Pressure variation analysis in the down-scaled SMART model

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1. Introduction

The SMART is abbreviation of 'system modular integrated advanced reactor' and advanced integral pressurized water reactor (PWR) of a small size. Main purposes of SMART are electricity generation and sea water desalination [1]. SMART has many advantages. It has a compact size, and more safe than commercial loop-type pressurizer water reactor, because no large pipe systems penetrate the reactor vessel. All the Main parts are located in vessel. Those are steam generator inlet (SGI) region, eight stream generators (SGs), four reactor coolant pumps (RCPs), core, flow mixing header (FMH) assembly, and flow skirt.
Previous research on the SMART safety had mainly focused on only a unit system. but our research is focused on overall SMART system.
In the present study, the objective is to predict the pressure distribution under nominal operation. We investigate the hydrodynamic characteristics using a commercial software package (FLUENT 6.3).

2. Experimental method

In this section, a down-scaled model, measuring point and test condition are described

2.1 SMART and Down-scaled model

SMART has very complex flow path. Therefore simplified model is designed by using conceptual ideas, and made 1/10 scaled. Because the value of pressure drop is only important, The first is leakage flow rate between components can be neglected. The Second is a reactor core, steam generators and control rod guides can be simplified by several orifice plate.

2.2 Configuration test loop

The test loop is consist of a bath, 4pumps, 4 flow meters and test model. And those are connected by several connecting hoses. The water bath is installed to maintain constant the water temperature at the 27℃ (300K)

2.3 Measuring equipment and Measuring point

Piezo-resistive pressure transducers (SENSYS, PSHK0001BCPG) are used to measure the mean pressure and the unsteady fluctuating pressure. 26 measurement points are machined on the outer surface of the vessel and 3 measurement points are machined on the inner structures as shown in fig.1.

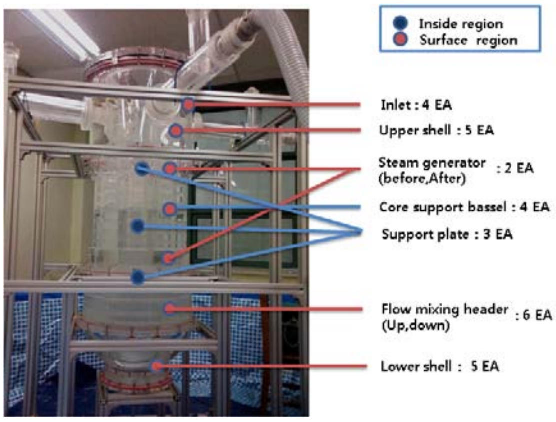

Fig. 1. Pressure measuring points in the test model.

2.4 Experimental Test Condition

The variation tests of the flow rate are conducted to estimate the pressure distributions at the test model. At the flow rate variation tests, the total of the flow rate is changed at 800lpm, 680lpm and 560lpm by controlling the rotation speed of pumps while the flow rate of each pump is equally maintained.

3. Numerical method

3.1 Flow domain configurations and meshing

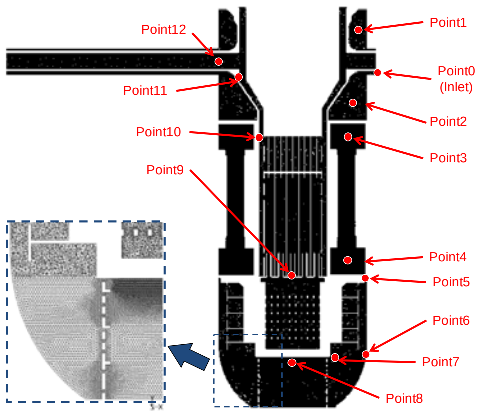

Fig. 2. Mesh shapes and pressure measuring points

The reactor flow of 800lpm and approximately 18kpa discharges to the steam generator, admits to flow mixing header assembly and flow skirt, goes upward through the core, and enters the pumps. Figure 2 shows the numerical grids in the SMART reactor for this study. They are generated by using GAMBIT grid generator.

3.2 Numerical procedure

A commercial CFD code, FLUENT 6.3.26, has been used in order to calculate the pressure. The code solves the three-dimensional Reynolds-averaged Navier-Stokes (RANS) equations using a first order upwind scheme and the SIMPLE pressure-correction algorithm. The standard k-ε model and the standard wall function were selected as a turbulence model and a wall function model.

4. Result and discussion

Fig. 3. shows the mean pressure distributions at the measuring points.Experimental and numerical data has similar value at each point. Most of pressure drop is occurred in the steam generators and the core such as 35.1% and 36.7%. The lowest pressure drop occur in the steam generator inlet region such as 0.4%. Because flow velocity is very low compared to other part.

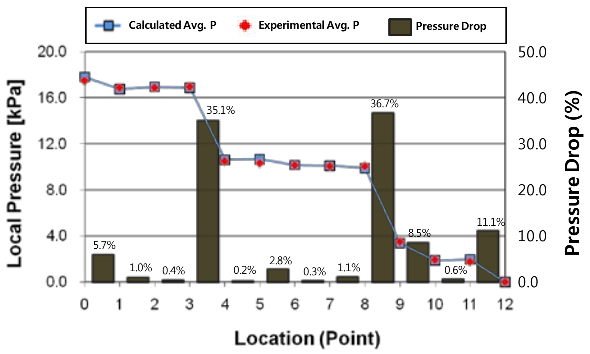

Fig 3. Comparison numerical averaged static pressure , experimental averaged static pressure and pressure drop.

5. Conclusion

In present study we calculated and measured the pressure distribution under norminal operation. The conclusions can be summarized as follows.

1. High pressure drops occurred in the steam generators and the core, such as 35.1% and 36.7%

2. Lowest pressure drop was 0.4% in the steam generator inlet.

3. Other pressure drops were 5.7%, 8.5%, 11.1% in the flow mixing header assembly the lower plenum and the chamber to pump, respectively

REFERENCES

[1] Chung, Y.-J., Kim, S.H., Chung, B.-D., Chung, M.-K., Zee, S.-Q., 2006, Two phase natural circulation and the heat transfer in the passive residual heat removal system of an integral type reactor. Annals of Nuclear Energy 33, 262-270.

[2] Becker, S., Laurien, E., 2003, Three-dimensional numerical simulation of flow and heat transport in high-temperature nuclear reactors. Nuclear Engineering and Design 222, 189-201..

[3] Chung, Y.-J., Lee, S.W., Kim, S.H., Kim, K.K., 2008, Passive cooldown performance of a 65MW integral reactor. Nuclear Engineering and Design 238, 1681-1689.

[4] In, W.K., Hwang, D.H., Yoo, Y.J., Zee, S.Q., 2002, Assessment of core protection and monitoring systems for an advanced reactor SMART. Annals of Nuclear Energy 29, 609-621.

[5] Lee, B.I., Kim, K.M., Cho, H.H., Jeong, K.H., Park, J.S., Measurement of pressure distributions on the shell surface of the downscaled SMART reactor. Proceeding of KSME 2010 Fall Annual Meeting, 3578-3761.