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Refrigerant Performance Evaluation Including Effects of Transport Properties and Optimized Heat Exchangers

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Highlights

- Performance of different fluids was evaluated in systems with serpentine heat exchangers.
- Optimization of refrigerant circuitry may have a significant impact on fluid's performance.
- An optimized circuitry provides a higher performance benefit to high-pressure refrigerants.

Abstract

Preliminary refrigerant screenings typically rely on using cycle simulation models involving thermodynamic properties alone. This approach has two shortcomings. First, it neglects transport properties, whose influence on system performance is particularly strong through their impact on the performance of the heat exchangers. Second, the refrigerant temperatures in the evaporator and condenser are specified as input, while real-life equipment operates at imposed heat sink and heat source temperatures; the temperatures in the evaporator and condensers are established based on overall heat transfer resistances of these heat exchangers and the balance of the system.

The paper discusses a simulation methodology and model that addresses the above shortcomings. This model simulates the thermodynamic cycle operating at specified heat sink and heat source temperature profiles, and includes the ability to account for the effects of thermophysical properties and refrigerant mass flux on refrigerant heat transfer and pressure drop in the air-to-refrigerant evaporator and condenser. Additionally, the model can optimize the refrigerant mass flux in the heat exchangers to maximize the Coefficient of Performance. The new model is validated with experimental data and its predictions are contrasted to those of a model based on thermodynamic properties alone.

Keywords: Simulation model, Working fluids, Cycle COP, Heating ventilation and air conditioning HVAC&R, Refrigerants thermophisical properties

NOMENCLATURE

c_p	specific heat at constant pressure (kJ·kg^{-1}·K^{-1})
COP	coefficient of performance
$factor_{\Delta p}$	pressure drop multiplication factor (dimensionless)
ID	inner diameter of tube (m)
LMTD	log-mean temperature difference (K)
$\dot{m}$	mass flow (kg·s^{-1})
N	speed (rev·min^{-1})
P	pressure (kPa)
$\dot{Q}$	cooling or heating capacity (kW)
Q_{vol}	volumetric capacity (kJ·m^{-3})