Evaluation of Power Maneuvering Capability for KALIMER-600

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1. Introduction

A sodium-cooled fast reactor (KALIMER-600) is under development at KAERI.[1] To analyze the performance of KALIMER-600, we developed a simple analyzer, a MMS-LMR-SG code, by modifying a commercial Modular Modeling System (MMS) code with specific features of KALIMER-600. [2,3,4] The code was developed by inserting a sodium property library into the user library of the MMS code and modifying some specific components model for fuel and pipehx.

Then, a power maneuvering capability with the constant averaged temperature of the primary pool (PHTS) was evaluated when the BOP (balance of plant) power was changed.

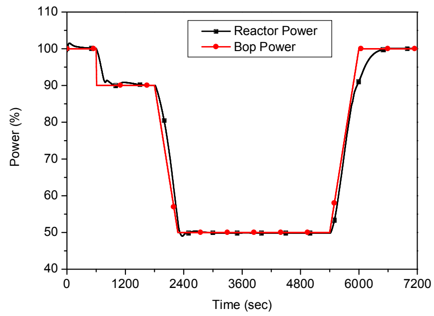
2. Evaluation Results

To develop the power maneuvering strategy, the power maneuvering states were evaluated when the BOP power was changed. We assumed the pressure and the temperature of the feedwater and the pressure of the steam were kept to be constant during power maneuvering. So, those were implemented as the boundary conditions in this effort. The suggested strategy for power maneuvering is to keep the average temperature of the PHTS constant in order to minimize the coolant effect on the core reactivity and the change of the volume of the PHTS. [5] In addition, the temperature of the cold pool should be less than 427℃ in order to avoid the creep conditions of the stainless steel used for the reactor vessel.

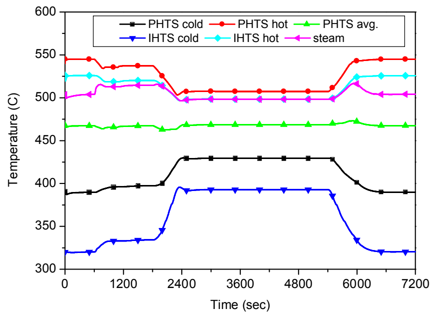
At first, we evaluated the power maneuvering event with the constant flow rates of the PHTS and the intermediate loop (IHTS). For this evaluation, the BOP power was kept as a full-rated power for 600 sec in order to analysis a steady state, and then the BOP power was suddenly dropped to 90% and maintained to 1800 sec. After that, the BOP power was decreased to 50% with ramp rate of 5%/min and kept to 5400 sec. Finally, the BOP power was recovered up to 100% and kept to the end of analysis.

The control rod position was programmed to compensate for the reactivity induced from the change of the BOP power. The objective of the control rod programming is to keep the measured average temperature of the PHTS constant, and concurrently to minimize the power difference between the reactor power and the BOP power.

Figure 1 shows the evaluation results. The reactor power followed to the BOP power, and the average temperature of the PHTS was kept constant. However, the cold temperature of the PHTS was increased to about 429 ℃. So, this strategy is not acceptable for the power maneuvering of KALIMER-600 because the cold temperature can threaten the integrity of the reactor vessel.



(a) Power



(b) Temperature

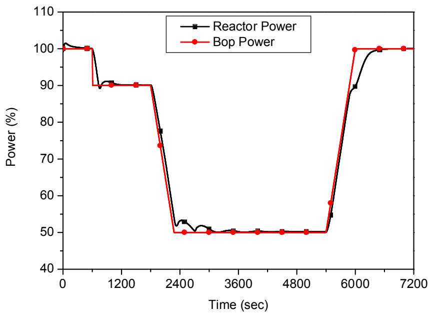
Fig. 1 Evaluation Results with constant flow rate

