Thermal-Hydraulic-Mechanical Analysis of a Repository for the Spent Nuclear Fuel: Impact on Re-saturation

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1. Introduction

The HLW repository in Korea is supposed to be constructed in a fully saturated crystal rock. The disposal concept is to excavate a tunnel with a vertical emplacement borehole from a tunnel floor by raising borehole machine. Thermal constrain to limit the maximum temperature in a buffer layer determines the spacing between deposition holes and tunnels.

The key functions of a bentonite buffer are to stably hold a waste container and to retard the transfer of a radionuclide from a waste container when it is failed by local corrosion. When bentonite buffer is emplaced, it is not fully saturated yet with its initial saturation of around 20%. But as soon as the bentonite comes into contact with ground water coming from an adjacent rock, its saturation begins. When groundwater comes into it, the bentonite takes up water, swells and reduces the pore space, and thereby decreases the permeability of the bentonite.

This process is influenced by the decay heat of a spent nuclear fuel which alters the mechanical stress in the near field. Also, if the temperature of a bentonite is over 120℃, retardation capacity of the bentonite beomes to be deteriorated. Therefore, the repository is designed not to be over 100℃ with 20 % safety margin.

After the closure of a repository, groundwater flows into the bentonite buffer via a fracture. It makes the bentonite buffer resaturated. Naturally the resaturation of the near field requires a certain period time. However, the previous studies neglect the resaturation time since it is small compared with the long post closure assessment time which is at the order of millions of years.

But it will be worthwhile to challenge this assumption and to try to understand the phenomena behind the scene. The main tasks will be :

1. What are the mechanisms for the resaturation?
2. How long does it take to resaturate the near field?
3. What is the impact of resaturation on the design and safety of a repository?

This study is the first step research to understand the quite detailed THM coupling processes in resaturation. For simplicity, at this stage, the swelling of bentonite is assumed to be negligible. However, the future study will revisit this issue and its implication to a repository

2. Results

Fig.1 shows the temperature change as a function of time for different initial saturation of bentonite. When a bentonite buffer whose initial saturation is 20%, the maximum temperaturse is around 110℃ and then decreased. When a bentonite buffer whose initial saturation is 40~80%, the maximum temperature is lower than 100℃. In reality, the initial saturation is around 20% so that the maximum temperature exceeds the temperature constraint limit 100 degree so that we might have to widen the spacing between holes to lower down the temperature or assume that around 5centimeter bentonite layer not to act as a barrier against the radionuclide migration.

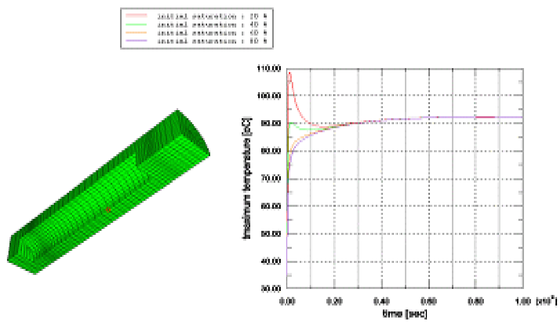

Figure 1. Effect of Initial Saturation on Resaturation

Fig.2 shows change of saturation in bentonite as a function of time for different hydraulic heads at the interface between a bentonite layer and an adjacent rock. Obviously the higher gradient produces the shorter saturation time. It is assumed that the pressure at the interface is between the lithostatic pressure and zero.

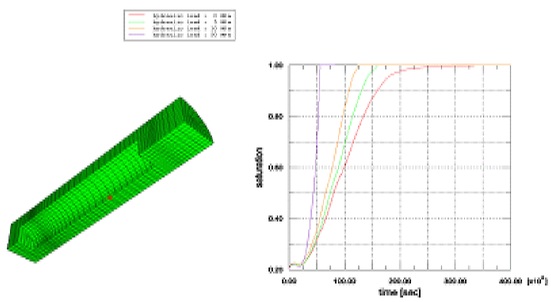

Figure 2. Effect of hydraulic load on resaturation

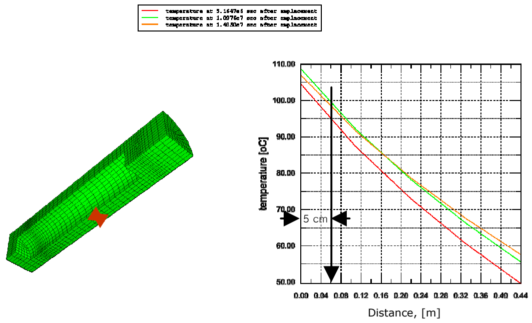

Figure 3. Identification of the higher temperature region

Fig.3 shows temperature of a bentonite as a function of distance from the interface between a waste container and a buffer layer for different times since emplacement. In case of 5.1647 × 10^6sec after emplacement, the maximum temperature is around 105℃ which is over the thermal constraint of the design. But as illustrated this trend occurs just within 5 centimeter layer so that it might be neglected in the design of a repository.

Before change the repository layout by this calculation, more detailed THM study considering the potential swelling and its effect will be done.

Acknowledgement

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