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《Technical Note》

Effects of Condensation Heat Transfer Model in Calculation for KNGR Containment Pressure and Temperature Response

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Abstract

Under severe accidents, the pressure and temperature response has an important role for the integrity of a nuclear power plant containment. The history of the pressure and temperature is characterized by the amount and state of steam/air mixture in a containment. Recently, the heat transfer rate to the structure surface is supposed to be increased by the wavy interface formed on condensate film. However, in the calculation by using CONTAIN code, the condensation heat transfer on a containment wall is calculated by assuming the smooth interface and has a tendency to be underestimated for safety. In order to obtain the best-estimate heat transfer calculation, we investigated the condensation heat transfer model in CONTAIN 1.2 code and adopted the new forced convection correlation which is considering wavy interface. By using the film tracking model in CONTAIN 1.2 code, the condensate film is treated to consider the effect of wavy interface. And also, it was carried out to investigate the effect of the different cell modelings - 5-cell and 10-cell modeling - for KNGR(Korean Next Generation Reactor) containment phenomena during a severe accident. The effect of wavy interface on condensate film appears to cause the decrease of peak temperature and pressure response. In order to obtain more adequate results, the proper cell modeling was required to consider the proper flow of steam/air mixture.

Key Words : film wavy interface, condensation heat transfer, natural convection, forced convection, minimum film thickness, cell modeling

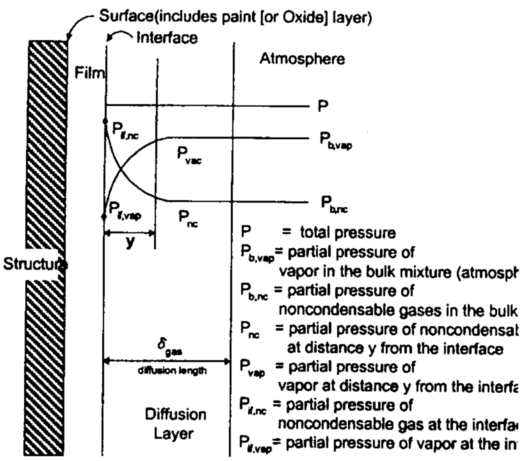

Fig. 1. The Influences of Noncondensables on Interface Resistance

1. Introduction

In a postulated severe accident, the inner space of the containment is filled with far much of steam at high pressure and temperature. Thus the containment atmosphere is characterized by steam/air mixed vapor. In this condition, mass transfer, which governs condensation and evaporation of vapor at the heat structure surfaces, is driven by the partial pressure difference of the condensable vapor. If a condensate film layer exists on the structure surface, the partial pressure of the noncondensable gas at this film layer will be higher than that of the bulk mixture. This condition occurs because the noncondensable gas is carried with the vapor toward the interface where it accumulates. The increase in the partial pressure of the noncondensable gas produces a driving force for diffusion of the noncondensable gas away from the surface. This force opposes the motion of the bulk mixture toward the surface[1][2]. As shown in Fig. 1, the total pressure of the bulk mixture remains constant, the vapor partial pressure at the interface is lower than that in the bulk mixture when the process is condensation and is higher than that in the bulk mixtures in case of evaporation. In this manner, it is well known that a few percent of a noncondensable gas in the vapor reduces the condensation heat transfer rate drastically. Also it is experimentally known that the wavy interface on the condensate film formed on structure surface increases the heat and mass transfer rate by enhancing the eddy motion at the concentration gradient layer of noncondensable gas[3]. therefore, the wavy interface plays a role as decreasing the thermal resistance of the noncondensable gas layer, and increases the rate of heat removal for the containment inner space. However, in a conservative stand point, CONTAIN calculations have a tendency to underestimate these heat transfer coefficients for safety because the condensation heat transfer model of the CONTAIN 1.2 code has only considered condensate film interface as smooth one. So, in this study, we investigated the condensation heat transfer model in CONTAIN 1.2 code, which regarded film interface as smooth one, and replaced it with the correlation with considering wavy interface, developed by S. K. Park and M. H. Kim[1997][3][4]. And also to adopt this new condensation heat transfer correlation, we used the film tracking model in CONTAIN 1.2 code.

The objectives of this study are to analyze the effects of the wavy film interface which affected the CONTAIN calculations for containment pressure and temperature response under severe accident conditions and to obtain the best-estimate condensation heat transfer coefficient.

2. CONTAIN Code

The CONTAIN code is an analytical tool for predicting the physical, chemical, and radiological conditions inside the containment and connected buildings of a nuclear reactor in the event of an accident[5]. CONTAIN was developed at Sandia National Laboratories under the sponsorship of the US Nuclear Regulatory Commission(USNRC) for analyzing containment phenomena under severe accident and design basis accident conditions. It is designed to predict the thermal-hydraulic response inside containments and the release of radionuclides to the environment in the event of containment failure. CONTAIN employs best-estimate models where possible with an emphasis placed on mechanistic detail and numerical robustness. Although the individual models in CONTAIN are in general mechanistic, overall the code has reasonable computational efficiency because of the highly efficient control volume framework of the code. The control volume approach has proven to be useful technique for modeling a wide variety of containment configurations as well as providing a suitable framework for modeling the many different containment subsystems. Previously, several separate codes were used to examine containment phenomena. Under such an approach, each code analyzes thermal-hydraulic phenomena, FP processes, aerosol behavior, and so on. By contrast, CONTAIN simultaneously treats these phenomena and others as well. The major modelings for heat transfer of CONTAIN code is as follows.

