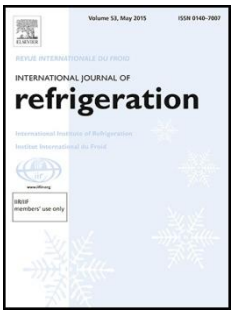

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Real-time Minimization of Power Consumption for Air-Source Transcritical CO_2 Heat Pump Water Heater System

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Highlights

- Real-time power optimization for CO_2 heat pump water heater is introduced.
- The control output is power consumption not the system COP.
- The mathematical validation and proof is provided.
- Simulation results demonstrate the reliability and applicability.
- The proposed approach is model free, which is beneficial for practice.

ABSTRACT

Based on Extremum Seeking Control, a real-time optimization strategy is proposed for minimizing the power consumption of a transcritical CO_2 heat pump system. An analytical framework is established to justify the equivalence between power minimization and the maximization of coefficient of performance. As compared to the COP feedback, power feedback based control avoids the need for several sensors beyond the simple and reliable power measurement. The proposed ESC scheme is based on three measurements of power consumption, high-pressure and gas cooler outlet water temperature. Simulations are conducted for several scenarios: a fixed operation condition, change of ambient condition and realistic ambient temperature condition. For all simulation cases, the water inlet temperature is fixed at 12°C, while the water outlet temperature is set as 60°C. Simulation results show that ESC is able to search and even track both fixed and slowly varying optimum discharge pressure without need for system model.

Keywords: Real-time optimization, Power consumption, Transcritical, CO_2 Heat pump, Extremum seeking control

Nomenclature

a_i	coefficient of adjustment	ρ_1	density of the suction gas, $kg \cdot m^{-3}$
A	heat transfer area, m^2	η_v	volume efficiency
b_i	coefficient of adjustment	η_m	mechanical efficiency