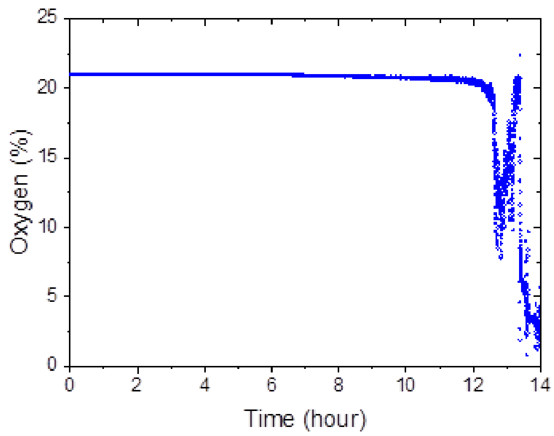

Fig. 2. Fuel assembly oxygen concentration profile with time of the SFP project phase-1 ignition test

3. Conclusions

This paper investigate the data of SFP project experiment and then a mechanism of zirconium fire phenomenon was discussed. It seems that the zirconium fire phenomenon might be a consequence of thermal mismatch between heat generation and dissipation. A large amount of heat might be generated by the air oxidation of zirconium alloy cladding immediately after the kinetic transition which is a breakaway phenomenon.

This paper discussed the relationship between the breakaway phenomenon and the zirconium fire in case of air oxidation of zirconium alloy cladding. This paper presents preliminary findings on the zirconium fire phenomenon from the open experiment data of the prototypic spent fuel severe accident scenario. It is expected that these findings would enhance the knowledge of zirconium cladding air oxidation and an understanding of the spent fuel pool accident scenario progression.

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