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Comparison of Heating Performance of Electric Vehicle Heat Pumps Using R1234yf and R290 Refrigerants.

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Extended Abstract

The automobile industry has undergone environmental regulations and refrigerants have been continuously changed. R12, which was used as an automobile refrigerant, was banned by the Montreal Protocol in January 1989 because it contains ozone-depleting substances, and was replaced with R134a refrigerant, which has an ozone-depleting potential (ODP) of zero. Unfortunately, however, the Kyoto Protocol, which came into force in 2005, gradually banned the use of R134a refrigerant with a global warming potential (GWP) of 1430 [1]. In addition, the European Union's F-gas regulation has completely banned the use of refrigerants with a GWP of 150 or more in all vehicles produced since 2017 [2]. Therefore, the R1234yf refrigerant currently used in automobiles is an eco-friendly refrigerant with a GWP of 4 and an ODP of 0. However, the R1234yf refrigerant is more expensive than the R134a refrigerant, and heating performance degradation may occur owing to poor latent heat performance. Therefore, it is possible to consider the application of R290 refrigerant that can compensate for the disadvantages of the currently used R1234yf refrigerant. However, since the R290 refrigerant has a flammability level of A3, it is necessary to apply the electric vehicle air conditioning system from direct to indirect systems (DS and IDSs) to ensure safety. Recently, R290 has been introduced as environmentally friendly and a next-generation alternative refrigerant to replace R1234yf. Liu et al. [3] experimentally studied the heating performance characteristics of a DS to which R290 refrigerant was applied. They showed that the heating capacity of DS-R290 increased by 40% and 55%, respectively, compared to that of DS-R1234yf at outdoor temperatures of 0 °C and −10 °C. However, system changes are inevitable for the DS-R290 because of safety issues [4]. The DS cannot be used as R290 is an A3 refrigerant. Thus, several studies have been investigated to examine the heating performance of IDS-R290. Hwang et al. [5] analyzed the heating performance of the IDS-R290 according to the compressor revolutions per minute and the opening of the expansion valve.

In this study, R1234yf and R290 refrigerants were applied to DS and IDSs, respectively, and the object was to compare heating performance characteristics according to outdoor air velocity and temperature. In addition, through comparison, the R290 refrigerant is intended to confirm the possibility of replacing the current automotive R1234yf refrigerant. To compare the DS applied with R1234yf and the IDS with R290, a bench test experimental device was developed, and the experiment was conducted on a psychometric calorimeter to control temperature and humidity. The heating performance was compared and evaluated while changing the outdoor temperature from –15 to 7 °C and the outdoor air speed at 0.5 and 3 m s^{-1} condition. Compared to the DS using R1234yf, the heating performance of the IDS using R290 increased by an average of 42.6% and the COP decreased by an average of 8.2%.

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