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Scalability Analysis of Large Loss-of-Coolant-Accident at 8% Power Level for APR1400 and ATLAS

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1. Introduction

KAERI (Korea Atomic Energy Research Institute) is now under the construction of ATLAS (Advanced Thermal-hydraulic Test Loop for Accident Simulation) as an effort to resolve the safety issues in APR1400 (Advanced Power Reactor 1400MW) with the aim of initiating the experiment soon this year. One of the experiments planed is a large break LOCA (Loss of Coolant Accident) test [1]. This large break LOCA requires much larger core power, which is almost impossible to be installed in ATLAS core in the form of electric heaters because of the limitation of electric power supply and so on. Thus, it is planed that the initial condition of large LOCA test is set at 8% power level.

Therefore, this study is to analyze the scalability of large LOCA of ATLAS at 8% initial power level using RELAP5/Mod3.3[2]. For the sake of the comparison, large LOCA at initial power level 100% was also referred in reference [3].

2. Steady State Analysis

The nodalization for APR1400 and ATLAS is presented in figure 1. The variable operation parameters according to power level are core power, enthalpy of main feedwater inlet, Steam Generator (SG) recirculation ratio, pressurizer water level, steam pressure in SG dome, and the temperatures in hot and cold legs. Detailed values for these operation parameters are attributed to references 4 and 5.

The steady state at 8% power level was obtained from the full power input with the modification in above operation conditions[3]. But, no change was taken in geometry inputs except for SG heat transfer areas and RCP (Reactor Coolant Pump) parameters. In order to satisfy the hot and cold legs temperature, SG heat transfer rate was artificially raised for the heat balance, as mentioned above. And, for the same primary flow rate, the head of reactor coolant pump was slightly increased compared with full power steady state.

Some gaps was resulted in on pressure drop in loop. Such gaps were mainly caused by not minor loss coefficient but friction. Thus, the pressure drops in fuel and U-tube are different from those at full power.

SG narrow range water level was set 37% (required condition is 44%), because trying to set the level 44% induced the asymmetry of both SG water levels. The calculated SG recirculation ratio was 17, while the required value at 8% power level was 32. However, no adjustment for the recirculation ratio was carried out, since the recirculation ratio was not a fatal parameter in large LOCA.

3. Transient Analysis

As shown in figure 2 the pressurizer pressure is not far different in full power and 8% power, and good scalability is maintained between two systems. Break flow shown in figure 3 shows slightly different results according to the power level, and it is readily caused by the difference in decay heat. However, the scalabilities for 100% power level and 8% power level are relatively good.

Water level is easy to be affected by just a small perturbations in other parameters, and the resulted downcomer and core water levels in figures 4 and 5 show also very large gaps between power level and system. The water level at the 100% power level is lower than that at 8 % level, which means the higher power level induces more water depletion in downcomer and core. And the water level in ATLAS is lower than that in APR1400.

Detailed discussions are described in reference 6.

4. Conclusion

This study analyzed the scalability of large LOCA at 8% core power level for APR1400 and ATLAS with the comparison of full power case. Most of the parameters showed relatively good scalability. However, the water levels in downcomer and core, which are very sensitive parameters, showed some gaps. As a whole the lower power level resulted in more effective core recovery, and the smaller system resulted in less effective core quenching.

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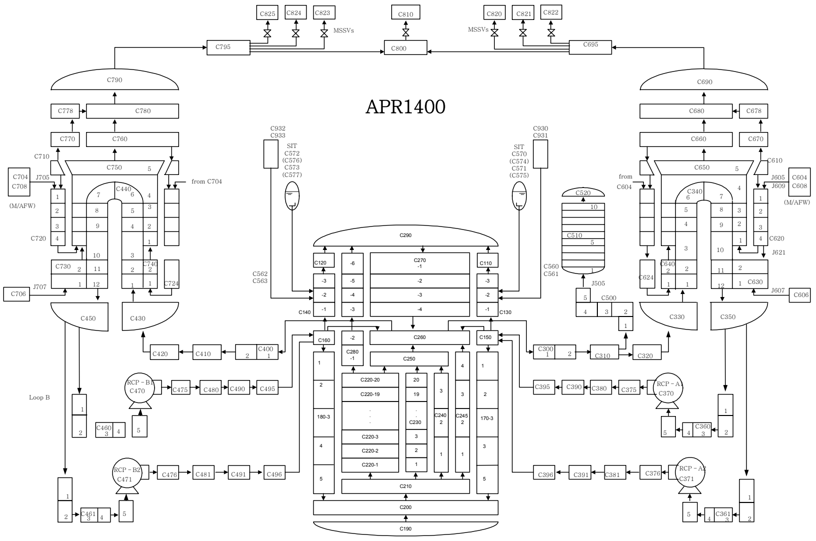

Figure 1. Nodalization of APR1400 and ATLAS for RELAP5 Analysis

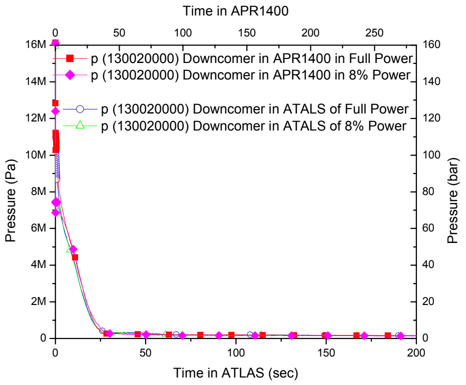

Figure 2. Pressurizer Pressure

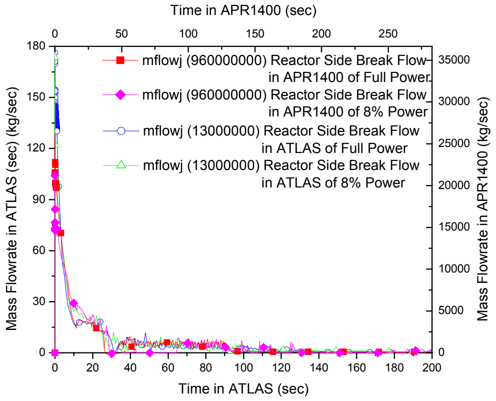

Figure 3. Break Flow from Reactor Side Break

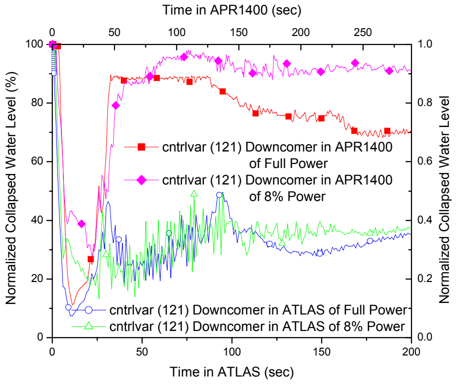

Figure 4. Downcomer Water Level

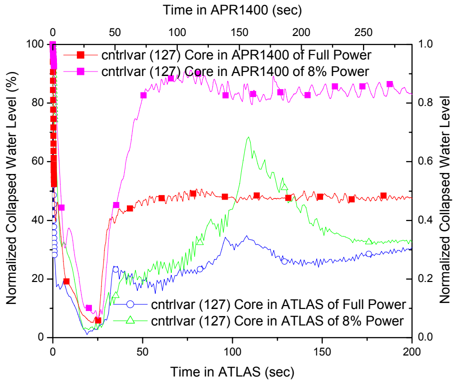

Figure 5. Core Water Level