THERMAL ENVIRONMENT ANALYSIS IN ONDOL-HEATED ROOMS

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"Ondol" has been widely used as a heating system in Korea. The traditional Ondol is composed of a series of horizontal flues under stone slabs, which not only form the floor of a room but also function as a thermal storage area. In contemporary Korea, a hydronic floor heating system is generally used instead. This hydronic system is commonly called "Ondol heating system" in Korea.

Because of increased energy-saving thermal insulation of buildings, comparatively low floor-surface temperatures are able to heat the space. But it is difficult to get the traditional warmth through low floor-surface temperatures. Therefore there is a growing interest in Practical Heating or Differential Heating Systems which can increase floor-surface temperature, in a smaller heated area.

A room's thermal environment is generally controlled by sensing room air temperature, which is different from floor-surface temperature. Likewise, floor-surface temperature is different from the insulation state, thermal capacity of structure, and outdoor weather conditions, etc. To evaluate and control the room thermal environment in Ondol-heated rooms, a useful index is necessary.

The purpose of this study was to develop a thermal analysis method and to find the control indices for maintaining the optimal thermal environment of an Ondol-heated room.

In this study, a thermal analysis method, was developed and verified by experiment, which can calculate room air temperature, each wall surface temperature, mean radiant temperature (MRT), operative temperature (OT), predicted mean vote (PMV), vector radiant temperature (VRT) and required heat flux under non-steady state. Response Factor Method and Gebhart's Absorption Factor Method were used for the calculation of heat flux under non-steady state and instantaneous radiant exchange in the analyzing method. In addition, thermal indices were calculated and analyzed on an Ondol-heated room.

From the results of case 1, it is difficult to maintain a uniform indoor thermal environment by controlling floor surface temperature. In this case, energy consumption was increased 5.1% for each 1°C (1.8°F) rise in room air temperature and the hot water heat supply for maintaining room air temperature changed significantly according to outdoor weather conditions, especially solar energy intakes.

In case 2, MRT was intimately connected with indoor surface temperature variation. It is difficult to estimate or control the thermal environment of an Ondol-heated space using only MRT.

From case 3 and case 4, when OT was controlled, the PMV value was not comparatively changed. Conversely, when the PMV value was constant, the fluctuation of OT did not vary much. OT and PMV in an Ondol-heated room have the following relationship:

$$PMV = 0.2924 \cdot OT - 6.62022 \quad (r^2=0.9985) \qquad (1)$$

Energy consumption was increased 5.25% per 1°C (1.8°F) increase of OT and 1.7% by increasing PMV value 0.1. Therefore OT and PMV could be considered as effective control and evaluation indices.

A thermal analysis method has been developed and verified from experimental results, and the thermal environments of an Ondol-heated room have been analyzed and discussed. OT was recognized as a very useful index to evaluate and control the thermal environment of an Ondol-heated room. And, OT and PMV have a good relationship each other as the equation suggests.

A more detailed investigation and a useful measuring technique are necessary for the future control or evaluation of the thermal environment of an Ondol-heated space.

References

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