Validation of the manometric oscillations in the TASS/SMR code

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1. Introduction

TASS/SMR (Transient And Setpoint/Small and Medium Reactor) code [1] is a computer program developed for the performance and safety analysis of SMART (System-integrated Modular Advanced Reactor). Since the technologies used for the SMART design are different from existing reactors, the analytical capability of TASS/SMR code has to be verified for its application to the system analysis of SMART. Also the reliability of the analysis results of the code need to be verified using proper experimental data. In this paper, the manometric oscillations problem was analyzed by the TASS/SMR code and the results were compared with the simplified theoretical results or analytic solutions.

2. Methodology

Basic conceptual and analytical problems are selected to evaluate the fundamental numerical anaysis capability of the TASS/SMR code. Fifteen problems including mass and energy conservation problems were selected [2]. The manometric oscillations problem is one of them.

2.1 Physics context

This benchmark problem was proposed by Ransom. It consists of calculating the gravitational oscillations of the liquid water contained in the bottom half of the manometer. The device is a U-shaped tube with two ends which are joined so that we have a closed loop. The system initially contains steam or air and liquid water.

2.2 TASS/SMR Code Input Modeling

Figure 1 shows the node construction of the manometric oscillations. The total length is 20m. The water length of Node(1) is 15m and the water length of Node(2) is 3m. Table 1 shows the analysis condition.

3. Results

As the friction of the liquid on the wall is assumed to be nil, the problem has an analytical solution if we only assume that the important equations are the equations of the mass and momentum of the liquid phase (the inertia of the gas phase being assumed to be negligible when compared with that of the liquid phase). These equations, intergrated over the length of the tube, are written in the following manner (Ransom):

$$\frac{dx(t)}{dt} = 2v$$
$$\frac{dv(t)}{dt} = -\frac{gx(t)}{L}$$

where $x(t)$ designates the difference between the water levels in the two branches at the time t, $v(t)$ designates the velocity of the fluid at this time, g denotes the acceleration of the gravity and L is the water length. The system of equations associated to the initial conditions:

$x(0) = 0$, $v(0)= v_0$

has the solution:

$$v(t) = v_0 sin(wt)$$
$$x(t) = \frac{2v_0}{w} sin(wt)$$
$$\omega = \sqrt{\frac{2g}{L}}$$
$$\therefore \tau = \pi\sqrt{\frac{2L}{g}}$$

Table 2 shows the period of the manometric oscillations. The calculated period of the manometric oscillations is nearly the same with the analytical solution and the interfacial boundary of each phase (liquid and steam) is well maintained during the whole calculation time.

Figures 2 and 3 show the liquid level of node 1. The liquid level of node 1 decreases from 15m to 3m, and it oscillates at 9m which is the center of the liquid level. The amplitude decreases continuously due to a frictional loss at the wall.

Figures 2 and 4 show the liquid level of node 2. The liquid level of node 2 increases from 3m to 15m, and it also oscillates at 9m which is the center of the liquid level.

4. Conclusions

TASS/SMR code can has an appropriate ability related to the manometric oscillations problem compared with the analytical reference solution. The code predicts the whole oscillation period well compared with the analytical solution.

Table 1 The initial conditions

		Value (Unit)
Pressure (Node1,2)		2.4563E05 (Pa)
Water Temperature (Node 1,2)		400.0 (K)
Steam Temperature (Node 1,2)		400.0 (K)
Water Length (L)	Node 1	15 (m)
	Node 2	3 (m)

Table 2 The period of the manometric oscillations

	Analytical Solution (sec)	TASS/SMR (sec)	The rate of error (%)
A cycle (τ) $=\pi\sqrt{\frac{2L}{g}}$	6.0193	6.0288	0.1576

