Thermal Conductivity Investigation of Korean Bentonite Buffer Materials

Seok Yoon*, Wanhyoung Cho, Changsoo Lee, and Geonyoung Kim
Korea Atomic Energy Research Institute, Daedeok-daero989ben-gil 111,Yuseong-gu, Daejeon, Republic of Korea
*syoon@kaeri.re.kr

1. Introduction

The concept of an engineered barrier system (EBS) is suggested to dispose high level waste (HLW). EBS is composed of a disposal canister with packed spent fuel, a buffer material, backfill material, and near field rock mass. A buffer material is very essential to guarantee the disposal safety of HLW, and play a very important role to protect the waste and canister against any external mechanical impact. Furthermore, it requires high thermal conductivity to release as much decay heat as possible from the spent fuel. The thermal conductivity of the buffer material is a crucial property that determines the temperature change owing to decay heat from spent fuel. There have been many researches to investigate the thermal conductivity of bentonite buffer materials or many types of soils. However, there is a lack of research on the overall evaluation of the thermal conductivity of Korean bentontonite buffer materials. Therefore, this paper investigated and analyzed previous researches on the thermal conductivity of the Korean bentonite buffer materials produced in Kyeongju.

2. Results and discussion

In Korea, Ca bentonite buffer materials have been produced in Kyeongju by CLIRIANT KOREA. Ca bentonite is named as KJ-I produced before 2015, and KJ-II after 2015 [1]. There have been several researches investigating thermal conductivity of KJ-I [2-4] considering various affecting factors such as the degree of saturation, dry density and temperature variation. Yoon et al. (2017) [5] also investigated thermal conductivity of KJ-II and suggested the prediction model considering various factors. Table 1 shows a quantitative analysis for KJ-I and KJ-II in order to analyze the mineral composition, and Table 2 shows the variation of thermal conductivity with respect to the degree of saturation and dry density.

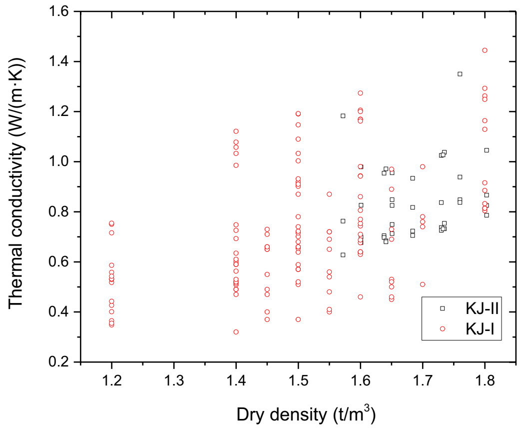
Table 1. Quantitative analysis for KJ-I and KJ-II bentonite

Bentonite Type	KJ-I				KJ-Ⅱ			
Sample No.	1	2	3	Avg.	4	5	6	Avg.
Montmorillonite	60.0	67.4	62.1	63.2	63.4	61.7	60.5	61.9
Albite (λ=1.96 W/mK)	27.2 (68.0%)	22.2 (68.1%)	27.5 (72.6%)	25.6 (69.6%)	19.4 (53.0%)	22.8 (59.5%)	20.4 (51.7%)	20.9 (54.9%)
Quartz (λ=7.69 W/mK)	5.0 (12.5%)	4.8 (14.7%)	5.0 (13.2%)	4.9 (13.3%)	5.8 (15.8%)	4.9 (12.8%)	5.3 (13.4%)	5.3 (13.9%)
Cristobalite (λ= 6.15 W/mK)	3.6 (9.0%)	1.8 (5.5%)	3.5 (9.2%)	3.0 (8.2%)	4.0 (10.9%)	4.5 (11.8%)	3.7 (9.4%)	4.1 (10.8%)
Calcite (λ=3.59 W/mK)	2.4 (6.0%)	2.0 (6.1%)	2.0 (5.3%)	2.1 (5.7%)	4.3 (11.7%)	3.3 (8.6%)	6.8 (17.2%)	4.8 (12.6%)
Heulandite (λ=1.09 W/mK)	1.8 (4.5%)	1.7 (5.2%)	(- %)	1.8 (4.9%)	3.0 (8.2%)	2.7 (7.1%)	3.3 (8.4%)	3.0 (7.9%)

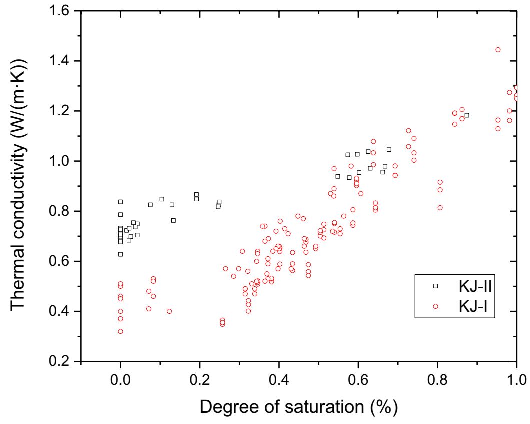
Table 2. Thermal conductivity of KJ-I and KJ-II bentonite

	Saturation (%)	Dry density (kg/m^3)	Thermal conductivity (W/mK)
KJ-1	0~100	1200~1800	0.301~1.249
KJ-2	0~100	1527~1803	0.627~1.345

The thermal conductivity of the bentonite buffer materials was proportional to the degree of saturation and dry density (Fig. 1). As shown in Table 1, the composition of montmorillonite was almost similar between KJ-I and KJ-II. However, KJ-II has more minerals with high thermal conductivity such as Quartz, Cristobalite, and Calcite than KJ-I, and it is thought that the thermal conductivity of KJ-II was higher than that of KJ-I.



(a) Thermal conductivity *vs* dry density



(b) Thermal conductivity *vs* degree of saturation

Fig.1. Thermal conductivity variation.

3. Conclusion

This paper summarized the thermal conductivity of the Kyeongju bentonite buffer materials. The thermal conductivity of KJ-II was higher than that of KJ-I because KJ-II has more minerals with high thermal conductivity such as Quartz, Cristobalite, and Calcite than KJ-I. Therefore, it is thought that KJ-II has more benefit for the buffer materials in terms of the thermal properties.

ACKNOWLEDGEMENT

This research was supported by the Nuclear Research and Development Program of the National Research Foundation of Korea (NRF-2017M2A8A5014857), funded by the Ministry of Science and ICT.

REFERENCES

[1] You, M., Choi, H.J., Lee, M.S., Lee, S.Y., Chemical and mineralogical characterization of domestic bentonite for a buffer of an HLW repository, KAERI/TR-6182(2015).

[2] Lee, M.S., Choi, H.J., Lee, J.O., Lee, J.P., Improvement of the thermal conductivity of a compacted bentonite buffer, KAERI/TR-5311(2013).

[3] Cho, W.J., Lee, J.O., Choi, H.J., Thermal conductivity of domestic compacted bentonite and bentonit-sand mixture, KAERI/TR-5561 (2014).

[4] Lee, J.W., Choi, H., Lee, J.Y., Thermal conductivity of compacted bentonite as a buffer material for a high-level radioactive waste repository, Ann Nucl Energy 94, 848-855 (2016).

[5] Yoon, S., Lee, M.S., Kim, G.Y., Lee, S.R., Kim, M.J., A prediction of thermal conductivity for compacted bentonite buffer in the high-level radioactive waste repository, J. Korean Geotech Soc 32, 55-64 (2017).