"KENTEX" Operation and Experimental Results on the Thermal-Hydro-Mechanical Behaviors

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1. Introduction

The engineered barrier system of a high-level waste(HLW) repository involves complex disposal conditions due to the radioactive decay heat from spent fuels, the infiltration of ground water from the surrounding rock, the thermal loading and the swelling pressure of the buffer, and the stress generated by overburden pressures. These disposal conditions complicate the thermal-hydro-mechanical (T-H-M) behaviors in the engineered barriers because these processes are not independent but may be strongly influenced by and coupled with each other. Therefore, it is of importance to the prediction of a repository performance and eventually the evaluation of its long-term safety, to investigate the T-H-M behaviors of the engineered barriers under disposal conditions. The present paper will be aimed at introducing an engineering-scale test facility named "KENTEX" and dealing with the T-H-M behaviors in the engineered barrier system of the Korean Reference Disposal System(KRS).

2. "KENTEX" Facility and Experimental Results

2.1 "KENTEX" Facility

The KENTEX facility is a third scale of the KRS (Figure 1). It consists of five major components: a heating system, a confining cylinder, a hydration tank, bentonite blocks, and sensors and instruments. The heating system measures 0.41 m in diameter and 0.68 m in length, which includes three heating elements in its inside, capable of supplying a thermal power of 1 kW each. The confining cylinder, which plays a role of the wall of a borehole excavated in the host rock, is a steel body with a length of 1.36 m and an inner diameter of 0.75 m, the inside wall of which is lined with layers of geotextile and the outside wall of which is mounted with 24 nozzles with two metal filters inserted into the inside of each, to uniformly apply the groundwater to the outer surface of the bentonite blocks. The bentonite blocks are fabricated of "Kyungju"bentonite which is being considered as a candidate buffer of the KRS. Total of 176 blocks are emplaced in 16 sections of the confining cylinder. The bentonite blocks have an average value of 13 % of a water content and the average dry density of the bentonite blocks in the confining cylinder is 1500 kg/m^3. Total of sixty eight sensors are installed to measure the temperature, humidity (eventually converted into water content), and total pressure. The heater control and data acquisition are operated automatically by means of a computer program.

2.2 Operation and Experimental Results

The KENTEX test which started on May 31, 2005 has been in a successful stage of operation (heating and hydration), except for an electric shutdown on 12 June, 2005 and repairs due to the malfunction of a heater-controlling system on 22 September, 2005 and on 15 April, 2006. When it comes to sensors, more than 99% of the temperature and total pressure sensors remained operative, while the humidity sensors, only one was operative and the rest were malfunctioning. The lack of hydro data due to the failure of the humidity sensors was supported by using a core sampling (drilling) method.

The temperature reached a steady state in a short time after the test start. The temperature was higher as it became closer to the heater, while it became lower as it was farther away from the heater(Figure 2). The water content had a higher value in a part close to the hydration surface than that in a heater part. The relative humidity data(Figure 3) suggested that a hydration of the bentonite blocks might occur by different drying-wetting processes depending on their position. The total pressure was continuously increased by the evolution of the saturation front in the bentonite blocks and thereby the swelling pressure(Figure 4). There was also a contribution of the thermal expansion of bentonite and the vapor pressure in the pores of the bentonite blocks, near the heater region.

3. Conclusions

The KENTEX test has been under a successful operation. The experimental results obtained may allow us to draw preliminary and quantitative conclusions on the T-H-M behaviors in the bentonite blocks. This test will still continue for a couple of years ahead. Also, a coupled T-H-M modelling will be conducted to explain the observed T-H-M behaviour and to verify the hypothesis of the T-H-M processes in the bentonite blocks. Final conclusions will be drawn based upon the results of those further works.

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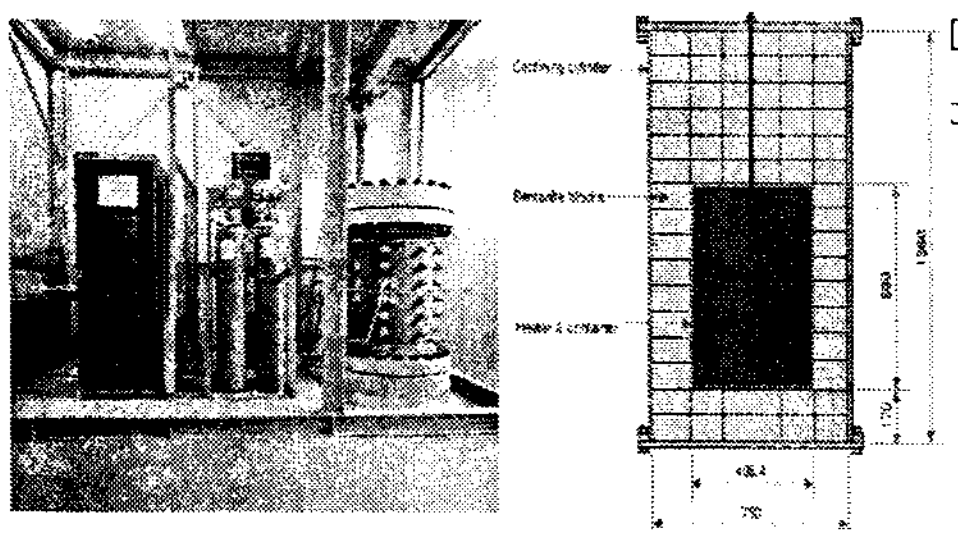