Secondly, we evaluated the power maneuvering event while changing the flow rates of the PHTS and the IHTS. The ratio of the flow rates was assumed to be the same as that of the reactor power. In this evaluation, the scenario of the BOP power was the same with that of the previous evaluation. Figure 2 shows the evaluation results. Like the previous evaluation, the reactor power followed the BOP power and the averaged temperature of the PHTS was kept constant, although the reactor power was a little oscillated before a steady state because the flow rates changed according to the reactor power. The more promising thing was that the temperature of the cold pool could be kept constant during power maneuvering unlike the previous evaluation. This evaluation showed the way to overcome the problem of a high cold temperature. So, we concluded that the power maneuvering strategy for

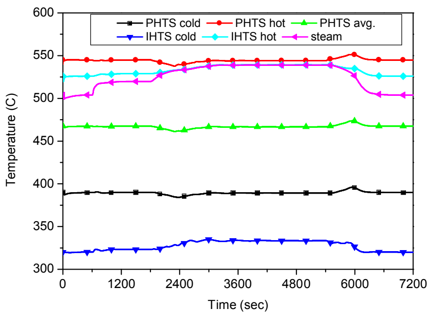
KALIMER-600 while changing the flow rate would be more acceptable.

Figure 3 shows the flow rates of the PHTS, the IHTS and the feedwater in both evaluation cases. The BOP power was simulated as the heat transfer rate through the steam generator, and the heat transfer rate was controlled by the flow rate of the feedwater.

The control rod positions of both evaluations in Figure 4 were close because the average temperatures of the PHTS were constant during the power maneuvering. Otherwise, the reactivity defects due to the density change of the sodium in the PHTS were close.



(a) Power



(b) Temperature

Fig. 2 Evaluation Results with variable flow rate

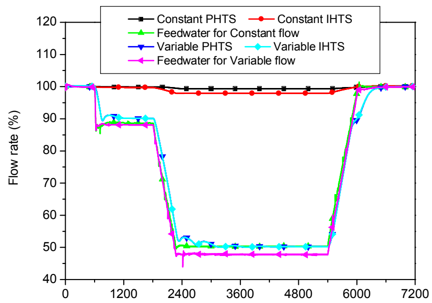


Fig. 3 Flow rate of both evaluations

Figure 5 shows the steam temperatures of both evaluations. The steam temperature in the condition of the variable flow rates was more largely changed. This requires more efforts to control the BOP system.

3. Conclusions

In this study, we evaluated the power maneuvering capability for KALIMER-600 in order to develop the strategy for power maneuvering. We concluded that the variable flow rate of the PHTS and the IHTS according to the power level gave an acceptable way to control the averaged temperature of the PHTS during power maneuvering, and the strategy with constant flow rates could make a problem of the integrity of the reactor vessel. However, the suggested strategy will take a long time for the reactor power to follow the BOP power due to the oscillation that occurred from the variable flow rates. Moreover, it will give more burdens to the controllers of the BOP system. We will develop the control algorithm for the flow rates which can reduce the oscillation of the reactor power and the control efforts of the BOP system during power maneuvering.

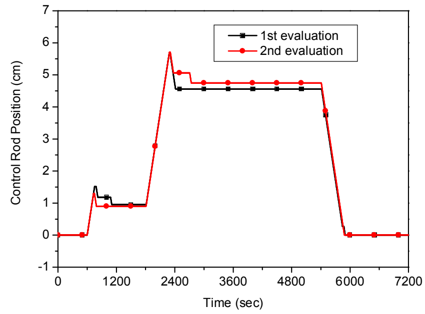


Fig. 4 Control rod position

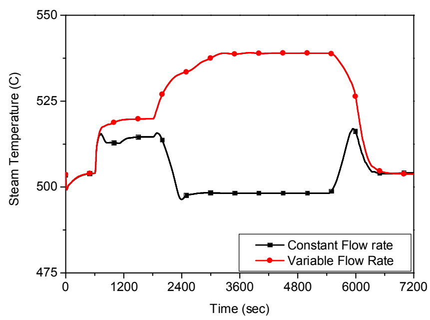


Fig. 5 Steam Temperature

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