

Experimental Study on the Heating Characteristics of Transcritical CO₂ Heat Pumps

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Abstract : Due to its outstanding environmental performance, higher heating temperature and excellent low-temperature performance, transcritical carbon dioxide (CO₂) heat pumps are receiving more and more attention. However, improperly set operating parameters have a serious negative impact on the performance of the transcritical CO₂ heat pump due to the properties of CO₂. In this study, the heat transfer characteristics of the gas cooler are studied based on the modified “three-stage” gas cooler, then the effect of three operating parameters, compressor speed, gas cooler water-inlet flowrate and gas cooler water-inlet temperature, on the heating process of the system are investigated from the perspective of thermal quality and heat capacity. The results shows that: In the heat transfer process of gas cooler, the temperature distribution of CO₂ and water shows a typical “two region” and “three zone” pattern; The rise in the cooling pressure of CO₂ serves to increase the thermal quality on the CO₂ side of the gas cooler, which in turn improves the heating temperature of the system; Nevertheless, the elevated thermal quality on the CO₂ side can exacerbate the mismatch of heat capacity on both sides of the gas cooler, thereby adversely affecting the system coefficient of performance (COP); Furthermore, increasing compressor speed mitigates the mismatch in heat capacity caused by elevated thermal quality, which is exacerbated by decreasing gas cooler water-inlet flowrate and rising gas cooler water-inlet temperature; As a delegate, the varying compressor speed results in a 7.1 °C increase in heating temperature within the experimental range, accompanied by a 10.01% decrease in COP and an 11.36% increase in heating capacity. This study can not only provide an important reference for the theoretical analysis and control strategy of the transcritical CO₂ heat pump, but also guide the related simulation and the design of the gas cooler. However, the range of experimental parameters in the current study is small and the conclusions drawn are not further analysed quantitatively. Therefore, expanding the range of parameters studied and proposing corresponding quantitative conclusions and indicators with universal applicability could greatly increase the practical applicability of this study. This is also the goal of our next research.

Keywords : transcritical CO₂ heat pump, gas cooler, heat capacity, thermal quality

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