Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 25-26, 2012

LBLOCA Analysis on SGTP Asymmetry Condition

Dong Kyu Lee , Jae Hoon Lee, Geol Woo Lee
KEPCO Nuclear Fuel Co., Ltd.
dklee@knfc.co.kr, jhlee@knfc.co.kr, gwlee@knfc.co.kr

1. Introduction

Uljin unit 3/4 plants are Optimized Power Reactor (OPR 1000), which are 2-loop plants and each loop has one steam generator and two reactor coolant pumps. Each steam generator has 8,214 heat transfer tube made of Inconel-alloy 600 material. Total number of tubes is 16,428.

Many damaged heat transfer tubes were detected during the overhaul period of Uljin unit 3/4. Tube plugging rate of steam generator has been raised from 8% to 18%. There is no guarantee that damage of heat transfer tubes happen symmetrically from the point view of tube plugging. Therefore effect of large break loss of coolant accident (LBLOCA) has been analyzed on the supposition that damaged heat transfer tube will occur asymmetrically.

2. Asymmetric SGTP Modeling

2.1. Analysis Methodology

The LBLOCA analysis was performed using the KREM [1] which is authorized to analyze the LBLOCA analysis of OPR1000. This methodology is developed based on the models and assumptions described in KINS/GT-N007-2 [2]. In the KREM, RELAP5/MOD3.1/K code is used for the calculation of ECCS thermal-hydraulics behavior and cladding temperature. Containment back pressure and temperature calculations are performed by CONTEMPT4/MOD5 code. Containment back pressure depends on the mass and energy release rate and thermal-hydraulics phenomena are dependent on the containment back pressure. RELAP5/MOD3.1/K and CONTEMPT4/MOD5 are merged to exchange their results in every time step.

2.2. Input Parameters and Assumptions

Table 1 lists the major plant input parameters used in the large break LOCA analysis. The nominal and break spectrum transient run was made with mostly nominal values, or conservative values in some cases. The limiting single failure in the large break LOCA analysis is assumed, which is the loss of one emergency diesel generator of ECCS. The values for the containment parameters were chosen to minimize containment pressure in order to minimize the core reflood rate.

Table 1. Major Plant Input Parameters

Parameter	Data
Power, MWt	2,815
Fq	2.318
Fuel Type	16X16 PLUS7
Total RCS Flow, kg/hr	50.78 X 10^6
Reactor Vessel Average Temperature, K	585.4
PZR Pressure, psia	2,250
Safety Injection Tank Coolant Volume, m^3	52.63
Safety Injection Tank Gas Pressure, psia	615.7

2.3. SGTP Modeling

When the tube plugging rate of the steam generator is changed, the secondary side operating condition, tube flow area, and heat transfer area of primary and secondary side of the steam generator are changed. Intact and broken loop steam generators are modeled with 0% and 18% tube pluggings respectively to simulate asymmetry tube plugging.

Table 2 shows steady state calculation result of the asymmetry steam generator tube plugging rate. As shown in table 1, the KREM is well predicted design data in both cases. Table 3 shows variables that can be changed according to the tube plugging rate when the steady state calculation is performed. As shown in table 3, the plugged loop (Intact) flow rate is less than unplugged loop (Broken). As the heat transfer from the primary side to secondary is decreased in plugged loop, steam generator secondary side steam flow and pressure are also less than those of unplugged loop. It is conclude that the KREM could model asymmetry tube plugging properly from the results given in Table 2 and 3.

Table 2. LBLOCA Steady State Calculation Result

Variables	Design Data	Symmetry	Asymmetry
Power, MWt	2,815	2,815	2,815
S/G Tube Plugging, %	18/18	18,18	0/18
Avg. SGTP Ratio, %	18	18	9
Total RCS Flow, kg/sec	14,540	14,545.2	14,528.6
PZR Pressure, Mpa	15.51	15.51	15.51
Hot Leg Temperature, K	601.8	601.9	601.5
Cold Leg Temperature, K	569.0	569.1	569.2
Core Outlet Temperature, K	602.7	602.6	602.3

Table 3. Comparison to steady state main variables

Variables	Symmetry (18%)	Asymmetry (0% / 18%)
Hot Leg Flow, kg/s	7,272.6	7.462.3/7066.3
Cold Leg Flow, kg/s	3,636.3	3,731/3,533
Secondary Steam Flow, kg/s	796.5	805.7/785.6
Secondary Pressure, kg/s	7.1357	7.0521 /7.0476

3. Results

Figure 1 and Figure 2 show the break flow at vessel and loop side. There is no significant difference appeared between symmetry and asymmetry tube plugging. Figure 3 and Figure 4 compare the peak cladding temperature (PCT) and core level for the symmetry and asymmetry conditions. The blowdown PCT difference is less than 2°C and the reflood PCT is increased slightly in the case of asymmetry condition as shown in Figure 3. However the difference is small and the behavior of core level is similar.