2.1. Convective Heat Transfer and Condensation Model

The heat transfer configuration is shown in Fig. 2 as three mechnism - convective heat transfer q_{conv}, mass transfer q_{mt}, and radiation q_{rad}[5]. This study is to analyze the heat transfer model and film tracking model which affects the heat removal of the containment atmosphere to predict the

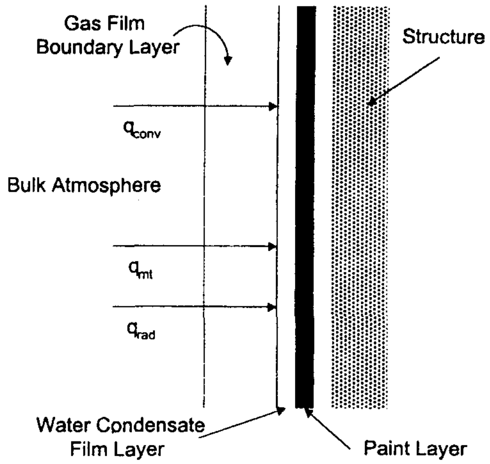

Fig. 2. Heat Transfer Configuration (not to scale)

temperature and pressure response of the inner containment under severe accident condition.

The convective heat transfer flux between the atmosphere or pool and a surface is in general given by

$$q_{conv} = h_{conv}\,(T_b - T_{if}) \tag{1}$$

where q_{conv} is the convective heat transfer flux(W/m^2) ; h_{conv} is the convective heat transfer coefficient ($W/m^2 \cdot K$) ; T_b is the bulk fluid temperature (K) ; and T_{if} is the interface temperature at the gas-liquid interface, the gas-solid interface, or the pool-surface interface, whichever is applicable. The heat transfer coefficient h_{conv} is related to the Nusselt number Nu by

$$h_{conv} = Nu\,\frac{k}{L} \tag{2}$$

where k is the thermal conductivity of the bulk fluid evaluated in general in the boundary layer, and L is the characteristic length for the surface. Three standard correlations are avaliable in CONTAIN for determining Nu in Eq. (2) for either forced or natural convection regimes.

By default the code uses a natural convection correlation. For vertical walls, downward facing ceilings, which are warmer than the atmosphere, and upward facing floors, which are warmer than the atmosphere, the following turbulent correlation is used

$$Nu_c = 0.14 \cdot (Gr \cdot Pr)^{0.33} \tag{3}$$

The following laminar correlation is used for downward facing ceilings, which are warmer than the atmosphere, and upward facing floors, which are colder than the atmosphere.

$$Nu_c = 0.27 \cdot (Gr \cdot Pr)^{1/4} \tag{4}$$

In situations where forced flow conditions are believed to exist, the user must give a table that specifies either a gas velocities or a Nusselt number as a function of times. If velocity is given, then the Reynolds number will be computed. The forced convection correlation

$$Nu_f = 0.037\, Re^{0.8}\, Pr^{0.33} \tag{5}$$

will then be used to calculate the Nu number. However, this Nu_f will only be used if it exceeds the value determined using the appropriate natural convection correlation.

Finally, the Nu number used in the convection model for structures can be specified directly by the user in a table as a function of time. Such values are not overridden by the natural convection correlation. To summarize, if Nu number is not specified by users, it can be expressed as

$$Nu = Max(Nu_c, Nu_f) \tag{6}$$

Because of the large scale of a typical containment building, the containment wall could be modelled as a vertical plate with gas flow parallel to the surface. The vapor-air mixture velocity along the wall, when a steam blowdown accident occurs, was estimated to reach the order of meters per second. If the length of the containment wall and some obstacles to disturb the flow were considered with the above velocity, the vapor-air boundary layer has to be considered as turbulent. Since the Chilton-Colburn analogy applies for fully turbulent flow parallel to plane surfaces at low mass transfer rates, it can be used to calculate the convective heat transfer coefficient near the containment wall[6][7][8],

$$\frac{h_{conv}}{\rho_g c_p u_g} = \frac{f}{2} E_H \tag{7}$$

$$E_H = Pr_t^{-1} = Pr^{-2/3} \tag{8}$$

where E_H is the ratio of the turbulent eddy diffusivity of heat ϵ_H to momentum ϵ_M. Now, for a plane wall the local skin-friction factor is given by

$$\frac{f}{2} = 0.0296\ Re_x^{-0.2} \tag{9}$$

for Reynolds numbers between 5×10^5 and 10^7. When this is combined with Eq. (7), the resultant local convective heat transfer coefficient is

$$Nu_x = \frac{h_{conv} x}{k} = 0.0296\ Re_x^{0.8} Pr^{1/3} \tag{10}$$

Since the Reynolds number is a function of x, the average turbulent convective heat transfer coefficient for the vapor-air boundary layer can be calculated by integrating over the surface.

