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Performance Evaluation of Fuel Assembly Simulator for SMART

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1. Introduction

SMART reactor has been being developed by KAERI for the generation of electric power and for seawater desalination. An experimental facility, called SCOP, is being constructed in order to evaluate the flow and pressure distribution in the SMART reactor core. The SCOP facility has a 1/5 linear scale of the prototype. The flow distribution at the inlet of 57 fuel assemblies will be measured at SCOP, and the experimental results will be used to evaluate the core thermal margin of SMART reactor. Each fuel assembly of SMART reactor will be simulated by single flow channel in the SCOP test facility[1]. The fuel assembly simulator has a venturi tube at the front part to measure the flow rate through the channel, and several perforated plates to preserve the total pressure drop of the SMART fuel assembly. A CFD analysis was carried out to draw basic design parameters of the venturi tube and the perforated plates in the fuel assembly simulator[1]. In the present work, the actual performance of the fuel assembly simulator was evaluated using a CALIP (Calibration Loop for Internal Pressure drop) test facility.

2. Experimental Setup and Results

Figure 1 shows the fuel assembly simulator of SCOP. A venturi tube is located at the front part, one perforated plate is installed at the inlet of the simulator, and three perforated plates are installed at the downstream of the venturi tube. Also sixteen large openings are provided at the downstream of the venturi tube in order to preserve the cross-flow characteristics between neighboring fuel assemblies.

Figure 2 shows the schematic of the CALIP test facility. It consists of a calibration section, a flow supply and measurement section, a water reservoir, and control and data acquisition section. The fuel assembly simulator and/or single perforated plate can be mounted at the calibration section. Ultra precise grade differential pressure (DP) transmitters were installed to measure the pressure drop of the whole fuel assembly simulator and/or single perforated plate as well as the discharge coefficient of the venturi tube. The flow rate of the water supplied to the calibration section was measured by coriolis mass flow meters, and the flow rate was controlled by adjusting the rotation speed pump impeller using VVVF inverter. The water temperature was adjusted constant at about 60 ^{o}C by PID controller. CALIP was equipped with the DP transmitters and flow meters having two different measurement ranges, and measurement redundancy were secured by providing two DP transmitters and two flow meters for each measurement range.

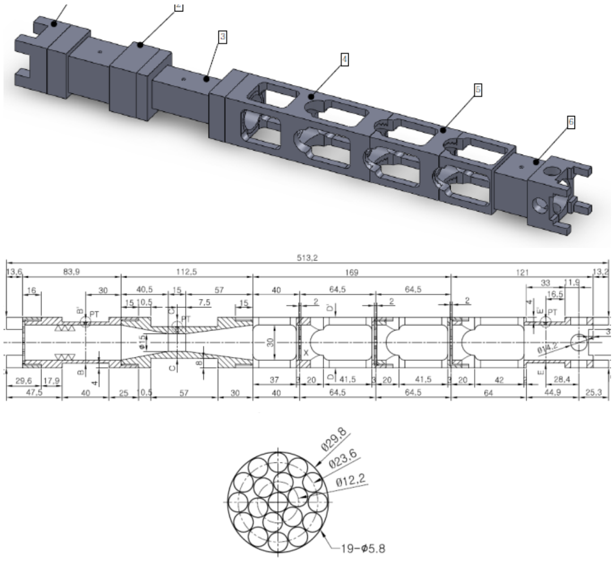

Fig. 1 Fuel assembly simulator of SCOP

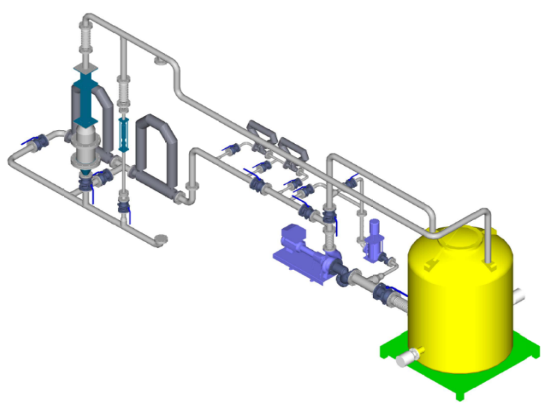

Fig. 2 Schematic of CALIP test facility

The pressure drop characteristics of the front perforated plate and the rear perforated plated were evaluated at a nominal flow rate (2.048 kg/s) and a density (983.2 kg/m^3) conditions for SCOP experiments. Three front plates and two rear plates were tested. The pressure drop due to a form loss was 8.80 kPa and 2.71 kPa for the front and rear perforated plates, respectively, and these values agreed well with the design target values.

Also, the total pressure drop of single fuel assembly simulator was evaluated at a nominal flow rate and a density condition. The pressure drop was 36.19 kPa, and the difference from the target value was about 1.2% . The discharge coefficient of the venture tube was evaluated for nine different flow rates covering from 40% to 120% of the nominal flow rate. The corresponding Reynolds number ranged from 150,000 to 443,800. The diameter was defined at the venture throat. The measured discharge coefficient was 0.9776 ~ 0.9842, and the average value was 0.9805. Figure 3 shows the discharge coefficient of the venture tube with regard to Reynolds number.

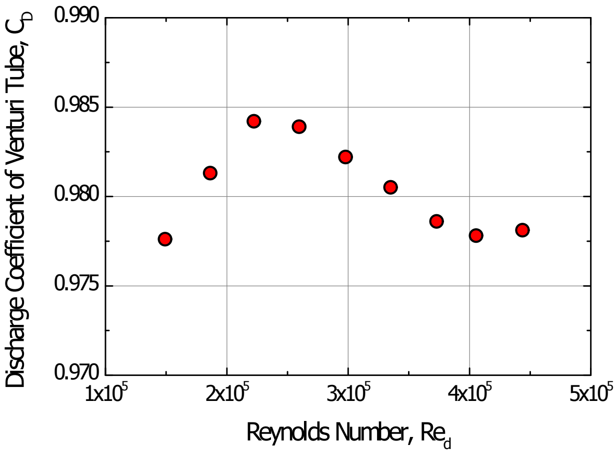

Fig. 3 Discharge coefficient of the venture tube installed in the fuel assembly simulator.

3. Conclusions

The pressure drop and discharge coefficient of the fuel assembly simulator for the SCOP test facility were precisely measured and evaluated using CALIP test facility. The performance agreed well with the design target values. However, slight modification will be made on the perforated plate and the venture tube for the fuel assembly simulator to meet the performance requirement better. Final performance evaluation will be carried out for whole 57 fuel assembly simulators which will be used in the SCOP experiments. Then, the identical performance evaluation will be carried out for whole 8 steam generator simulators for SCOP experiments.

REFERENCES

[1] Yung Joo Ko, Hwang Bae, Dongjin Euh, Tae Soon Kwon, A CFD Simulation for a Design of Core Flow Simulator for SMART, Transactions of the Korean Nuclear Society Spring Meeting, Pyeongchang, Korea, May 27-28, 2010.