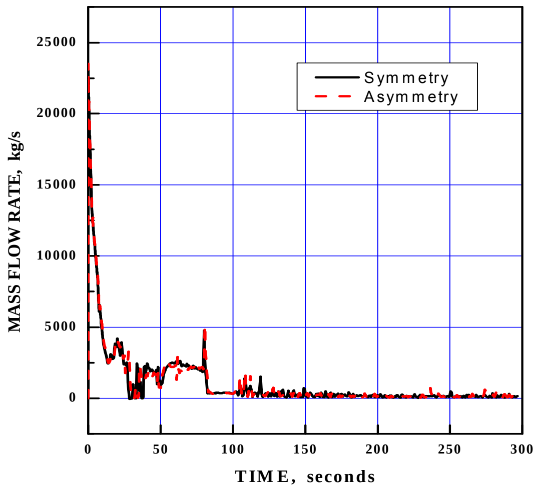

Figure 1. Break Flow (Vessel Side)

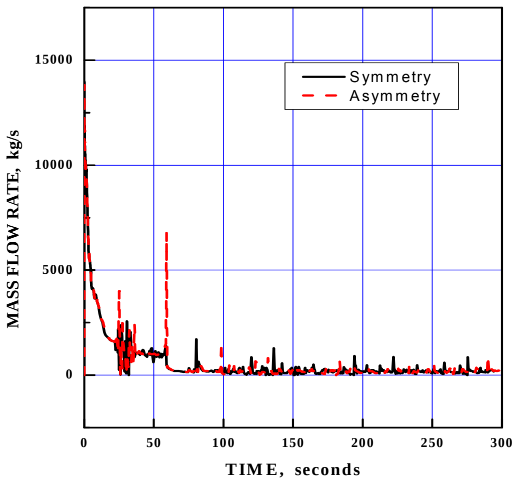

Figure 2. Break Flow (Loop Side)

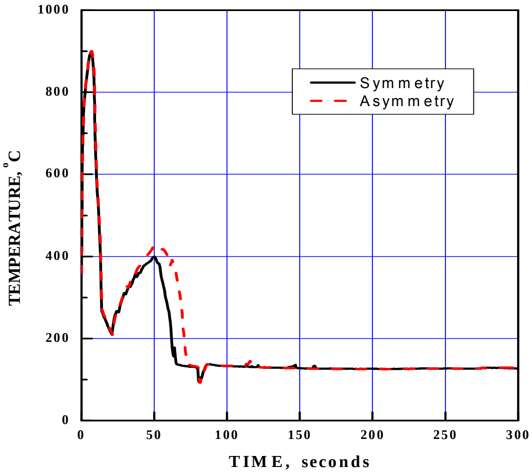

Figure 3. Peak Cladding Temperature

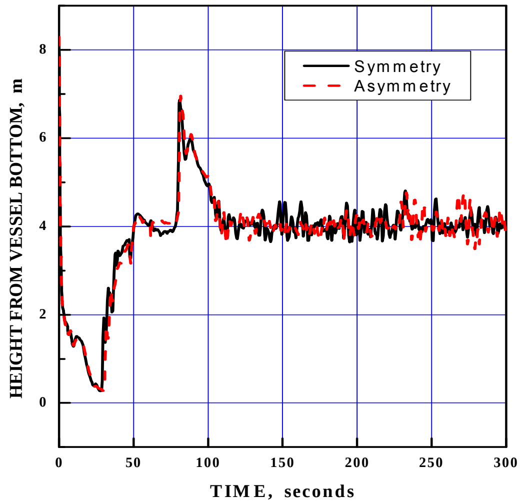

Figure 4. Core Level

4. Conclusion

As the result of analysis carried out the analysis of the asymmetry tube plugging in LBLOCA for Uljin unit 3/4 steam generator, reflood PCT is increased slightly, however the difference is small and the behavior of core level is similar in case of asymmetry condition. It is conclude that asymmetry tube plugging rate of the steam generator does not affect peak cladding temperature (PCT). It is confirmed that previous analysis assuming symmetry tube plugging rate for Uljin unit 3/4 plant is appropriate.

REFERENCES

[1] TR-KHNP-0010, “Topical Report for the LBLOCA Safety Analysis Methodology of Korea Standard Nuclear Power Plant”, KEPRI, July 2007.
[2] KINS/GT-N007-2, "Technical guide book for the conservative evaluation methodology on performance of ECCS of PWR nuclear power plant," January 2004.