Coupled Heat, Moisture and CFD Modeling in the Built Environment

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Introduction: Museum buildings strive for a steady indoor climate to reduce the risk of cultural object degradation. In order to reduce these risks, museums often install (parts of) an HVAC system to control the indoor climate of exhibition rooms. The indoor climate is often assessed based on bulk environment which does not reflect possible parameter gradients that cause strains and stresses in heritage objects. The purpose of this research is to create a COMSOL Multiphysics® model that simulates conditioned air flow and its impact on the local indoor climate.

Computational Methods: To reduce computational effort only the air volume of the room is considered. Non-isothermal k-ε turbulent flow and heat, air and moisture transport are used Multiphysics nodes [1]. Inlet conditions are shown in Fig. 1. Fig. 2 shows the geometry of the model and the mesh used in this problem.

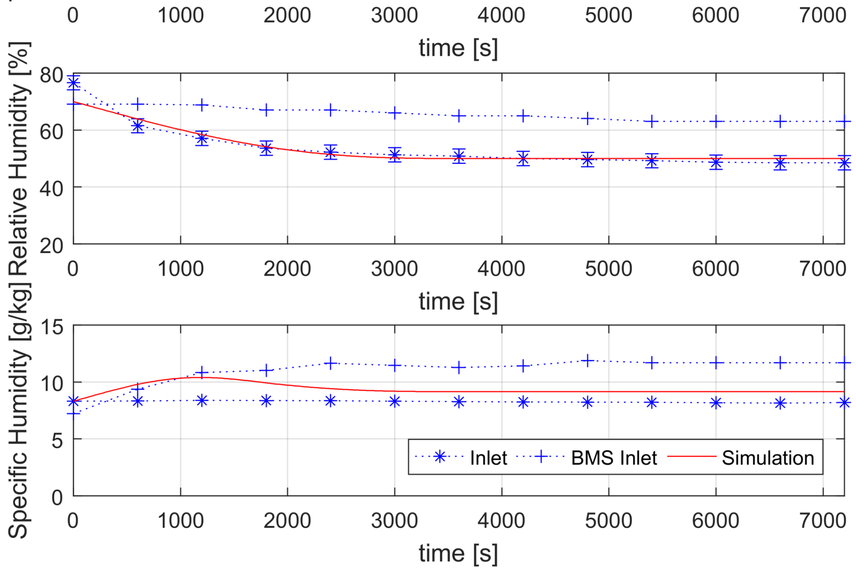

Figure 1. Measured inlet conditions, Building Management System (BMS) inlet conditions and the imposed simulation inlet conditions.

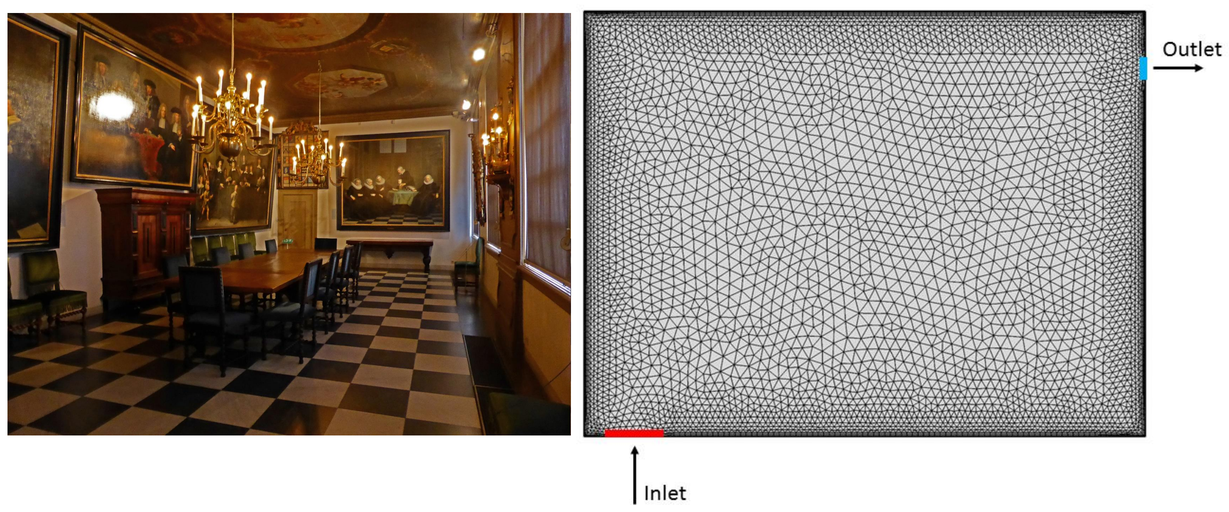

Figure 2. Interior of case study (left). Geometry and imposed boundary conditions and mesh visualization (right).

Results: Fig. 3 compares the simulated data to the experimental data. Both temperature and relative humidity are overestimated. This could be related to simplifications in the model to reduce computational effort. Fig. 4 shows the outcome at t = 7200 s for temperature and air flow (left) and relative humidity distribution (right).

