Analyses of Reflood Experimental results with 3x3 Deformed and Intact rod bundle

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1. Introduction

The Loss Of Coolant Accident, which called LOCA, can be classified as LB(Large Break), MB(Medium Break), and SB(Small Break) depending on the size of break on the cold legs and it makes different phenomena in Pressurized Water Reactor. When the coolant was completely lost we called LBLOCA. However, if the coolant remained in the reactor vessel before start of reflooding, we classified as MB or SB LOCA. Following this reason, the phenomena on each accident will vary depending on various situations. In addition, the fuel rod can be ballooned owing to the increase of wall temperature with loss of coolant situation. The ballooning rod bundle also changes the flow distribution and phenomena on the sub-channel. Therefore, we conducted the reflooding experiment using 3x3 deformed and intact rod bundle to investigate the effect of ballooning on the internal flow. To simulate the LOCA conditions, we control the pressure, initial temperature of rod, initial water level and power. The reflood rate and initial water temperature were adjusted to measure the effect of reflood conditions.

2. Literature survey

Experiments on reflooding phase under low, medium and high pressure conditions with intact fuel rods have been carried out in different experimental facilities in KAERI [1-3]. The well-known THETIS experimental reports presented the SBLOCA simulation experiments. The experimental data was constructed into database by the interaction with both water and steam during water level with a little waves lapping on the fuel rod with boiling heat transfer[4]. The JAERI and ROSA-IV reports [5,6] investigated the reflooding phenomena on high pressure and temperature conditions in the SB LOCA using non-deformed fuel rod. IRSN carried out reflooding experiments to particularly analyze the phenomena from LB LOCA to SB LOCA[7]. Table 1 summarizes the test conditions of the aforementioned experiments. We determined the test variable and range of conditions more than the literature survey. We expected that the experimental results can be used for analyses the LOCA scenarios.

Table 1 Experimental condition for several facilities

	THETIS	JAERI	ROSA -IV	IRSN
Rod bundle matrix(flow blockage)	7×7(4×4)	4×4	5×5	7×7
Heater length (m)	3.58	3.71	-	-
Pressure (bar)	2-40	20-80	5-120	1-40
Power (kW)	10-150	0-800	-	-
Initial level (m)	1.07-3.22	-	-	-
Initial temperature(°C)	-	700	0-650	600-700

3. Methods and Results

31 Experimental methods

The experimental facility for reflood experiments were made of 3 by 3 Inconnel 600 heater rod. The rods arranged in the square lattice array. Thermocouples were located at six different elevations on each fuel rod and center of subchannel to measure the temperature on the deformed rod bundle as shown in Fig. 2. The test conditions were varied as pressure in the range of 10-80 bar, the total power in the range of 10-40 kW, the initial water level in the range of 0-1.5 m, the reflooding rate in the range of 1-7cm/s. The results show different reflooding phenomena particularly the center rod temperature, peak cladding temperature and quenching time depending on changes of the main test parameters.

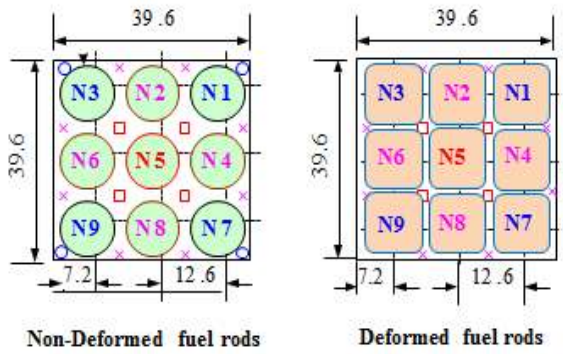

Fig. 1. Top view of the rod.

