Steady State Analysis using the MELCOR1.8.6 Model for the SMART Severe Accident Analysis

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1. Introduction

SMART (SMAll and medium integral ReacTor) has a unique design concept adopting the integrated reactor system and the passive residual heat removal system. The severe accident analysis for SMART is needed to prepare the safety review and the licensing. For the safety review of SMART design, identifying the safety issues in the early design stage is necessary because it helps to prevent the unexpected cost increase and the delay of a SMART licensing schedule.

In this paper, the MELCOR1.8.6 model[1] for SMART severe accident was developed and the steady state analysis was performed. And the major design parameters such as a primary pressure, temperature, and RCS mass flow rate were compared with the SMART design values.

2. Methods and Results

2.1 Design Characteristics of SMART

As shown in Figure. 1[2], SMART is the small and medium power reactor which of the core, RCS(Reactor Coolant System) pumps, SGs(Steam Generators), and the pressurizer are designed in a reactor vessel. As the large connection pipes between the primary components are eliminated, the LBLOCA(Large Break Loss of Coolant Accident) is originally prevented. Also to improve the safety performance, SMART is designed to introduce passive safety technologies. The safety system of SMART consists of the reactor coolant system, passive residual heat removal system, safety injection system, and chemical and volume control system[3].

2.2 MELCOR1.8.6 Model for SMART

In this paper, the MELCOR1.8.6 model for SMART was developed for the steady state analysis. In Figure 2, SMART primary side consists of the core, RCS pumps, the SGs, pressurizer, flow mixing header assembly, and lower plenum. The volumes of the reactor core and the lower plenum were nodalized by the 14 axial levels(core cell 10, lower plenum cell 4), 8 radial rings. Total 4 RCS pumps, 8 SG cassettes were designed in SMART, and a RCS pump take charge of one set of 2 cassettes. As a heat transfer boundary between the primary side and the secondary side, helical tubes in SG cassette were designed to enhance the heat transfer.

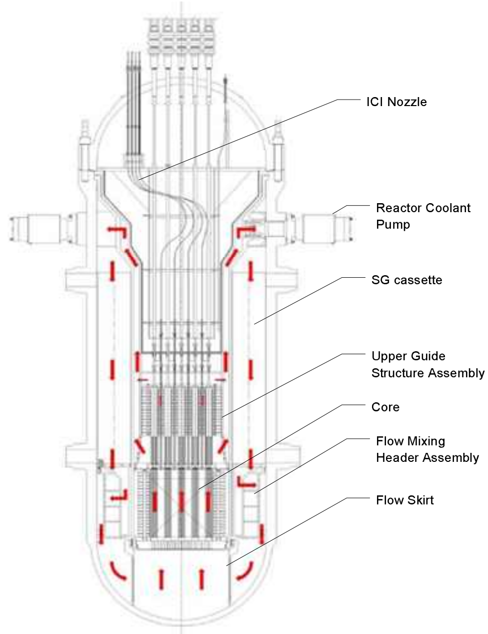

Fig. 1. Flow path of the SMART reactor vessel assembly.

However the heat transfer model of MELCOR 1.8.6 cannot support helical type and the study to simulate the effect of the helical tube is needed. In this paper, the helical tubes were modeled simply as the cylindrical type and the effective heat transfer area of helical tube was considered.

In the secondary side, to remove thermal energy from RCS coolant in primary SG cassettes, total 8 SG tubes lines were modeled. To maintain the constant flow rate in helical tube, the coolant mass source volume and the coolant mass sink volume were modeled in the inlet and outlet of the helical tubes.

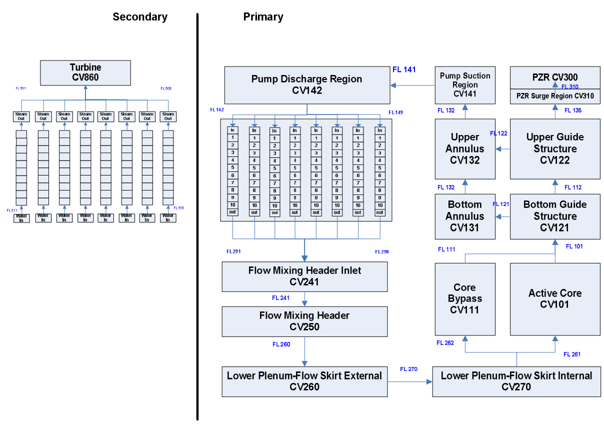

Fig. 2. Nodalization of the SMART MELCOR model.