$$\begin{aligned} Nu_L &= \frac{h_{conv} L}{k} \\ &= \frac{1}{L}\int_0^L Nu_x\, dx = 0.037\ Re^{0.8} Pr^{1/3} \end{aligned} \tag{11}$$

which is same with Eq. (5). Similarly, the mass flux diffusing through the vapor-air boundary layer can be estimated by using the Chilton-Colburn analogy.

$$\frac{g}{\rho_g u_g} = \frac{f}{2} E_D \tag{12}$$

$$E_D = Sc_t^{-1} = Sc^{-2/3} \tag{13}$$

where E_D is the ratio of the turbulent eddy diffusivity of mass ϵ_D to momentum ϵ_M. When Eq. (12) is compared with Eq. (7), the heat and mass transfer coefficient are correlated

$$Sh = Nu \left(\frac{Sc}{Pr} \right)^{1/3} \tag{14}$$

From Eqs. (11) and (14) the condensation mass transfer coefficient can be predicted

$$Sh = 0.037\ Re_L^{0.8} Sc^{1/3} \tag{15}$$

$$\frac{g}{\rho_g u_g} = 0.037\ Re_L^{-0.2} Sc^{-2/3} \tag{16}$$

The mass transfer flux can be calculated as

$$\dot{m}'' = g \frac{X_{if} - X_b}{1 - X_{if}} \tag{17}$$

and the condensation heat transfer coefficient is then given by the following equation.

$$h_{cond} = \frac{\dot{m}''\,(h_b - h_{if})}{(T_b - T_{if})} \tag{18}$$

2.2. Film Tracking Model

The film tracking model in CONTAIN 1.2 code simulates the behavior of film flow and treats the minimum film thickness as the point of condensate film flow being started. This model uses film flow correlations derived for films on the top side of an inclined surface ($0 < \theta < 90°$) or on a vertical surface ($\theta = 90°$). Films on the underside of an inclined surface, such as the containment dome, are not stable, and the correlations presented here are not strictly applicable. Nevertheless, these correlations are made available for such films, for lack of more appropriate modeling, because they may be useful in parametrically representing the film behavior on such surfaces[5].

Under the severe accident condition, the films are formed by temperature difference between surface of a structure and containment atmosphere on structures in the containment, and move to the near structure by gravity and others. In this case, the path and the amount of the moving films are affected by the roughness of each surface and the angle of the inclined one. Thus, these moving films affect drastically to the heat transfer rate of the cell. therefore, CONTAIN 1.2 code uses film tracking model fôr film flows by using minimum film thickness, δ_m. To modify these film flows in CONTAIN code, it is considered that these films are formed but not flow by roughness of the surface and that film flow being started at the point that film depth exceeds the minimum film thickness. Finally, the relationship between the film depth and the minimum film thickness for the film flow is in general summarized as following expression.

$$\begin{cases} \delta < \delta_m : \textit{Film Flow is not allowed} \\ \delta > \delta_m : \textit{Beginning of Film Flow} \end{cases}$$

3. Model Developed for Wavy Interface

As mentioned above, the forced convection correlation in CONTAIN code only uses formula for the smooth film interface. Since it has been estimated that the wavy interface between vapor/air and condensate film affects condensation rate, we replaced the forced convection model in CONTAIN 1.2 code with the experimental correlation developed for wavy interface. S. K. Park and M. H. Kim[1997][3][4] developed an experimental condensation correlation for steam/air mixture to model the condensation heat transfer model on a containment wall. In this experiment, the parameters considered were air-mass fraction(W = 0.0, 0.1, 0.2, 0.3, 0.5, 0.7), vapor velocities(U_{in} = 1.4, 3, 5, 7 m/s) and condensate film Reynolds numbers, which is up to 18,000, corresponding to the wave structures of condensate film. The correlation was obtained as a function of air-mass fraction, vapor Reynolds number, condensate film Reynolds number, Prandtl number, and Schmidt number[3].

In this experiment, the heat flux of steam-air condensation in the saturation state is separated into condensing and sensible heat fluxes

$$q = q_c + q_s = m'' h_{fv}|_i + k \frac{\partial T}{\partial y}\Big|_i \tag{19}$$

From the energy balance, the vapor-side heat transfer coefficient becomes

$$h_v = h_c + h_s \tag{20}$$

where subscript c and s means the condensation and sensible, respectively. From this experiment the vapor-side heat transfer coefficient, h_v, was obtained by

$$h_{v,s} = C_m\ Re_v^{0.8}\ Sc^{1/3}\left[k_c + \frac{C_s}{C_m}\cdot\left(\frac{Pr}{Sc}\right)^{1/3} k_s\right]\frac{1}{x} \tag{21}$$

In this formula the coefficient C_m and C_s/C_m was estimated as 0.0283 and 2.5 respectively, and the reason why C_s is greater than C_m by 2.5 times was supposed that the multiplier considering the effect of suction was included in the sensible heat transfer coefficient[3].

