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A Summary of the MARS Analysis Results about OECD/SETH PANDA Tests

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1. Introduction

The thermal-hydraulic phenomena in a multi-compartment space like the containment building under accidents are very complicated and unpredictable as a result of many interacting processes, such as sprays, hydrogen recombiners, etc. Many thermal-hydraulic phenomena, governing the containment response under postulated accidents, have been identified by the SESAR/CAF (OECD) as 'research needs' for current and advanced LWRs [1]. Due to the recent extension of the numerical computation capability and the technology, the safety analysis field is requested to expand their analysis domain beyond the current primary system. In particular, hydrogen mixing and transport has been found to be of special importance for safety and regulation.

Up to dates, OECD/CSNI has been leading many experimental projects, for example, OECD-PKL, ISP47, OECD-PANDA, focusing the gas mixing, stratification and vapor condensation phenomena. As the one of the activities, the OECD-SETH group has launched the PANDA Project in order to provide an experimental data base for a multi-dimensional code assessment [2] in 2002. PANDA is a large scale thermal-hydraulic facility to provide a resolved experimental data base about the gas mixing and stratification phenomena. OECD-SETH group expects the PANDA Project will meet the increasing needs for adequate experimental data for a 3D distribution of relevant variables like the temperature, velocity and steam-air concentrations that are measured with a sufficient resolution and accuracy.

2. OECD/SETH PANDA Tests

The scope of the PANDA Project is the mixture stratification and mixing phenomena in a large bulk space. Total of 24 test series are performed in PSI, Switzerland. These whole test cases are categorized to Wall Plume, Free Plume, and Horizontal Jet tests according to the steam injection velocity and the direction.

The PANDA facility consists of 2 main large vessels (Drywell 1 and Drywell 2) and 1 inter-connection pipe (IP) as shown in Figure 1. Within the large vessels, the steam injection nozzle and the outlet vent are arranged for each test case.

KAERI has also participated in the SETH group since 1997 so that the multi-dimensional capability of the MARS code could be assessed and developed [3]. Among the 24 PANDA tests, the test 17, 16, 9 and 9bis cases have been selected and simulated.

Test 17, 16, and 9 cases are Wall Plume tests. The steam is injected through the horizontal pipe and the injection velocities are approximately 5, 3, and 1 m/s, respectively. With these test series, the effect of steam injection moment to the distribution of the steam temperature and stratification is investigated.

In addition, Test 9 and 9bis cases are selected to view the effect of the condensation to the steam concentration distribution in the bulk space.

Table 1 represents the initial and boundary conditions for the selected test cases.

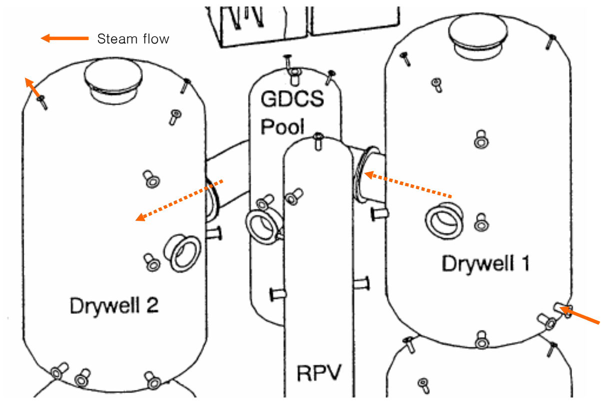


Figure 1. The perspective view of the PANDA test facility.

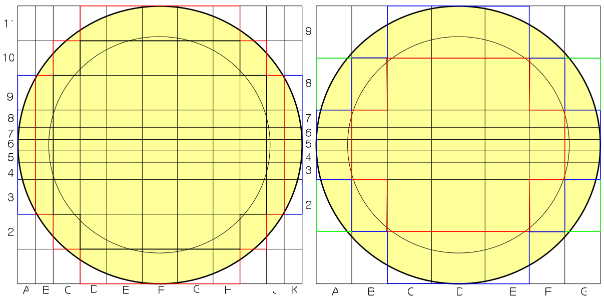
Table 1. Initial and boundary conditions for selected PANDA Tests.

