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Experimental study on an inverter heat pump with HFC125 operating near the refrigerant critical point

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ABSTRACT

An experimental study on an inverter heat pump with HFC125 operating near the refrigerant critical point was carried out. The coefficient of performance (COP) and exergy efficiency of the system were investigated under different compressor speed, water flow rate and different hot water temperatures of the condenser. The exergy defect in each component was determined. The results show that the exergy efficiency of the system increases initially and then decreases while the COP constantly decreases with the increase of the temperature of hot water. The results of this study can provide useful guidelines for optimal design and operation of this type of heat pump system in its present or future applications.

Heat pumps can work as high energy-efficient equipment in many heating and cooling applications, and have already played an important role in energy systems. But if this technology is to achieve more widespread use, a decisive effort should be made to further optimization of this technology [1]. Recent progresses in heat pump systems were focusing on advanced cycle designs for both heat- and work- actuated systems, improvement of cycle components (including choice of working fluid), and utilization in a wider range of applications [2].

Recently, extensive works were carried out in testing new refrigerants to improve the energy efficiency and performance of heat pumps [3]. Aprea et al. [4,5] presented an experimental analysis of the refrigeration plant with a variable speed compressor using R22, R407C, R507 and R417A as refrigerants. It was observed that when an inverter was employed, the average electrical energy consumption was about 12% less than the conventional one using refrigerant R407C. Compared with R417A, R22 was better in terms of COP and exergy efficiency. Arora et al. [6] reported a theoretical analysis of a vapour compression refrigeration cycle based on exergy analysis. The results indicated that R507A was a good alternative for R502 and R404A. In another study [7], a thermodynamic analysis on R422 serial refrigerants, acted as alternative refrigerants to R22, was carried out. The results showed that, the volumetric cooling capacity, COP and exergy efficiency of R22 were higher than that of R422A, R422B, R422C and R422D. Bi et al. [8] presented a comprehensive exergy analysis of three cycles and the whole systems of a ground-source heat pump operating both in heating and cooling modes. It was found that the exergy indexes should be used integrally, and compressor held the maximum exergy loss ratio in the whole system. Pandilla et al. [9] conducted a comparative test for R413A and R12 in a domestic vapour compression refrigeration system based on exergy analysis. Key results from their work indicated that the overall energy and exergy performance of the system working with R413A were consistently better than that working with R22.

Several researches have been conducted on the performance of heat pump systems employing inverter devices. Aprea et al. [10] investigated the performance of a vapour compression plant, both as water chiller and heat pump, by varying the scroll compressor speed. A significant energy saving, on average about 20%, was obtained compared with the classical thermostatic control for different working conditions. Chen et al. [11] proposed a new modified minimal stable superheat line based on experimental results to resolve the problem of unstable operation when compressor speed varied from time to time for the capacity control. An experimental refrigeration system working with R404a was studied by Kızılkan et al. [12] under variable compressor speed. The results showed that the irreversibility rates of the system decreased and the exergy efficiencies increased with the decrease of the compressor speed.

Researchers, such as Sarkar et al. [13], Agrawal et al. [14] and Tao et al. [15] have studied the performance of heat pumps employing

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