On the basis of this result, the relation between smooth interface and wavy one was given by

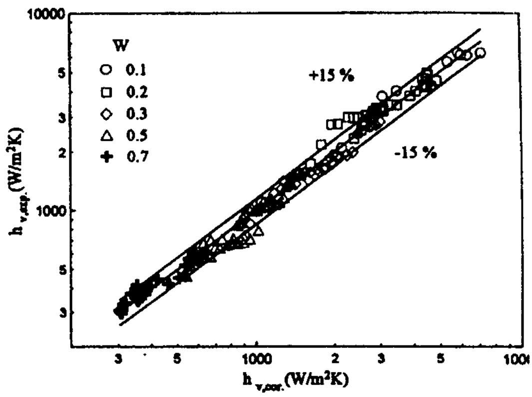

Fig. 3. Comparison Between the Experimental Data and the Correlation

$$\frac{h_{v,w}}{h_{v,s}} = 1 + 1500\ Re_f^{0.65}\ Re_v^{-1.1} \tag{22}$$

Thus the enhanced heat transfer coefficient due to the wavy interface was correlated as

$$h_{v,w} = 0.0283\cdot(1 + 1500\ Re_f^{0.65}\ Re_v^{-1.1})\cdot Re_v^{0.8}\ Sc^{1/3}\left[k_c + 2.5\cdot\left(\frac{Pr}{Sc}\right)^{1/3}\cdot k_s\right]\frac{1}{x} \tag{23}$$

Most of the experimental data estimated are within ±15% error shown in Fig. 3. In this study, we adopted this new correlation into forced convection model in the CONTAIN 1.2 code which did not consider film waviness. Now, for wavy interface, we must average the Eq. (23) over the surface, then

$$\begin{aligned}\bar{h}_{v,w} &= \frac{1}{L}\int_0^L h_{v,w}\,dx \\ &= 0.03575\ Re_v^{0.8} Sc^{1/3}\cdot W\cdot\left\{k_c + 2.5\left(\frac{Pr}{Sc}\right)^{1/3} k_s\right\}\frac{1}{L}\end{aligned} \tag{24}$$

where W=(1+3428.56$Re_f^{0.65}$ $Re_v^{-1.1}$). We can represent Eq. (24) as Nusselt and Sherwood number, respectively.

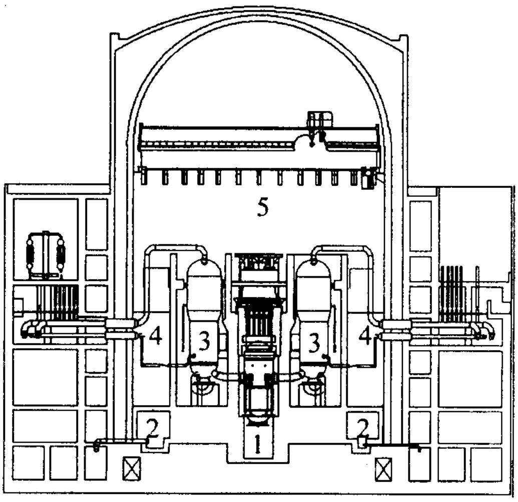

Fig. 4. 5-cell Modeling for KNGR Containment

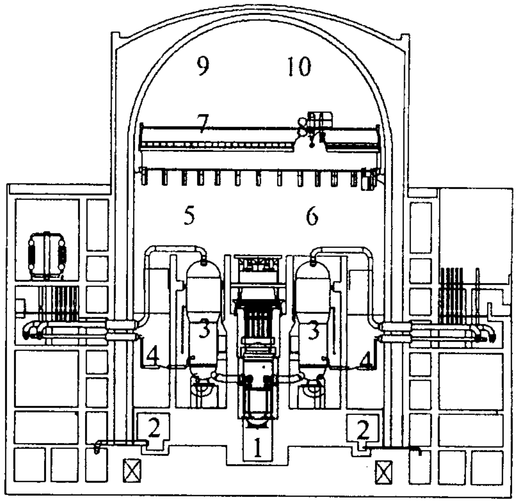

Fig. 5. 10-cell Modeling for KNGR Containment

$$Nu_w = 0.03575 \cdot \{2.5 \cdot W\}\, Re_v^{0.8} Pr^{1/3} \qquad (25)$$

$$Sh_w = 0.03575 \cdot W \cdot Re_v^{0.8} Sc^{1/3} \qquad (26)$$

4. Calculation and Results

4.1. Cell Modelings for KNGR Containment

Since CONTAIN code performed the calculation by dividing the containment inner space as arbitrary space called "Cell", both proper and logical cell modeling is one of the major factor in the analysis of containment pressure and temperature response. therefore, on the basis of the characteristics of the KNGR containment, it was carried out to investigate the effect of the different cell modelings : 5-cell and 10-cell modeling. The schematic drawings for each cell modeling are shown in Fig. 4 and Fig. 5.

