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A Steam Jet Plume Simulation in a Large Bulk Space with a System Code MARS

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1. Introduction

From May 2002, the OECD-SETH group has launched the PANDA Project in order to provide an experimental data base for a multi-dimensional code assessment [1]. 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.

The scope of the PANDA Project is the mixture stratification and mixing phenomena in a large bulk space. Total of 24 test series are still being performed in PSI, Switzerland. The PANDA facility consists of 2 main large vessels and 1 connection pipe as shown in Figure 1. Within the large vessels, a steam injection nozzle and outlet vent are arranged for each test case. These tests are categorized into 3 modes, i.e. the high momentum, near wall plume, and free plume tests. 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 [2]. Test17, the high steam jet injection test, has already been simulated by MARS and shows promising results [3]. Now, the test 9 and 9bis cases which use a low speed horizontal steam jet flow have been simulated and investigated.

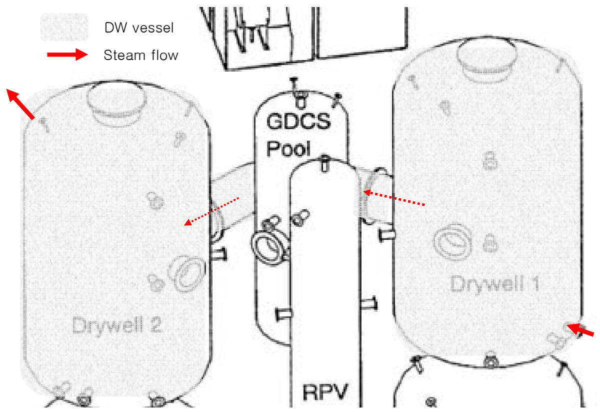

Figure 1. The perspective view of the PANDA test facility.

2. MARS Modeling of PANDA Facility

The main facility of the PANDA project is 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.

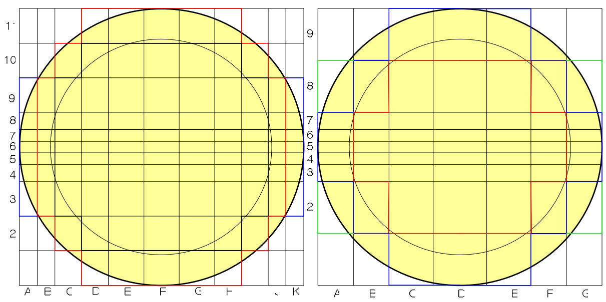

Figure 2. The plane view of the two panda vessel nodalization schematics; DW1 and DW2

Total of 3400 multi-dimensional volumes are prepared and the initial 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.

Table 1 represents the initial and boundary conditions for test 9 and 9bis cases.

Table 1. initial and boundary conditions for test9 and 9bis.

	Pressure (bar)	Steam injection rate (g/s)	Steam temperature (°C)	Initial vessel air temperature (°C)
Test9	1.3	14.0	136.0	108.0*
Test9bis	1.3	14.0	109.2	76.0*

*: nominal value.

The main interest of test9 and 9bis is the effect of a condensation. As shown in Table 1, the initial condition of test9bis is adjusted to motivate the condensation of steam. In the experiment, the condensation is checked by the vent flow rate. The steam concentration profile in the connection pipe is also of interest for both tests. MARS simulation is performed to verify its' capability to establish the difference of both tests and the condensation effects of Test9bis. The problem time is set as 7000 seconds for both calculations.

4. Results

The temperature and concentration profile are compared between the experiment and the calculation along profile lines V1 and V2, are shown in Figure 4. It is recognized that the prediction capability of a multi-dimensional calculation is promising even though there are some discrepancies of the absolute values.

