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Results from the First Validation Phase of CAP code

Yeon Joon Choo*, Soon Joon Hong[a], Su Hyun Hwang[a], Min Ki Kim[a], Byung Chul Lee[a],
Sang Jun Ha[b], Hoon Choi[b]
[a] *FNC Tech., SNU 135-308, Daehak-Dong, Kwanak-Gu, Seoul, 151-742, S. Korea*
[b] *Korea Electric Power Research Institute, 65 Moonjiro, Yuseonggu, Daejeon, 305-380 , S. Korea*
**Corresponding author: yjchoo@fnctech.com*

1. Introduction

The second stage of Safety Analysis Code Development for Nuclear Power Plants was lunched on Apirl, 2010 and is scheduled to be through 2012, of which the scope of work shall cover from code validation to licencing preparation. As a part of this project, CAP(Containment Analysis Package) will follow the same procedures. CAP's validation works are orgnaized hieratically into four validation steps using;

1) Fundamental phenomena.
2) Principlal phenomena (mixing and transport) and components in containment.
3) Demonstration test by small, middle, large facilities and International Standard Problems.
4) Comparison with other containment codes such as GOTHIC or COMTEMPT.

In addition, collecting the experimental data related to containment phenomena and then constructing the database is one of the major works during the second stage as a part of this project.

From the validation process of fundamental phenomean, it could be expected that the current capability and the future improvements of CAP code will be revealed. For this purpose, simple but significant problems, which have the exact analytical solution, were selected and calculated for validation of fundamental phenomena. In this paper, some results of validation problems for the selected funcdamental phenomea will be summarized and discussed briefly.

2. Validation Problems for Fundamnetal Phenomena

Five categorized problems were selected for the fundamental phenomena and tabular summarization is shown in Table I.

Table I: Selected Validation Problems

Categories	Phenomena Description
Thermo-Dynamics Phenomena[TDP] (P1~P10)	- Static process in closed system - Thermal mixing - Adiabatic expansion
Hydro-Dynamics Phenomena[HDP] (P11~P16)	- Friction flow - Jet flow - Oscillating and turnover flow
Conductive Heat Transfer[CDHT] (P17~P21)	- Constant and conductive boundary conditions
1 Phasic Convective Heat Trasnfer [SPHT] (P22~P25)	- Internal and external flow
2 Phasic Convective Heat Trasnfe [TPHT] (P26~P29)	- Condensation - Entrainment / Deentrainment

3. Results and Discussion

This section shows three representative results among the validation problems listed in Table I. Three problems are the *Static Process of Steam in Closed System (P2)* in Category TDP, *Manometer (p11)* in Category HDP and *Internla Flow with Constant Wall Temperature (P24)* in Category SPHT.

3.1 P2: Static Process of Steam in Closed System

Problem 2 represents the *Static Process of Steam in Closed System* that is nodalized with one lumped volume(LVol) and one cooler component. Steam is filled initially in an LVol at the superheated state(1 MPa and 250 ^oC). A cooler serves as a heat sink at the rate of 53.95 kJ/sec. Pressure and temperature estimated analytically after 10 seconds are 0.35 MPa and 138.9 ^oC. CAP simulation results, as depicted in Fig. 1, agree with analytical results exactly and show the transient processs form superheated steam to statuated one.

3.2 P11: Manometer

Problem 11 is of the Manometer that is nodalized with 20 LVols and each LVol is connected with junction. Each volume has an area of $1.0x10^{-2}$ m^2 and a length of 1.0 m. The left and right five bottom volumes are filled initially with saturated water at $2.0x10^5$ kPa and 120 ℃. The remaining volumes are filled with saturated steam at same pressure and temperature as saturated water. Two pressure boundary junctions are connected with left and right pipes and exist in the same gaseous state filled in upper part of pipe. Initial velocity of -0.1 m/s was placed to initiate the oscillation at each junction. Two cases are calculated; the first one is without friction and second one with friction.

Typical oscillation pattern at a junction connecting LVol 10 and 11 is shown in Fig. 2. Water level with the simillar periodic oscillating pattern can be expected to track within LVol 5 and 6. The theoretical period of the oscillation is given by 2π /(2g/L)1/2 where L is the length of the liquid in the manometer and g is the gavitational constant. Theoretical value of oscillating period gives 4.486 seconds with L=10 m and this value agrees with that calculated by CAP.

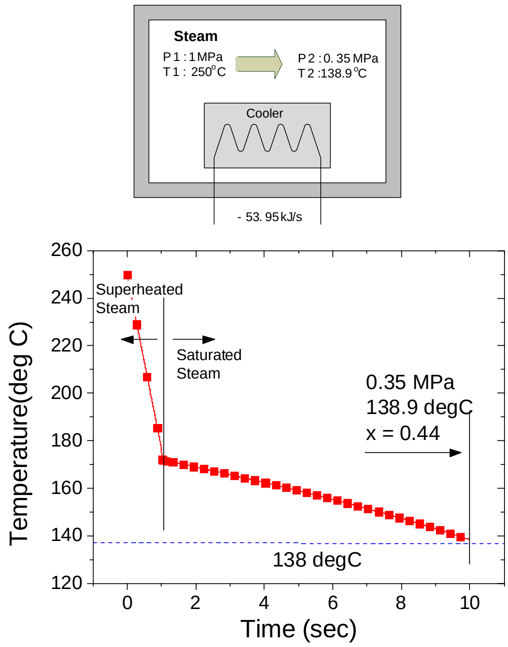

Fig. 1. Temperature transition of in Problem 2.

