Steam Generator heat transfer model validation in TASS/SMR-S code using MRX experimental results

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1. Introduction

In order to identify the applicability of the TASS/SMR-S (Transient and Setpoint Simulation/ System–integrated Modular Reactor-Safety) code to the safety analysis of the SMART, the code should be validated by using proper experimental data. A two-phase friction pressure drop and heat transfer coefficients in a once-through steam generator with helically coiled tubes were investigated with the model test rig of an integrated type marine water reactor.

This paper deals with the validation of the TASS/SMR-S code by using a separate effect test. The TASS/SMR-S code is briefly introduced and the experimental validation of the TASS/SMR-S code follows. The experimental validation of the TASS/SMR-S code is explained by focusing on the heat transfer model of the helically coiled steam generator. The behavior of the major thermal hydraulic parameters including the system pressure, fluid temperature and heat transfer rate are mainly described. Finally, the conclusions are drawn.

2. Methods and Results

2.1 Overview of the TASS/SMR code

To analyze the thermal hydraulic performance of an advanced integral reactor under a full range of reactor operating conditions, the Korea Atomic Energy Research Institute (KAERI) has developed the TASS/SMR-S code. In order to identify the applicability of the TASS/SMR-S code to the safety analysis of the advanced integral reactor, the code should be validated by using proper experimental data. Recently, several kinds of experiments have been performed to support its validation by focusing on an identification of the heat transfer characteristics for the major components, i.e. a helically coiled steam generator and a heat exchanger of the passive residual heat removal system, and the system characteristics of the passive residual heat removal system.

2.2 Validation of the heat transfer model of the helically coiled steam generator

Figure 1 shows the configurations inside the pressure vessel of experimental facility. Primary water from the circulation pump enters into pressure vessel, heats up the secondary water in the steam generator, is heated at the heater and returns to the circulation pump. Secondary water is cooled in the cooler. And it is pressurized by the feed pump, and flows through feed water heater into the heat transfer tubes at the steam generator in pressure vessel to become superheated steam, and then goes out of the pressure vessel.

The measurements were conducted with the fourth tube in the experiment. The coil diameter and inside/outside diameters of the tube were measured to be 595 mm and 14.3/20.0 mm, respectively. The total length and the helical coil portion length of the heat transfer tube are about 61 m and 56 m, respectively. Temperatures of the secondary fluid were measured with sheathed thermocouples at 15 points along the heat transfer tube. Each thermocouple was penetrating the tube wall and hard soldered to measure the temperature of the fluid at the center in the tube.

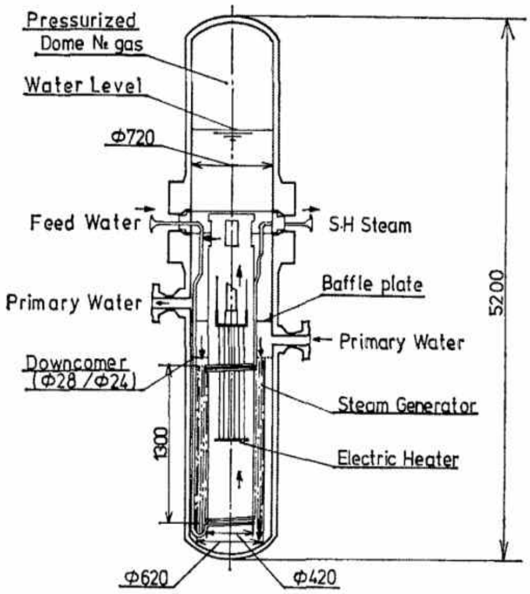

Fig. 1. Configurations inside pressure vessel

The nodalization for a validation of the heat transfer model of a helically coiled steam generator is shown in Fig. 2. The primary water and secondary fluid were fully represented by 34 nodes and 32 flow-paths, respectively. In the nodalization, the mass flow rates and enthalpies at the inlet positions of the secondary fluid and the primary water were treated as boundary conditions. In addition, the exit positions of the primary water and the secondary fluid (node numbers 17 and 34) are modeled as pressure boundaries.