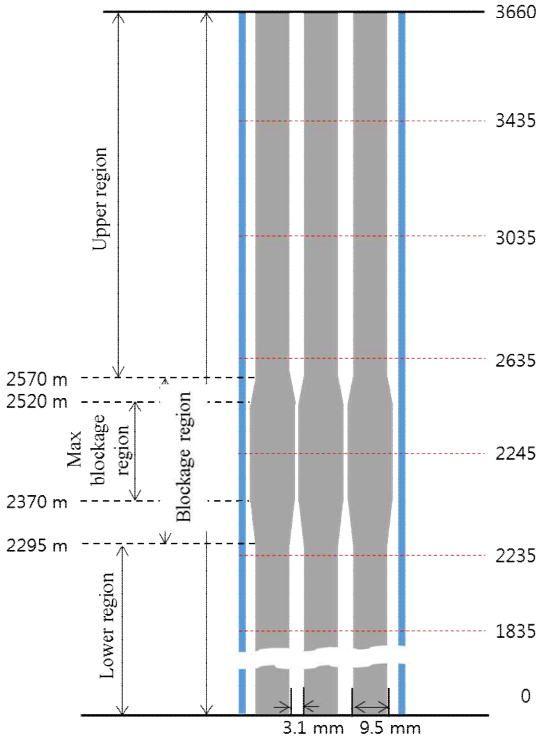

Fig. 2. Position of T/C on the deformed rod bundle.

3.2 Experimental results

The reflood experiments were conducted with different geometric condition as intact rod and deformed rod. We observed the maximum temperature on the wall with varied conditions. The initial water level, reflood rate, power, pressure effect to the temperature. From the results, there are some difference of maximum heater wall temperature cause of the variation. As shown in Fig. 3, the lower water level present the high maximum heater wall temperature. The lower water level reach to the quenching time early. Fig. 4 shows that the high reflood rate makes low maximum wall temperature and rapid water quenching time. The cause of those effect can be explained that the water quenching level measured approximately equal with the same conditions.

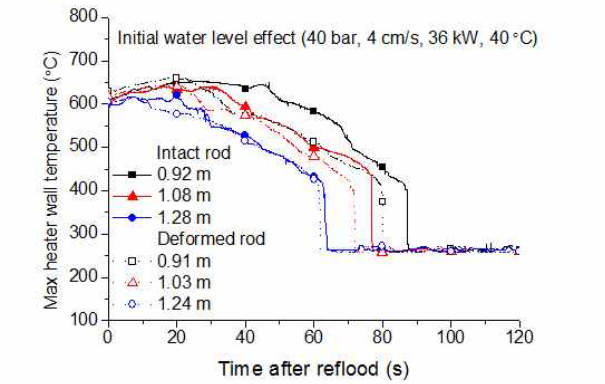

Fig. 3 Initial water level effect.

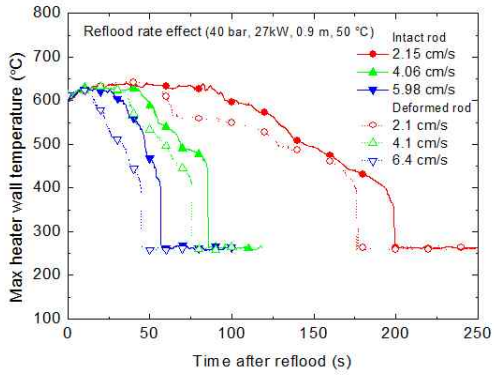

Fig. 4 Reflood rate effect.

From the results, the difference between the intact rod bundle and the deformed rod bundle measured that the intact rod bundle tend to get the higher temperature than the deformed rod bundle due to the blockage region. There several representative effect on the blockage region that enhance the velocity of a moving fluid and increase the droplet collision with the wall.

4. Conclusions

To analyze the SB, MB LOCA in PWR, we observe the several value on the 3x3 intact and deformed rod bundle. The several condition that pressure, initial temperature of rod, initial water level, power, reflood rate and initial water temperature was varied to investigate the those effects. First of all, the initial temperature of rod, the initial water level, the pressure, the power and the reflood rate have an effect to the maximum heater wall temperature and quenching time. However, from the initial water temperature makes no difference on the results. Second, the difference between the intact rod bundle and deformed rod bundle were measured owing to the blockage effects.

Acknowledgements

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