A Study on Characteristics of Airborne Materials for Pyroprocess Using MELCOR

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1. Introduction

As unsealed radioactive materials are treated in pyroprocess, airborne materials may occur in a facility. The airborne materials are diffused as aerosol and vapor by aerodynamic process including forced flow, deposition, agglomeration, and by condensation/evaporation. The diffusion of the materials in a pyroprocess facility can cause contamination of hot cells, operation rooms, flow systems and equipment, and off –site effluent. Thus, it is important to assess the behavior of airborne materials in the facility. In this study, basic characteristics of airborne materials for pyroprocess are assessed using MELCOR code [1] to produce data as a basis of assessment for a specific facility in the future.

2. Materials and Methods

2.1 MELCOR modeling

MELCOR is a fully integrated, engineering-level computer code that models the progression of severe accidents in light water reactor nuclear power plants. Because MELCOR model the behavior of airborne radioactive materials by RN (RadioNuclide) package, however, MELCOR can be applied to pyroprocess facilities. In this study, CVH (Control Volume Hydrodynamics), FL (Flow Path), HS (Heat Structures), and RN (RadioNuclide) packages of MELCOR are used. In order to assess characteristics of airborne materials, an arbitrary hot-cell and ventilation system are modeled as Fig. 1. The volume No. 201 of the figure is location of initial airborne source term and the volume No. 901 remains in atmospheric pressure. It is assumed that temperature in the all location of the modeled system remains in room temperature.

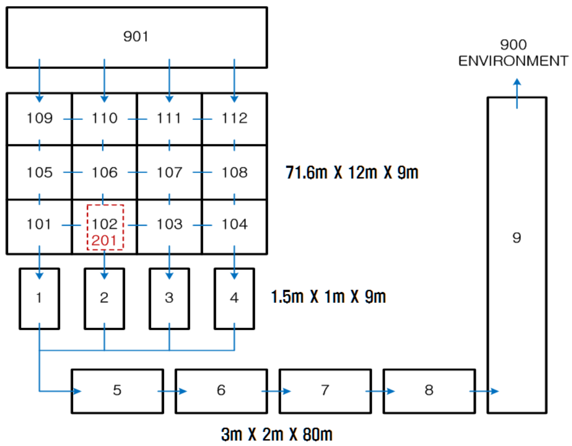

Fig. 1. MELCOR modeling of arbitrary hot-cell and ventilation system for parametric study.

2.2 Parametric study

In order to identify characteristics of airborne materials, parametric study is performed in this study. Velocity of ventilation flow, initial state of source term, and aerosol particle size are selected as parameter. In the parametric study, changes of deposition fraction and off-site release fraction are observed by changing the selected parameters. Table 1 shows the initial conditions for the parametric study.

3. Results and Discussion

Fig. 2 shows the one example result which shows mass in each volume section for 1 kg of initial Cs source term by time (vapor, 10m/s). Fig. 3 shows the one example result which shows deposited mass in all volume sections for 1 kg of initial Cs source term by time (10 μm aerosol, 10 m/s). Table 2 shows the result of parametric study. According to the results, deposition fraction of the airborne materials largely depends on the flow velocity, and aerosols whose size is below 10 μm are hardly deposited on the structures for 10 m/s of flow velocity.

Table 1. Initial conditions for the parametric study

Parameter	Value	Fixed condition
Flow velocity	1 m/s	Cs 10 μm aerosol
	5 m/s	
	10 m/s	
Initial state of source term	vapor	Cs 10 m/s
	0.25 μm aerosol	
	0.88 μm aerosol	
	3.00 μm aerosol	
	10 μm aerosol	
Element	Cs (aerosol)	10 μm aerosol 10 m/s
	Xe (noble gas)	

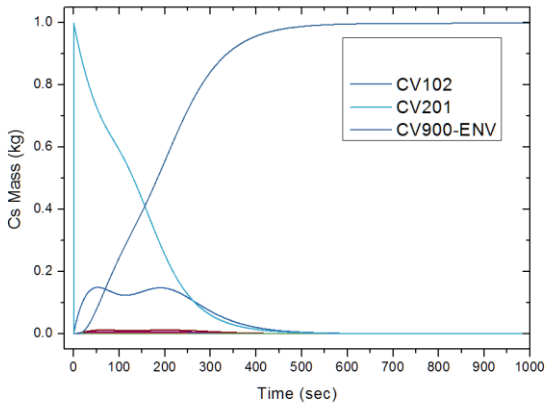

Fig. 2. Example result which shows mass in each volume section for 1kg of initial Cs source term by time (vapor, 10m/s).

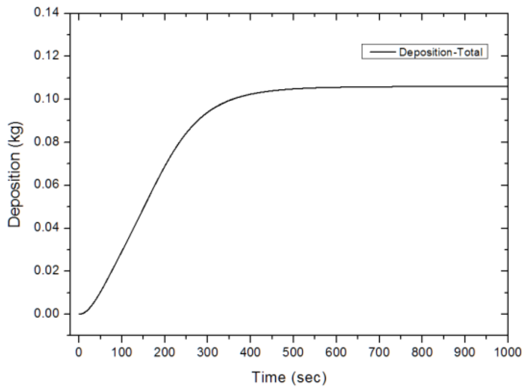

Fig. 3. Example result which shows deposited mass in all volume sections for 1 kg of initial Cs source term by time (10 μm aerosol, 10 m/s).

Table 2. Result of the parametric study

Value	Fixed condition	Deposition fraction
1 m/s	Cs 10 μm aerosol	0.628
5 m/s		0.233
10 m/s		0.106
vapor	Cs 10 m/s	0.0019
0.25 μm aerosol		0.0019
0.88 μm aerosol		0.0020
3.00 μm aerosol		0.0083
10 μm aerosol		0.106
Cs (aerosol)	10 μm aerosol 10 m/s	0.106
Xe (noble gas)		0

4. Conclusion

In pyroprocess facilities, it is important to predict the behavior of airborne materials. Thus, the study on characteristics of airborne materials for pyroprocess is performed using MELCOR code. Changes of deposition fraction of the materials are observed by changing of ventilation flow, initial state of source term, and aerosol particle size. According to the results, deposition fraction of the airborne materials largely depends on the flow velocity, and aerosols whose size is below 10 μm are hardly deposited on the structures for 10 m/s of flow velocity. The results of this study will be used in design and safety assessment for pyroprocess facilities.

ACKNOWLEDGEMENT

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REFERENCES

[1] L.L. Humphries, R.K. Cole, D.L. Louie, V.G. Figueroa, and M.F. Young, MELCOR Computer Code Manuals, SAND2015-6691R, 2015.