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Modelling of Air-Cooled Adiabatic Membrane-Based Absorber for Absorption Chillers Using Low Temperature Solar Heat

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Abstract : Absorption cooling chillers have received growing attention over the past few decades as they allow the use of low-grade heat to produce the cooling effect. The combination of this technology with solar thermal energy in the summer period can reduce the electricity consumption peak due to air-conditioning. One of the main components, the absorber, is designed for simultaneous heat and mass transfer. Usually, shell and tubes heat exchangers are used, which are large and heavy. Cooling water from a cooling tower is conventionally used to extract the heat released during the absorption and condensation processes. These are clear inconvenient for the generalization of the absorption technology use, limiting its benefits in the contribution to the reduction in CO2 emissions, particularly for the H2O-LiBr solution which can work with low heat temperature sources as provided by solar panels. In the present work a promising new technology is under study, consisting in the use of membrane contactors in adiabatic microchannel mass exchangers. The configuration here proposed consists in one or several modules (depending on the cooling capacity of the chiller) that contain two vapour channels, separated from the solution by adjacent microporous membranes. The solution is confined in rectangular microchannels. A plastic or synthetic wall separates the solution channels between them. The solution entering the absorber is previously subcooled using ambient air. In this way, the need for a cooling tower is avoided. A model of the configuration proposed is developed based on mass and energy balances and some correlations were selected to predict the heat and mass transfer coefficients. The concentration and temperatures along the channels cannot be explicitly determined from the set of equations obtained. For this reason, the equations were implemented in a computer code using Engineering Equation Solver software, EES™. With the aim of minimizing the absorber volume to reduce the size of absorption cooling chillers, the ratio between the cooling power of the chiller and the absorber volume (R) is calculated. Its variation is shown along the solution channels, allowing its optimization for selected operating conditions. For the case considered the solution channel length is recommended to be lower than 3 cm. Maximum values of R obtained in this work are higher than the ones found in optimized horizontal falling film absorbers using the same solution. Results obtained also show the variation of R and the chiller efficiency (COP) for different ambient temperatures and desorption temperatures typically obtained using flat plate solar collectors. The configuration proposed of adiabatic membrane-based absorber using ambient air to subcool the solution is a good technology to reduce the size of the absorption chillers, allowing the use of low temperature solar heat and avoiding the need for cooling towers.

Keywords : adiabatic absorption, air-cooled, membrane, solar thermal energy
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