Modeling and Parameter Optimization of a Thermal Model for an Automotive Cabin

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A thermal model for an automotive cabin [1] will be used to show an actual problem XRG is working on. An optimizer has been used to adapt the model to test bench results of the manufacturer. The optimization process needed some preparation which shall be presented here.
To simulate large systems, the behavior is often modeled as physical subsystems, which are coupled with each other for the simulation. For the performance analysis of an automotive refrigeration system it is required to simulate the cabin together with the refrigerant cycle. An efficient coupling of both systems is usually achieved by one-dimensional modeling approaches. Since the cabin represents a fairly complex three-dimensional system a simplified one-dimensional model requires a calibration process in order to obtain comparable accuracy with regard to a three-dimensional modeling on the one hand and measurements on the other hand. The contribution will show how to create a calibrated cabin model by using an optimization tool.
The XRG approach is a simplified one-dimensional of the cabin written in the Modelica modeling language for Dymola as simulation tool. The base components of this model are from the XRG HumanComfort Library. A calibration of this model with test bench data from the manufacturer has been carried out. A simulation model of the cabin with the same boundary conditions as the test bench is used for this purpose. The aim is to minimize the difference between selected simulation results and the corresponding measured values. An objective or error function has to be defined which computes the deviation of the simulation from the measured values and results in a single scalar value. Some model parameters are defined as *tuners*. The XRG optimization software ModelOpt is used to find a parameter set with a minimal error result. Only derivation-free optimization algorithms can be used here, as the cabin model is considered a black box model. Some of the implemented optimization algorithms are searching local to a start vector. Any improvement of the previous result is accepted as next step, all other attempts are ignored. The common problem of these algorithms is that they tend to stick in local minima. Box oriented algorithms can scan a selected range of input values but are typically slow. They are often used to find promising start values for the local algorithms.
Measurements are seldom error-free. Measured data must always be reviewed before using it for calibration. Often a model shall be calibrated for different cases, here for pull-up and pull-down, which cannot be simulated together. Not all tuners are calibrated with all cases. Some tuners may only have an influence for pull-up or for pull-down. The result of this calibration is a model which can be simulated together with a heating and cooling circuit.

References

[1] S. Wischhusen, *Modelling and Calibration of a Thermal Model for an Automotive Cabin using HumanComfort Library*. Proceedings of 9th Modelica Conference, Munich, Germany, September 3-5, 2012.