Transient Analysis of the Thermal and Flow Characteristics in the KALIMER-600 Reactor Pool

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1. Introduction

The PSDRS transient of KALIMER-600 is characterized by a reactor trip followed by a primary and intermediate pumps coastdown. Sodium flow in the IHTS is assumed to drop to zero in a short time period resulting in no heat removal through the IHX at later times. Subsequent heat removal is done by the PSDRS only. This transient is expected to produce thermal loads due to a thermal shock and coolant stratification within the pool.

As a primary pump coasts down, the annulus gap will be filled with sodium instead of helium gas, and both the free surface of the sodium of the hot and cold pool will have the same elevation. Since the temperature of the surface of the hot pool is not expected to experience a large variation for the early part of the transient, it is assumed that the top surface has the same heat transfer rate as that of the free surface of the hot pool during a normal operation.

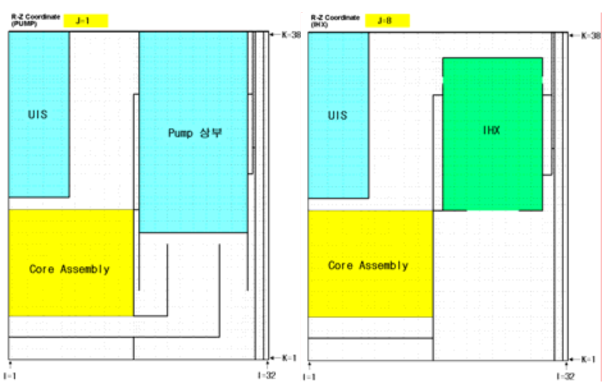
Calculation models and performance results of a short term transient from the COMMIX[1] analysis are presented in this paper.

2. Methods and Results

2.1 Geometry and Mesh

As the steady state analysis[2], the PHTS and the surroundings have been modeled using the cylindrical geometry option in the code. A core grid is modified due to a core structure change[3]. Also, the grid of the circumferential direction considers the DHX and the number is increased.

Several views of the grid system for this study are shown in Figure 1.



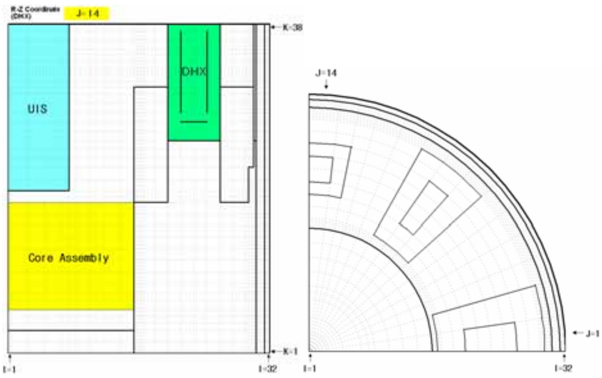


Figure 1. Grid System of the COMMIX Model

2.2 Operating and boundary condition

Steady-state calculation at a 100% power has been made for the initial condition of the transient calculation.

The boundary conditions for the transient calculation are the product of an initial value times a transient scaling factor called the transient function. There are six transient functions; the FVAL(1) is for the normalized flow rate of the intermediate side of the IHX : the FVAL(2) is for the normalized inlet temperature of the intermediate side of the IHX: the FVAL(3) is for the normalized heat sources of the fuel: the FVAL(4) is for the normalized heat sources of pumps: the FVAL(5) is for the normalized pump coastdown flow rate: the FVAL(6) is for the normalized air flow rate in the PSDRS and is a function of the temperature of the reactor vessel outer wall: FVAL's for this study are shown in Figure 2. It is assumed theat the IHX inlet temperature of the intermediate side is constant and no heat is generated from the pumps during the transient.

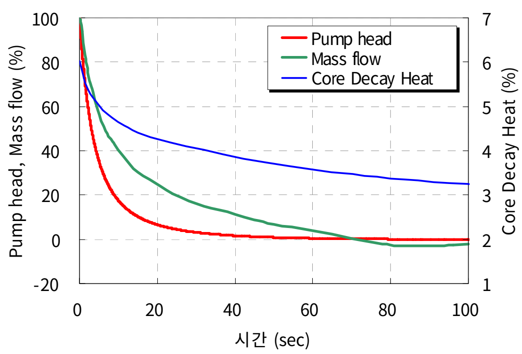


Figure 2. FVAL(3) and FVAL(5) coastdown graph and Core Mass flow rate percentage graph

IHX inlet sodium flow rate of the intermediate side is assumed to drop to zero within 2 seconds.

2.3 Results

The steady state calculation is terminated when the changes of the velocity components and enthalpy per step divided by the maximum magnitude in the entire field are less than 6×10^{-4}. Results for the calculation over its first 30 minutes are presented.

Temperature variation of the core inlet and core outlet is shown in Figure 3. While the pump head becomes lower as in figure 2, the mass flow of the core inlet is decrescent, showing some reverse flow at about 70 seconds. Because core decay heat decreases more rapidly than the mass flow rate, in figure 3, as the mass flow rate decreases, the core outlet temperature decreases.

The core outlet temperature rapidly decreases to 410 ℃ at about 40 seconds and then steeply increases to 540 ℃ at approximately 400 seconds and then it smoothly increases. The core inlet temperature is steadily increasing from the beginning of the transient.

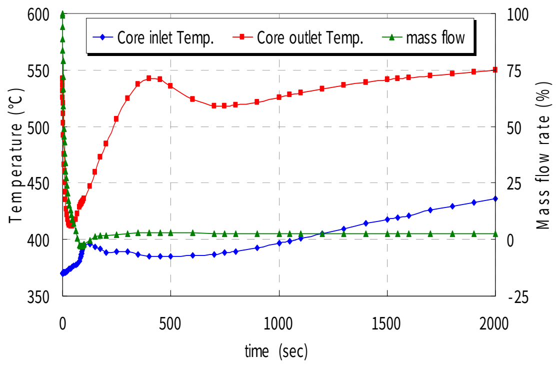


Figure 3. Mass flow and Temperature variation of core inlet and core outlet

3. Conclusion

The KALIMER-600 thermal hydraulic calculations have been made using the multi-dimensional thermal hydraulic code COMMIX-1AR/P. Some thermal stratification appears in the hot pool, but there is no place where a local thermal stress happens.

The temperature responses are used for the evaluation of the thermal loads of the structural analyses.

Acknowledgement

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[3] Reactor core design data for safety analysis 1st, IOC-CD-006-2004, KAERI, KALIMER , 04-09-08