Simulation of a radiant capillary heating and cooling system

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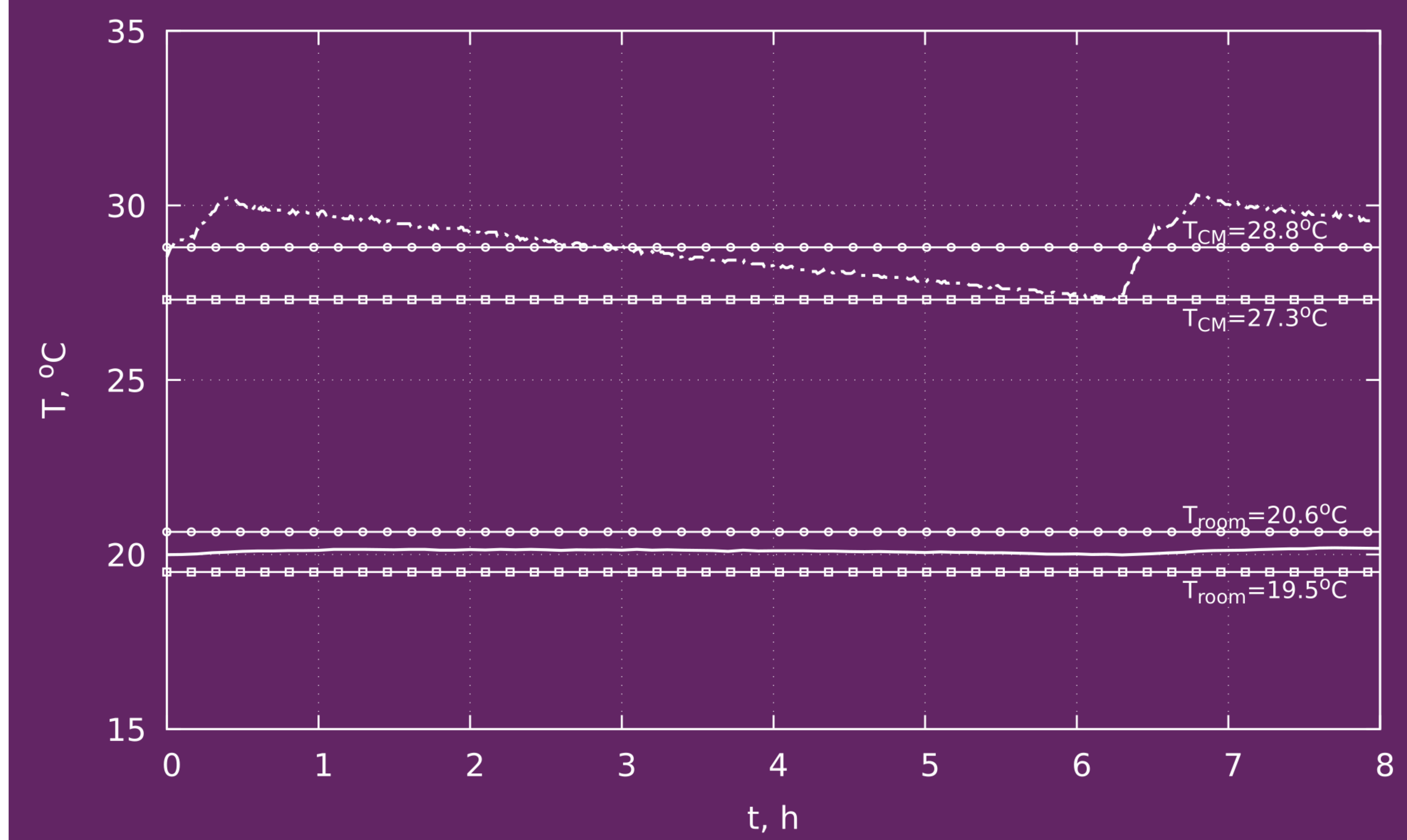
Main equation and visual results of calculations

Room heat balance equation

$$\varphi_{CMwf}Q_{CM}+\varphi_{ww}Q_{wall}+\varphi_{fw}Q_{floor}+Q_{out}=0$$

Q_{CM} – heat transferred from capillary mat (CM) to constructions, Q_{wall} – heat transferred between walls, Q_{floor} – heat transferred between floor and walls, Q_{out} – heat looses to outer atmosphere. φ_{CMwf} – view factor between CM and constructions, φ_{ww} – view factor between walls, φ_{fw} – view factor between foor and walls.

Comparison between experimental and numerical data.



[- · -] – average measured capillary mat temperature,
[- -] – average measured room temperature,
○ – numerical results T_{CM}=28.8 °C, □ – numerical results T_{CM}=27.3 °C.

Introduction

In this paper, a specific system based radiant capillary mats was considered. Its main advantages include a relatively low operating temperature (28-30°C) in heating mode, as well as the ability to operate in cooling mode at temperatures of 16-18°C.

