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Performance analysis of the single-stage absorption heat transformer using a new working pair composed of ionic liquid and water

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ABSTRACT

The performance simulation of a single-stage absorption heat transformer using a new working pair composed of ionic liquids, 1-ethyl-3-methylimidazolium dimethylphosphate, and water (H_2O + [EMIM][DMP]), was performed based on the thermodynamic properties of the new working pair and on the mass and energy balance for each component of the system. In order to evaluate the new working pair, the simulation results were compared with those of aqueous solution of lithium bromide (H_2O + LiBr), Trifluoroethanol (TFE) + tetraethylenglycol dimethylether (E181).

The results indicate that when generation, evaporation, condensing and absorption temperatures are 90 °C, 90 °C, 35 °C and 130 °C, the coefficients of performance of the single-stage absorption heat transformer using H_2O + LiBr, H_2O + [EMIM][DMP] and TFE + E181 as working pairs will reach 0.494, 0.481 and 0.458 respectively. And the corresponding exergy efficiency will reach 0.64, 0.62 and 0.59, respectively. Meanwhile the available heat outputs for per unit mass of refrigerant are 2466 kJ/kg, 2344 kJ/kg and 311 kJ/kg, respectively.

The above excellent cycle performance together with the advantages of negligible vapor pressure, no crystallization and more weak corrosion tendency to iron-steel materials may make the new working pair better suited for the industrial absorption heat transformer.

1. Introduction

In order to reduce the CO_2 discharge and reuse large amounts of industrial waste heat, absorption heat transformers (AHT) which can upgrade waste heat from low temperature level to a higher one have been used in some industrial processes [1]. The available temperature lift for single-stage absorption heat transformers (STAHT) is usually in the range of 30 °C–40 °C, while a higher available temperature lift must be obtained by adopting two-stage absorption heat transformer (TSAHT) or double absorption heat transformer (DAHT).

The cycle performance of an AHT not only depends on its configuration (for example, STAHT or DAHT) but also on thermodynamic properties of working pairs usually composed of refrigerant and absorbent. The commonly-used working pairs in AHT is aqueous solution of lithium bromide (H_2O + LiBr). However, corrosion and crystallization are its major disadvantages in industrial applications. Therefore, seeking more advantageous working pairs with good thermal stability , minimum corrosion and without crystallization has become the research focus in the past two decades.

The organic working pairs such as Trifluoroethanol (TFE) + tetraethylenglycol dimethylether (E181), TFE + N-methyl1-2-pyrrolidone (NMP), etc are usually non-corrosive, completely miscible and thermally stable. These excellent physical properties have attracted many researchers to study the cycle performance of absorption refrigerator, absorption heat pump (AHP) and AHT adopting these organic working pairs [2–12].

Ionic liquids (ILs) are new types of environmental-friendly solvent and remain liquid state at near or below room temperature. ILs are composed of the organic cation and inorganic anion. They constitute a huge family of chemicals because there are many types of organic cation and inorganic anion which can be converted into ionic liquids. In the past decades, ILs have attracted considerable attention because of their unique properties, e.g. negligible vapor pressure, non-flammability, good thermal stability, low melting points, wide range of liquid state from room temperature up to 200 or 300 °C, and good solubility to many organic or inorganic chemicals.

Because of their excellent properties, it is very possible that ILs can be used as a new type of absorbent of refrigerants. With this goal in mind, some researchers began to look for the suitable ILs which can match common refrigerants and have excellent physical and chemical properties. Kima and Shin *et al.* researched the

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