Analyses of Double Layered Disposal System for the Spent Nuclear Fuels Considering the Deposition of Time Difference

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1. Introduction

The electricity from the nuclear power plants is about 30 % of total electricity in Korea. And as long as the nuclear power plants are operating continuously, the spent nuclear fuels from them are increasing and accumulating. Accordingly, it is expected that the disposal area for them is also becoming huge. With this reason, a study on the improvement of the disposal efficient such as reduction of disposal area is needed. There can be lots of ways to reduce the repository area, such as a longer term storage, improvement of the EBS (Engineered Barrier System) performance and a reprocessing of the spent nuclear fuels, etc.

In this study, for the purpose of reduction of disposal area, the multi-level repository and the deposition of time difference were considered. To do this, a double layered disposal concept was drawn. After then, preliminary thermal analyses were carried out to confirm the thermal stability of the disposal system. These results will be used in the optimization of the disposal system lay-out.

2. Reference disposal system

With the current technology, a deep geological disposal is considered as the safest disposal concept for spent nuclear fuels, where the spent fuels are encapsulated into disposal canisters and disposed of in a repository excavated deep into bedrock (Deep geological repository (Fig. 1).

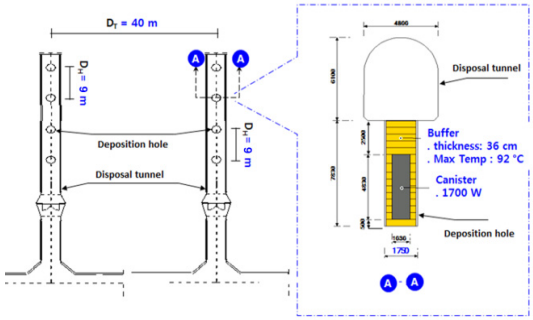

Fig. 1. Reference disposal concept.

The most important design requirement is that the peak temperature of buffer should be lower than 100°C. That is to assure the long-term integrity of EBS, that is to say, to preserve the physical and chemical properties of buffer(bentonite blocks). The result of thermal analysis for the reference concept is shown in Fig. 2 and the thermal requirement was satisfied.

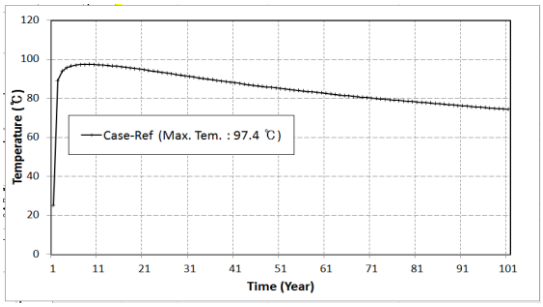

Fig. 2. Result of analysis for reference concept.

3. Double layered repository concept

Based on the reference concept, several concepts for multi-level repository concepts can be drawn. In this study, a double layered repository concept with the distance 100 m upward direction from the depth of 500 m which is the location of reference repository depth (Fig. 3).

With this concept, the deposition of time differences for each layer was considered. Also, the case of the first deposition of lower layer and the case of the first deposition of upper layer were considered.

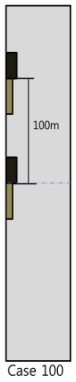

Fig. 3. Double layered repository concept.

The thermal analyses to check whether the thermal requirement of the system was satisfied were carried out (Fig. 4).

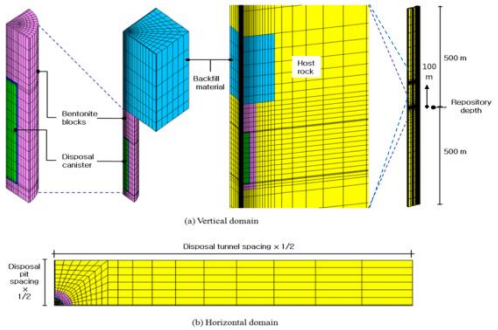

Fig. 4. Repository model for the thermal analysis.

A model for the thermal analysis of a geological repository is implemented in a three-dimensional quarter model, as shown in Fig. 4. The initial conditions were set up with the assumptions that the temperature of the groundwater at the surface was 10℃, and the thermal gradient was 3℃ for every 100 m depth. So, the top and the bottom of the analyzed domain were considered to be constant temperatures boundary and set 10℃ and 40℃, respectively according to the geothermal condition of the repository [3]. The density, thermal conductivity and specific heat of the rock, buffer, backfill and canister were shown in Table 1.

Table 1. The material properties for the analyses

Items	Density (kg/m^3)	Thermal Conductivity (W/m℃)	Specific Heat (J/kg℃)
Cast insert	7,200	52	504
Outer shell	8,900	386	383
Buffer	1,970	1.0	1,380
Backfill	2,270	2	1,190
Rock	2,650	3.2	815

4. Results and Discussion

The results of the thermal analyses for the double layered repository concepts were shown in Fig. 5 and Fig. 6.

As show in the figures, for the reduction of disposal area, the double layered repository concept with the proper distance from reference disposal depth can be an available option.

When considering the deposition of time difference, the shorter the deposition time difference, the lower the maximum temperature of the system. And, in the case of the first deposition of lower layer, the time difference can be up to 50 years, but in the case of the first deposition of upper layer, the time difference can be up to 30 years.

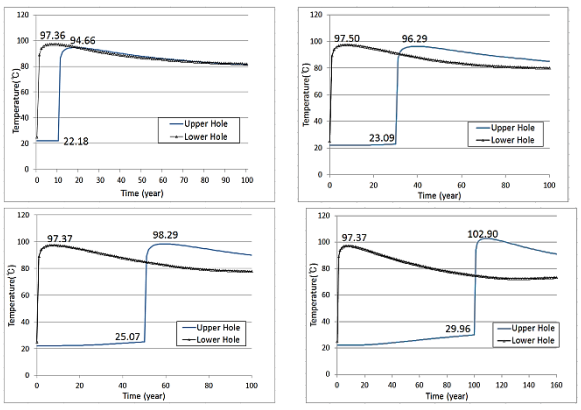

Fig. 5. Results for the case of the first deposition of lower layer.

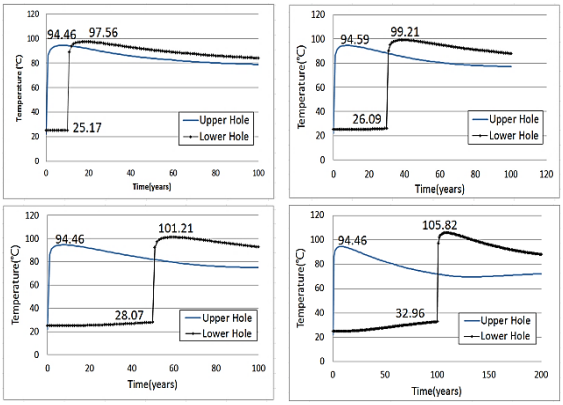

Fig. 6. Results for the case of the first deposition of upper layer.

5. Concluding Remarks

In this study, to reduce the disposal area, the concepts of the double layered repository concept was drawn and the thermal analyses for the concepts were carried out. From this study, followings were described as concluding remarks.

For the efficiency of the spent nuclear fuels disposal, the double layered repository concept with the proper distance from reference disposal depth could be an available option.

And for the deposition of time difference, the case of first deposition of lower layer is more advantageous than the other case.

The results need to be checked by real disposal site data later. And the results of this study can be used in the optimization of the disposal system lay-out.

Acknowledgement

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