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Interference Analysis of Indoor Units in Multi-evaporation Pressure Heat pumps Under Cooling Conditions

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Extended Abstract

Multi-split heat pump (MSHP) systems are widely adopted in residential and commercial buildings due to their ability to provide individualized heating and cooling to separate zones, offering both operational flexibility and improved energy efficiency [1]. In commercial MSHP systems, all indoor units operate under a common refrigerant pressure, resulting in a shared indoor saturation temperature. Consequently, significant differences in thermal loads between zones often lead to frequent thermo on/off cycling of individual indoor units [2]. This operating pattern not only compromises thermal comfort but also degrades the overall energy efficiency of the system. Previous studies have investigated approaches such as adjusting the set evaporating pressure or incorporating discharge bypass valves to address this issue [3,4]. However, these methods are limited in enabling real-time control and independent operation of each indoor unit. Moreover, they fail to account for the pressure interference effects that may arise between simultaneously operating units.

To address this research gap, the present study investigates the pressure interference effects between indoor units under multi-pressure regulation through a combined experimental and simulation-based approach. In particular, flow control valves (FCVs) were installed at the outlet of each indoor unit to enable independent evaporating pressure control under cooling conditions. Experimental measurements were conducted to evaluate how adjusting the FCV opening of one unit affects the evaporating pressure in adjacent units. These interactions caused unintended fluctuations in evaporating temperature, leading to system performance instability. The degree of interference was found to vary depending on the number of simultaneously operating indoor units and their respective thermal loads.

In parallel, a dynamic simulation model of the MSHP system was developed based on the Modelica language to assess interference effects under broader operating conditions. The model was validated against experimental data with a deviation within 5%, ensuring reliability. A parametric study was then conducted by varying the number of active indoor units from 1 HP to 8 HP, while maintaining constant temperature, humidity, and airflow at each indoor unit. Additionally, the FCV openings of selected units (1, 2, 3, and 5 HP) were reduced in 10% increments to evaluate sensitivity to flow restriction. Simulation results indicated that pressure interference became noticeable beyond a specific FCV opening threshold and occurred earlier as the capacity of the controlled indoor unit increased. Moreover, the increase in evaporating pressure caused by a reduction in FCV opening remained relatively consistent regardless of the number of operating indoor units, as the mass flow rate through each unit was maintained. In addition, as the total system capacity increased from 1 HP to 8 HP, the pressure interference effects observed in the 1, 2, 3, and 5 HP units progressively decreased to 78%, 68%, 64%, and 62%, respectively. This reduction is attributed to the distribution of the disturbance effect across a larger number of active units, thereby mitigating localized pressure imbalance.

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References

[1] C. Han, J. Jang, S. Kwon, J. Lee, C. Song, Y. Sa, Y. Kim, "Acoustic comfort improvement of simultaneous heating and cooling heat pumps using control logic for flow-induced noise reduction," *Appl. Therm. Eng.*, vol. 251, 123620, 2024.

[2] S. Jang, N. Park, Y. Ahn, "A study on the energy saving effect of VRF system adopting variable refrigerant temperature control algorithm," *J. Korean Soc. Power Syst. Eng.*, vol. 23, no. 4, pp. 84–90, 2019.

[3] M. S. Elliott, B. P. Rasmussen, "Model-based predictive control of a multi-evaporator vapor compression cooling cycle," in *Proceedings of the American Control Conference*, Seattle, WA, 2008, pp. 1463–1468.

[4] M. S. Elliott, B. P. Rasmussen, "A model-based predictive supervisory controller for multi-evaporator HVAC systems," in *Proceedings of the American Control Conference*, St. Louis, MO, 2009, pp. 3669–3674.