Figure 1.Picture and schematic diagram of the "KENTEX" facility.

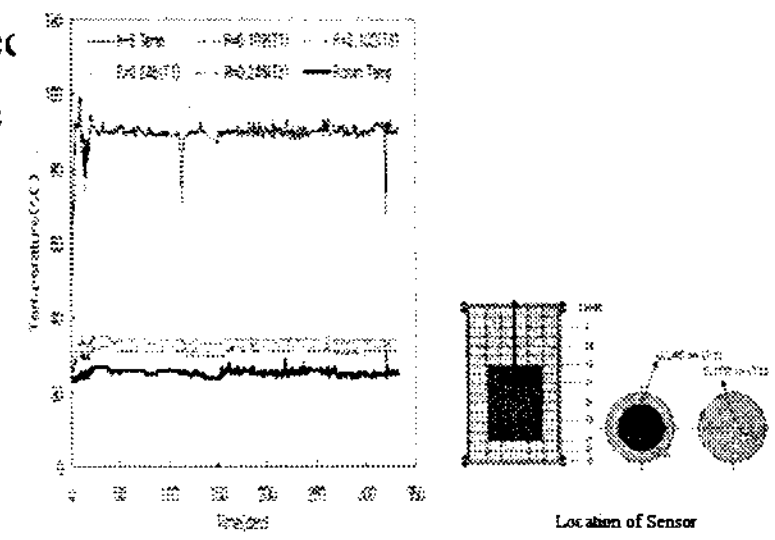

Figure 2. Temperature distribution as a function of height at R=0.246 m.

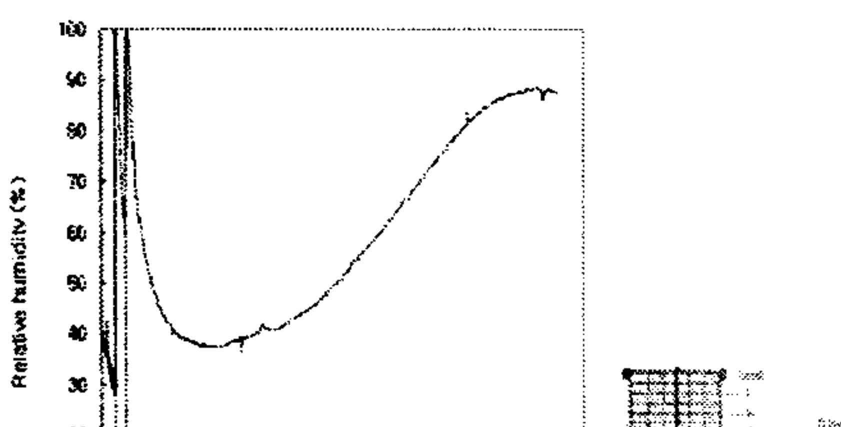

Figure 3. Evolution of the relative humidity at H = 0.34 m and R = 0.246 m.

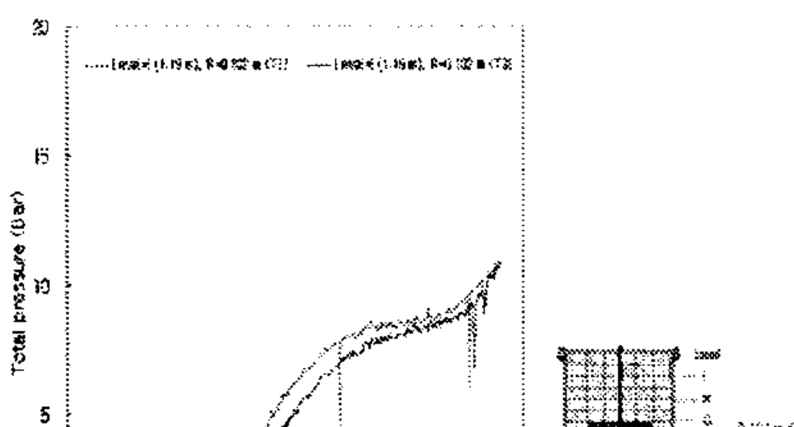

Figure 4. Evolution of the total pressure at a Level = I (1.19 m).