Table 1. Design value of SMART system

	Contents	Design value
Primary	Core power	330MWth
	Operating pressure	15 Mpa
	RCS flow rate	2090 kg/s
	Coolant temperature in core	Core inlet: 568.85 K Core outlet: 596.15 K
	Temperature of SG inlet/outlet	SG inlet: 596 K SG outlet: 568K
Secondary	Operating pressure	5.2 Mpa
	Flow rate	160.8 kg/s
	Coolant temperature in SG inlet/outlet	SG tube inlet: 473 K SG tube outlet: 571K

3. Results

To estimate that the MELCOR1.8.6 model can simulate the steady state of SMART, the data of the core thermal power, RCS head difference, secondary flow rate, initial core temperature etc. was entered and then the similar condition to SMART design value was investigated by varying the RCS form loss.

Figure 3, 4, and 5 indicate the calculation results of the RCS pressure, RCS mass flow rate, and the core inlet/outlet temperatures for the steady state of SMART. In Figure 3, the RCS pressure is constant with the time at $1.5x10^7$pa and this value is similar to SMART design value. Also in Figure 4, it is confirmed that the RCS mass flow rate is similar to the SMART design value of 2090kg/s. Figure 4 indicate temperatures of the reactor core and lower plenum and the GS(Guide Structure) above the core. The design value of the core inlet and outlet is 568.85K, 59615K respectively, also these values and calculation results are similar and the temperature difference between core inlet and core outlet is constant.

4. Conclusions

In this paper, the MELCOR1.8.6 model was developed and the steady state calculations of SMART were performed. In results, it is confirmed that the RCS pressure, RCS mass flow rate and temperature were similar to design values of SMART. To conduct the severe accident analysis for SMART, the containment and safety features should be modeled and the severe accident scenario should be determined. This study can be utilized usefully in the safety review of SMART design.

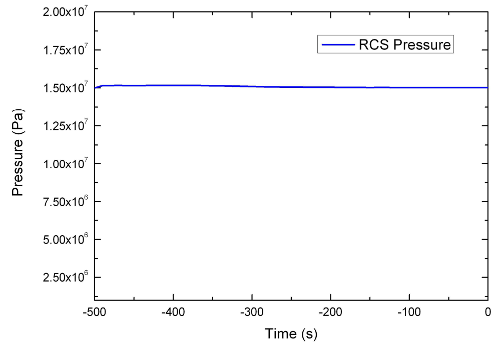

Fig. 3. RCS Pressure from the steady state calculation of SMART

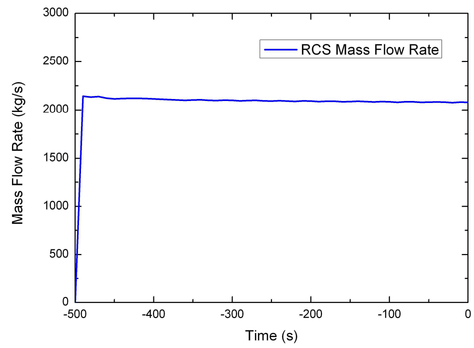

Fig. 4. RCS flow rate from the steady state calculation of SMART

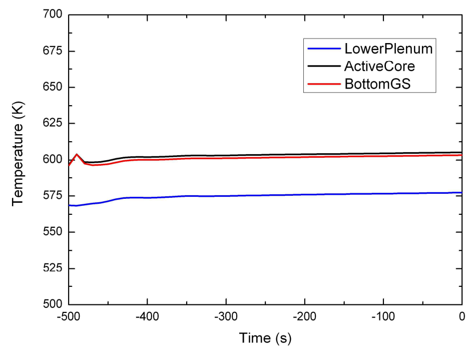

Fig. 5. Coolant temperature in active core and lower plenum from the steady state calculation of SMART

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