	Steam injection rate (g/s)	Steam temperature (°C)	Initial vessel air temperature * (°C)
Test 17	65.06	141.63	108.0
Test 16	40.01	139.7	108.0
Test9	14.01	136.0	108.0
Test9bis	14.02	109.2	76.0

*: nominal value.

3. MARS Modeling of PANDA Facility

The main facility of the PANDA consists of the two 4.0x8.0 m vessels which are connected by a 1.0m diameter horizontal pipe. Total length of the connection pipe is 5.0 m. The curvature of the connection pipe has been neglected. Figure 2 shows the MARS nodalization schematics for the two main vessels, DW1 and DW2, respectively. The grid size near the jet injection region is smaller than the other bulk regions. The vertical grid size is also designed to have smaller length scale near the steam injection. In the DW1 grid, the 10 cm intrusion of the steam injection pipe into the DW1 interior has been modeled. From the CFD benchmark calculations [4], it is observed that the pipe intrusion affect severe influences on the steam plume behaviors.



DW1 DW2

Figure 2. The plane view of the two panda vessel nodalization schematics; DW1 and DW2

Finally, total of 3415 multi-dimensional volumes are prepared for the 180 m^3 vessel volumes and the initial and boundary conditions are adequately assigned. Steam jet is injected through a 0.153 diameter pipe horizontally connected at 1.8 m above the DW1 bottom level. The surface heat leak is modeled as 43.0 W/m^2. Figure 3 shows the multi-dimensional modeling of the PANDA facility.

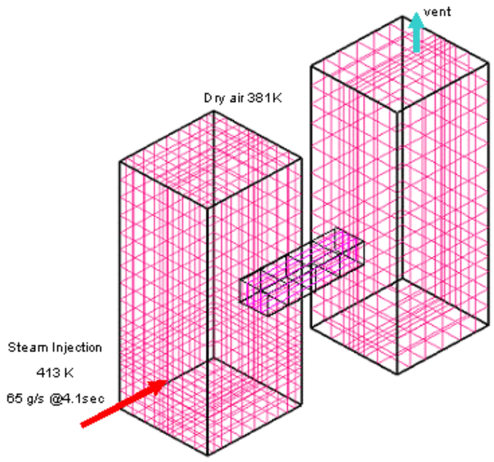


Figure 3. Multi-dimensional grid arrangement of the PANDA facility.

4. Results

The temperatures and concentration profiles are compared between the experiment and the calculation along profile lines V1 and V2, which is shown in Figure 4. The monochromatic steam concentration data are also monitored at the V3 and the DW2 vent position.

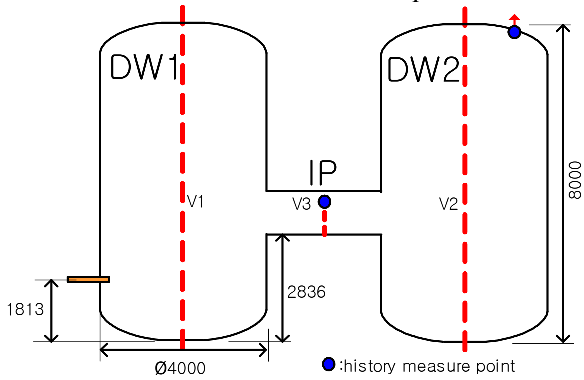


Figure 4. Schematic of the profile line positions for the result comparisons

5. Conclusion

A benchmark calculation of selected OECD-PANDA Test number 17, 16, 9 and 9bis have been carried out by using the multi-dimensional component of the system code, MARS. A summary of the simulation results are represented in this report. As the simulation of the Wall Plume tests, it is recognized that the multi-dimensional calculation has some restrictions in the case involving a strong momentum flows. But in the low momentum cases, the multi-dimensional component shows the promising prediction capability with the 1/10 meter length scale.

Acknowledgement

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