As shown in figures, since the containment dome of 5-cell modeling occupies over 75 % of the containment total volume, it is not proper to simulate the practical flow pattern for containment

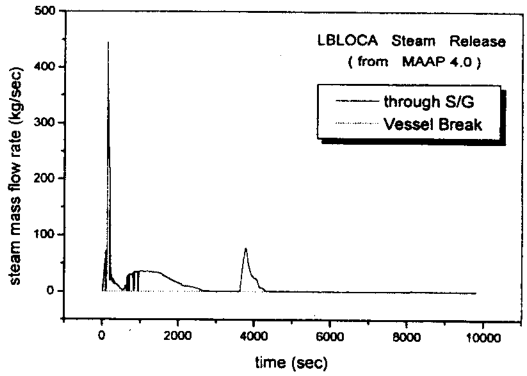

Fig. 6. Steam Release rate (MAAP 4.0)

atmosphere. It is necessary to divide the containment dome in detail in order to analyze the flow near the containment wall. therefore, we carry out the 10-cell modeling which divided the containment dome into 6 parts. The user input data for these cell modelings listed in Tables 1 through 4. On the basis of these cell modelings, the analysis of the effects of condensation heat transfer model of CONTAIN 1.2 code was performed for KNGR containment phenomena in a postulated severe accident scenario of LBLOCA. Since the CONTAIN code must use the source

Table 1. Geometry for KNGR 5-cell Modeling

Cell	Name	Volume(m^3)	Height(m)	#of Heat Sink
1	Cavity and Chute	533.716	6.6346	4
2	IRWST	794.760	1.1292	3
3	S/G Room	7420.543	27.7368	10
4	All Subcompartments except S/G Room	11646.209	17.0688	12
5	Everything above Subcompartments	69769.567	52.8828	13

Table 2. Junction Data for KNGR 5-cell Modeling

Flow Path (Cell)	Flow Area(m2)	AVL*(m)	Flow Loss Coeff.
1 - 3	9.281	0.1024	1.32
1 - 4	6.689	0.2173	1.32
2 - 4	18.581	0.5819	1.25
3 - 4	13.949	0.3308	1.085
3 - 5	100.539	1.6568	1.175
4 - 5	54.636	0.8559	1.612

$^*AVL = \frac{A_{ij}}{L_{ij}}$; Area to length ratio of the flow path between cell i and j

data calculated from primary system code, such as MAAP, we made use of the results of MAAP 4.0 code[9]. The source data, such as steam mass flow rate, released into the containment inner space are shown in Fig. 6.

4.2. Results and Discussion

Fig. 7 shows the ratio of the condensation heat transfer coefficient with the wavy film interface to that with the smooth one corresponding to the fixed film Reynolds number. In this analysis, the velocity of the mixed vapor and vapor Reynolds number ranges from about 0 to 20 m/sec and up

Table 3. Geometry for KNGR 10-cell Modeling

Cell	Name	Volume(m^3)	Height(m)	# of Heat Sink
1	Cavity and Chute	533.716	6.6346	4
2	IRWST	794.760	1.1292	3
3	S/G Room	7420.543	27.7368	10
4	All Subcompartments except S/G Room	11646.209	17.0688	12
5	Containment Upper Volume-1	20760.68	30.0228	8
6	Containment Upper Volume-2	20760.68	30.0228	8
7	Comtainment Dome-1	8600.625	11.43	3
8	Comtainment Dome-2	8600.625	11.43	3
9	Comtainment Dome-3	3909.375	11.43	2
10	Comtainment Dome-4	3909.375	11.43	2

Table 4. Junction Data for KNGR 10-cell Modeling

Flow Path (Cell)	Flow Area (m^2)	AVL*(m)	Flow Loss Coeff.
1 - 3	9.281	0.1024	1.32
1 - 4	6.689	0.2173	1.32
2 - 4	18.581	0.5819	1.25
3 - 4	13.949	0.3308	1.085
3 - 5	77.71	1.8467	0.5
3 - 6	73.39	1.745	0.5
4 - 5	7.525	0.1799	1.0
4 - 5	12.821	0.3065	1.0
4 - 6	7.525	0.1799	1.0
4 - 6	19.788	0.473	1.0
5 - 6	693.21	27.709	0.01
5 - 7	738.78	15.4	0.01
6 - 8	738.78	15.4	0.01
7 - 8	398.79	20.4885	0.01
7 - 9	573.2556	15.8176	0.01
8 - 10	573.2556	15.8176	0.01
9 - 10	235.755	15.7532	0.01

$^*AVL = \frac{A_{ij}}{L_{ij}}$; Area to length ratio of the flow pathbetween cell i and j

