Experimental study on the dehumidification performance of a window-type liquid desiccant ventilation system

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SUMMARY

This study proposes the feasibility of a window-type liquid desiccant ventilation system for residential buildings. Using a LiCl solution, the system was designed and experimentally evaluated under hot and humid conditions. The results indicated a 19% reduction in relative humidity and effective latent heat removal, showing significant dehumidification performance. The system maintained its dehumidification performance even with reduced humidity, suggesting improved thermal comfort. Future research will focus on optimizing dehumidification strategies under various conditions.

KEYWORDS

Window-type ventilation, façade system, Liquid desiccant, Dehumidification performance, Experimental study

1 INTRODUCTION

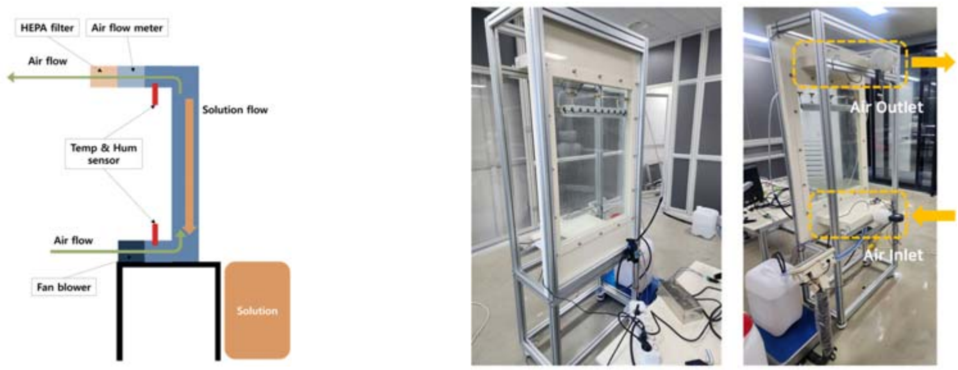
As climate change causes the outdoor environment during the summer in Korea to transition into a hot and humid subtropical climate, maintaining a comfortable indoor thermal environment necessitates proper control of indoor temperature and humidity. Generally, the refrigerant dehumidification system used for humidity control has the advantage of easily adjustable dehumidification levels. In contrast, it suffers from energy efficiency drawbacks due to overcooling and reheating processes. In contrast, liquid desiccant systems utilizing liquid desiccants such as LiCl offer potential for energy savings through latent cooling for humidity control. Moreover, the alleviation of latent heat load during summer can reduce the possibility of condensation, thus potentially reducing peak summer loads and increasing thermal comfort time along with the possibility of using radiant cooling. However, existing studies primarily focus on the individual performance analysis of air conditioning systems installed in buildings or standalone dehumidification units, with experimental evaluations of dehumidification effects and applicability in residential spaces being rare. Therefore, this study proposes a window-type liquid desiccant ventilation system module applicable to residential buildings and presents its feasibility through an experiment.

2 MATERIALS AND METHOD

The dehumidification performance of a window-type liquid desiccant ventilation system was analysed by designing and fabricating the system module and conducting experiments under hot and humid conditions. Design conditions, such as the type of desiccant and airflow direction, were considered.

2.1 System design

The window-type liquid desiccant ventilation system module presented in this study is shown in Fig. 1. The LiCl solution was used, designed to be expelled in a thin film. The incoming air was directed from the bottom to the top of the window-type liquid desiccant ventilation system module, passing through the solution for dehumidification. Additionally, to prevent contamination of the indoor air by LiCl, a HEPA filter was added to the outlet part. The gap between the glasses was designed to be a minimum of 25 mm, to facilitate effective dehumidification.



(a) System Diagram (b) Proto-type module

Figure 1: Window-type liquid desiccant ventilation system

2.2 Experimental condition

The experiment was conducted in an isolated space of 86.1 m³ with minimal external influence under the conditions of 25 °C and 60% humidity for one hour. The humidity was consistently maintained by operating an ultrasonic and a mist humidifier throughout the experiment. Data was measured at one-minute intervals. As a result, the maximum wind speed, air volume flow rate, and LiCl flow rate were 2.24 m/s, 55.6 m³/h, and 5.5 L/min, respectively. The change in the concentration of the LiCl solution was shown by measuring the weight change.

3 RESULTS AND DISCUSSION

The dehumidification performance results of the window-type liquid desiccant ventilation system under hot and humid conditions are shown in Fig. 2. The average relative humidity was calculated as the mean of the relative humidity measured during each condition period. The dehumidification performance was assessed by evaluating the difference in relative humidity between the outlet and the inlet. Before the start of the experiment, in the initial conditions ((a) in Fig. 2, 0-6 min), the uniformity of the inlet and outlet air conditions was confirmed prior to the start of dehumidification. After the start of dehumidification ((b) in Fig. 2, 7-41 min), the humidity dropped rapidly within one minute. The average relative humidity at the inlet and outlet showed a significant dehumidification performance, with a 19% decrease from 62% to

43%. Additionally, the decrease in LiCl concentration from 40% to 38.45% confirmed the effective latent heat removal capability of LiCl. To verify the additional dehumidification effect under low humidity conditions, the humidifier was turned off ((c) in Fig. 2, 42-60 min). Despite the decrease in air relative humidity after stopping the humidifier, the system demonstrated an average relative humidity difference of 8%, indicating dehumidification performance even under low humidity conditions.

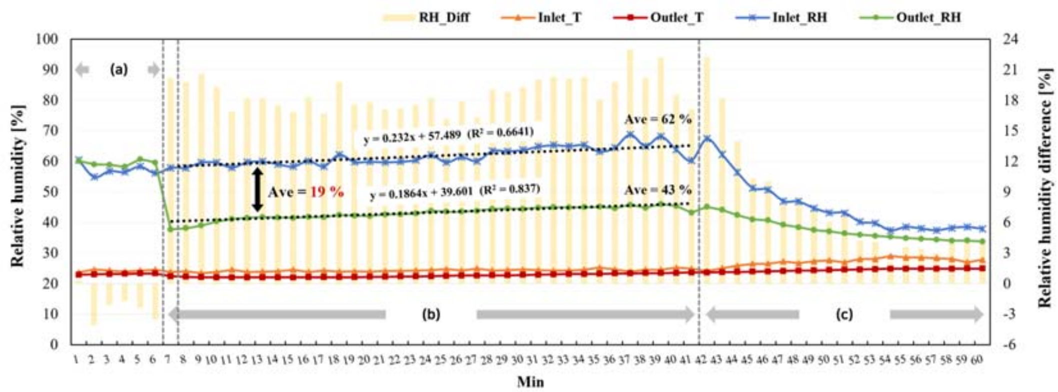


Figure 2: Evaluation results of dehumidification performance:

(a) Initial condition; (b) Dehumidification condition; (c) Humidifier off condition;

4 CONCLUSION

To address climate change and ensure comfortable humidity control, this study proposes the feasibility of a window-type liquid desiccant ventilation system for residential buildings. Using a LiCl solution, the system was designed and experimentally evaluated under hot and humid conditions. The results indicated a 19% reduction in relative humidity and effective latent heat removal, showing significant dehumidification performance. The system maintained its dehumidification performance even with reduced humidity, suggesting improved thermal comfort. Future research will aim to evaluate dehumidification capabilities under various experimental and control conditions to propose optimal dehumidification operation strategies.

5 ACKNOWLEDGEMENTS

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