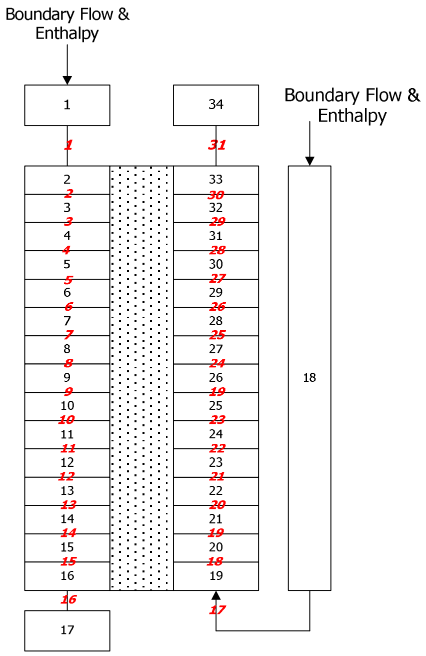

Fig. 2. TASS/SMR nodalization
for helically coiled steam generator

2.3 Results

Figure 3 shows temperature distributions for subcooling, boiling and superheating regions along the tube length in the case of the 397 kg/h secondary flow rate and 4.93 MPa exit steam pressure. The lengths of subcooling, boiling and superheating regions were determined from the temperature distributions along the heat transfer tube.

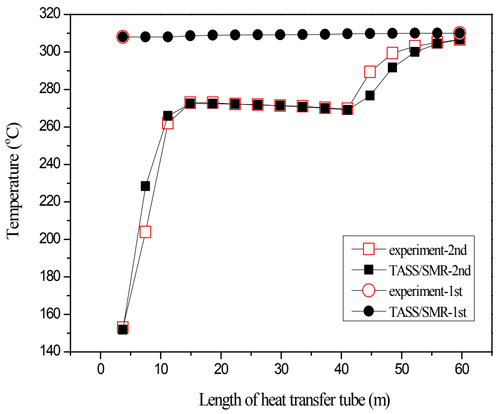

Fig. 3. The fluid temperatures with axial location

Figure 4 shows the pressure difference between the inlet and outlet of the heat transfer tube or total pressure drop. The overall heat transfer rates through a heat transfer tube are shown in Fig. 5. According to the calculation results using the TASS/SMR-S code, it predicts the heat transfer rates through the steam generator to within a 22% error.

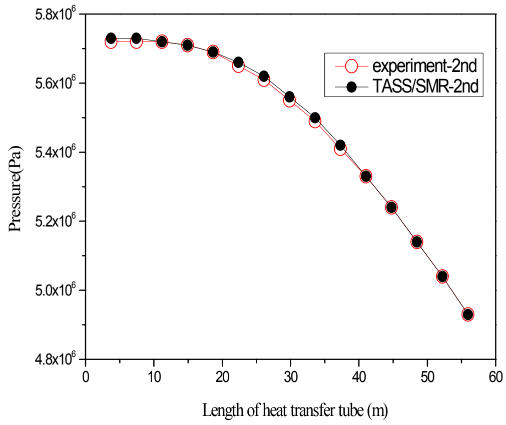

Fig. 4. The pressure with axial location

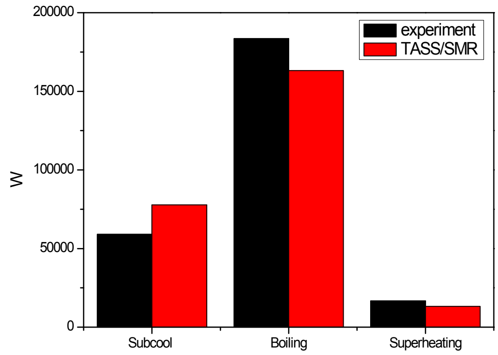

Fig. 5. Heat transfer rate of secondary side

3. Conclusions

The helical steam generator heat transfer model of the TASS/SMR-S code has been validated by using experimental data with the model test rig of an integrated type marine water reactor.

According to the analysis results for the validation, the major thermal hydraulic parameters, including the pressures at the inlet positions of both the primary and secondary sides, the fluid temperatures at the exit position of the primary side, and the heat transfer rates are accurately predicted by the TASS/SMR-S code.

Acknowledgements

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