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Theoretical and experimental study of multi-effect vacuum membrane distillation systems for liquid desiccant air conditioning and zero liquid discharge

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ABSTRACT

Since its first description in literature, a variety of different system configurations for distillation over hydrophobic membranes have been invented. General advantages are the applicability at relatively low operation temperatures, low fouling potential, high product quality and the possibility to operate the system at very high feed concentration. This is why membrane distillation (MD) is applied more and more in the field of zero liquid discharge. One main drawback of MD, the low specific distillate production, can be partially overcome by using a vacuum enhanced process. Furthermore, with help of a multi-effect arrangement as known from multi-effect distillation (MED) or multi-stage flash (MSF), energy efficiency can be significantly enhanced. For application in seawater desalination, the vapor pressure reduction of the treated feed waters is mainly limited by the solubility limit of sodium chloride. For electrolyte solutions used for air dehumidification in liquid desiccant air conditioning (LDAC), much lower vapor pressures are reached, which significantly reduces the performance of thermal regeneration systems. With the aim of efficiency enhancement of desiccant regeneration in LDAC an experimental study has been conducted on a vacuum multi-effect membrane distillation system. As desiccant an aqueous solution of calcium chloride up to 45 m% has been used. A systematic sensitivity analysis on feed concentration, temperature levels and number of effects shows the operation limits of the plant. Especially for high feed concentrations, the number of stages shows a significant influence on the process performance.

Keywords: Vacuum membrane distillation; Multi-effect; Zero liquid discharge; Liquid desiccant air conditioning; Experiment

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