Numerical and experimental investigation of thermosyphon-driven liquid desiccant loop performance for sustainable indoor humidity removal

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Indoor humidity management is one of the most challenging aspects of the control of indoor environment and is energy intensive, especially in hot and humid climates. A promising approach is the removal of the water vapor from the room using hygroscopic materials, otherwise known as desiccants. Desiccant cycles are thermally driven but require a heat sink and electricity-driven mechanical parts for desiccant circulation. Accordingly, this work proposes a thermosyphon-driven membrane-based liquid desiccant loop for sustainable humidity pumping between two areas at different humidity conditions. Mathematical models were developed for the different system subcomponents, which were validated with published data and in-house experiments. The models were used in a parametric study to determine the influence of the design and operation parameters on the system performance under different air conditions surrounding its various sections.

It was found that the system was able to pump the air moisture from high to low and low to high humidity areas. Four cases were considered with outdoor conditions raging from moderate and hot and humid to semi-arid climates. The latent load removal density per unit area of the exposed membrane varied between 4 W/m2 to 35 W/m2 over the entire range of considered cases at required heat inputs varying between 150 W and 570 W respectively. The heat input increased with the channel height and the air humidity surrounding both system sides. The added sensible load depended on the heat sink temperature and was more than 65 % lower than removed latent load in most considered cases.