Assessing the performance limits of a variable-speed residential heat pump system

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ABSTRACT

Over the last years, the need for more efficient heat pump systems increased significantly due to concerns on energy consumption and awareness of environmental issues including global warming. Moreover, equipment manufacturers are facing challenges with the forthcoming more stringent minimum energy rating requirements for residential heat pumps that will be imposed by the U.S. Department of Energy by 2023. Most of the ducted split-type heat pump systems feature fixed-speed compressors and fans. To meet rating performance and optimize the seasonal performance of the units, variable-speed equipment offers significant advantages for load modulation. Novel electrical motor technologies such as permanent magnet motors (PM) can reduce the power consumption of the drives by up to 25-45% compared to the widely used permanent split capacitor motor (PSC). An additional change to a multi-speed or variable-speed system can further increase the heat pump efficiency.

In this study, a ducted fixed-speed heat pump system with a cooling capacity of 17.6 kW and an efficiency rating of 14 SEER is analyzed to quantify the theoretical performance limits that could be obtained by increasing the motor efficiency of the condenser fan, the evaporator fan as well as the compressor. A detailed charge-sensitive system model that was previously developed by the authors and validated with the same unit has been employed to carry out parametric studies and evaluate the impact of optimized variable-speed compressor and indoor/outdoor fans on the SEER rating.

Keywords: Optimization, Variable Speed Compressor, Fan Efficiency, Permanent Magnet Motor