Spacing Sensitivity Analysis of HLW Intermediate Storage Facility

Bum-Soo Youn, Kwangho Lee
Korea Electric Power Research Institute, 103-16 Munji-Dong, Yuseong-Gu, Daejeon, 305-380, Korea
bsyoun@kepri.re.kr, khlee1@kepri.re.kr

1. Introduction

Currently, South Korea's spent fuels are stored in its temporary storage within the plant. But the temporary storage is expected to be reaching saturation soon. For the effective management of spent fuel wastes, the need for intermediate storage facility is a desperate position [1]. However, the research for the intermediate storage facility for waste has not made active so far. In addition, in case of foreign countries it is mostly treated confidentially and the information isn't easy to collect [2]. Therefore, the purpose of this study is creating the basic thermal analysis data for the waste storage facility that will be valuable in the future.

2. Methods and Results

The waste thermal analysis for Intermediate storage facilities needs to consider various circumstances. In this study, the important consideration is spacing between the storage containers in the facility and the sensitivity analysis is performed by ANSYS CFX code.

2.1 Code Overview

ANSYS CFX offered a fast and accurate analysis results is a powerful CFD tool. CFX process the analysis from CAD to Post in the Workbench environment of ANSYS. ANSYS Design Modeler use or import geometry created in CAD software, the shape can be implemented directly. Workbench Meshing Application using a simple grid can be created. Complete GUI environment and physics setup guide that provides CFX-Pre, extracting data and graphics processing, as well as video production and 3-D graphic images using the CFX-Post. There is a good point that offered first-time users to easily obtain the correct interpretation of the results.

2.2 Methods

The sensitivity analysis method is as follows. First, the collapse heat of fuel to be cooled is calculated. This is a heat source for thermal analysis. Second, the collapse heat of spent fuel and random basket inside temperature is calculated to obtain the temperature of fuel cladding. Third, the basket inside temperature is determined by using the calculated cladding temperature and NUREG limit. This is used as heat source for the spacing sensitivity analysis. This method can be considered as effective. Finally, a proper range of gap size of the facility is obtained.

2.3 Decay Heat Source

The calculation of heat source in the shielding analysis is done by ORIGEN-ARP code to evaluate the characteristics of radionuclide composition of spent fuel and nuclear materials. The combustion conditions of PWR fuel are assumed of 37.5W/gU during 400 days, the specific power of 100%, and the fuel burned 2 times during the whole 3 fuel cycles. The spent fuel from the core is assumed to keep the natural decay for 60 days. To use decay heat changes with time variation as heat source of long-term decay heat distribution in the dry storage facility, the spent fuel decay heat vs. time is calculated by using SAS statistical regression program with C. M. Malbrain criteria [5].

2.4 Boundary Conditions

The collapsed heat from the spent fuel is assumed to be 700 watts, which is the released energy from the cooled spent fuel after 6~10 years. According to the NUREG-1567, after 10 years the initial inside temperature of storage basket should not exceed 340^{o}C [3]. The storage container is assumed to fill with an ideal gas of helium with pressure of 200 kPa . Lattice of the inner grid is assumed to be made of Stainless Steel.

2.5 Cladding Temperature Calculation

It is assumed that the temperature of long-term dry storage containers increases from 400^{o}K with 50^{o}K intervals and the maximum cladding temperature is calculated at each point. According to IAEA criteria and the regulatory restrictions in NUREG, the cladding temperature of normal operating conditions is limited to 613.5^{o}K [4]. Figure 1 shows the cladding temperature and the basket temperature for the long-term dry storage containers.

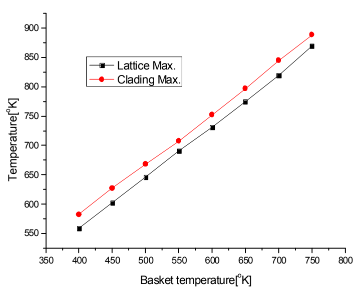

Fig. 1. Cladding temperature and maximum lattice temperature.

2.6 Facility Spacing based on Sensitivity Analysis

In case of foreign countries, the ground type long-term dry storages are arranged by 2 columns. For adjusting the facility spacing of the ground type long-term dry storage, the thermal analysis is performed at steady state, and the proper spacing is found with satisfying NUREG limit. CFX model for the facility spacing sensitivity is from a model used in the flow-path sensitivity analysis in the previous study. Air flow-path of the concrete is 5 X 90cm^2. And then, basket and concrete temperatures are calculated as increasing the facility spacing. Figure 2 and Table I show the results of this sensitivity analysis.

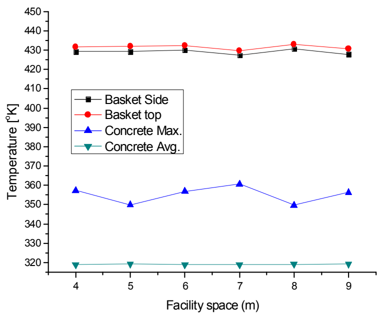

Fig. 2. Temperature changes of the basket and concrete for the facility spacing.

Table I: Temperature change of the ground type long-term dry storage for the facility spacing

	Basket temperature (K)	Concrete temperature (K)
4m	429.3	318.8
5m	429.2	319.2
6m	430.0	318.8
7m	427.4	318.9
8m	430.7	319.0
9m	427.8	319.3

3. Conclusions

As shown in Figure 2, if facility spacing is expanded, then nothing can be seen in difference of temperatures inside the basket and concrete container. The above results satisfies NUREG limit which is 4m interval or longer in the normal operation of state facilities to be secured. The limit of 4m interval is minimum value for the space required for maintenance of the proposed facility [6]. To have the confident results, it is necessary to do a experimental work.

REFERENCES

[1] 조동건, 심지층처분시스템 설계를 위한 기준 사용후 핵연료 선정 및 선원항 평가, KAERI/TR-3084/2005, 한국원자력연구원, 2005.
[2] S. W. Lee, D. K. Cho, J. W. Choi, H. J. Choi, Burnup and Source Term Analyses for a CANDU Spent Fuel, Transactions of the Korean Nuclear Society Autumn Meeting, 2007
[3] “Optimization Strategies for Cask Design and Container Loading in Long Term Spent fuel Storage”, IAEA-TECDOC-1523, IAEA 2006.
[4] “Operation and Maintenance of Spent fuel Storage and Transportation Cask/Container”, IAEA-TECDOC-1532, IAEA 2007.
[5] C. M. Malbrain, and R. K. Lester, Analytical Approximations for the Long-term Decay Behavior of Spent fuel and high-level Waste, Nuclear Technology, Vol.57, p. 292, 1982.
[6] 최희주, 고준위폐기물 처분기술 개발/처분시스템 개발, KAERI/RR-2765/2006, 한국원자력연구원, 2006.