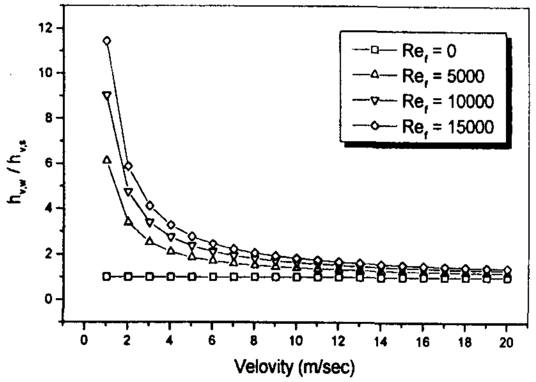

Fig. 7. The Effect of Wavy Interface Corresponding to the Film Reynolds Number

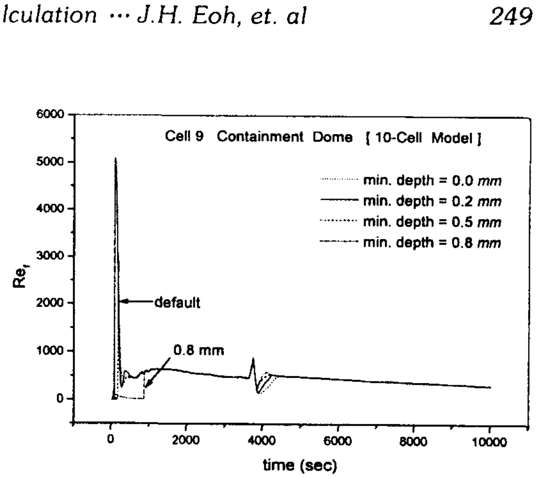

Fig. 9. Film Reynolds Number Change in Containment Dome

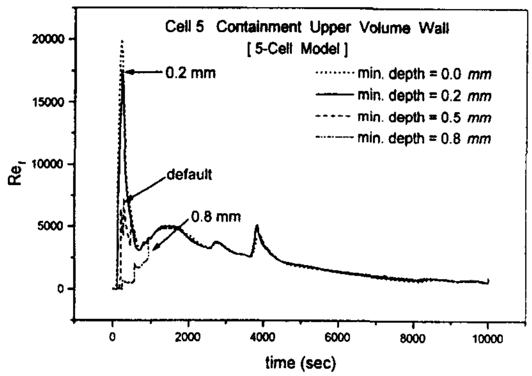

Fig. 8. Film Reynolds Number Change on Containment Wall

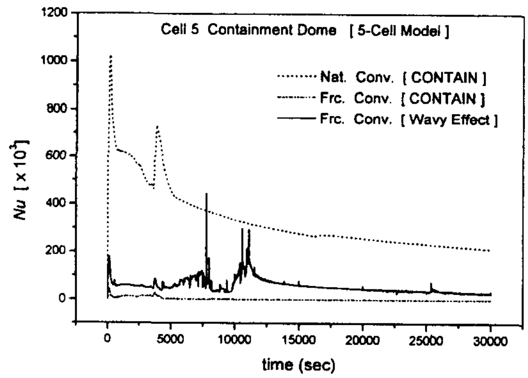

Fig. 10. Nusselt Number Change in Containment Dome [5-cell Modeling]

to 1.2×10^6, respectively. As shown in this figure, it is clear that the more activated film flow, the better effects of wavy interface is obtained. However, as the velocity of the containment atmosphere increased, we could find that the wavy effect decreased. This is due to the fact that, as the containment atmosphere is well mixed, the flow of the atmosphere is dominant compared with the film flow, and thereby the noncondensable gas layer has somewhat lower effect to the heat transfer relatively.

Fig. 8 and Fig. 9 show the film Reynolds number corresponding to the minimum film thickness used in film tracking model. In these figures, as the minimum film thickness considered the surface roughness increased, the film flow and film Reynolds number decreased. These results are similarly shown in 10-cell modeling. therefore it is suggested the value of minimum film thickness as 0.2 mm which is more activated film flow with compared to the default value of 0.5 mm in CONTAIN 1.2 code. Also, it was proved that the film over the vertical plate was formed steadily from the experiment[3][4].

In this study, the analysis of the effects of condensation heat transfer model of CONTAIN

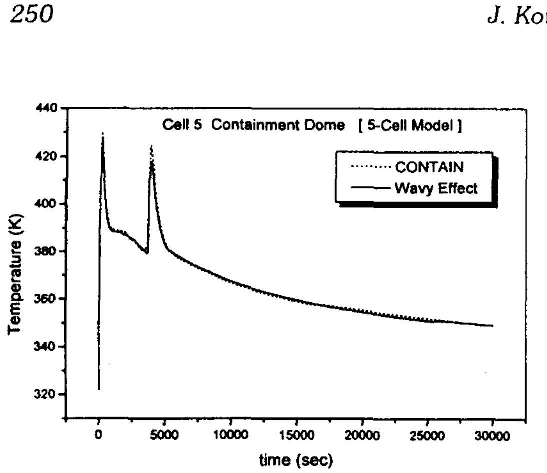

Fig. 11. Temperature Change in Containment Dome [5-cell Modeling]

