Thermal Impact on the Korean Repository System with Increased CANDU Spent Fuel Burnup

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1. Introduction

Out of the three options for a management of spent nuclear fuel(reprocessing, direct disposal and wait-and-see), the wait-and-see option is today the most common management strategy that simplify focuses on the long-term storage of a spent fuel. Because of a low economical potential for fissile materials in a CANDU spent fuel, a direct disposal of a CANDU spent fuel is taken into consideration in a Korean Repository System(KRS) developed by the Korea Atomic Energy Research Institute(KAERI). Analyses concerning the safety aspects of the KRS were performed, however, a statistical analysis for a burnup of a CANDU spent fuel discharged from 1985 to 2007 for a CANDU spent fuel revealed a higher average burnup than the reference burnup used in the thermal analyses for the KRS concept. In this paper, thermal analyses with a decay heat corresponding to a high burnup CANDU fuel are performed with the KRS concept to confirm the thermal integrity of the KRS.

2. Thermal Analyses for a Higher Burnup CANDU Spent Fuel

2.1 Decay heat from a CANDU spent fuel

As noted above, an average burnup and the standard deviation performed for four CANDU reactor sites from 1985 to 2007 were found to be 6,937 and 1,177 respectively which in turn means that the representative burnup can be defined as 8,100 MWD/MtU. This representative burnup derived from the statistical analysis for the CANDU spent fuels covers about 85% of the whole spent fuels and the spent fuels exceeding this burnup can be accommodated by combining them with a spent fuel with a low burnup fuel. As the representative burnup was revealed to be higher, thermal analyses using the decay heat as an input, requires to be re-calculated to confirm the thermal integrity from a higher decay heat. Decay heat from CANDU spent fuels corresponding to each discharge burnup was derived from ORIGEN-ARP and the cooling time was assumed as 40 years. Eq 1 was used for calculating the decay heat, and Fig 1 shows the decay heat corresponding to the burnup. The value of 5.066E+06 is different from the decay heat at the beginning time.

