

Computational Modeling of the Impact of Solar Irradiance on Chemical Degradation of Painted Wall Hangings in an Historical Interior

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Abstract

The historic Hofkeshuis in Almelo (The Netherlands) locates a unique work of art: three walls in the rear salon of the private house are covered with an 18th century series of painted wall hangings (Figure 1). The simple and similar pigmentation of the paintings, their original hanging, and the few cleaning interventions make it possible to use the degree of the formation of lead soaps, so-called saponification, as an internal marker for the chemical degradation of the oil paint. We expect that incoming solar radiation in the room critically affects the microclimate near the paintings and may therefore be an important cause of chemical degradation of the paint layers. This requires an accurate analysis of how solar irradiance enters the salon and how it affects the microclimate around the paintings. Measurements of the indoor climate conditions in the salon were conducted with combined temperature/relative humidity sensors and a thermographic camera (Figure 2).

The purpose of this study is to create a model in COMSOL Multiphysics® that simulates incoming solar radiation in the salon of the Hofkeshuis during one summer month and calculates the surface temperature of the paintings as a result of the outdoor temperature, wall conditions, and radiant source. The advantage of the COMSOL Multiphysics® model is that microclimate conditions can be analyzed at every position on the wall hangings and boundary conditions such as glazing types, curtains, and heating in the salon, can easily be adjusted. In this way both the present indoor climate as well as the historical indoor climate can be simulated.

The COMSOL model consists of a Conjugate Heat Transfer physics interface with a solar source as an external radiation source, heat flux through external walls, and natural ventilation by air flow through open boundaries. A geometry of the salon is created with an external wall at the east side, including three single-glazed windows, and an external wall at the south side. The internal north wall and west wall, floor and ceiling are modeled as adiabatic walls. The outdoor temperature and solar irradiance are based on meteorological data that were collected at the building site and the indoor temperature is kept constant. The COMSOL model calculates surface temperatures based on heat transfer through the external walls and incoming solar irradiation. The

microclimate conditions at various positions on the wall hangings are compared to the observed degree of formation of lead soaps at these positions.

The expected results of the study will give an indication whether there is a correlation between surface temperature, solar irradiance and chemical degradation of oil paintings. Additionally, by varying the boundary conditions in the COMSOL model, it is possible to assess the impact of historic glazing types and different styles of curtains on incoming solar irradiation in the salon. Based on the results, recommendations can be made for temperature guidelines related to conservation of oil paintings on canvas. Maintaining these guidelines in exposition rooms may prevent new or further chemical degradation of oil paintings in future.

Figures used in the abstract



Figure 1: Image of the northeast corner in the salon. The wall hanging on the internal northern wall is partially visible, as well as the external eastern wall.

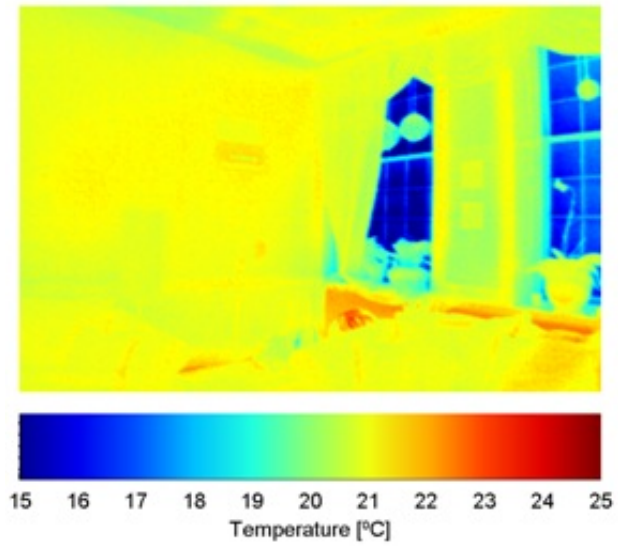


Figure 2: Thermographic image of the northeast corner in the salon taken on 31 October 2012 around 2 p.m.