論文 / 著書情報
Article / Book Information

題目(和文)	酸化マグネシウム／水系ケミカルヒートポンプのための伝熱促進複合材料に関する研究
Title(English)	A Study on Heat Transfer-Enhanced Composites for a Magnesium Oxide/Water Chemical Heat Pump
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種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
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論 文 要 旨

THESIS SUMMARY

専攻： Department of	Nuclear Engineering 専攻	申請学位（専攻分野）： Academic Degree Requested	博士 （Engineering） Doctor of
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

The magnesium oxide / water chemical heat pump (MgO/H_2O CHP) is a promising technology for heat storage and load leveling in cogeneration systems or for recovering unused heat from industrial processes at temperatures in the range between 350 and 450°C. The principle is based on a reversible chemical reaction, which consists of exothermic hydration of MgO (heat output mode) and endothermic dehydration of magnesium hydroxide ($Mg(OH)_2$, heat storage mode). Low values of thermal conductivities of MgO and $Mg(OH)_2$ make the technology impractical, therefore heat transfer enhancement of materials is crucial for its utilization. Expanded graphite (EG) was employed as thermal conductivity enhancer. Mold-ability and chemical stability of EG are also advantageous properties for its practical utilization into heat exchangers for packed bed reactors. In this work, a mixing method for the preparation of a $Mg(OH)_2$ and EG composite was developed. This material was called EM. It was obtained by mixing powders of $Mg(OH)_2$ with EG in a water emulsion. Three kind of EM composite were prepared, characterized by a different mass mixing ratio $Mg(OH)_2$ to EG, respectively 16:1, 8:1 and 4:1. They were called EM16, EM8 and EM4, respectively. Thermal conductivities of EM slabs were measured with a thermal conductivity meter based on the hot wire method. Thermal conductivity of EM4 slab resulted 1.9 W m^{-1} K^{-1}, which was about 10 times larger than the one of a packed bed of $Mg(OH)_2$ pellets (corresponding to 0.16 W m^{-1} K^{-1}). Thermal conductivity of EM slabs showed anisotropic behavior. Dehydration and hydration reactions were investigated on packed beds of $Mg(OH)_2$ pellets (diameter ϕ_{pellet} = 2.0 mm, average length l_{pellet} = 10.0 mm) and of EM tablets (diameter ϕ_{tablet} = 7.0 mm, average thickness t_{tablet} = 3.5-4.5 mm) loaded in an experimental CHP reactor (diameter $\phi_{reactor}$ = 48 mm, height $z_{reactor}$ = 48 mm). It was demonstrated that, under identical dehydration conditions, the higher thermal conductivities of packed beds comprising EM tablets made it possible to reach higher and more homogeneous bed temperatures. Compared with pure $Mg(OH)_2$ bed of pellets, the dehydration in the packed beds of EM tablets was completed in a shorter time. The rate of dehydration was enhanced by the larger thermal conductivity of the packed bed of EM tablets. EM tablets could sustain repetitive cyclic reaction, preserving their original shape and ensuring stable performances of heat storage and output. From the experimental results of volumetric heat storage capacity, $q_{d,v}$ [MJ m_{bed}^{-3}], it was observed that in the packed bed of EM8 tablets the value of $q_{d,v}$ increased faster than in case of EM16 ones and its value was larger than in case of EM4 ones. EM8 was then utilized for other experiments, aiming to further increase the value of the $q_{d,v}$, at first by piling larger size EM8 tablets inside of the reactor (ϕ_{tablet} = 10.0 mm, t_{tablet} = 6.5 mm) and finally, by filling the reactor completely with an EM8 block (ϕ_{block} = 48 mm, z_{block} = 40 mm). After 120 minutes of dehydration, EM8 block showed a value of $q_{d,v}$ = 750 MJ m_{bed}^{-3} rather than 500 MJ m_{bed}^{-3} obtained from a bed of $Mg(OH)_2$ pellets or a bed of EM8 piled tablets. For hydration under water vapor pressure of 361 kPa, the EM8 block showed a mean heat output rate in 30 minutes, $w_{h,mean}$, of 407 kW m_{bed}^{-3}, which was almost two times larger than 218 or 258 kW m_{bed}^{-3} obtained from a bed of $Mg(OH)_2$ pellets or a bed of EM8 piled tablets, respectively. EM8 block demonstrated to be the most valid candidate for a practical application of the MgO/H_2O CHP technology. Dehydration in a bed of $Mg(OH)_2$ pellets and one of EM8 piled tablets was analyzed numerically. Experimental values of thermal conductivity, specific heat capacity and reaction rate constant were utilized. The results of simulations agreed with experimental results. Local reaction conversion of $Mg(OH)_2$ to MgO was calculated in several positions of the packed beds: the results indicated that 7 minutes after starting heating the reactor, the bed of EM8 piled tablets started to store heat also at its center, but this was possible only after 15 minutes in the $Mg(OH)_2$ bed. The utilization of the chemical heat storage for thermal load leveling in power plants was discussed. A model of a system including the Rankine cycle of a nuclear power plant (120 MWt / 50 MWe) and a chemical heat storage reactor was proposed. The heat storage capacity and mean heat output rate calculated from the packed bed experiments were utilized for this numerical analysis. For a heat storage of 3.6 MWt in 1 hour (3% of total thermal power output), a bed filled with 17.7 m^3 of EM8 (block) was required; the same amount of heat could be stored in a bed of $Mg(OH)_2$ pellets of 30.0 m^3. The volume of EM8 block required for storing the same amount of heat of $Mg(OH)_2$ pellets resulted 41% smaller. This study demonstrated the operability of EM as a heat storage material for CHP.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。
Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).