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Graduate School of Science and Engineering, Aoyama Gakuin University

Title: Improvement of thermal comfort and energy saving by global and individual heating and cooling system

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Abstract

In office-occupied spaces, the ratio of energy consumption by air-conditioning and lighting that maintains the environment comfort accounts for about 70%.

On the other hand, according to a survey about the office environment, more than 40% of the persons claimed that they were dissatisfied with the temperature of the air conditioning. Therefore, there is concern about the work efficiency reduction caused by current air-conditioning control. In this research, we propose an automatic control system that both improves the energy saving and the thermal comfort of all indoor users by quantifying individual differences in thermal comfort from biological information. However, it cannot be realized using only the Global Heating and Cooling System (GHCS) such as the air-conditioner. Therefore, we propose to combine GHCS with an Individual Heating and Cooling System (IHCS) that can directly heat and cool individuals.

As a method of evaluating the user's thermal comfort, we propose the Sensation Discomfort Index (SDI). SDI is calculated based on adding the individual difference of user's thermal comfort and correction of IHCS to conventional Discomfort Index which defines the environment's thermal discomfort. We use the Total Heat Consumption (THC) calculated by adding GHAC and IHAC heat consumptions. Besides, we define the thermal comfort error as the absolute value of the difference between the user's SDI and the nearest boundary of the maximum thermal comfort range (MTCR). Since SEAU and THC can be uniquely determined by the Target Discomfort Index (TDI) in the room, we defined the optimum setting to be the conditions that minimize both the Sum of Error of All Users (SEAU) and THC. Therefore, we examined the change of SEAU and THC according to the change of the SDI. The results showed that the optimum setting is the SDI that has the smallest absolute difference with the current DI in the room within the MTCR.

We conducted a simulation in the case of operating for 1 hour under the following three conditions: using only GHAC, using only IHAC, and the proposed system. The results revealed that the power consumption reduction ratio of using the proposed system compared to using only GHAC increases with a larger indoor volume and fewer indoor users. In the case of using only GHAC or IHAC, SEAU increases proportionally with the number of users. On the other hand, in using the proposed system, resulted in keeping SEAU to 0 all the time.

In the future, it is necessary to create a detailed model and verify the effect in a real environment.