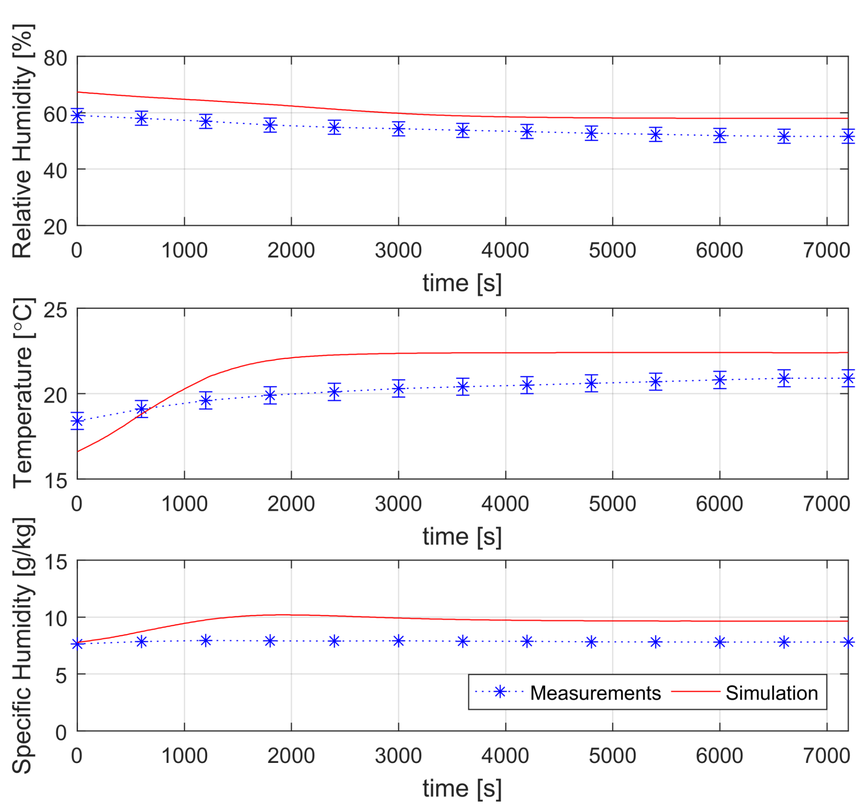

Figure 3. Results of COMSOL simulation compared to experimental data at the cabinet near painting.

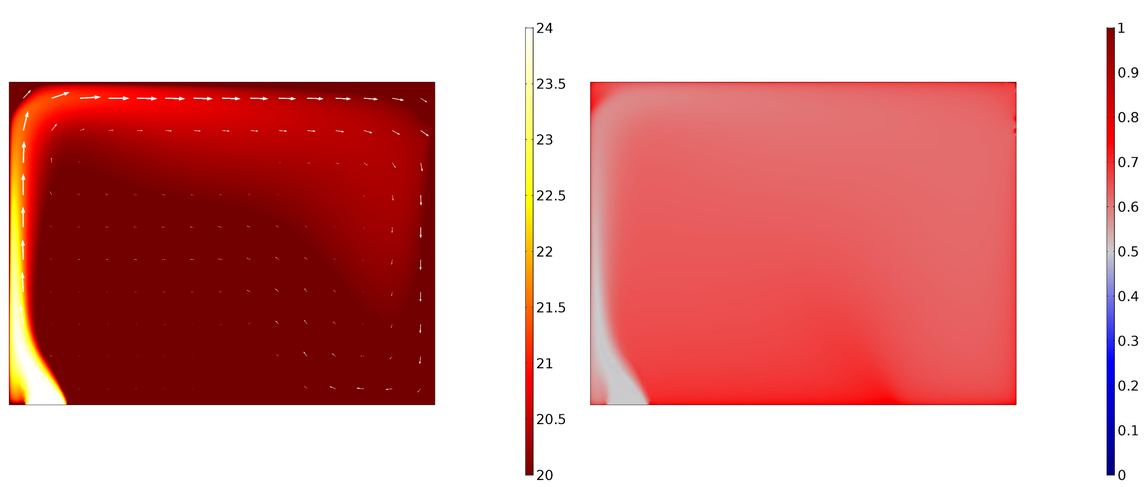

Figure 4. Results of COMSOL simulation with temperature distribution and flow field (left) and relative humidity distribution (right) at t = 7200 s

Conclusions: COMSOL Multiphysics® is suitable as computational tool for modeling the museum indoor environment.

The outcome is valuable for locating critical areas in exhibition and archive rooms.

Further research is necessary to perform a comprehensive validation study including a grid sensitivity analysis and different turbulence models.

References:

1. N. Bannach, “Intro to Modeling Evaporative Cooling,” 2014. [Online]. Available: https://www.comsol.nl/blogs/intro-to-modeling-evaporative-cooling/.