

INVESTIGATION OF THERMODYNAMIC BEHAVIOR AND ENERGY CONSUMPTION OF REFRIGERANTS IN A DOMESTIC REFRIGERATION SYSTEM USING MACHINE LEARNING

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Abstract

In this study, the thermodynamic behavior of R134a, R600a, and R1234yf refrigerants in a domestic refrigerator was investigated using a combination of experimental measurements and machine learning methods. A No-Frost refrigerator with an inverter compressor and an internal volume of 260 L was used as the experimental platform; low and high-pressure lines, temperatures at various points of the cycle, internal cabinet temperature, and the instantaneous electrical power consumption of the compressor were monitored simultaneously. The experiments were conducted at an ambient temperature of approximately 23 °C and 50% relative humidity, with a target cabinet temperature of +7 °C, and data were recorded at 15-second intervals. Thermodynamic properties such as evaporator temperature, condenser temperature, superheat, and subcooling were derived from the raw measurements. To predict compressor power consumption, XGBoost Regressor, CatBoost, LightGBM, Random Forest, Gradient Boosting, Support Vector Regression, K-Nearest Neighbors, and Bayesian Ridge models were compared. The results showed that model performance varied significantly depending on the refrigerant used. While KNN-N2, CatBoost, and Random Forest exhibited high test performance, particularly on the R600a dataset, overfitting and poor generalization were observed in various models on the R134a and R1234yf datasets. The findings reveal that in modeling transient and steady-state regimes of refrigeration cycles using data-driven methods, not only training success but also test performance and physical regime behavior must be evaluated together.