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Experimental and Analytical Investigation of Refrigerant Charge Impact on the Performance of a Novel Heat Pump Integrated Dishwasher

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Extended Abstract

Manufacturers of household appliances need to develop products that consume less energy due to the competition in the market. Furthermore, reducing CO2 emissions to prevent global warming is one of the main concerns of household appliance manufacturers. To achieve this purpose, an air source heat pump system is utilised, which is preferred these days due to its high efficiency and environmental friendliness. This study aims to examine the impact of the refrigerant charge on an energy-efficient air source heat pump integrated dishwasher experimentally and analytically.

The only difference in the air source heat pump integrated dishwasher is that instead of the electrical water heater element, the dishwasher is integrated with an air source heat pump system that operates with R600a refrigerant due to its low global warming potential (GWP). By running through the shell side of the condenser, the temperature of the water increases in the main wash and hot rinse phases.

The experiments will be performed in a controlled room considering the COMMISSION REGULATION (EU) 2019/2022 [1] with standard ambient conditions. The 15 to 30-gram refrigerant charges are applied to the system. For these amounts, the temperature and pressure values of the refrigerant are measured from the suction and discharge points of the compressor, the outlet of the condenser, and the inlet of the evaporator. By obtaining the measured values, a thermodynamic analysis will be conducted using the EES [2] programme to calculate the COP of the system for specific states of time during the washing cycle. To understand the heat transfer properties, the finned tube type evaporator in the system will be modelled for each refrigerant charge to compare with the measured results. Furthermore, validation of the experiments for energy consumption values is done by comparing the analytical results with the measured values from the data acquisition system.

The main purpose of this research is to decrease the energy consumption of the dishwasher beyond the A efficiency class dishwashers regarding Energy Label Regulation [1], evaluate its performance by varying refrigerant charge, and identify the optimised operational parameters that result in lower energy consumption. The outcome of this study can provide perspectives on air source heat pump-integrated household appliances and improve their design and performance.

In conclusion, this research focuses on analysing an air source heat pump integrated dishwasher experimentally, validating the results analytically, and investigating the effect of gas charge amount on its performance. To accomplish these goals, the study employs both computational simulation and experimental data. The findings of this research could aid in the development and improvement of efficient heat pump-integrated household appliances that significantly influence the reduction of energy consumption and lower greenhouse gas emissions in the white goods sector.

References

[1] Commission Regulation (EU) 2019/2022. (2019). Laying down ecodesign requirements for household dishwashers pursuant to Directive 2009/125/EC of the European Parliament and of the Council amending Commission Regulation (EC) No 1275/2008 and repealing Commission Regulation (EU) No 1016/2010 (Text with EEA relevance).
[2] EES. (2021). EES - Engineering Equation Solver. Retrieved September 10, 2021, from https://www.fchart.com/ees/