審査の結果の要旨

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This dissertation pursues the development of hydrophobic hollow fiber membrane-based absorption refrigeration system as an automobile application. Even though vapor absorption refrigeration system promises a bright future for vehicle air-conditioning system, several obstacles which have to be solved remain as challenges before portable application can be achieved. To this purpose the hydrophobic hollow fiber membrane is proposed as a key item for making the absorption system compact and lightweight.

Three main original achievements are as follows:

1. Hollow fiber membrane-based generator was proposed as a new concept of compact and lightweight generator in vapor absorption refrigeration system. The proposed generator was experimentally examined to evaluate the effect of various driving conditions on the heat and mass transfer performance. Moreover, using the permeability value obtained by the gas permeation test, an established theoretical model validated the experimental analysis.
2. Hollow fiber membrane-based solution mass exchanger using the typical hollow fiber membrane module was proposed for mass recovery process, enhancing the performance of absorption system. The theoretical analysis clarified the effect of various working conditions on the mass recovery process; however, the negative mass recovery was observed under the certain conditions.
3. A new type of hollow fiber membrane-based solution mass exchanger was proposed. In the proposed traditional mass exchanger, the heat is transferred between two streams of the feed solutions, which has negative effect on the mass recovery process; however, the new type of mass exchanger does not allow the heat transfer so that the performance of mass recovery is maximized.

This dissertation consists of six chapters. In the chapter 1, problems with the existing automotive air conditioning system are first discussed within the framework of the energy and environmental issues. A single effect vapor absorption refrigeration system (VARs), which uses the lithium bromide (LiBr)

and water, is then described as an alternative portable air-conditioning system. Challenges which have to be overcome are proposed for compact and lightweight automobile VARs. This chapter also includes the literature review regarding the measures to improve the heat and mass transfer in the conventional VARs and the attempts for the use of VARs on the vehicles.

The chapter 2 contains the research objectives to develop the automotive compact VARs. To this purpose, a hydrophobic hollow fiber membrane (HFM) is proposed to overcome the limitations that the conventional VARs have had as a portable application. The literature review section involves the membrane distillation processes and the membrane-based heat and mass exchangers in VARs.

The chapter 3 first presents the basic terminologies of membrane parameters. The structure of the (HFM) used in this study is clarified by the SEM images. The gas permeation test is conducted to estimate the gas permeability across the HFM to characterize the mass transfer.

In the chapter 4, a hollow fiber membrane-based generator (HFM-G) is introduced to substitute the conventional generator in VARs. Theoretical heat and mass transfer model is firstly illuminated and the theoretical simulation results are shown to comprehend the mechanism of the HFM adiabatic desorption process. The effect of the HFM-G on the proposed VARs are then intensively represented under various operating conditions. Transient experiments are also shown to examine the heat and mass transfer characteristics of the HFM-G under various working conditions. The comparison results between experimental and theoretical analysis are described for the validation of theoretical models.

This chapter 5 presents two types of hollow fiber membrane-based solution mass exchangers (HFM-SME). Mass recovery process is emphasized by understanding the simultaneous heat and mass transfer. The characteristics of mass recovery process, which is a form of the traditional HFM module (named “traditional HFM-SME”), are clarified in terms of the flow direction of the solutions. The improved type of the HFM-SME (named “new type of HFM-SME) is also suggested with the theoretical analysis as an alternative to the traditional HFM-SME to achieve maximized mass recovery performance.

In the chapter 6, this paper is finalized with the conclusion by summarizing research contribution and discussion of the perspective work directions. The iso-thermal type of HFM-based heat and mass exchangers are designed for the future works. It is expected that the proposed iso-thermal types make up for shortcomings that the adiabatic HFM-based heat and mass exchangers have shown.

本論文は、論文提出者が主体となって疎水性中空糸膜を利用したコンパクト吸収冷凍機の理論設計と実験的研究を行ったものである。特に新型中空糸膜式溶液熱交換器、吸収器および再生器の理論計算及び実証実験より、従来機器より大幅な小型化が可能であることを明らかにした。未利用熱である自動車の排熱駆動用小型吸収式冷凍機の研究開発として、その独創性と有用性は十分である。本論文は、博士学位論文として合格と認められる。したがって、

論文提出者に博士（環境学）の学位を授与出来ると認める。

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