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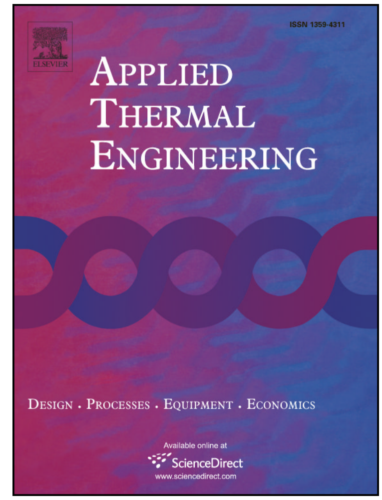

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The counter-flow dew point evaporative cooler: analyzing its transient and steady-state behavior

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Abstract

The counter-flow dew point evaporative cooler offers a markedly improved approach to air cooling instead of the conventional vapor compression chiller. Earlier studies have focused on investigating the steady-state cooling effectiveness and energy efficiency of the evaporative cooler. However, there exists limited knowledge of the cooler's transient characteristics and flow resistance. In addition, existing cooler prototypes mostly employ a water distribution system to spray the water into the wet channel, whereas the effect of water spray remains unclear. Therefore, in this paper, we present a transient and steady-state analysis of the counter-flow dew point evaporative cooler. The channel plate temperature development after water spray was measured and analyzed. A cooler prototype was designed and engineered with a horizontal orientation according to the test results, and a 2-D mathematical model was developed to simulate its performance. The model was able to accurately predict the product air temperature, cooling effectiveness, cooling capacity and COP with a maximum discrepancy of ±5.0%. Key results that emerged from this study revealed that the transient responses of the channel plate and the cooler agreed well with an exponential decay function. The pressure drops for the dry and wet channels spanned 16.0–29.1 Pa and 19.9–52.3 Pa, respectively. The achieved product air temperature ranged from 15.9 to 23.3 °C, with a COP spanning 8.6–27.0.

Keywords: counter-flow, dew point evaporative cooling, transient response, pressure drop, cooling performance

Nomenclatures

A	coefficient	*Subscripts*	
C	specific heat at constant pressure, kJ/(kg·K)	0	initial state
D	diffusion coefficient, m^2/s	a	air