Simulation study on the effects of humidity reduction regulation and detection on indoor temperature comfort

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Abstract. This study would discuss about the installation of indoor smart monitoring and control system and propose a feasible structure to establish a smart system for sensing and controlling the temperature and humidity inside the building. The sensor offers the capability of learning and automatically controlling the indoor temperature and humidity to automatically adjust the indoor heat environment.

1 RESEARCH METHODS AND SIMULATION SETTING

This study was focused on investigating and improving residential thermal environment. Temperature and humidity were manually adjusted, and computer simulation approach was employed to analyze the feasibilities of improving indoor thermal environment and comfort.

1.1 Study Subject

The study subject of this study was a low-rise residential building located in Tainan City of Taiwan. The space of the investigation was on the first floor with a dimension of 702 cm (L) × 620 cm (W) × 330 cm (H). Five indoor monitoring points were established.

Fig. 1. Floor plan of the study subject.

1.2 Establishment of Local Meteorological Data

Using the same indoor comfort environment, it was assumed that the meteorological parameters measured indoors at 12:00 noon were the basis for defining the indoor parameter boundary condition, and that the indoor air-conditioner was operating at steady state. Table 1 shows the conditions based on the meteorological data.

Table 1. Boundary Conditions of Meteorological Parameters.

Attributes	parameter
WIND	V=2.0 (m/s)
Humidity	69%
Scope of Calculation	Summer T0=32°C

1.3 Establishment of Local Meteorological Data

Fig. 2. (a) Temperature Field Simulation of the current situation ; (b) Humidity Field Simulation of the current situation.

The above analysis results indicate that the monitoring point measured maximum temperature of 32.92°C and minimum temperature of 29.81°C (at Monitoring Point 5). The overall indoor humidity level ranged between 50% and 70%. Therefore, the overall indoor temperature was overly high, indicating an uncomfortable living environment.

Table 2. Simulation design.

Module	Simulation Content
Case1	Adjust temperature to 32°C: Humidity 64%
Case2	Adjust temperature to 32°C: Humidity 59%
Case3	Adjust temperature to 32°C: Humidity 39%

2 NUMERICAL SIMULATION AND ANALYSIS

2.1 CASE 1 Adjust Temperature to 32°C: Humidity 64%

Fig. 3. Simulation of Case 1, Adjust temperature to 32°C: Humidity 64%: (a) Current Temperature Field of the current situation ; (b) Improved Temperature Field Simulation of the current situation.

The above analysis results indicated that when humidity was reduced by 5%, the cooling effect observed in Monitoring Points 1, 2, and 3 was weaker than that of the current situation. The overall average temperature measured at Monitoring Points 4 and 5 was reduced by 0.15–0.37°C compared with the current situation. Therefore, reducing humidity by 5% did not significantly improve the overall thermal environment.

2.2 CASE 2 Adjust Temperature to 32°C: Humidity 59%

Fig. 4. Simulation of Case2, Adjust temperature to 32°C: Humidity 59%: (a) Current Temperature Field of the current situation ; (b) Improved Temperature Field Simulation of the current situation.

The analysis results showed that when humidity was reduced by 10%, the cooling effect observed in Monitoring Point 3 showed approximately 0.13°C lower in temperature than that of the current situation, and the overall average temperature of Monitoring Point 4 was reduced by 0.47°C, compared with the temperature of the current situation. Therefore, reducing humidity by 10% achieved optimal improvement of 0.13–0.47°C in overall thermal environment compared with the current situation.

2.3 CASE 3 Adjust Temperature to 32°C: Humidity 39%

Fig. 5. Simulation of Case 3, Adjust temperature to 32°C: Humidity 39%: (a) Current Temperature Field of the current situation ; (b) Improved Temperature Field Simulation of the current situation.

The analysis results indicated that when humidity was reduced by 30%, the cooling effect observed in Monitoring Points 1, 2, and 3 reflected 1°C cooler in temperature than that of the current situation. The overall average temperature measured at Monitoring Points 4 and 5 was reduced by 1.22–1.38°C compared with the current situation. Therefore, reducing humidity by 30% significantly improved the overall thermal environment in comparison to the scenario in Cases 1 and 2.

3 CONCLUSION

The simulation results showed that when humidity and temperature were not adjusted, the optimal thermal module was indoor temperature of 32°C, humidity of 39%, and wind speed of 2.0 m/s. At this condition, significant cooling effect was observed. The overall average temperature decreased by 1°C when humidity was reduced by 30%. When cooling effect was achieved by adjusting temperature, the overall temperature cooled by roughly 4–5°C; however, according to research, for every decrease in 1°C temperature, it increases 7–10% in electricity load, suggesting that from energy conservation point of view, although directly reducing temperature produced the best effect, but it also consumes the most amount of energy. because the locations of the monitoring points differed, the overall indoor environment can generate erroneous readings, causing some areas to reflect low comfort level. Subsequent studies could analyze the influence of distance and height of different indoor monitoring locations to calculate the mean values of the area, which provides input data for a smart control system to achieve temperature reduction and energy conservation.

References

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