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Calculation Method of Steam Generator Level for swelling and shrinking effects in YGN 1/2 Simulator

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1. Introduction

In August 2006, the development of new simulator for YGN 1/2 Simulator was completed. The NSSS (Nuclear Steam Supply System) T/H(Thermal-Hydraulic) module in this simulator was developed with ARTS code based on RETRAN, which is a best estimate thermal-hydraulic code designed to analyze several operational transients by EPRI(Electric Power Research Institute). RETRAN, however, has some limitations in real-time calculation capability and its robustness to be used in the simulator for some transient conditions. To overcome these limitations, its robustness and real-time calculation capability have been improved with simplifications and removing of discontinuities of the physical correlations of the RETRAN code. And some supplements are also developed to extend its simulation scope of the ARTS code. In comparison to KNPEC(Kori Nuclear Power Education Center) #2 simulator, the simulator based on YoungGwang Unit 1 developed in the year 2001, the ARTS code was upgraded that it extended its calculating region to the steam line and common header before turbine while it had calculated to the steam generator exit before steam line in KNPEC#2 simulator. Consequently, the number of volume and fill/normal junction in ARTS nodalization increased to 109 and 174 from 62 and 125, respectively [1].

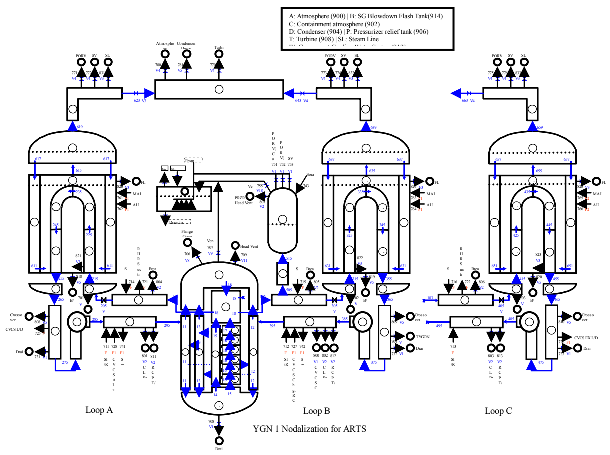

Figure 1. Nodalization for YGN 1/2 ARTS

In this paper, it is described the calculation method of steam generator level for swelling and shrinking effect in YGN 1/2 Simulator, and the results of steam generator level behavior according to calculation methods at two transient accidents are presented.

2. Method and Results

2.1 Calculation Method of Steam Generator for swelling and shrinking effects in YGN 1/2 Simulator

For swelling and shrinking effects, the level of steam generator in the simulator is calculated as follows;

First, a collapsed level is calculated from RETRAN code originally and it is used the sum of downcomer and steam dome collapsed level by ARTS code. Second, a difference of two flow rates between feedwater and main steam is calculated and a lag function is applied to it. In the end, the delta flow rate, the result of the second step, is multiplied by collapsed level and added to the collapsed level. It is called the level in simulator in this paper.

When it comes to swelling and shrinking effect, it was proven that a liquid volume level of steam generator had a good performance in KNPEC#2. The method, however, had a problem that steam generator level at low power was very unstable. So, the liquid volume level calculation method was excluded in YGN 1/2 Simulator.

In steam generator, water exists in saturated state that both liquid and bubble-formed steam exist in company with. On the assumption of the same mass in steam generator, the more bubbles are included in water, the higher the level is. In operation of Nuclear Power Plant, if a steam pressure in steam generator decreases because of sudden steam flow rate increase, a steam volume in water increases and the level rises. This phenomenon is called swelling effect. If a steam pressure in steam generator increases because of abrupt steam flow rate decrease, a steam volume in water decreases and the level falls. This phenomenon is called shrinking effect. In case that a feed water with low temperature is provided for steam generator, the feed water makes water in steam generator condensed and the level decreases rather than increases until the feed water provided gets heated in steam generator to the extent that its temperature reach the water temperature in steam generator.

2.2 Result of Swelling Effect

It was performed a MSLB (Main Steam Line Break) transient accident for swelling effect in steam generator. The main steam line in loop 'A' is broken fully (100%) in containment vessel.

When a steam line is broken, all of three generators respond in company with until MSIV (Main Steam Isolation Valve) closed because they share a common header. All steam generators, therefore, show a swelling effect even though a steam line breaks. When the steam generator pressure drops and the steam flow rate increases abruptly, each steam generator level swells until MSIVs are closed by reactor trip following safety injection signal. Figure 2 shows how steam generator levels behave at MSLB 'A' accident according to calculation methods. A collapsed level is calculated from RETRAN code originally and a mass level is calculated with a correlation formula of reactor power and liquid volume in steam generator by ARTS code. In Figure 2, the level in simulator only shows a swelling effect while the collapsed and mass levels fall with no effect.

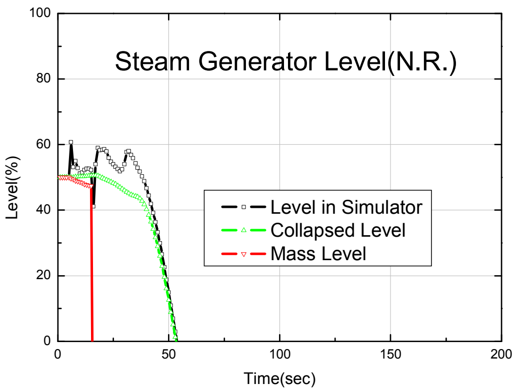

Figure 2. Comparison of Steam Generator Level at MSLB 'A' (100%) Accident

2.3 Result of Shrinking Effect

It was performed all MSIVs closed transient accident for shrinking effect in steam generator. The fail to close position of MSIVs cause turbine trip that its behavior after all MSIVs get closed, is similar to that of turbine trip accident. When a MSIV is closed, steam flow rate drops abruptly, steam generator pressure increases and bubbles in water burst that steam generator level shrinks. Figure 3 shows how steam generator levels behave at All MSIVs closed accident according to calculation methods. In Figure 3, the level in simulator only shows a shrinking effect while the collapsed level displays no effect and the mass level does a swelling effect instead.

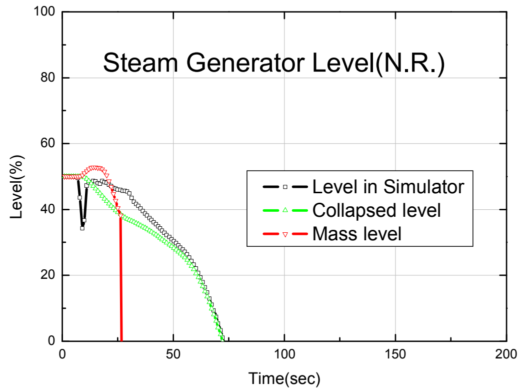

Figure 3. Comparison of Steam Generator Level at All MSIVs Closed Accident

3. Conclusion

Through MSLB and All MSIVs closed accident, several calculation methods of steam generator level are compared with each other for swelling and shrinking effect. From the results, it is shown that the calculation method of steam generator in YGN 1/2 simulator has a good performance for the swelling and shrinking effect of steam generator.

The results also show that the response such as real time, repeatability and values of parameters, for the simulator resulting from malfunctions can be considered acceptable and meet the general and testing requirements in ANSI/ANS3.5 [2].

REFERENCES

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[2] Nuclear Power Plant Simulators for Use in Operator Training and Examination, ANSI/ANS-3.5-1998, American Nuclear Society, 1998.