The main purpose of this paper was to develop an appropriate tool for power, area and placement calculation of capillary mats in rooms of different types.

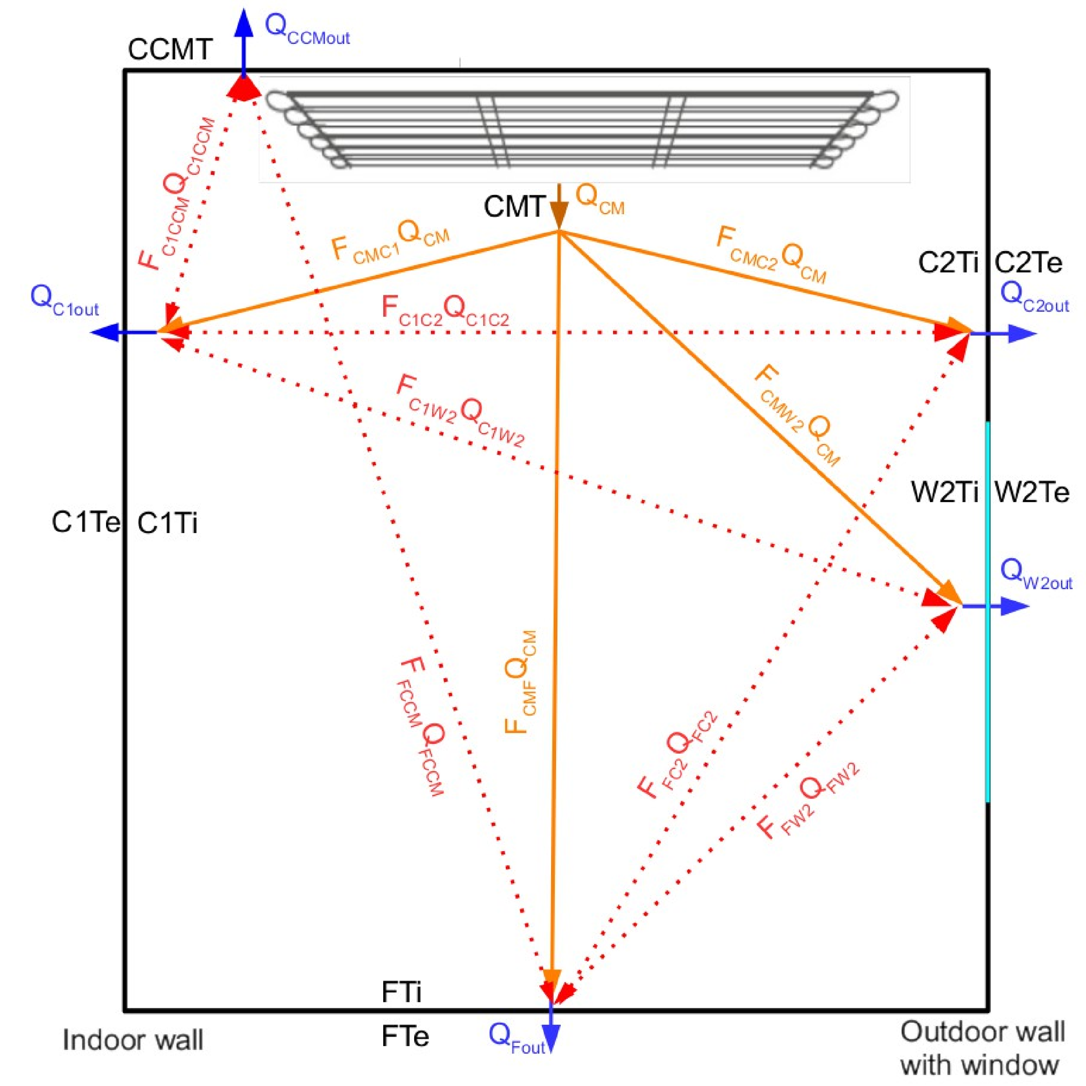
The developed model was implemented for numerical calculation and verified by experimental data collected in a test building with an installed capillary heat exchange system.

