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Core Heat Transfer Model Validation of the TASS/SMR-S Code using the Bennett's Test

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1. Introduction

The SMART (System-integrated Modular Advanced ReacTor) which is a 330 MWt advanced integral PWR was developed by the KAERI (Korea Atomic Energy Institute) for electricity generation and seawater desalination [1]. A thermal hydraulic evaluation and analysis of the SMART is performed by the TASS /SMR-S (Transient And Setpoint Simulation/System-integrated Modular Reactor-Safety) [2].

The TASS/SMR-S code has various models reflecting the design features of the SMART such as the drift flux model, the core models (core power & core heat transfer model), the component models, and the specific models.

One of the core models is the core heat transfer model. The role of this model is to calculate the heat flux and radial temperature profiles at a fuel rod surface using the relevant heat transfer correlations for all of the heat transfer modes. Also it is modeled to meet the requirements of the 10 CFR 50 appendix K EM model for the CHF (Critical Heat Flux) and post CHF conditions. In this paper, the validation of the core heat transfer model was carried out using the Bennett's heated tube tests.

2. Validation of the Core Heat Transfer Model

2.1 Overview of the Bennett's Heated Tube Tests

For the measurement of temperature distributions in the region beyond the dryout point, the Bennett's heated tube tests were performed on evaporative heat transfer to upflow boiling water in a vertical electrically heated 12.6 mm inner diameter, 5.54 m length tube at 6.89 MPa [3]. The diagram of the Bennett's heated tube tests is shown in Fig. 1.

Three of the Bennett tests were selected by the mass flux condition to evaluate the core heat transfer model. The selected tests are test 5358 (low condition), test 5294 (intermediate condition) and test 5394 (high condition). Initial and boundary conditions for the tests are presented in Table I.

Table I: Test conditions of the Bennett's heated tube tests

Test No.	Pressure (MPa)	Heat flux (MW/m^2)	Mass Flux (kg/m^{2}s)	Subcooling (K)
5358	6.89	0.5117	379.74	34.41
5294	6.89	1.097	1952.97	18.80
5394	6.89	1.752	5180.80	13.78
SMART	15.0	0.394	1010.0	27.30

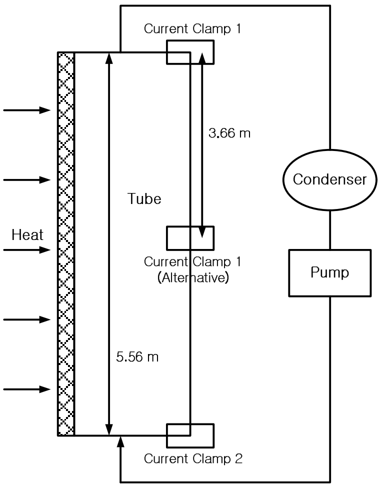

Fig. 1. Diagram of the Bennett's heated tube tests

2.2 Analysis Methods and Modeling with TASS/SMR-S

Fig. 2 shows the TASS/SMR-S nodalization of the Bennett's heated tube tests. The core section is consists of 20 nodes equally spaced. The lower and upper section is comprised of 3 nodes respectively to model the uniform velocity distributions in the flow.

The upper section is connected to the big volume to control the outlet boundary condition. The feedwater is put in the bottom node of the lower section. To model the heat generation in the core section, the core section is heated equally using the core power model.

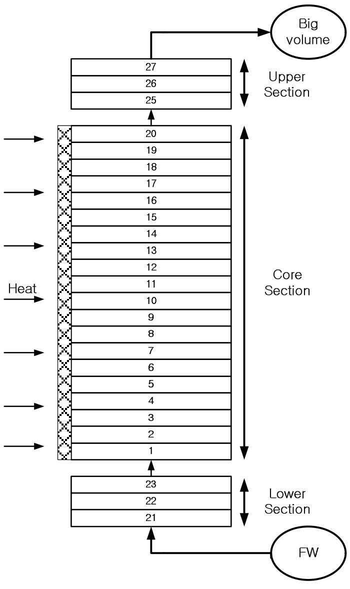

Fig. 2. TASS/SMR-S nodalization of the Bennett's heated tube tests

2.3 Analysis Results

The dryout points and axial temperature distributions at a fuel rod surface were calculated by the selected test conditions using the TASS/SMR-S code. And these results were compared with test.

For the low mass flux condition (Test 5358), the dryout occurred at a lower position. Also the axial temperature distributions of a fuel rod surface are reasonably predicted with the test data until the dryout point. In the post dryout region, it is overestimated compared to the test results.

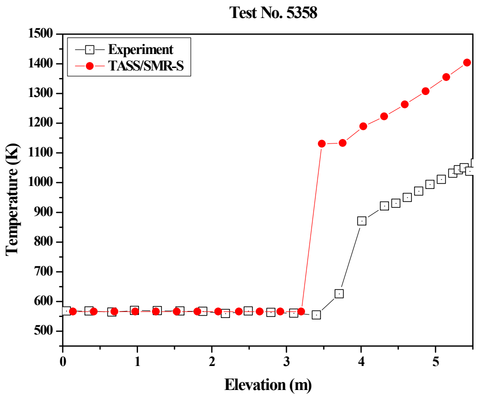

Fig. 3. Calculated axial temperature distributions at a fuel rod surface-Test 5358

Fig. 4 shows the results of the intermediate mass flux condition (Test 5294). In this test condition, the dryout occurs at a slightly lower elevation and the surface temperature profiles of a fuel rod are similarly calculated to the test results.

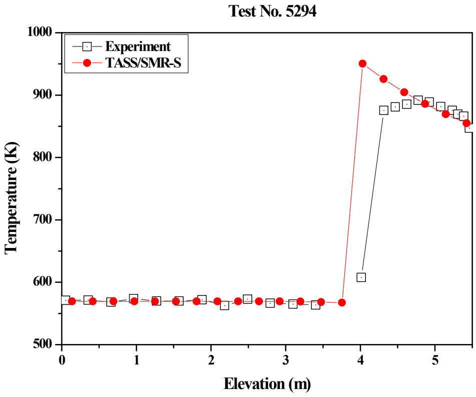

Fig. 4. Calculated axial temperature distributions at a fuel rod surface-Test 5294

Test 5394 is high mass flux condition shown in Fig. 5. Unlike the results of the low and intermediate mass flux conditions, the dryout in the high mass flux condition occurred at a much lower position of the core section.

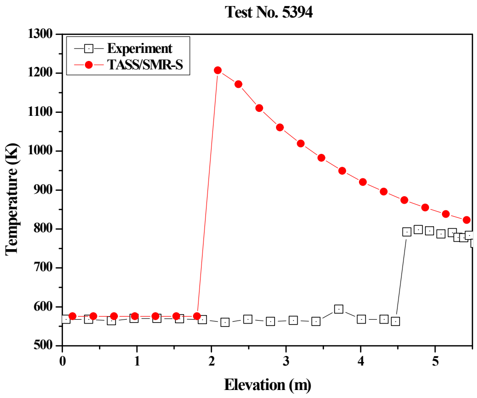

Fig. 5. Calculated axial temperature distributions at a fuel rod surface-Test 5394

3. Conclusions

The validation of the core heat transfer model in the TASS/SMR-S code was performed with the Bennett's heated tube tests.

Three of a number of test conditions were selected by the low, intermediate and high mass flux.

According to the selected test conditions, the dryout points and the axial temperature profiles at a fuel rod surface were calculated and compared with the test data.

From the results of the calculation, the dryout point and the surface temperature of a fuel rod at the post dryout region were predicted conservatively rather than the test results.

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

Acknowledgement

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