$$P(t) = 252.12EXP(-0.02442t)+5431.4EXP(-0.71648t)+47.23 \quad (1)$$

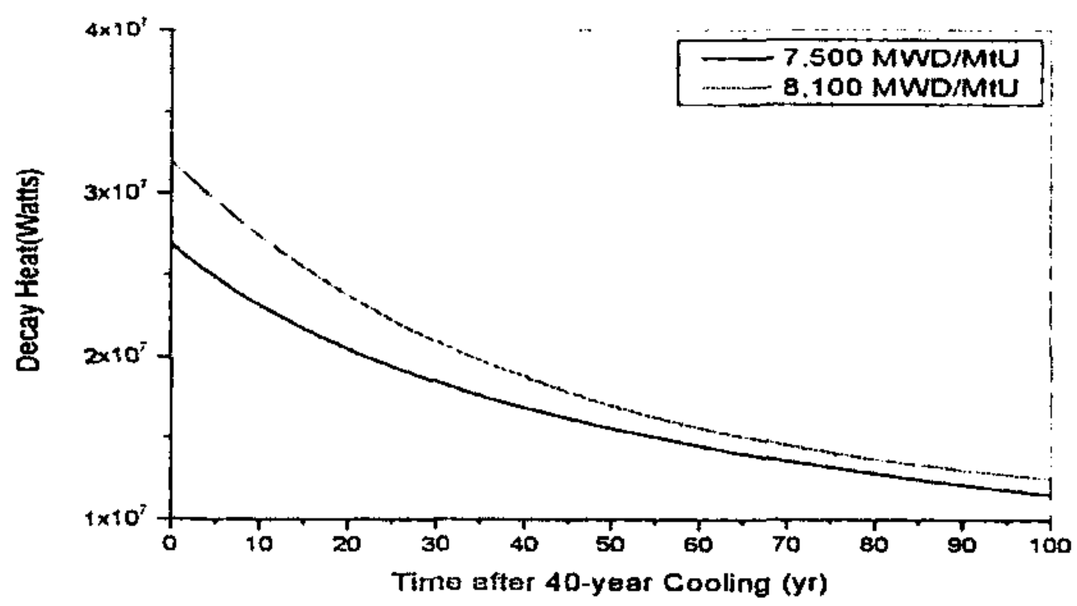

Figure 1. Decay heat corresponding to each burnup

2.2 Thermal analyses for a higher burnup CANDU spent fuel

In this research, NISA program which is a general purpose finite element analysis code was used and the initial conditions of the thermal analyses with a burunp of 8,100 MWD/MtU were identical to those used in the thermal analyses with a discharge burnup of 7,500 MWD/MtU. Since the KRS concept considers disposing of CANDU spent fuels at a depth of 500m, the top and bottom boundary condition used to calculate the temperature profile were set at ground level and 1,000 m below ground level, respectively. It was assumed that the surface temperature was maintained at 15°C and increases by 3°C every 100 m in depth as an initial boundary condition. And the reference deposition tunnel spacing and deposition hole spacing are considered as 40m and 4m, respectively with a consideration of thermal margin and structural constraints of the buffer. Moreover, additional cases for thermal analyses are performed.

2.3 Calculation Results

Since the thermal performance is directly related to the design of the KRS which is composed of engineered barrier and natural barrier, the maximum temperature of the buffer which is one of the engineered barrier should be calculated. Compared to the maximum temperature of the buffer with a burnup of 7,500 MWD/MtU using a reference deposition tunnel spacing and deposition hole spacing, the maximum temperature of the buffer with the representative burnup was 9.2°C higher. And the maximum temperature of the buffer was calculated at 20 years. The results satisfied the thermal criteria that the maximum temperature at the interface between the buffer canister is below 100°C and has a thermal margin. Additionally, other case with a deposition hole spacing was performed to see the sensitivity of a deposition hole spacing.

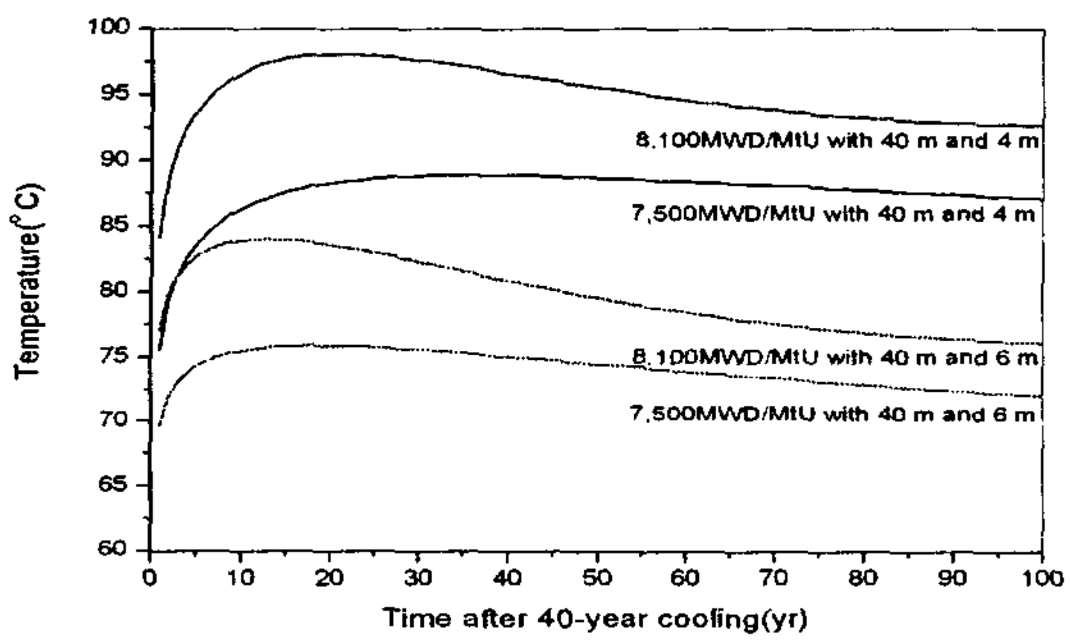

Figure 2. Results of thermal analyses

3. Conclusions

As CANDU spent fuel burnup was revealed to be higher than the reference burnup used in thermal analysis for the KRS, research on the thermal impact corresponding to the decay heat from an increasing burnup is performed. Disposing a CANDU spent fuel with a higher burnup satisfied the thermal criteria of the KRS with a thermal margin. Results from this research are expected to give an insight to the future repository system and to be used for optimizing the KRS.

REFERENCES

[1] Seung-Woo Lee, Dong-Keun Cho, Jong-Won Choi, Heui-Joo Choi, Burnup and Source Term Analyses for a CANDU Spent Fuel, Transactions of the Korean Nuclear Society Autumn Meeting, Korea, October 25-26, 2007