Model description

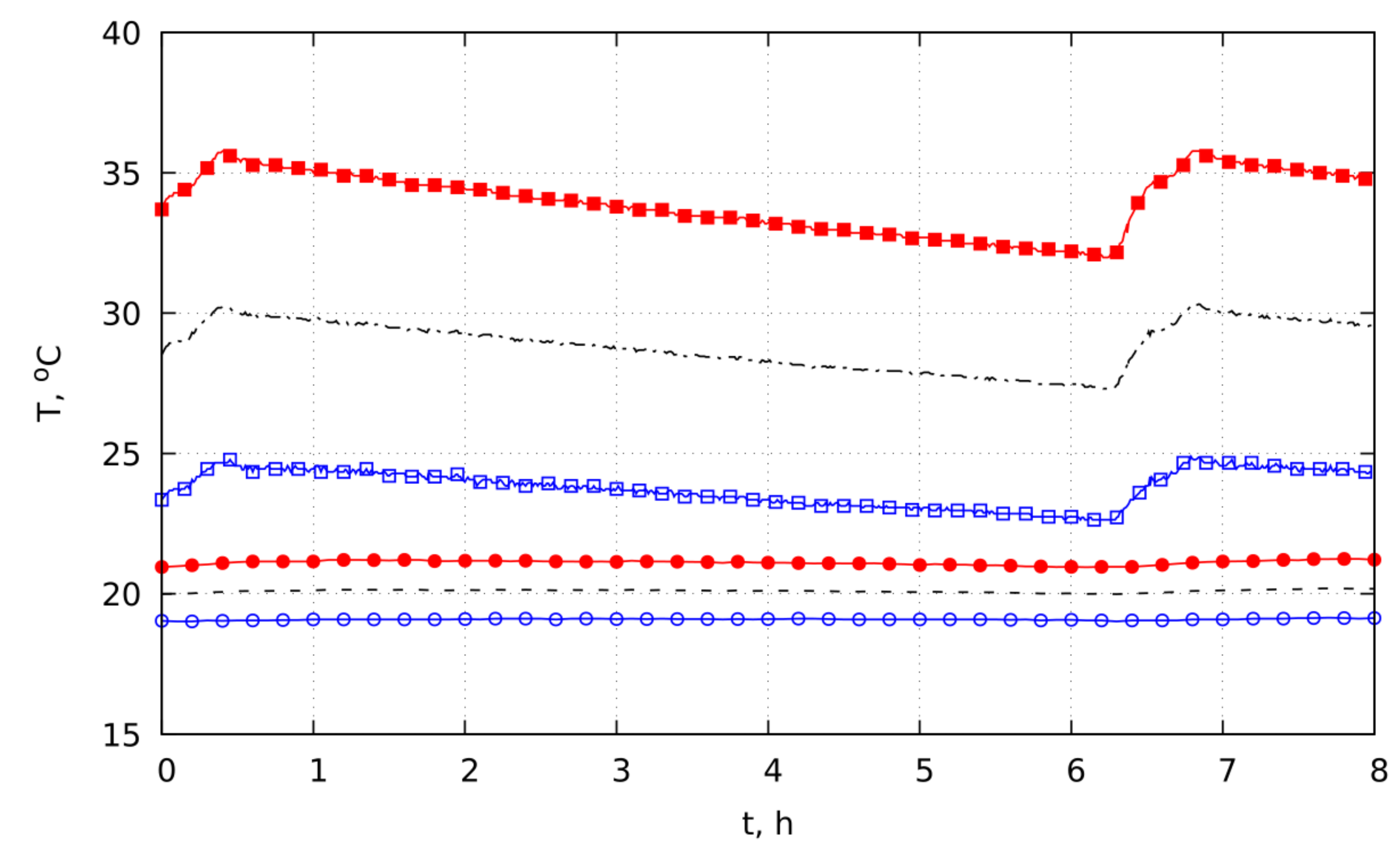
Capillary mat (CM) with constant temperature (CMT) is the only thermal energy source in the room. Heat generated by the capillary mat (QCM) is distributed between the enclosing structures (floor (F), four walls (C1-C4), wall openings (W1-W4), the ceiling region (CCM) not occupied by the mat) depending on the view factors. The heat received by the surfaces is partially redistributed between them in a process of radiative reemission, after which heat exchange with the outdoor environment occurs; the temperature of the outdoor environment (Te) is also known and constant. Thus, composing a system of correct thermal balance equations for all enclosing structures, we can determine the inner surfaces temperatures.

Next assumptions made for it:

1. The indoor air is not involved in radiant heat exchange;
2. Convective heat exchange is not taken into account in this model;
3. The emitted radiation is diffusely distributed within the space;
4. There are no additional sources of thermal energy inside (human or electrical appliance) and outside (sun) the room.



To determine the average room temperature, floor and ceiling sensors were taken, whereby a value of 20.1 °C was obtained. Similarly, the average capillary mat temperaturewas derived from the inlet and outlet water temperatures, to get a value of 28.8 °C. Another important parameter is capillary mat power, since it allows us to evaluate its operational efficiency, total power value of 200 W was obtained (T_{CM}=27.3 °C).



Conclusion

Developed model was tested using experimental data and obtained results allow us to say that the model has sufficient accuracy in calculating the temperature of the indoor atmosphere, as well as the radiating capillary mat's power. Nonetheless, at the current stage, the model contains a significant number of assumptions, primarily related to the absence of convective heat transfer and another heat sources that will be added in the next version of this model.

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