Resuspension Analysis of Aerosol Using MELCOR Code for Gas Cooled System

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1. Introduction

A high temperature gas-cooled reactor (HTGR) uses a helium coolant to transfer heat from primary loop to secondary loop. During a normal operation, the fission product(FP) species are released to the primary loop by a diffusion. The released FP may deposit on the pipe surface or circulate with the coolant. The amounts of deposited FPs will be used for the standard of safety protection during normal operation or maintenance. Moreover, the deposit and circulating FPs might be an initial source term under the pipe rupture accident. Therefore, an analysis for the FPs transport is necessary to secure the safety of the HTGR.

Korea Atomic Energy Research Institute (KAERI) has been developing the FPs transport code in the primary coolant (POSCA)[1] and in the containment (MENTAS). As a code verification process, the MELCOR code[2] has been applied in the KAERI's project. In the current paper, the aerosol deposition and resuspension process under the condition of the HTGR system were analyzed using the MELCOR code.

2. Methods and Results

The MELCOR code was initially developed for water cooled reactors. Therefore, many models implemented in the code were focused on predicting the severe accidents of water cooled reactors. After 2006, the MELCOR development team has been modifying the MELCOR code to apply non-LWR systems[3]. But, the model of the FP transport is still under development. Therefore, it is necessary to assess the MELCOR code to apply to the HTGT system. Section 2.1 shows the FP deposition amounts and the results of resuspension calculation by MELCOR under the pipe break accident.

2.1 Fission Product Release and Resuspension

To assess the resuspension, the accurate amount of the release rate and deposition should be calculated. Table I represents the release rate to the coolant by the MELCOR and COPA[4] code. The current MELCOR ver. 2.2.21402[3] has implemented the fission product release for the gas cooled reactor. But, there are still discrepancies at the bottom region. For the current study, the release rates of COPA were applied.

Table I: Cs Release rate [Kmol/s]

	Inner	Middle	Outer
Top(COPA)	6.59E-114	2.85E-124	2.13E-142
MELCOR	*4.59E-25*	*9.79E-20*	*7.29E-22*
Middle(COPA)	1.42E-18	8.09E-30	2.21E-60
MELCOR	*2.37E-18*	*1.10E-18*	*1.01E-19*
Bottom(COPA)	2.079E-15	3.37E-16	2.75E-21
MELCOR	*2.38E-18*	*1.39E-18*	*3.11E-19*

Fig. 1 represents the release path using PCHE heat exchanger. If the FPs release to the reactor cavity, the FPs may release to the environment through the vent line.

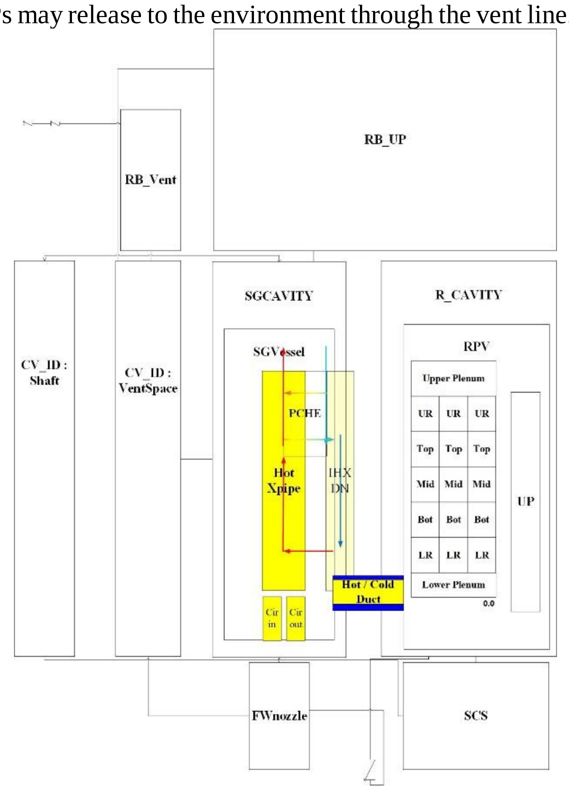


Fig. 1. HTGR Release path

A user can activate the resuspension model implemented in MELCOR[5]. There are three input options for the resuspension model below.

HS_LBAR (1) (2) (3)

(1) Fraction of resuspension
(2) Surface roughness
(3) Critical diameter, $D_{crit} = \frac{4\times10^{-5}}{\pi\tau_{wall}}$

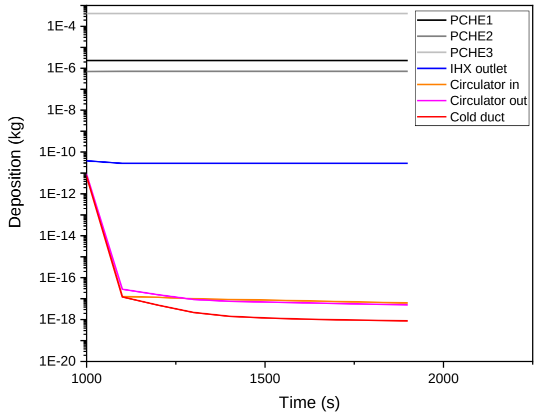
The aerosol larger than diameter written in (3) will resuspend in the calculation.