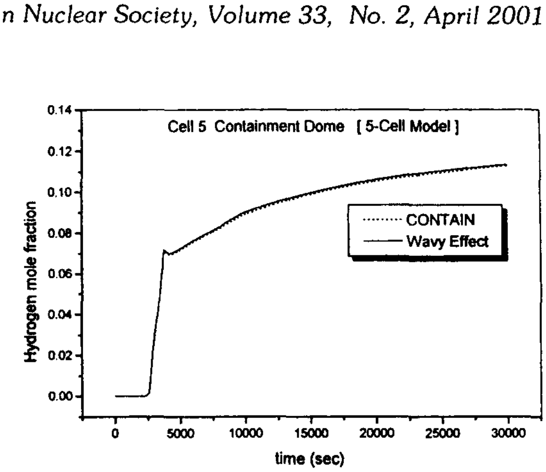

Fig. 13. H_2 Mole Fraction Change in Containment Dome [5-cell Modeling]

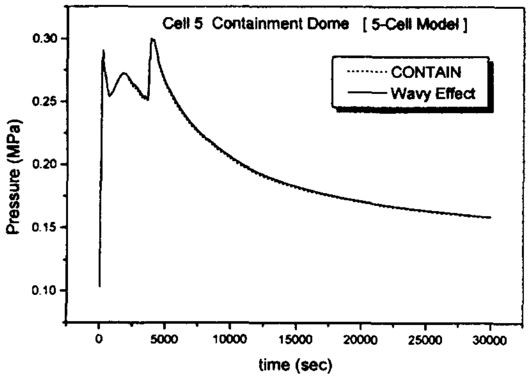

Fig. 12. Pressure Change in Containment Dome [5-cell Modeling]

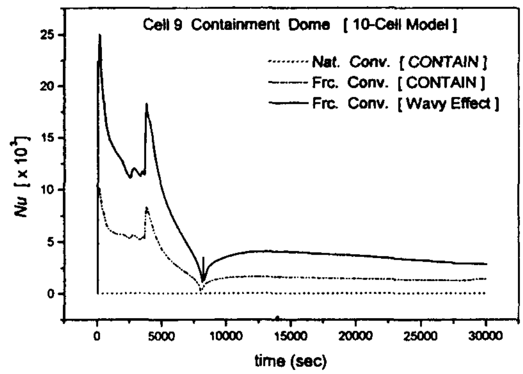

Fig. 14. Nusselt Number Change in Containment Dome [10-cell Modeling]

1.2 code was performed until 30,000 sec just after being started of the accident. And also emphasis was placed on calculation for containment dome compartment, because the containment dome has very large volume and thereby the flow of this compartment affects the calculation for any other cell dominantly.

Fig. 10 shows the Nusselt number change in containment dome for 5-cell modeling. As shown in this figure, the Nusselt number calculated by the forced convection in CONTAIN is very small value compared to the results by the natural one. This is due to the fact that the volume of the containment dome is very large compared to any other cell and thereby the flow of containment atmosphere has somewhat low velocity and that a large characteristic length is used in Nusselt number calculation for the natural convection.

Figs. 11 through 13 show the temperature, pressure and hydrogen mole fraction change, respectively. As shown in these figures, it is certified that the forced convection model did not affect the calculation for the temperature and pressure response by the above reason. therefore, in case of adoption for new experimental correlation which is considered wavy effect, the calculation results are almost same to the old one because the natural convection is still dominant

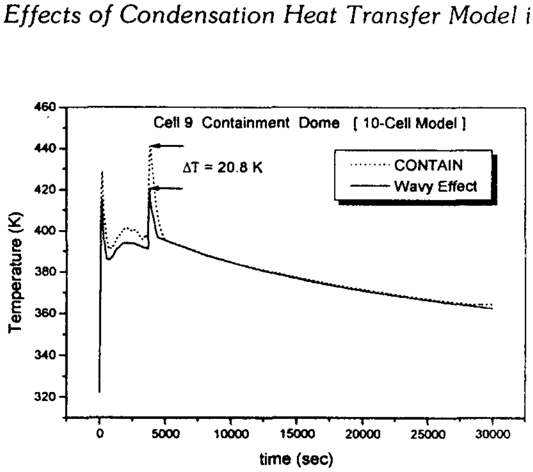

Fig. 15. Temperature Change in Containment Dome [10-cell Modeling]

