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# Experimental Study on the Heating and Cooling Performance of a Vapor Injection Heat Pump Using Low-GWP Refrigerants

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## Extended Abstract

Heat pumps have been used in buildings owing to their high energy efficiency and low carbon dioxide emissions. However, the performance degradation of heat pumps is inevitable under severe weather conditions. In recent years, the refrigerant injection technique has been extensively investigated to mitigate this problem. Among various injection cycles, the vapor injection cycle (VIC) is one of the most popular types and is widely used due to its simple control. Heo et al. [1] investigated the performance of a flash tank VIC at low temperatures. The coefficient of performance (COP) and heating capacity of the heat pump increased by 10% and 25%, respectively, at -15 °C. Qin et al. [2] tested an internal heat exchanger VIC for electric vehicles at -20 °C. It was found that the heating capacity increased up to 31% compared to that of the conventional cycle.

As the concerns on global warming have been increased rapidly, the EURO F-gas regulation and Kigali amendment restrict the use of hydrofluorocarbon (HFC) refrigerants with a high global warming impact (GWP) [3,4]. Therefore, R134a, which is one of the most widely used refrigerants in VICs, will be phased out until 2040. Alternative refrigerants to R134a have been developed and tested. Among many candidates, hydrofluoroolefin (HFO) refrigerants such as R1234yf and R1234ze(E) are considered as alternatives with almost zero GWP. R152a is also regarded as an appropriate alternative owing to the higher COP compared to R134a. However, few experimental studies have been investigated the performance of a VIC employing low-GWP refrigerants. Furthermore, the effects of injection mass and pressure on the performance are not considered, although these parameters are crucial for determining the performance of the VIC. The objective of this study is to evaluate the performance of a VIC using low-GWP refrigerants to cope with phase out of R134a and investigate the effects of injection parameters to maximize the performance of the VIC.

In this study, both the heating and cooling performance of the VIC using R134a, R152a, and R1234yf were investigated experimentally. The experimental setup was composed of the inverter-driven compressor, plate heat exchangers, and two electronic expansion valves. Experimental parameters were set as load temperature, source temperature, and injection mass flow rate. The COP and capacity were evaluated in both heating and cooling modes. The trends of the COP and capacity were consistent regardless of refrigerants. In the heating mode, both the COP and capacity increased compared to the conventional cycle. However, only the capacity improvement was shown in the cooling mode. As a result, the heating COP of the VIC using R152a was enhanced by an average of 3.46% compared to the conventional cycle. However, the COP of the VIC using R134a and R1234yf were only enhanced by an average of 2.83% and 2.64%, respectively. In the cooling mode, the VIC using R1234yf represented the highest capacity improvement of 8.83% among refrigerants. Meanwhile, the cooling capacity of the VIC using R134a and R152a increased up to 8.02% and 7.08%, respectively. In conclusion, R152a is more favourable in the heating mode and R1234yf is more appropriate in the cooling mode.

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