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The Global Warming Impact of Various Refrigerants Evaluated by the Life Cycle Climate Performance

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論 文 名　：The Global Warming Impact of Various Refrigerants Evaluated by the Life Cycle Climate Performance（冷媒のライフサイクル温暖化影響評価に関する研究）
Title

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Category

論 文 内 容 の 要 旨
Thesis Summary

This work aims to evaluate the global warming impact of low GWP refrigerants by the life cycle climate performance (LCCP) during heat pump systems operation. In this research, the method of LCCP is studied comprehensively based on a guideline published by the International Institute of Refrigeration (IIR). A calculation example on domestic heat pump systems with various refrigerants, such as R410A and R32, is introduced here. Two binary blends, R32/R1234yf and R32/R1234ze(E) are also investigated based on a GWP value of 300. The operating conditions and systems performances in the scenario are collected from the experimental data of our laboratory. The example results outline that greenhouse gases (GHG) emissions from the system energy consumption are the most important contributor to global warming impact instead of the GWP values.

Therefore, an experimental platform of the heat pump system is established to investigate the influencing factors of the system performance. R410A is chosen as the refrigerant for the experiment because of its stability, safety, and efficiency. Based on the experimental results, the system performance is mainly involved by the heating or cooling demand, the refrigerant charge amount, and the operating conditions. The coefficient of performance (COP) would reduce with the increase of heating loads. And it can obtain the best value with an optimum charge amount in different conditions. The energy consumption of the compressor would increase simultaneously.

Since investigating the system performance with various low GWP refrigerants by experiment is difficult, the simulation model is developed based on the data from experimental work. However, some errors occur between the experimental and simulated

results. The reason is the manual mistakes in the experiment setup and the limitation of the simulation model compared with a realistic system. But the results show the same tendency to discuss the influencing factors of the system performance. And the validity of the simulation model is verified by software CYCLE_D-HX from the National Institute of Standards and Technology (NIST).

This study evaluates the global warming impact of five commercial low GWP refrigerants by LCCP methods, including R451A, R454A, R454C, R455A and R459B. R32 is regarded as the reference refrigerant. Two designed mixtures, R32/R1234yf and R32/R1234ze(E) with GWP values lower than 100, are also discussed. The system performances with testing fluids are evaluated by the simulation model. R32 results in the largest GHG emission caused by its high GWP value of 675. But the difference compared to other refrigerants is reduced with the increase of energy demand and operating time, which is due to the great system efficiency with R32. R451, with the lowest GWP value among the commercial refrigerants, causes the second high emissions because of its worst performance on the heat pump system. The total LCCP values of other commercial refrigerants are similar, while R459B gets the least emissions. Mix 2, combined with R32 and R1234ze(E) in mass fractions as 14% to 86%, has the best COP value and lowest GHG emissions in all the testing fluids. However, this result responds to the ideal cycle, which can obtain the same compressor efficiencies with various refrigerants. A real system with the same compressor might get a different result.

In conclusion, LCCP analysis provides a different perspective of refrigerant compared to the GWP metric. The system performance and energy consumption are essential factors for global warming impact on HVAC&R systems. This research provides evidence to encourage developing the optimum system for low GWP refrigerants. The performance of the heat pump system with low GWP refrigerants might be limited, while the system can get good performance with R32. Once the heat pump performance of low GWP refrigerant is as good as that of R32, the global warming impact can be reduced efficiently.