A posteriori modeling error estimation for thermal building applications

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ABSTRACT

In thermal building applications, simplified physical models are commonly used by engineers. In multizone models [1], a building is decomposed into zones and envelopes. As the temperature is assumed homogeneous in the zones, the time evolution of the zone temperature is described by an ordinary differential equation. Concerning the envelopes, a one-dimensional partial differential equation is considered. This simplified physical model allows to simulate at a reasonable computation cost the thermal behavior of the building. It is particularly useful to evaluate the energy efficiency of the building and to propose an optimal control of the building systems such as the heating and the ventilation.

Generally in existing buildings, the geometrical characteristics and the thermal properties of the envelopes are not well known. Inverse problems combining a physical model and sensor outputs are solved to update the thermal model parameters. The number of sensors being limited in thermal building applications, a restricted number of model parameters can be updated. Indeed, the identification of all the thermal properties and all the thickness layers in the envelope may not be achieved. Consequently, instead of modeling all the layers in the envelope, we use a single homogenized layer envelope or an envelope with two homogenized layers (the wall and the insulation). Herein, the evaluation of the error on quantities of interest due to the model simplification is performed by a posteriori error estimators. The authors in [2] formulated fully computable model error bounds on a quantity of interest for steady Navier-Stokes and mechanical problems. Then, we derived in [3] the model error bounds for thermal building applications without considering model simplification in the unsteady terms. In the proposed article, the error bounds take into account the unsteady terms. Hence, all the model simplifications involved in practical thermal building applications are now considered. The studied quantities of interest are the temperatures at the wall surfaces and the heat flux. Numerical results on a real building envelope will be presented.

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