

Coupled Heat, Moisture and CFD Modeling in the Built Environment

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Abstract

Museum buildings strive for a stable indoor climate to reduce the risk of cultural object degradation. An incorrect temperature or relative humidity can induce or accelerate deterioration processes such as biological, chemical or mechanical 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 climate near objects. The use of COMSOL Multiphysics® provides the advantage to study the micro-climate in the room and different physics that are influenced by one another. Boundary conditions such as temperature, relative humidity and air flow velocity, can easily be altered to study multiple variations. Both air flow of the exhibition room and its impact on temperature and relative humidity near objects can be studied.

Measurements of the indoor climate conditions of an exhibition room were conducted with combined temperature and relative humidity sensors and infrared thermography. The results of this experimental study are used to validate the COMSOL Multiphysics® model. A Conjugate Heat Transfer model combined with the Heat and Moisture Transport module is applied to simulate heat, air and moisture transport through the building structure and air volume. A simplified geometry representing a museum exhibition room is created. The COMSOL Multiphysics® model calculates surface and air temperature and relative humidity. At representative locations of the exhibition room the quality of local climates is assessed. The wall surface temperature and relative humidity are compared to the observed infrared thermograms to assess the accuracy of the COMSOL Multiphysics® model.

The expected results of the study will give an indication to what extent indoor climate control in museum buildings influences the behavior of local climates near objects. Additionally, by varying boundary conditions of the model, it is possible to assess the impact of different building envelope qualities on the local climate behavior. Based on the results, different climate control strategies will be assessed to fully understand the impact of dynamic HVAC control on the indoor climate of an exhibition room and the risk of object degradation.

Figures used in the abstract

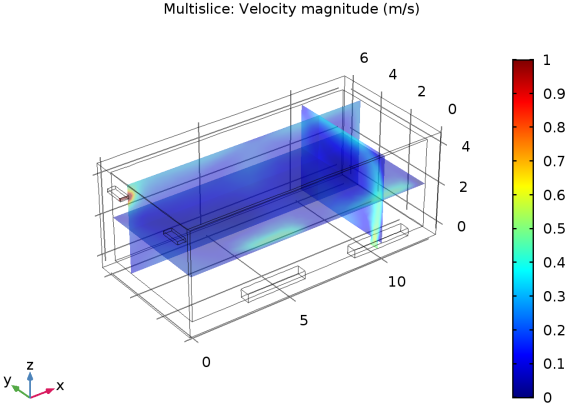


Figure 1: Velocity flow field of museum exhibition room.