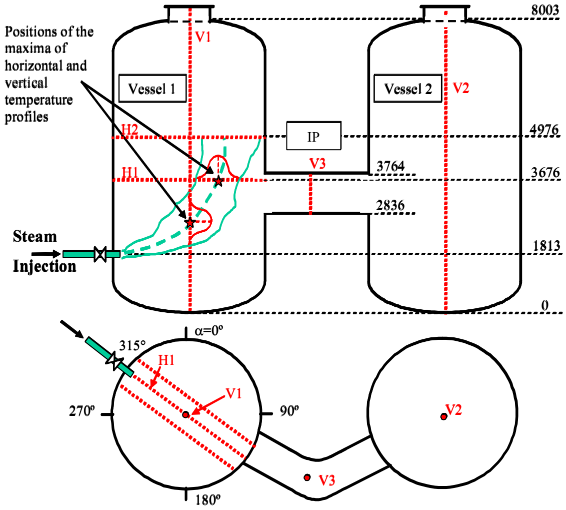

Figure 4. Profile line position schematics for the comparison

Figure 5 shows the outlet mass flow rate for both tests. The absolute quantities of the mass flow rates differ from experiment and MARS calculation. But the difference between test9 and 9bis is detectable in the MARS calculations. Further, experiment and simulation results clearly show an outlet vent mass flow rate decrease around 2800 second for the Test9bis case.

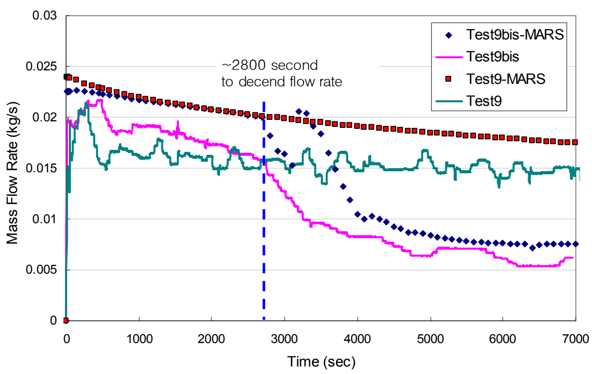

Figure 5. comparisons of DW2 vent outlet flow

Figure 6 shows the calculated steam concentration history at the connection pipe. In the experiment, the first appearance of steam is detected at around 100 second. MARS calculation shows that the steam appears earlier at the top position of the connection pipe. At the lower position, steam appears 300 seconds later. The concentration difference is calculated as 0.08 mole/mole.

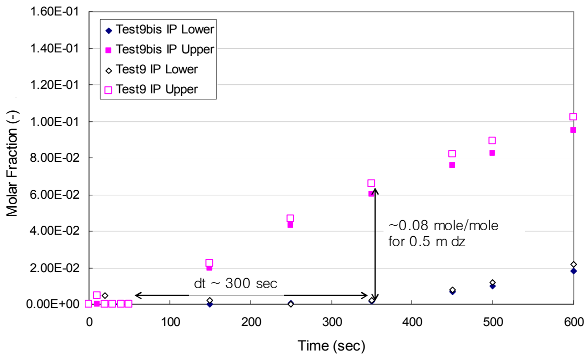

Figure 6. The steam concentration profile at lower and upper position of connection pipe

5. Conclusion

A benchmark calculation of OECD-PANDA Test number 9 and 9bis have been carried out by using the multi-dimensional component of the MARS code. The calculation results provide some meaningful spatial distributions for the physical quantities like the noncondensible mass concentration and the temperature in a bulk space. The results will be compared with other detailed CFD calculations and experimental data through the OECD SETH benchmark meetings.

Acknowledgement

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REFERENCES

[1] G.Yadigaroglu, J. Drier, The proceeding of OECD SETH Project First Meeting of the Program review Group, Erlangen, 22-23 May, 2002.

[2] B.D. Chung, *et. al.*, Development of Multidimensional Component, MULTID for Thermal Hydraulic System Analysis Code, MARS, 2003 KNS Autumn Meeting, KNS, 2003.

[3] S.W. Bae, et. al., Assessment of Multi-dimensional Analysis Capability of the MARS using the OECD-SETH PANDA tests, *Proceeding of 2004 KNS Spring Meeting*, KNS, 2004.