Silica gel/Water Based Adsorption Cooling System Employing Compact Fin-Tube Heat Exchanger

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論　文　要　旨

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論 文 内 容 の 要 旨

A central challenge in cooling science today is the development of thermally powered miniaturized chillers employing environmentally benign adsorbent-refrigerant pairs. The general aim is to develop a device that is: (1) compact, (2) environmentally benign, (3) virtually free of moving parts or highly reliable, (3) capable of exploiting low-temperature waste heat, and (4) highly efficient in converting input to cooling power.

From the above perspective, this thesis presents the theoretical and experimental studies of adsorption cooling cycles which utilize low-temperature heat sources such as waste heat from fuel cells or solar thermal energy. Silica gel and water have been considered as the adsorbent/adsorbate pair as silica gel is abundantly available and water is a natural refrigerant with high latent heat of vaporization and the working pair is environmentally friendly.

In analyzing silica gel-water based adsorption cooling system, thermophysical properties and water vapor uptake performance of silica gels are important. In this study, thermophysical properties of three different sizes of RD 2060 type silica gels are determined using N_2 adsorption isotherm data by volumetric adsorption characteristic analyzer.　Water vapor adsorption dynamic on to cylindrical silica gel has been analyzed using finite volume based ANSYS FLUENT environment.

The equilibrium isotherm characteristics of water onto granular RD type silica gel have been experimentally studied at three evaporation temperatures employing an innovative compact fin and tube type adsorbent bed (heat exchanger). The adsorbents were packed between the fins of the compact heat exchanger. The experimental adsorption equilibrium isotherms data have been fitted with popular isotherm models and the modified Freundlich equation which is known as the S-B-K adsorption isotherm model fits satisfactorily the present experimental results.

The theoretical study modelled the mass and energy balances of the adsorption cooling cycle that operates in a batch manner, using the governing equations developed based on thermodynamic property fields of an adsorbent/adsorbate system.　Dynamic behavior of silica gel-water based adsorption cooling system employing the innovative fin and tube type heat exchanger has been determined in terms of cooling capacity and coefficient of performance (COP) by varying heat transfer fluid (hot, cooling and chilled water) inlet temperatures, heat transfer fluid flow rates, adsorption/desorption cycle time and switching time.

Finally, the performance of silica gel-water based adsorption cooling systems powered by two different temperature levels of waste heat from polymer electrolyte fuel cell (PEFC) and solid oxide fuel cell (SOFC) has been determined. System performance in terms of specific cooling capacity (SCC) and COP are determined and compared and are found to be suitable for low-temperature waste heat utilization. In short, these cited advantages of low-temperature thermally powered adsorption cycle offers great potential for a large scale implementation for cooling applications.