Validation of the TASS/SMR-S Code for the PRHRS Condensation Heat Transfer Model

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1. Introduction

When some accidents or events are occurred in the SMART, the secondary system is used to remove the core decay heat for the long time such as a feedwater system. But if the feedwater system can't remove the residual core heat because of its malfunction, the core decay heat is removed using the Passive Residual Heat Removal System (PRHRS). The PRHRS is passive type safety system adopted to enhance the safety of the SMART. It can fundamentally eliminate the uncertainty of operator action [1].

TASS/SMR-S (Transient And Setpoint Simulation/ System-integrated Modular Reactor-Safety) code has various heat transfer models reflecting the design features of the SMART [2]. One of the heat transfer models is the PRHRS condensation heat transfer model. The role of this model is to calculate the heat transfer coefficient in the heat exchanger (H/X) tube side using the relevant heat transfer correlations for all of the heat transfer modes. In this paper, the validation of the condensation heat transfer model was carried out using the POSTECH H/X heat transfer test [3].

2. Validation of the Core Heat Transfer Model

2.1 Overview of the POSTECH H/X Heat Transfer Test

For the measurement of condensation heat transfer coefficients in the H/X tube side, the test was performed on the POSTECH. The test facility is consisted of three parts with steam supplying system, coolant supplying system and test section (H/X tube). The length and inner diameter of H/X tube is 1.5 m, 15.8 mm respectively. The schematics of the H/X tube side heat transfer test facility is shown in Fig. 1. The four tests were selected to evaluate the condensation heat transfer model as a function of pressure. The selected tests are test E2-2 (1.0 MPa), test B1-2 (2.0 MPa), test C2-2 (4.0 MPa) and test D1-2 (6.0 MPa). Initial and boundary conditions for the test are presented in Table I.

Table I: Test conditions of the H/X tube heat transfer test

Test No.	Pressure (MPa)	Steam flow rate (kg/sec)	Coolant flow rate (kg/sec)	Coolant temperature (K)
E2-2	1.103	0.0069	0.083	9.67
B1-2	2.124	0.0069	0.079	27.07
C2-2	3.865	0.0070	0.085	26.40
D1-2	6.101	0.0068	0.089	26.43
SMART	< 15.0	< 0.0068	-	< 40

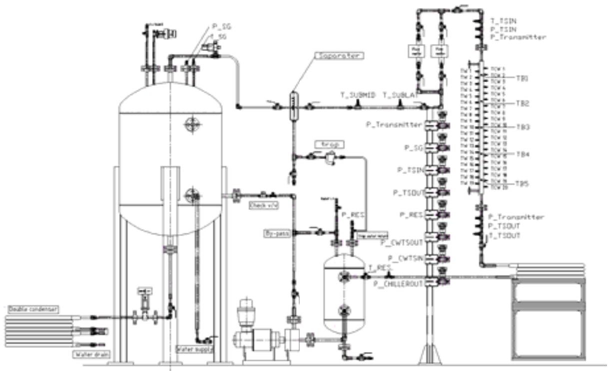

Fig. 1. Schematics of H/X tube heat transfer test

2.2 Analysis Methods and Modeling with TASS/SMR-S

Fig. 2 shows the TASS/SMR-S code nodalization for the H/X tube side heat transfer test. The tube and coolant pool side of the test section are consists of 15 nodes respectively according to the thermo coupler elevation of the test. The upper and lower nodes of the each section are connected to the boundary condition. The coolant is put in the H/X pool FW header of the lower section. The super heated steam is injected in the H/X tube steam header of the upper section.

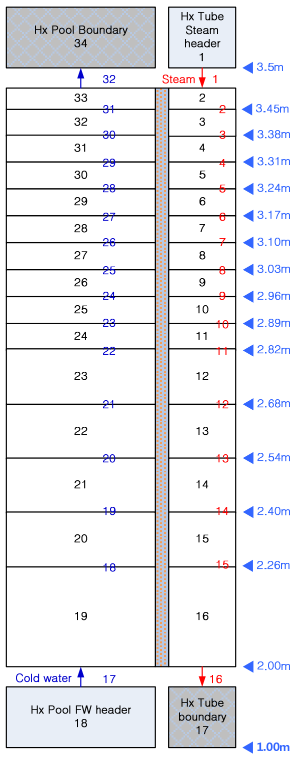

Fig. 2. TASS/SMR-S nodalization for the validation

2.3 Analysis Results

The steam/coolant temperature and local heat transfer coefficient at the test section were calculated as a function of pressure using the TASS/SMR-S code. The comparison results of temperature profile with the test data are shown in Fig. 3~6. The full condensation region decreases with an increase in the steam pressure. Although TASS/SMR-S code predicts full condensation region more widely than the test, the steam temperature at the tube outlet is calculated highly and the coolant temperature at the tube inlet is predicted lowly rather than the test results.