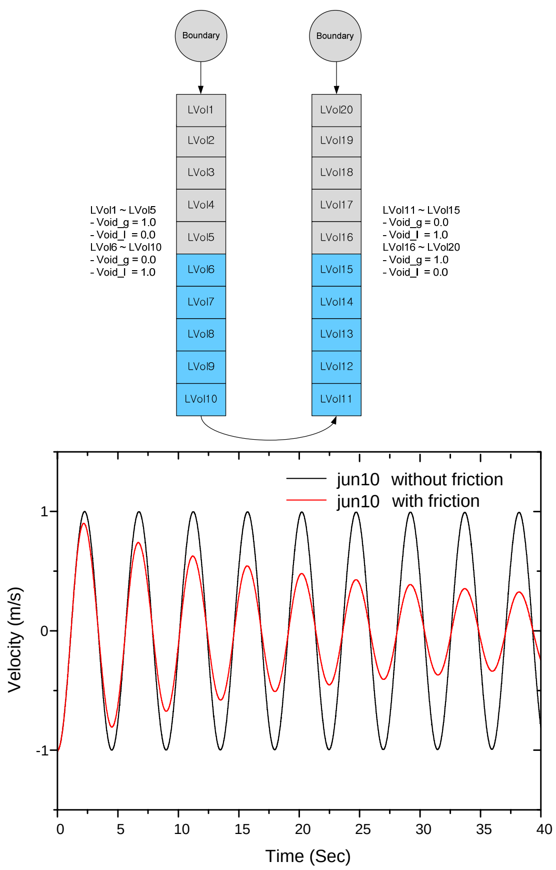

Fig. 2. Velocity oscillation of junction 10 in Problem 11.

3.3 P24: Internal Flow with Constant Wall Temperature

Problem 24 represents the *One Dimensional Conduction with Constant Wall Temperature* that is nodalized with two lumped volumes, one flow boundary and one pressure boundary. One lumped volume serves as internal space and is filled with subcooled water (1.0x10^5 Pa and 15℃). Subcooled water enter from a flow boundary into the pipe (inner diameter: 50 mm) at the mass flow rate of 0.25 kg/sec and exit the pipe to a pressure boundary. While, outer wall of pipe is maintained at a constant temperature of 100 ^{o}C.

Temperature at the exit is increasing with time and saturated finally at a tempearature of 57 ^{o}C. This value agrees with an analytical value using the Logarithmic Mean Temperature Difference (LMTD).

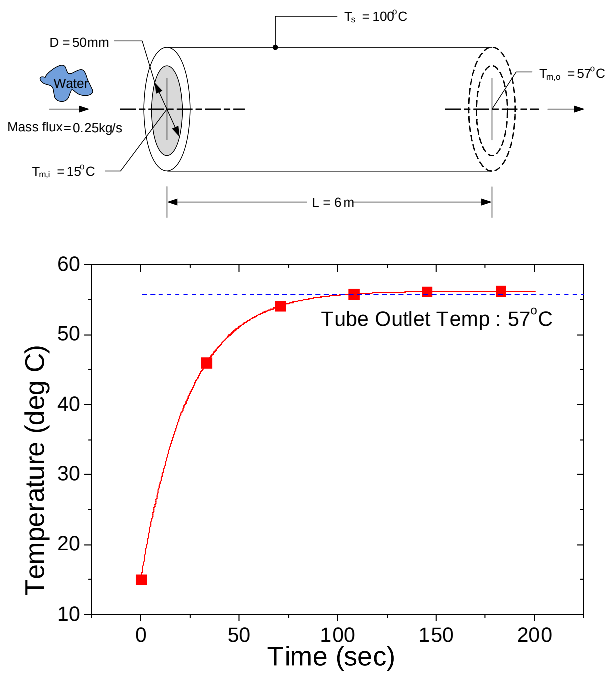

Fig. 3. Temperature transition in Problem 24.

3. Conclusions

CAP code is in its early phase of the second stage when is for the validation and licencing preparation. First validation work is of the fundamental phenomena, which is composed of 5 categories and total 29 problemes. In this paper, three representative problems are summarized and those results are discussed.

REFERENCES

[1] USNRC (United State Nuclear Regulatory Commission), 2001, RELAP5/MOD3.3 Code Manual, NUREG/CR-5535.
[2] Y. J. Choo and et al. CAP Manual, Volume 4, Validation Manual(in Korean), 2010.