SUMMARY OF Ph.D. DISSERTATION

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Title

Development of a heat storage system using metal hydrides

Abstract

The application of an innovative heat storage system with metal hydrides to a building air-conditioning is studied in this thesis.

The key factor of the increase in electricity demand is mainly the increase in air-conditioning load. This electricity demand has the maximum in the afternoon of summer day. This maximum demand is called the peak. In order to compensate this peak, new electric power stations are required. There is a big difference in the electricity demand in summer between that in the afternoon and that in the night. Therefore, surplus electric power occurs at night. In order to minimize difference, the electric power industries promote the heat storage that cold water is stored with the surplus electric power at night to use for air conditioning of daytime. Moreover, carbon-dioxide emissions can be reduced with the reduction of electric power supply by the heat storage.

In conventional heat-storage systems, water or ice is used as the heat storage material. Rather large heat-storage vessels are required for conventional heat-storage systems and also chlorofluorocarbons are necessary to produce cold water or ice. However, chlorofluorocarbons may be factors in causing significant problems of the global environment.

Metal hydrides (MH) characteristically generate heat through the absorption process and absorbs heat through the discharge process, therefore the heat storage system using MH with a compressor for hydrogen transfer dose not use chlorofluorocarbons. Moreover, by applying MH to a heat storage system, heat storage density becomes large. This system is composed of two heat storage vessels as heat exchangers filled with MH and of a compressor equipped for hydrogen transfer.

The first chapter is an introduction in which the necessity of heat storage system, conventional heat-storage systems, the research and development trend, and the purpose of this research are described.

In the second chapter, the heat storage vessel designed and manufactured for this heat storage system is introduced. From the experimental results, cold-water of the required temperature could be obtained during the required period, and a heat storage vessel with high heat-storage density was obtained.

Since the heat storage vessel must be cooled to the take-off temperature of cold-water to bring the cold water out of the heat storage vessel, considerable amount of hydrogen is used to cool down both the vessel and MH to the take-off temperature of cold-water.

In the third chapter, the amount of hydrogen that cannot be utilized for cooling water to take off is defined as the “ineffective amount of transferred hydrogen” and an operating method to reduce the relative amount of the hydrogen is proposed and evaluated by experiments.　The proposed method is indicated to be effective to increase the heat storage amount by the increase in storage hydrogen per unit MH mass compared with the basic operating method or the operating method of initial temperature leveling.

In the fourth chapter, the results of experiments carried out under an actual load condition in a basic heat-storage method referred to the “peak cut method” for the MH heat-storage system are described. In this method, heat storage is carried out using a compressor in the nighttime. Subsequently, cooling is carried out through hydrogen discharge based on the pressure difference between the MH heat-storage vessels. From the experimental result, it is confirmed that this heat storage system has sufficient heat storage capability.

In the fifth chapter, the results of experiments carried out under an actual load using a “peak shift method” are described. In this method, heat storage is carried out using a compressor in the nighttime, and cold water is stored in the heat storage tank. Subsequently, during the daytime, cooling is performed using a compressor and stored cold water. From the experimental result, the coefficient of performance of this system is almost same as the coefficient of performance of ice heat storage system

The sixth chapter summarizes the results obtained and describes the applicability of the heat storage system with metal hydrides.