Thermal Performance Optimization of a Transcritical CO_2 Heat Pump

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CO_2 refrigeration systems aim at reducing the refrigerant impact on the environment in comparison with synthetic fluids and at limiting the problems of toxicity and flammability of other natural refrigerants. Furthermore, CO_2 is a good alternative for air-conditioning and residential heat pump systems due to its attractive physical and transport properties. This paper presents an experimental characterization of the thermal behaviour of a transcritical CO_2 heat pump. The influence of the refrigerant charge amount and the high pressure on performances of the system is investigated for steady-state conditions. In the experimental set-up, no accumulator is used in order to control precisely the charge amount influence. The gas cooler is a compact spiral heat exchanger where the CO_2 is cooled by water. The heat pump is also tested at different water temperatures. The CO_2 system shows a large variation of the performance according to refrigerant charge amount like an increase of the heat flux. The COP trends indicate that the heat pump is very sensitive to the charge amount and the high pressure. A numerical model is developed to allow the study of the gas cooler by calculation of the heat transfer coefficient and the heat flux transferred to the water. Good agreement between model predictions and experimental results is found. The model is used to calculate the gas cooler efficiency and to determine optimum working conditions.