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Heat Transfer Evaluation Of R1336mzz(Z) In Falling Film Evaporator At High-Temperature Operating Conditions

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Extended Abstract

The global target to decrease greenhouse gas emissions requires a substantial decrease in the supply of industrial process heat derived from fossil fuels. In 2015, European industrial process heating and cooling constituted approximately 50% of the industry's total final energy consumption. Electrically powered heat pumps emerge as a promising technological solution for enhancing system efficiencies and reducing greenhouse gas emissions, leveraging the potential of emission-free electricity [1]. In the industrial sector, high-temperature heat pumps have been attracted to replace conventional boilers owing to their high energy efficiency and low carbon emission. Therefore, it is essential to analyze the performance of heat pump components under high-temperature operating conditions. Especially, in the heat exchanger sector, a falling film evaporator has a potential to replace the conventional flooded-type evaporator. In a falling film evaporator, the refrigerant is distributed through a distributor and absorbs heat from the tube in the form of a thin film while heat exchange occurs with the refrigerant pooled in the tube. Therefore, it has the advantages of high heat transfer performance and low refrigerant charge. Extensive studies on refrigerants and enhanced tubes in falling film evaporators have been conducted to enhance the heat transfer performance. Li et al. [2] concluded that the heat transfer coefficient of water in smooth and enhanced tubes increased and decreased at specific Film Reynolds numbers owing to increased film thickness. Zhao et al. [3] studied that the heat transfer performance of R134a increased the threshold film Reynolds number and maintained at a constant value because of its well-wetting characteristics with low surface tension and viscosity. Existing studies showed different trends depending on thermophysical properties and tube structure and focused on low-temperature operating conditions. In addition, studies on evaporation heat transfer of low global warming potential (GWP) for high-temperature heat pumps have rarely been conducted in the literature. However, the evaporation heat transfer performance of low GWP must be investigated to provide design guidelines. In this study, the evaporation heat transfer characteristics of R-1336mzz(Z) were analyzed through experiments for various tubes under high-temperature operating conditions. The three main loops are constructed: R-1336mzz(Z), hot water, and cold water. The refrigerant line consisted of a pump, preheater, falling film evaporator, and condenser. The mass flow rate of refrigerant was controlled through the pump. The inlet quality was regulated through a preheater. Hot water passed through the tubes in the falling film evaporator and supplied heat to the refrigerant. Cold water in a condenser connected to a constant water bath controlled the system pressure. The heat transfer coefficient of R-1336mzz(Z) in all tubes increased until the threshold Reynolds number showed a plateau trend. This trend was validated in the previous study [3]. In addition, the heat transfer rate in the enhanced tube was 91% higher than that of the smooth tube. As the water inlet temperature increased from 80 to 90 °C, the heat transfer coefficient of R1336mzz(Z) increased from 2.02 to 2.18 kW m^{-2} owing to increased nucleation density. This study provides useful information for designing falling film evaporator under high-temperature conditions.

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