Parametric Analysis for Core Degradation in COMPASS Simulation

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1. Introduction

COMPASS has been developed as a stand-alone simulation tool which can be run for a variety of prescribed ex-vessel boundary conditions. At the same time, to make up the in-vessel module including the primary loop, the core degradation model in COMPASS have been coupled with the SPACE code, which is DBA code developed in Korea. And, it will finally build up the integrated severe accident analysis code, CINEMA, through the coupling with the severe accident ex-vessel module.

The objective of this paper is to assess the core degradation modeling in COMPASS code by the parametric analysis of some parameters with the different values in each nodes system.

2. Methods and Results

2.1 Numerical Simulation Methods

The nodalization system used in COMPASS calculation is shown in Figure 1. Parametric analyses have been made based on the shown nodalization system with the different nodal number in a core.

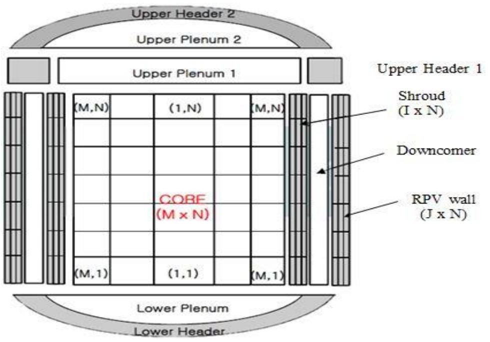

Figure 1: Node system of COMPASS code

2.2 COMPASS Parameters:

This study has been conducted to analyze the severe accident progression characteristics in COMPASS code. Two main parameters have been used in two types of nodalization system (3x5 and 9x11). The two main parameters are: Radial radiation view factor, and the consideration of slump effects.

2.3 Numerical Results

2.3.1 Radial Radiation View Factor:

The radial radiation view factor is one of the important input parameters in COMPASS. It is related to the heat transfer efficiency between different core's components in radial directions. This analysis has used different view factors on variety of nodalization input. Three values of view factors (0.2, 0.5 and 0.8) have been used to perform the comparison between the selected nodalization input (3x5 and 9x11) for the purpose of finding the best parameter value to be used in further research analysis. In this analysis, two nodal points have been chosen to compare; The First point is located in the central region, and the second point is at the outer region in radial direction. In this study, the clad temperature has been compared to see the main effects of the heat transfer when changing the view factor value in the input, because the radial view factor is related to the heat transfer in the radial direction.

Figure 2, shows the behavior of the clad temperature during the accident scenario in both of the nodalization systems with the value of the view factor, 0.2. The figure shows that, the radial heat transfer is more vigorous in the 3x5 nodes compared with the 9x11 nodes, which means the results are largely depend on the node system when the low value (0.2) of radial radiation view factor is used.

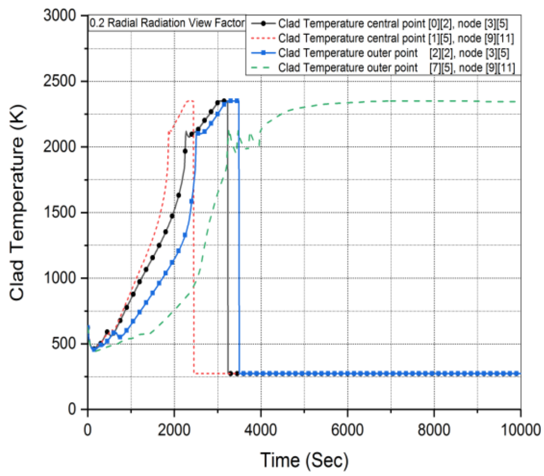

Figure 2: Clad Temperature variation with the radial radiation view factor of 0.2

Figure 3 shows the results of the same scenario accident with different view factor value (0.5). As it shown in the figure, the 3x5 nodes still has more vigorous radial heat transfer compared with the 9x11 with increasing of the view factor value. Moreover, though the green line shows the weak–heat transfer in the radial direction, it is better from the perspective of the time needed to melt compared with the results of using view factor (0.2).

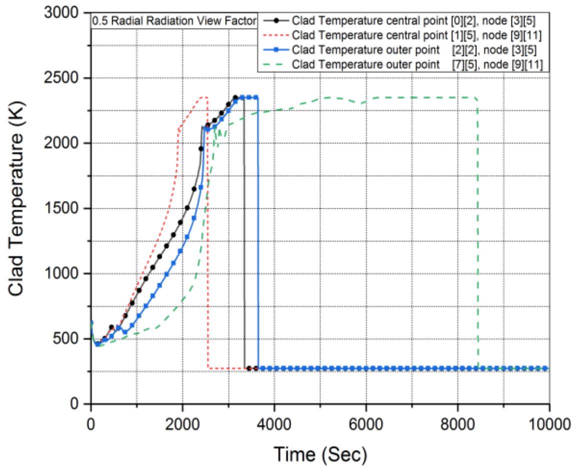

Figure 3: Clad Temperature variation with the radial radiation view factor of 0.5

Figure 4 shows the results of the same scenario accident with the large value of radial radiation view factor (0.8). As it shown in the figure, the 3x5 nodes and 9x11 almost has similar melting behavior by using the large value of radial radiation view factor (0.8), which shows that the dependency of nodal number is minimal when the large value of radial radiation view factor (0.8) is used from the perspective of the time needed to melt compared with the results of using view factors (0.2 and 0.5).

