Performance analysis of commercial air conditioning systems using natural refrigerants

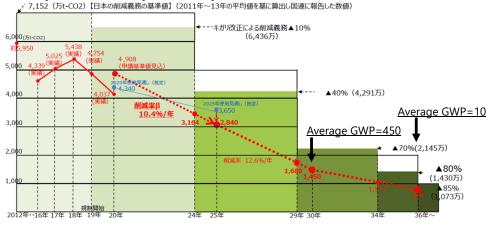
Jongsoo Jeong Yoichi Miyaoka Kiyoshi Saito, Waseda University

Abstract

In assessing the impact of air conditioning systems on global warming, it is necessary to consider not only the direct environmental impact from refrigerant leakage of air conditioning systems but also the indirect impact from CO₂ emissions associated with the electricity consumed by these systems. Therefore, this study conducted a detailed performance evaluation of commercial air conditioning systems using natural refrigerants, employing a refrigeration cycle simulator.

Background

To curb the worsening effects of global warming, international efforts are underway to reduce greenhouse gas emissions. As part of these efforts, there is a demand to transition to next-generation refrigerants with lower GWP for heat pump systems. In the EU, new fluorinated greenhouse gas regulations took effect on March 11, 2024. These regulations set targets to reduce the annual maximum quantity of HFCs placed on the market by 95% compared to 2015 levels by 2030 and by 100% by 2050.



Current issues

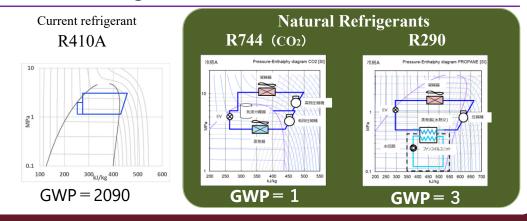
The shift toward low-GWP refrigerants with minimal greenhouse effects and the tightening of EU F-gas regulations may accelerate the transition to natural refrigerants like CO₂ and R290. However, no single refrigerant exists that offers low GWP, safety, and high performance. Consequently, several "mixture refrigerants" combining multiple refrigerant components and "natural refrigerants" have been proposed.

To mitigate global warming, it is necessary to consider not only the direct impact of refrigerant leakage but also the indirect impact of CO₂ emissions associated with the power consumption of air conditioners. On the other hand, the lack of a unified performance evaluation metric for refrigerants makes it difficult to properly compare the performance of system when natural refrigerants are introduced into actual devices.

Purpose

Performance Evaluation of Systems Incorporating Natural Refrigerants CO₂ and R290 in Commercial Air Conditioning Systems

Evaluated refrigerants



Simulation results

Cooling conditions for simulation

12.0

7.0

100

°C

13.5

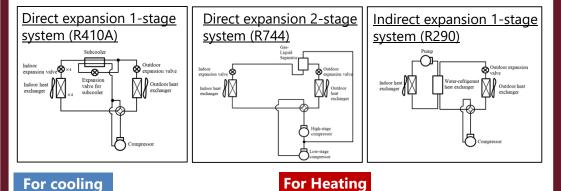
8.5

74.0

15.0

10.0

47.0



cascaded CO₂ system

Simulation method & conditions

Performance evaluation was conducted using the general-purpose energy analysis simulator "Energy Flow+M" based on the assumption of installing a VRF system (rated capacity 28kW (10 horsepower unit)) in a commercial building.

Simulation conditions

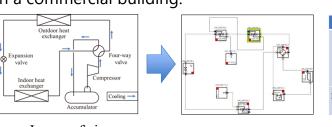
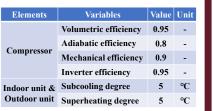


Image of airconditioning cycle GUI of Energy Flow +M simulator



Lower performance due to fan coil unit of R290 cooling system



CO2 R290 R410A

7
6.81 CO2 R290 R410A

rivals that of R410A

Conclusion

- 1. Performance evaluation of commercial air conditioning systems incorporating natural refrigerants was conducted using a cycle simulator.
- 2. It was found that cascaded cycle in CO₂ air conditioning systems improves performance under high-load, demanding environmental conditions.
- 3. Evaluation based on European EN standards clarified the impact of water temperature levels on system performance in fan coil units for R290.
- 4. Annual COP showed that R290 systems using water-based methods had lower values compared to R410A systems, while CO₂ systems exhibited a slight decrease but no significant difference in performance.
- 5. These analysis results enabled fundamental studies toward the practical implementation of air conditioning systems using CO₂ refrigerant.