New method for estimating thermal comfort in low-energy buildings at the design stage

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Indoor environments that are too hot, too cold or draughty create discomfort and lower human productivity. MSc (Tech) Riikka Holopainen from VTT Technical Research Centre of Finland, has written a doctoral thesis on a new method for estimating the actual level of human thermal comfort in low-energy buildings. The method is also the first of its kind to be integrated with a building simulation tool. Factoring in the different ways in which buildings are used and the different kinds of people using them at the design stage can help to improve energy efficiency and human comfort.

Energy-efficient passive and zero-energy buildings require considerably less heating than traditional buildings. Traditional HVAC solutions are therefore no longer suitable for designing indoor environments for low-energy buildings.

The Human Thermal Model (HTM) is a new technique developed by Senior Scientist Riikka Holopainen from VTT in her doctoral thesis, which can be used to design and create optimal indoor environments for low-energy buildings. One of the novelties of the method is the fact that it allows scientists to measure how different solutions are likely to affect human thermal comfort and the energy efficiency of buildings at the design stage.

The model is based on the physiological thermal control system of the human body, and it can be used to calculate the actual level of human thermal comfort in both steady-state and transient thermal environments.

The thesis introduces the first ever mathematical application that integrates a building simulation tool with human thermal sensation. The model also produces information about previously complex comparisons, such as the effects of different structural solutions and HVAC systems on human thermal sensation.

Earlier models for measuring the comfort of indoor environments have not taken account of the human body's own thermal control system. These methods are also insufficient for designing passive and zero-energy buildings. Models based on laboratory measurements, for example, overestimate the heat perceived by humans in warm conditions and underestimate it in cool conditions. They also factor in clothing as a hermetically sealed unit similar to a diving suit.

Both internal and external factors affect human thermal sensation. Internal factors include personal characteristics, anatomy, activity level, whether work is physical, and clothing. External factors include room temperature, which covers air and surface temperature, as well as air velocity and relative humidity. Holopainen has demonstrated that the most important factors contributing to thermal sensation and comfort are air and surface temperature, activity level and clothing.

Ensuring building optimisation and human comfort at the design stage

Indoor environments that are too hot, too cold or draughty create discomfort and lower human productivity. Bed-bound patients in hospitals, for example, spend a great deal of time lying still and therefore need a sufficiently warm indoor environment and bedclothes. Checkout operators in shops, on the other hand, may have to sit in heat in summer and in cold and draughts in winter. Factoring in the different ways in which buildings are used and the different kinds of people using them at the design stage can help to optimise indoor environments and improve human comfort. Employees can also be given clothing advice.

The Human Thermal Model is suitable for both new builds and renovations. Engineering firms and the construction industry can now develop their products to better meet the needs of different buildings and users.

In the future, the HTM and building automation systems will work together to automatically regulate ventilation, heating and cooling according to actual needs, incorporating human thermal comfort as an integral aspect of workplace productivity enhancement.

More information: The doctoral thesis 'A human thermal model for improved thermal comfort' is available online at www.vtt.fi/inf/pdf/science/2012/S23.pdf .

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