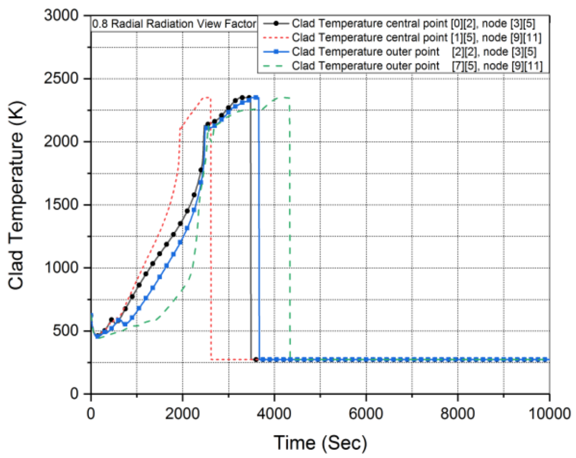

Figure 4: Clad Temperature variation with the radial radiation view factor of 0.8

2.3.2 Slump Consideration Effects:

For studying the slump effects, the analysis is conducted on the 3x5 nodalization configuration, and 5 nodes in the central region have been chosen for this analysis. This analysis is to study the mass change (slump) of the clad in the axial direction.

In this analysis, two parametric calculations have been conducted to see slump effect on the clad. The first one is conducted with excluding the slump effects. The second one is, by including the slump effect with the different slump fraction values (0.1, 0.2 and 0.3) to see the slump effect. The slump effect represents the decrease of fuel rod height by the clad rupture phenomenon. A comparison study has been made between the case without slump consideration and the case with the most severe consideration of slump (slump fraction value = 0.3).

Figure 5 shows the accident consequences without regarding the slump effects in the COMPASS simulation. At first, there is a small increase in the clad mass due to the oxidation phenomenon on the clad surface, and then the clad mass in the lower region increases by the accumulated mass melted from the upper regions.

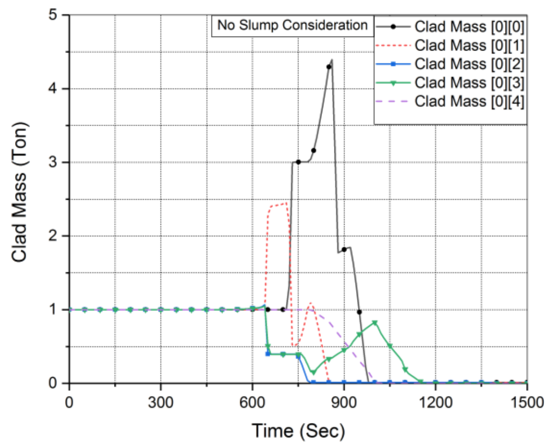

Figure 5: Clad mass variation without the consideration of slump effect

Figure 6 shows a different behavior due to the consideration of slumping (the slump fraction factor = 0.3).The figure shows that a slump starts to occur after the oxidation takes place. As seen in the figure, the oxidation starts to form after reaching the required temperature for it, then the slumps occur which causing an increasing in the nodal mass in lower region and continuously increases by the accumulated molten mass until the failure of the reactor pressure vessel occurs.

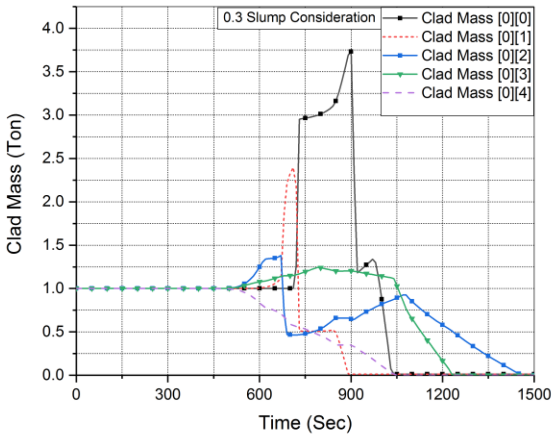

Figure 6: Clad mass variation with the consideration of slump effect (Slump fraction factor = 0.3)

3. Conclusions

This study has been conducted to analyze the severe accident progression characteristics in COMPASS code through the parametric calculation for the two main parameters: Radial radiation view factor and the consideration of slump effects.

As these results have shown, as the value of the radial radiation view factor increases, the 3x5 nodes and 9x11 almost has similar melting behavior, which shows that the dependency of nodal number is minimal when the large value of radial radiation view factor (0.8) is used from the perspective of the time needed to melt compared with the results of using view factors (0.2 and 0.5).

Moreover, when the slump effect is considered, the core degradation process is happened faster compared with the case without the consideration of slump effect, because of the consideration of the clad rupture phenomenon.

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