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ScienceDirect

Energy Procedia 132 (2017) 405–410

Energy Procedia

www.elsevier.com/locate/procedia

11th Nordic Symposium on Building Physics, NSB2017, 11-14 June 2017, Trondheim, Norway

Calibration of Hygrothermal Simulations by the Help of a Generic Optimization Tool

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Abstract

Hygrothermal simulation represents an established method for the performance evaluation of building constructions. Some validation cases are known where the validity of these models was approved in form of a comparison between measured and simulated quantities under controlled boundary conditions. A further step is commonly not explained but also included, the calibration of uncertainly known model settings, e.g. surface exchange coefficients or measured material properties with a relevant uncertainty range. This paper summarizes a calibration procedure, which was carried out for the data analysis of a hygrothermal test stand with two- and three-dimensional junctions, including brickwork and joist ends. The calibration procedure is based on the definition of quantitative criteria (target values) that describe the accordance between measured and simulated data series. Starting with the thermal two-dimensional simulation model, uncertain parameters are defined with their start values, ranges and steps of variation. This is used as an input for the identification of the best-fitting parameter combination via generic optimization algorithm. The final calibrated simulation model shows a remarkably better accordance to the measurement results. The procedure is systematic and reproducible.

Keywords: Hygrothermal Simulation, Calibration, Thermal and Hygric Transfer Coefficients, Test Stand

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10.1016/j.egypro.2017.09.645

1. Introduction

Hygrothermal simulation software such as DELPHIN [6] is an appropriate method to evaluate complex engineering problems concerning heat and moisture transport through the envelope of a building. The initialization of such projects requires a number of input variables and functions. Some of them, e.g. the sorption curves for the moisture storage, are based on values, which are measured in a lab and converted into material functions as part of a systematic calibration procedure. These values are assumed to have a low uncertainty range, which is depending on the exactness of the lab measurements and the procedure itself. Further variables of the hygrothermal simulation project, such as surface transfer coefficients, are defined pragmatically on the base of national standards or the individual engineer's experience. This is a feasible method for typical engineering projects, where detailed information about initial conditions, boundary conditions etc. is often not available. It is less constructive for the simulation of laboratory tests where the accordance between measured and simulated data series is crucial for the results interpretation.

The main challenge of this application field for hygrothermal simulations is a systematic and reproducible identification of uncertainly known input variables. Typically, only one parameter is varied and optimized, while the other values remain fixed. This is continued for the next input variable(s) and therefore a time-consuming procedure. Because a variation of the first input variable yields a non-optimal constellation for the other variables which have to be adjusted as well in an iterative way. The achieved accordance is thus only a partial one that is strongly depending on the start values, the intuition of the user etc. Despite this, congruency of measured and simulated data series is mostly not rated numerically, with defined statistic key values, but either visually, with subjectively selected data series and accordance criteria.

2. Systematic Procedure with a Generic Optimization Algorithm

The systematic procedure is based on the application of a generic optimization program, GenOpt [7]. This software comprises a number of optimization algorithms, which allow the minimization of a defined cost-function that is laborious to be evaluated and whose analytical properties are not available. GenOpt has been developed for the application in the field of building energy use, namely the cost resp. energy demand minimization. A general procedure description for this case is part of the manual. A modified procedure as shown in the graph below was necessary for the mentioned application case of hygrothermal modelling calibration with DELPHIN.

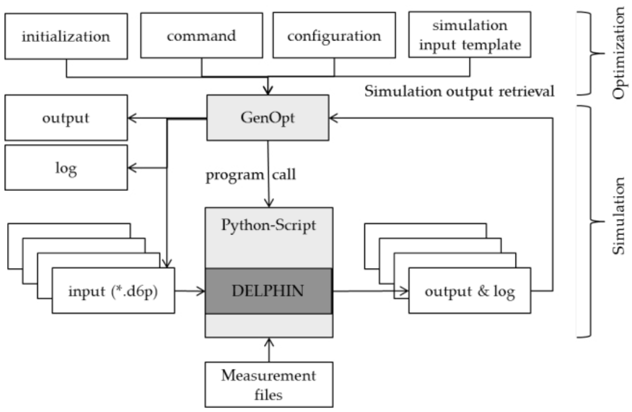

Fig. 1. Modified interface scheme and file references for GenOpt with DELPHIN.

GenOpt is set up with four constituent parts that describe the specific problem. The configuration part describes the syntax of the simulation software call. The initialization part describes the project-specific input files, namely the directly executable project file and a template file based on it, which includes the placeholders for the parameters to be varied, the log files carrying the error messages and an output file, which defines the target parameter to be minimized. The command part specifies all variation parameters and the optimization algorithm that is used. Based on this information GenOpt manages the input for the simulation tool, in this case .d6p-files for DELPHIN 5.8. This file is submitted to the executing software, a Python-script, the tool response (log-file) is checked and the output (target value to be minimized) is evaluated. The Python script is used to wrap the problem due to the fact, that the result of