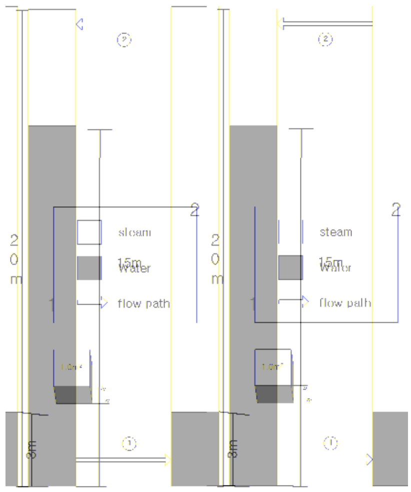

Figure 1 The node construction of the manometric oscillations

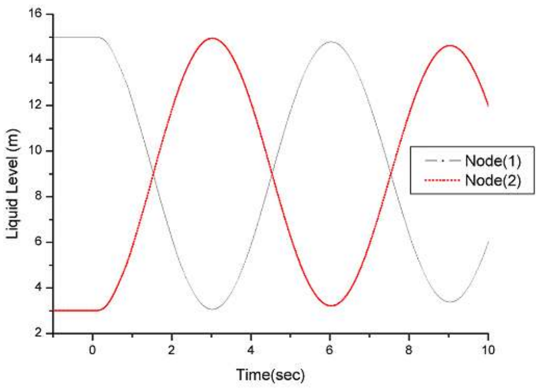

Figure 2 The liquid level of node 1 & 2

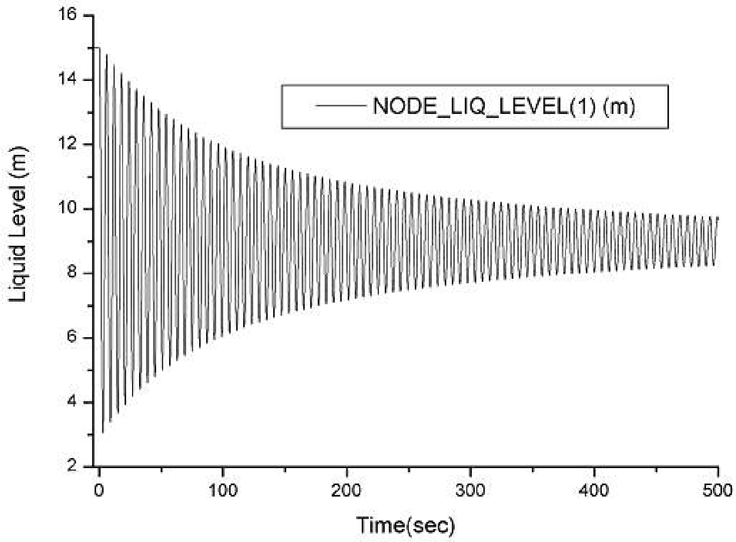

Figure 3 The liquid level of node 1

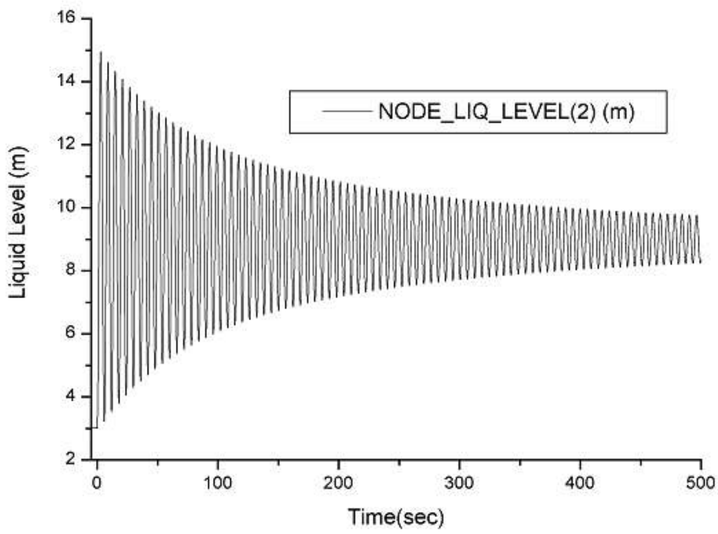

Figure 4 The liquid level of node 2

Acknowledgement

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REFERENCES

[1] Y.D. HWANG, et. al., “Model Description of TASS/SMR Code”, KAERI/TR-3082/2005, December 2005.

[2] “Evaluation of the Thermal-Hydraulic System Analysis Code for SMART”, KAERI/CM-883/2005, March 2006.