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Heat and moisture transfer modeling in enthalpy exchangers using asymmetric composite membranes

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ABSTRACT

Enthalpy exchangers using water vapor perm-selective membranes are used in building ventilation systems due to their small footprint, simplicity, reduced contaminant crossover, and relatively high efficiency.

Moisture permeation properties of the membrane media that vary with operating air humidity and temperature lead to significant changes in the performance of an enthalpy exchanger and thus the whole ventilation system, impacting building energy efficiency. Evaluation of the actual energy savings potential of such energy recovery devices in building ventilation systems requires models that account for this variable membrane performance.

A theoretical model is developed for current generation asymmetric composite membranes used in enthalpy exchangers. This model predicts the membrane permeability as a function of local values of air humidity and temperature, based on a limited number of kinetic water vapor sorption tests of the membrane material.

The membrane model is coupled with a finite-difference model of the conjugate heat and mass transfer in full cross-flow enthalpy exchanger cores. The model predictions are validated against experimental data of a commercial-scale enthalpy exchanger.

The model is used to predict the influence of outdoor air parameters (temperature, humidity) on an enthalpy exchanger and the predictions are compared against a baseline case that assumes constant membrane permeability. Such assumption can result in deviations in effectiveness predictions by up to 15%. Depending on the mode of operation, outdoor air relative humidity can increase or decrease the effectiveness of enthalpy exchangers by up to 12%. In contrast, outdoor air temperature appears to have only a minimal influence on effectiveness parameters.