Table II explains the break condition and aerosol data. The hot/cold annular duct was considered as the break position. For the first 1000s, the Cs-137 released into the coolant by scaling up as much as 40 years release. After 1000s, the pipe breaks and the suspended and deposited FP releases into the reactor cavity.

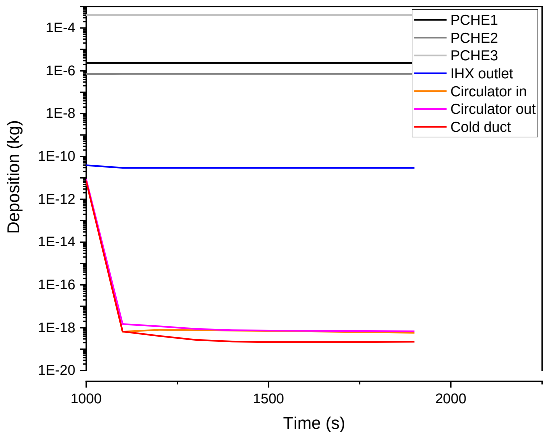
Table II: Resuspension study cases

	Break area $[m^2]$	Critical Dia. [m]	Min/max Dia[μm]
Case 1	2.0	1.E-7	0.1 / 50
Case 2	<u>1.0</u>	<u>1.E-7</u>	0.1 / 50

Fig. 2 represents the deposition amount variation by resuspension of case 1 and 2. The PCHE regions with a narrow flow area did not show significant resuspension rate. However, pipe of large diameter near the cold duct showed large resuspension rate.



a) Deposition variation by resuspension of Case 1



b) Deposition variation by resuspension of Case 2

Fig. 2. Deposition variation by resuspension of Cs-137

Table III explains the deposited amounts before the accident and 1000s after. The resuspended fraction from IHX outlet is about 25% whereas those from Circulator and cold duct are about 100%. However, the absolute amounts of resuspension are similar.

Table III: Deposition amount change

	Case 1[kg]		Case 2[kg]	
	before	after	before	After
PCHE1	2.34E-6	2.35E-6	2.34E-6	2.35E-6
PCHE2	7.06E-7	7.16E-7	7.06E-7	7.18E-7
PCHE3	4.09E-4	4.09E-4	4.09E-4	4.09E-4
IHX outlet	3.85E-11	2.92E-11	3.85E-11	2.92E-11
Circulator in	8.06E-12	6.28E-18	8.06E-12	5.80E-19
Circulator out	8.57E-12	5.13E-18	8.57E-12	6.75E-19
Cold duct	6.96E-12	8.75E-19	6.96E-12	2.22E-19

Fig. 3 explains the prompt release of Cs-137 to environment within several minutes in Case 1. The results of Case 1 and Case 2 were very similar. Even if there is resuspension in some regions of the primary loop, most FPs remain in the PCHE region. Therefore, the amount of the FP released to the environment is small about 0.8% (3.36E-6 kg of 0.295Ci) during the prompt release. For long-term release, the FPs from cores may release directly to the building and environment without deposition in the PCHE. That phenomena will be studied in the further research.

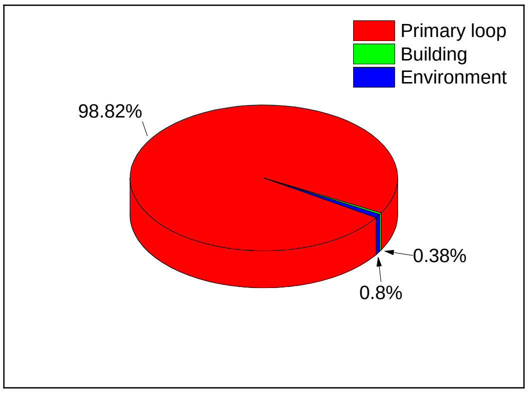


Fig. 3. Prompt Release of Cs-137 to Environment

3. Conclusions

The MELCOR code was used to investigate the deposition and resuspension of the aerosol in the HTGR system. The MELCOR has been updated to apply non-LWR systems. But, there was still discrepancies for the FP diffusion model. With the COPA's results for the release rate, the FP deposition and resuspension were investigated for the prompt release under the accident. The amount of the Cs-137 to the environment was small because most remained in the PCHE region. The long-term release to the environment will be studied in the further study.

Acknowledgements

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