CFD vs. lumped models applied to HAM: a comparison between HAM-Tools and Comsol

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Abstract

CFD models have several advantages in comparison with zonal-models, due to the more accurate calculation of the airflow distribution within the built environment. Nevertheless, in currently available CFD software the simulation of mass transfer cannot be directly extended from the fluid region to the solid region. In the whole-building moisture transport studies, the mass coupling between the indoor environment and the wall system is usually achieved by third party programming. The Annex 41 research project of the International Energy Agency (IEA) was carried out to explore the complex physics governing the whole building heat, air and moisture (HAM) transfer, by developing several models to couple 3-D CFD simulations with hygrothermal models of walls.

The objective of this study is to develop a coupled CFD model able to simulate the HAM transport in a single environment (i.e. a simple test room), influenced by the room factors. A numerical method was utilized to model the indoor environment and the moisture transport process in the simple room and inside the wall system as influenced by the moisture loads and ventilation conditions.

The comparison between the CFD and a lumped model allows us to demonstrate how a simplified model can be reliable in predicting the RH variation inside a room, also taking into account the indoor material buffering effect.

1. Introduction

HAM-Tools is a building simulation software implemented on the Simulink-Matlab platform by the Chalmers University of Technology (Gotheborg, Sweden) and the Technical University of Denmark (Lygby, Denmark) within the Annex 41 project. The main objective of this tool is to run simulations of transfer processes related to building physics, i.e. heat and mass transport in buildings and building components in operating conditions. Nevertheless, results from literature demonstrate how simulations made with the HAM-Tools lumped model over-estimate about twice the moisture dampening effect than what was actually measured experimentally (Ramos et al., 2012). The authors then focused on the air-flow pattern, comparing experimental measurement results to theoretical ones. An appreciable difference between the measured hygroscopic inertia and the calculated one was found due to the air velocity field that caused the development of several dead zones inside the test chamber. This meant that the perfect mixing of the room air, a simplification commonly assumed in HAM simulations, had a clear impact on the results of this kind of problem. If perfect mixing is assumed, all the hygroscopic surfaces would be fully active; but since this is not true, the flux chamber simulations overestimated the moisture buffering effect.

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7. Nomenclature

Symbols

D_φ	liquid conduction coefficient (kg/ms)
c_p	specific heat capacity (J/kgK)
$\dot{g}_a$	density of air flux (kg/m² s)
$\dot{g}_v$	density of moisture flux (kg/m² s)
H	volumetric heat capacity (J/m³ K)
h_v	evaporation enthalpy of water (J/kg)
T	absolute temperature (K)
t	time (s)
p_c	suction pressure (Pa)
p_v	vapour pressure (Pa)
$p_{v,s}$	vapour pressure at saturation (Pa)
u	moisture content by mass (kg/kg)
w	moisture content by volume (kg/m³)
x	thickness (m)
δ_P	vapour permeability (kg/m s Pa)
λ	thermal conductivity (W/m K)
λ_l	liquid conductivity (s)
ϱ_0	density of dry material (kg/m³)
φ	relative humidity (-)
ξ	moisture storage capacity (kg/m³)

References

P. Amissah. 2005. "Indoor air quality - Combining air humidity with construction moisture." PhD thesis. Glasgow, U.K.: University of Strathclyde.

EN ISO 13791:2012. Thermal performance of buildings. Calculation of internal temperatures of a room in summer without mechanical cooling. General criteria and validation procedures.

A. Erriguible, P. Bernada, F. Couture, and M. Roques. 2006. "Simulation of convective drying of a porous medium with boundary conditions provided by CFD." *Chemical Engineering Research and Design* 84 (A2): 113-123.

H. Janssen, B. Blocken, and J. Carmeliet. 2007. "Conservative modeling of the moisture and heat transfer in building components under atmospheric excitation." *International Journal of Heat and Mass Transfer* 50 (5-6): 1128-1140.

M. K. Kumaran. 1996. "Heat, Air and Moisture Transfer in Insulated Envelope Parts. Final Report, Volume 3, Task 3: Material Properties." In *International Energy Agency Annex 24.* Belgium: K. U. Leuven.

A. Neale. 2007 "A study in computational fluid dynamics for the determination of convective heat and vapour transfer coefficients". Master's thesis. Montreal: Concordia University.

B Nusser and M. Teibinger. 2012. "Coupled heat and moisture transfer in building components - implementing WUFI approaches in COMSOL Multiphysics." In *Proceedings of the COMSOL Conference*, Milan.

N.M.M. Ramos, Kalagasidis A.S., de Freitas V.P., and Delgado J.M.P.Q. 2012. "Numerical simulation of transient moisture transport for hygroscopic inertia assessment." *Journal of Porous Media* 15 (8): 793-804.

C. Rode, R. Peuhkuri, L.H. Mortensen, K. Hansens, B. Time, A. Gustavsen, T. Ojanen, J. Ahonen, K. Svennberg, L.E. Harderup, and J. Arfvidsson. 2005. "Moisture buffering of building materials." *Technical Report ISSN 1601-2917, ISBN 87-7877-195-1*, Technical University of Denmark.

H.J. Steeman, A. Janssens, J. Carmeliet, and M. De Paepe. 2009. "Modeling indoor air and hygrothermal wall interaction in building simulation: Comparison between CFD and well-mixed zonal model." *Building and Environment* 44 (3): 572-583.

UNI TS 11300-1:2014. Energy performance of buildings. Part 1: Evaluation of energy need for space heating and cooling.