Measurements and simulation results of a local bench heating system

Dionne Limpens-Neilen[1], Mariëlle Schoffelen[1], Henk Schellen[1]

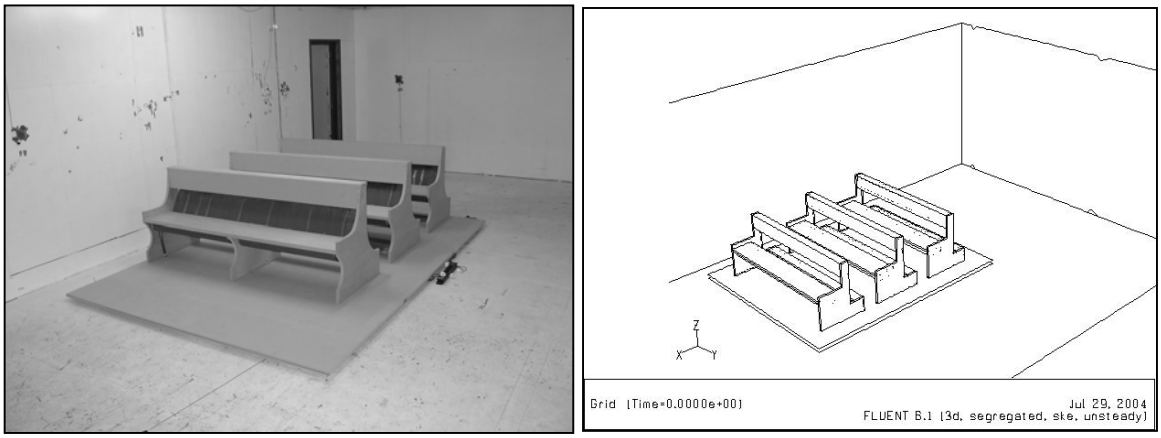
[1]Eindhoven University of Technology; Department of Architecture, Building and Planning; research group FAGO, Eindhoven, The Netherlands

ABSTRACT

Problems with the conservation of art works and interior of monumental churches are mostly a result of using a heating system that introduces abrupt variations in the indoor climate. These problems can be prevented by introducing a minimum amount of heat only where it is needed; near the people in the benches. Within the European project "Friendly Heating", such a local bench heating system is being designed on the basis of radiant heating foil.

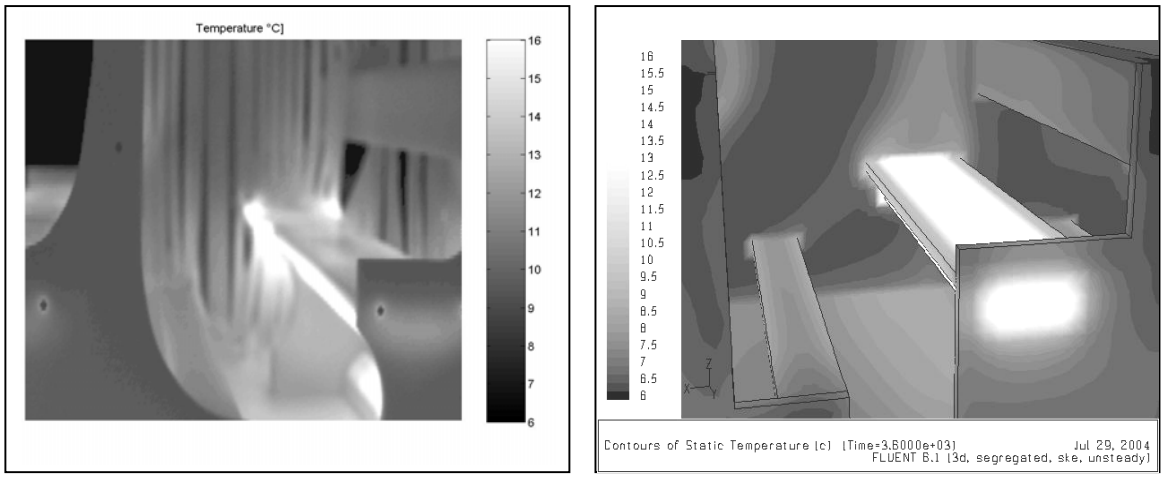
The performance of this local heating system is simulated with help of the CFD package Fluent. Besides the simulations, reference measurements on the pews equipped with the heating system are performed in a climate room under steady conditions. The results of these measurements are used for verification of the computer simulations on the same climate room set-up. The main question is how to model the local heating systems that are applied in the benches. To answer this question, we have to know the influence of heating system on the local climate in the pews, i.e. what changes in temperatures and air velocities are introduced?

Later on, the effect of the local heating system on the overall climate in a church can be investigated with regard to the conservation criteria.



Measurement set-up in the climate room and the CFD model of the benches with the local heating system.

The CFD results and verification measurements presented here, are from the climate room set-up: the heating system applied in the benches under steady climate (boundary) conditions. The simulation results and the measurement results show good agreement; the figures show the same temperature distribution on the wooden benches and the heating system. This indicates that the correct boundary conditions are applied to the CFD model, and the right models are used for calculating the radiation and buoyancy driven air flows.



Air and surface temperatures in climate room set-up; IR thermal image (left) and CFD simulation result (right). Small temperature range set in order to see detail level. Maximum surface temperature of the heating system is higher (around 35 °C).

From this research we can conclude that the results from the CFD model can be trusted, and that this model can be used to predict the influence of the heating system on the local climate around the benches.
The next step is to upgrade the model to the real situation in the church building with the actual (transient) outdoor climate conditions.

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REFERENCES
[1] Arendt, Claus, 1993: *Raumklima in grossen historischen Raümen*: Heizungsart, Heizungsweise, Schadensentwicklung, Schadensverhinderung. ISBN: 3-481-00564-4
[2] Schellen, H. L., 2002: *Heating monumental churches: indoor climate and preservation of cultural heritage.* Dissertation Eindhoven University of Technology, The Netherlands. ISBN: 90-386-1556-6
[3] www.isac.cnr.it/friendly-heating
[4] Loomans, M.G.L.C, 1998: The measurement and simulation of indoor airflow. Dissertation Eindhoven University of Technology, The Netherlands. ISBN: 90-6814-085-X
[5] Fluent Inc., Fluent User’s Guide, version 6.1, Lebanon, USA, February 2003