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Thesis Outline

Title:	Reaction Performance Enhancement of Chemical Heat Storage Material by Lithium Bromide for Magnesium Oxide/Water Chemical Heat Pump
Student's name:	Odtsetseg Myagmarjav
Academic Advisor:	Yukitaka Kato

This thesis deals with development of a novel candidate chemical heat storage material with the potentially higher reaction performance and thermal conductivity used for magnesium oxide/water chemical heat pump at working medium temperatures of 200 to 300 °C. The thesis consists of seven chapters.

Chapter 1 (**Introduction**) reviews the background of research for thermal energy storages, and particularly, a magnesium oxide/water (MgO/H_2O) chemical heat pump (CHP). Previous research has considered the combining MgO/H_2O CHP with small pressurized water reactor for district heating, because the dehydration and hydration temperatures of the CHP materials (250-300 °C) are compatible with both small nuclear reactor and district heating networks. For this combined system, a design space was large for the CHP. By improving the energy density of the storage materials for the CHP it is a possible to decrease the space required. To further this approach, a novel candidate chemical heat storage material, called EML, which was obtained by mixing pure magnesium hydroxide ($Mg(OH)_2$) with expanded graphite (EG) and lithium bromide (LiBr), which offer higher thermal conductivity and reactivity, was developed and its kinetics was discussed experimentally.

Chapter 2 (**Experimental Techniques for Preparation of EML Composite and Apparatuses**) introduces a mixing method for the preparation of the EML composite. Two indexes of mixing ratio were defined to prepare the EML composite: 1) mixing mole ratio, α [-], which was defined as the mole ratio between LiBr and $Mg(OH)_2$; and 2) mixing mass ratio, w [-], defined as the mass ratio between EG and $Mg(OH)_2$.

Chapter 3 (**Thermogravimetric Analysis of EML Composite**) presents the results of the dehydration and hydration behavior of the EML composite. The effects of LiBr modification was demonstrated on reactivity enhancement. Kinetic analyses for the EML composite was performed based on thermogravimetic method by using first order reaction model for dehydration and shrinking core model for hydration, respectively.

Chapter 4 (**Kinetic Analyses of Effects of Mixing Molar Ratios of LiBr-to-$Mg(OH)_2$ and of Mass Ratios of EG-to-$Mg(OH)_2$ on Dehydration and Hydration**) addresses investigation of the effects of α and w values on dehydration and hydration rates. The tests was performed at five mixing molar ratios: α = 0.300, 0.100, 0.050, 0.010, 0.005, and seven mass ratios: w = 0.50, 0.67, 0.75, 0.80, 0.83, 0.86 and 0.88 from which the kinetic parameters, i.e., the reaction rate constants and activation energies, were obtained for both reactions. From the evaluation of kinetic parameters it was identified which is the optimal mixing ratios.

Chapter 5 (**Thermogravimetric Analysis of EML with Optimal Mixing Ratio**) discusses main three results: a thermogravimetric analysis for the EML composite with optimal mixing ratios, thermal conductivity measurement of the EML slab with optimal mixing ratio and finally, a study of thermogravimetric analysis for the EML tablet with optimal mixing ratio.
In the first part of this Chapter, the dehydration and hydration behavior of the EML composite with optimal mixing ratio of $\alpha = 0.10$ and $w = 0.83$ were investigated by thermogravimetric method and kinetic analyses were performed. Hydration reactivity was measured at a series of reaction pressures and temperatures, and its relationship was explained. In order to demonstrate the durability of the EML composite, fifty repetitive cyclic experiments were done. In the second part of the Chapter, the thermal conductivity of the EML composite with optimal mixing ratio was measured with a quick thermal conductivity meter in order to quantity the enhancement in thermal conductivity, achieved by the utilization of EG. Final part of the Chapter, a compressed EML in tablet form (called as "EML tablet") was experimentally discussed as an elemental sample of the slab. Dehydration and hydration behavior of the EML tablet with optimal mixing ratio was investigated experimentally based on thermogravimetric method. Furthermore, the effects of density and mixing mass ratio of the tablets on dehydration and hydration were investigated. The cyclic ability of the tablet was discussed.

Chapter 6 (**Combination of CHP using EML Tablet and Small Nuclear Reactor for District Heating**) discusses main two results: evaluation of heat storage and output performance of the EML composite and tablet, and preliminary evaluation of potential use of the EML tablet for load leveling of the combined system of a MgO/H_2O CHP and a small pressurized water reactor in district heating system.
In the first part of this Chapter, reaction performances of the EML composite and tablet were evaluated based on the results from dehydration and hydration experiments. The amount of stored energy per unit volume is the key indicator for the quality of heat storage. Therefore, volumetric heat storage and output capacity of the EML tablet were evaluated and the results were discussed. The last part of the Chapter, a potential use of the EML tablet for load leveling of the combined system of a magnesium oxide/water chemical heat pump and a small pressurized water reactor in district heating system preliminary was evaluated, and required amount of the EML tablet for load leveling was estimated.

Chapter 7 (**Conclusions**) concludes the thesis.