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Annual Energy Consumption of Indirect Air Conditioning Systems for Electric Vehicles Using Alternative Refrigerants

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Extended Abstract

R134a refrigerant has been applied to air conditioning systems for automobiles. However, R134a with a global warming potential (GWP) of 1430 should be phased out based on the Kyoto Protocol. Furthermore, in 2017, the European Parliament passed a law banning sale and operation of all automobiles that use refrigerants with a GWP of 150 or higher. Thus, R1234yf with a GWP of 4 is being applied to the air conditioning system for electric vehicles. However, R1234yf is more expensive than R134a [1]. Furthermore, when the outside temperature is below -10 ℃, the evaporator decreases to the vacuum pressure and the heating performance of an air source heat pump is significantly degraded [2]. Therefore, R152a, R290, and R600a are considered as alternative refrigerants [3] that have a low GWP and excellent thermodynamic properties with a relatively low price. However, these refrigerants have not been considered as alternatives to R134a owing to safety concerns with high flammability. The stability of the flammable refrigerants can be ensured by applying an indirect air conditioning system. The indirect system avoids the driver's exposure to flammable refrigerants and the coolant circulates the vehicle cabin for cooling and heating. The objective of this study is to quantitatively analyze the annual energy consumption of an indirect air conditioning system using R134a, R152a, and R290. Based on cycle simulations, an optimum alternative refrigerant for the indirect air conditioning system is proposed.

The outside air temperature was calculated using the bin method for climate data in Seoul. The required cooling and heating capacities were determined assuming that electric vehicles run at high speed. When the heat pump simulation converged to the target cooling or heating capacity, the power consumption (W) of the compressor was calculated. At the same time, the power consumption (kWh) was calculated by estimating the heating/cooling time (h) of the electric vehicle through the daily driving rate and thermal comfort according to the outside temperature. Based on the analysis, the annual energy consumption of the air conditioning system for the electric vehicle in Seoul was mainly used for heating rather than cooling. It was confirmed that the annual energy consumption of the indirect air conditioning system using R290 and R152a increased by 16% and 18%, respectively, compared to that using R134a.

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