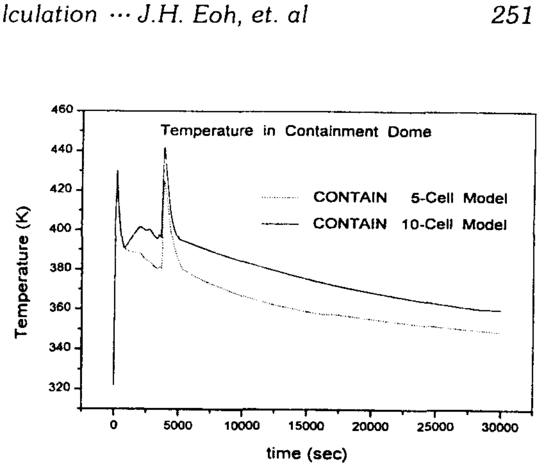

Fig. 17. Comparison of Temperature in Containment Dome

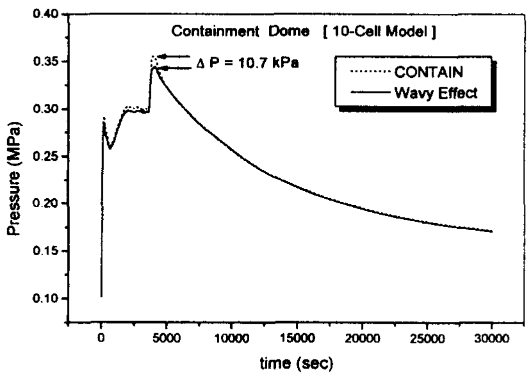

Fig. 16. Pressure Change in Containment Dome [10-cell Modeling]

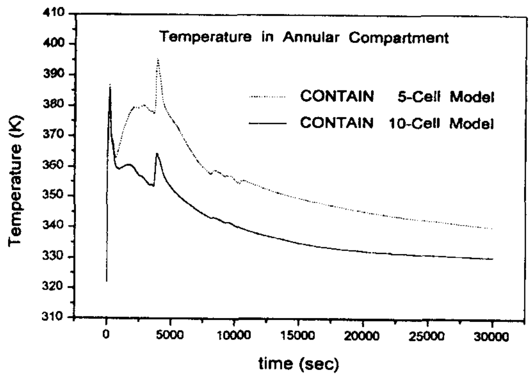

Fig. 18. Comparison of Temperature in Annular Compartment

compared with the forced one with new correlation.

On the basis of theses analyses, it is resulted that the wavy effects are not properly predicted in 5-cell modeling. therefore, to correct these improper cell modeling for practical flow description in the containment dome compartment, we performed 10-cell modeling. Fig. 14 shows the Nusselt number change in containment dome. As shown in this figure, the forced convection is dominant compared to the natural one, thereby the Nusselt number change calculated by forced convection correlation with waviness has the opposite effects to the 5-cell modeling. This is due to the fact that the flow velocity in dome compartment increased by separating the containment dome compartment as 6 parts and each cell volume is reduced. therefore, in Fig. 15, the peak temperature of the containment dome decreased by about 20° compared to the old calculation. This meant that the new forced convection correlation considered with wavy effect was used in calculation and thereby the wavy interface on the condensate film strongly affected the CONTAIN calculation. This result similarly resulted in peak pressure decrease by about 10.7 kPa as shown in Fig. 16.

Also, in this study, to investigate the proper cell modeling for KNGR containment, it is carried out to compare the temperature distribution for each cell modeling. Fig. 17 and Fig. 18 show the comparison of temperature in containment dome and annular compartment, respectively. In Fig. 17, since the containment dome is devided into 6 parts in 10-cell modeling and thereby each cell volume is decreased, we uses the data of temperature averaged over the 6 cells of containment dome. According to these comparison, we can find that the temperature distribution predicted in 10-cell modeling is higher than that of 5-cell modeling in containment dome and is lower than it in annular compartment. The reason is supposed that, in 10-cell modeling, since the number of flow path from the lower compartment to the upper dome increased compared to 5-cell modeling, the flow induced from the lower one is more activated rather than 5-cell modeling.

On the basis of these analyses, it is resulted that the cell modeling for containment dome is very sensitive to the flow condition near its wall. therefore it is suggested that the proper and logical cell modeling should be needed for analysis of CONTAIN calculations for KNGR containment pressure and temperature response.

5. Conclusions

By using the forced convection correlation included the effects of the wavy interface on the heat and mass transfer, this study carried out the analyses of the containment phenomena under severe accident, such as LBLOCA, conditions. On the bases of these analyses, it is shown that the more activated film flow, the better effects of wavy interface is obtained and thereby it is suggested the value of minimum film thickness as 0.2 mm which is more activated film flow with compared to the default value of 0.5 mm in CONTAIN 1.2 code.

Under the given conditions it was carried out to investigate the effect of the different cell modelings : 5-cell and 10-cell modeling. The effect of wavy interface on condensate film appears to cause the decrease of peak temperature and pressure, but its effect was not shown at 5-cell modeling. The reason is supposed that the natural convection heat transfer model is dominant compared with the forced one in 5-cell modeling, and CONTAIN 1.2 code calculates the condensation heat transfer coefficients by using natural convective heat transfer correlation only. So it is clear that cell modeling is the very important factor for determining the flow velocity and condensation heat transfer coefficient in a cell. therefore, in order to estimate the integrity of the KNGR containment both in safety and economically, it is concluded to be very important to use a proper cell modeling and a good model for the condensation heat transfer coefficient on the containment wall.

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