Comparative Analysis of ATWS for OPR1000 by using RETRAN-3D and CESEC-Ⅲ Codes

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1. Introduction

An Anticipated Transients without Scram (ATWS) is an anticipated operational occurrence accompanied by a failure of the reactor to trip when required. ATWS events are of concern since, under certain conditions (e.g., additional component and/or system failures) these could lead to unacceptable consequences up to and including core melt and release of radioactivity to the environment. The major concern of the ATWS derives from the consequences of the expected high primary system pressure, which is characteristic of this transient.

RETRAN-3D [1] is a best-estimate thermal-hydraulic transient code and is used as a system analysis code in the development of a non-LOCA safety analysis method for the future application to Optimized Power Reactor (OPR1000) design.

A lot of efforts are now being made to investigate the applicability of the RETRAN-3D code especially to Non-LOCA analysis, by comparing the analysis results with those from the current licensing code, CESEC-III. The comparative simulations of Steam Line Break (SLB) [2] and Locked Rotor event [3] already showed that the RETRAN-3D code is applicable to the analysis of Non-LOCA events. However, ATWS analysis of OPR1000 using RETRAN-3D has not been performed.

In this paper, detailed thermal hydraulic analyses for a loss of main feedwater event assuming that the DPS is not available in addition to the failure of RPS were performed using the RETRAN-3D code. To investigate the applicability of the RETRAN-3D to ATWS analysis of OPR 1000, the calculation results were also compared with those of CESEC-Ⅲ.

2. Event Analysis

2.1 Initial conditions and assumptions.

The complete loss of main feedwater, without turbine trip is assumed to occur without reactor scram.

The same initial conditions and assumptions are applied to both RETRAN-3D and CESEC-Ⅲ codes. Initial core power is 2815 Mwt. Initial reactor coolant flow rate, pressurizer level, steam generator level, pressurizer pressure, feed water enthalpy are assumed to be at full power steady state condition. As the critical flow model for PSV, Homogeneous Equilibrium Model (HEM) is used. A wide range of the moderator reactivity experienced during a core cycle was evaluated for this study.

2.2 Description on ATWS

The ATWS scenario begins with the loss of normal feedwater which causes a reduction in the steam generator inventory and reduces the secondary heat sink. The NSSS control systems (except those related to CEA movement) are assumed in the automatic mode and functioning normally. The steam generators can no longer remove the heat produced in the reactor and the reactor coolant temperatures increase. The assumed failure of the reactor trip (on low steam generator level) continues the secondary inventory depletion process. The expansion of the primary coolant increases the pressurizer level and pressure. The auxiliary feedwater system is actuated on low steam generator level and delivers auxiliary feedwater. The steam generators nearly dry out and the reduced secondary heat sink cause an increase in the pressurization rate. Soon, the RCS pressure exceeds the high pressurizer pressure trip setpoint and generates another reactor trip signal, which is unsuccessful.

The increasing pressurizer pressure opens the Pressurizer Safety Valves (PSVs) which first pass steam and then liquid. The discharge through PSVs sharply reduces the RCS pressure and causes the hot leg saturation. The negative reactivity insertion due to the increase in the reactor coolant temperature and void formation in the core reduces the core power.

3. Analysis Results

Figure 1 shows the comparison of core power between CESEC-III and RETRAN-3D. The result shows that the trend of RETRAN-3D is very similar with that of CESEC-III. Before 250 seconds, the core power of RETRAN-3D is less than that of CESEC-III, but after 250 seconds, the result shows reverse trend because the total reactivity of RETRAN-3D becomes greater than zero, which increases the core power.

Figure 2 shows the pressurizer pressure trend. Before the closing of PSVs, the result of RETRAN-3D show similar trend to that of CESEC-III, but after 120 seconds, RETRAN-3D predicts more severe transient than CESEC-III. The difference mainly results from the pressurizer model. In fact, RETRAN-3D uses the two-region nonequilibrium model, which is different from the two-region equilibrium model of CESEC-III. To examine the difference, detailed sensitivity studies are needed for the parameters affecting the pressurizer pressure.

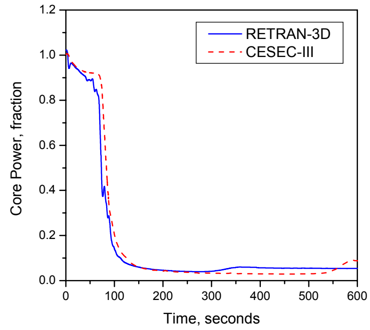

Figure 1. Normalized core power

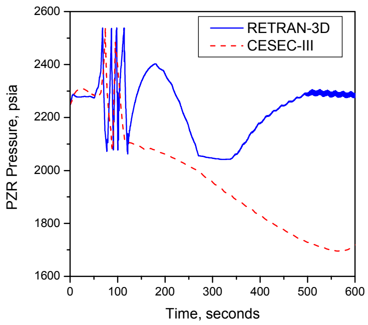

Figure 2. Pressurizer pressure

Figure 3 shows the comparison of SG pressure between CESEC-III and RETRAN-3D. The result shows that the result of RETRAN-3D shows the good agreement with that of CESEC-III.

Figure 4 shows the comparison of RCS temperature between CESEC-III and RETRAN-3D. The result shows that after 80 seconds, the result of RETRAN-3D becomes lower than that of CESEC-III but after 350 seconds, the result shows reverse trend because the total reactivity of RETRAN-3D becomes greater than zero, which increases the core power.

4. Conclusion

As the first work, ATWS analyses for OPR1000 were performed by using RETRAN-3D and CESEC-III and the code predictions were compared. As a result of the comparison, the observed differences are originated from the difference models used in the two codes. Especially, a significant difference between the predicted pressurizer pressures is attributable to different pressurizer models. In order to confirm the applicability of RETRAN-3D to the ATWS analysis, more detailed sensitivity studies are needed for the parameters affecting the pressurizer pressure.

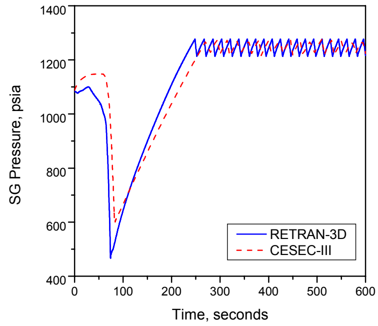

Figure 3. Steam generator pressure

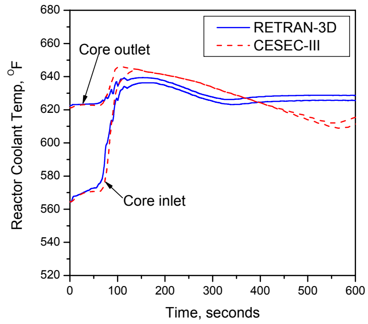

Figure 4. RCS temperatures

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