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# Performance Evaluation of Automotive HVAC Systems Using Nozzle Integrated Electronic Expansion Valves

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## Extended Abstract

As the adoption of electric vehicles (EVs) continues to grow, improving energy efficiency and extending driving range have become critical areas of research. One of the key energy-consuming components in EVs is the Heating, Ventilation, and Air Conditioning (HVAC) system, which directly affects vehicle efficiency and passenger comfort. Therefore, optimizing HVAC systems to minimize power consumption while maintaining performance is essential. [1]

The efficiency of an HVAC system largely depends on the design and performance of its key components, including the compressor, condenser, evaporator, and expansion device. The electronic expansion valve (EEV) is widely used due to its precise control of refrigerant flow, which enhances system stability and efficiency under various operating conditions. However, EEVs alone present limitations in pressure loss management and heat exchange optimization. To address this issue, integrating a nozzle with the EEV can improve refrigerant velocity and enhance heat transfer efficiency.

This study evaluates the performance of an EEV-based automotive HVAC system equipped with nozzles of different diameters (0.8mm, 1.0mm, and 1.2mm). Experiments were conducted in a controlled environmental chamber to analyze the effects of nozzle integration on key performance indicators, including refrigerant temperature drop, power consumption, cooling capacity, and coefficient of performance (COP). The results indicate that using a 0.8mm nozzle led to a total refrigerant temperature drop of 16.3°C, while the 1.0mm and 1.2mm nozzles resulted in temperature drops of 13.3°C and 12.7°C, respectively. In terms of power consumption, systems with nozzles demonstrated improved efficiency, with the 1.0mm nozzle achieving the highest cooling capacity of 1456.7W. The COP values for the 0.8mm, 1.0mm, and 1.2mm nozzles were 1.8, 2.2, and 1.7, respectively, showing that the 1.0mm nozzle provided the most significant performance improvement—an increase of 36.0% compared to the EEV-only system.

The findings suggest that integrating a properly sized nozzle can significantly enhance the efficiency of HVAC systems in EVs. Among the tested configurations, the 1.0mm nozzle was identified as the optimal design for achieving the best performance in terms of cooling efficiency and energy savings. This study provides valuable insights for the design and development of high-efficiency HVAC systems, contributing to improved energy management and extended driving range in electric vehicles.

## References

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