Fig. 7 shows the local heat transfer coefficient as a function of steam pressure including three times test results. The heat transfer coefficients in the TASS/SMR-S code are under predicted rather than test data. And the heat transfer coefficients decrease slightly with an increase in the steam pressure.

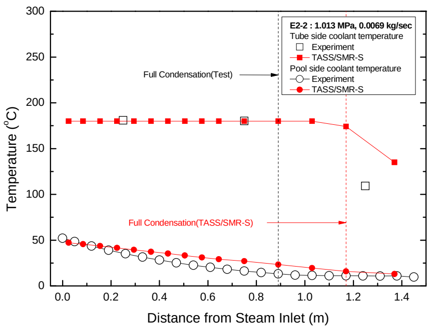

Fig. 3. Steam/coolant temperature at1.0 MPa

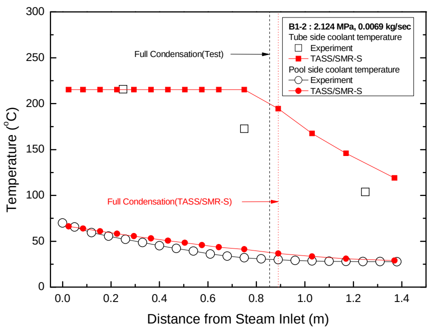

Fig. 4. Steam/coolant temperature at 2.0 MPa

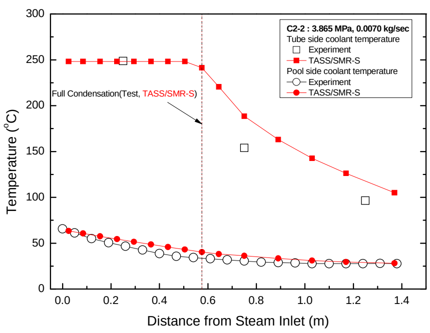

Fig. 5 Steam/coolant temperature at 4.0 MPa

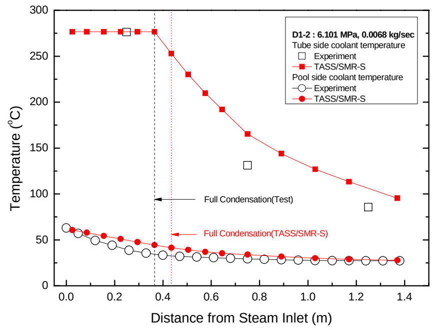

Fig. 6. Steam/coolant temperature at 6.0 MPa

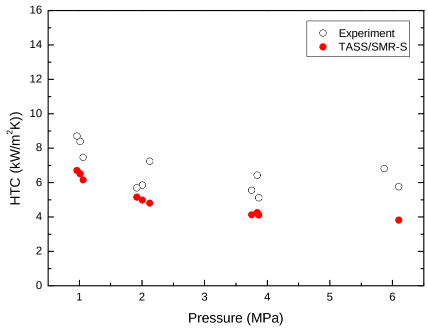

Fig. 7. Local condensation heat transfer coefficient by steam pressure

3. Conclusions

The validation of the PRHRS condensation heat transfer model in the TASS/SMR-S code was performed with the POSTECH H/X tube side heat transfer test.

From the results of the calculation, the steam temperature at the tube outlet is calculated highly in the all cases. Also the coolant temperature at the tube inlet and local heat transfer coefficients in the two phase region were under predicted rather than the test results. In the heat removal for the reactor coolant system (RCS), TASS/SMR-S code predicts conservatively rather than the test results.

As a further study, many validations should be performed with the various thermal hydraulic conditions.

Acknowledgement

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