TLK-Thermo GmbH

Optimization Suite

Optimization and Fitting

Optimization Suite

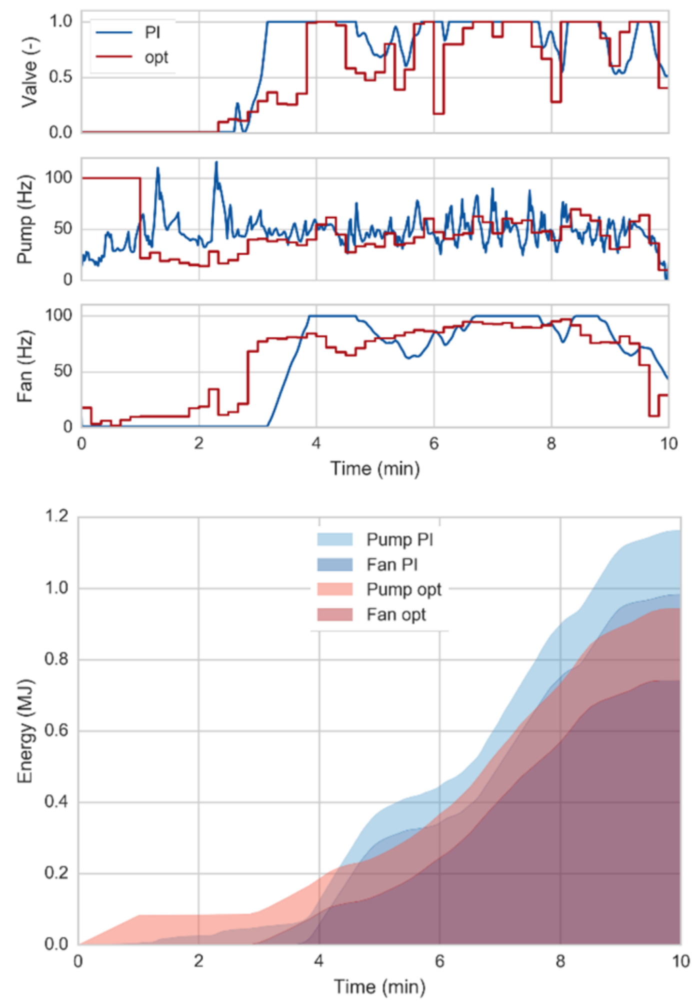
Highlights

- Separation of simulation and optimization techniques: Complex models can be simulated by suiting, well tested solvers.
- Robust transient and steady-state simulation techniques, especially for thermal systems (ODE, DAE, algebraic solvers)
- Integration in TLK's or user's toolchains for model management, visualization, evaluation, parallelization and automation
- Support of various kinds of models: FMU (Co-Simulation and Model-Exchange), Dymola models, TISC interface
- Use of open-source (e.g. SciPy) and commercial optimizers as well as TLK algorithms (e.g. Nelder-Mead algorithm including globalization)

Optimization Suite

Optimization Problems

- **Stationary Optimization Problem:** Parameter optimization, often used for design optimization
- **Dynamic Optimization Problem:** Parameter optimization for systems that are defined by transient behavior
- **Optimal Control Problem:** Trajectory optimization of actuating variables
- **Stationary Fitting Problem:** Fitting model parameters to sets of stationary measurements
- **Dynamic Fitting Problem:** Fitting model parameters to measurement curves

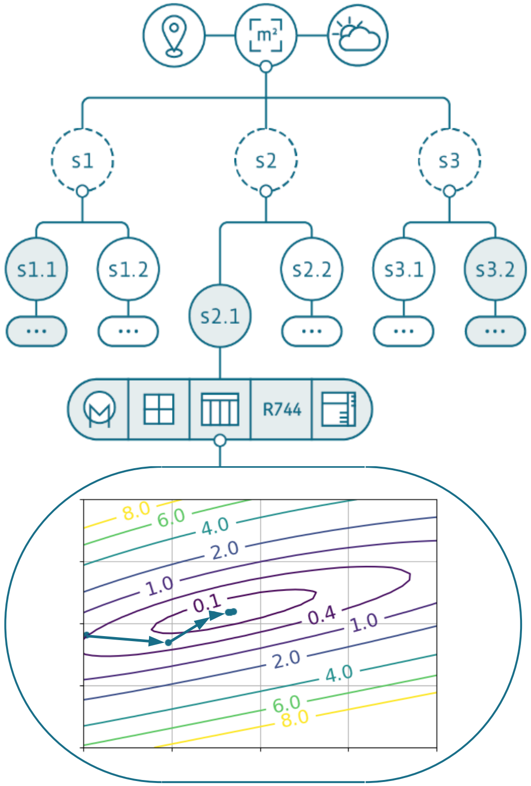


Optimal control

Optimization Suite

Successful Applications

- Design of energy-optimal heat pump and cooling cycles
- Structural design optimization of an electric vehicle battery cooling plate
- Optimal control of a heat pump dryer
- Automated control parameter optimization for varying boundary conditions
- Automated parameter fitting of a large number of compressors



Dynamic optimization of different refrigerant cycles topologies.

Optimization Suite

Optimization Problems

1. Stationary optimization problem
2. Dynamic optimization problem
3. Stationary fitting problem
4. Dynamic fitting problem
5. Optimal control

Supported Model Formats

Dymola Model

FMU

Optimization Methods

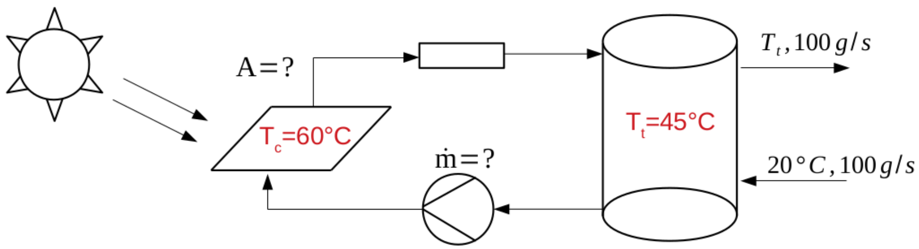
- TLK Nelder-Mead
- SLSQP
- COBYLA
- IpOpt
- Least Squares / Levenberg-Marquardt
- All others with Python interface

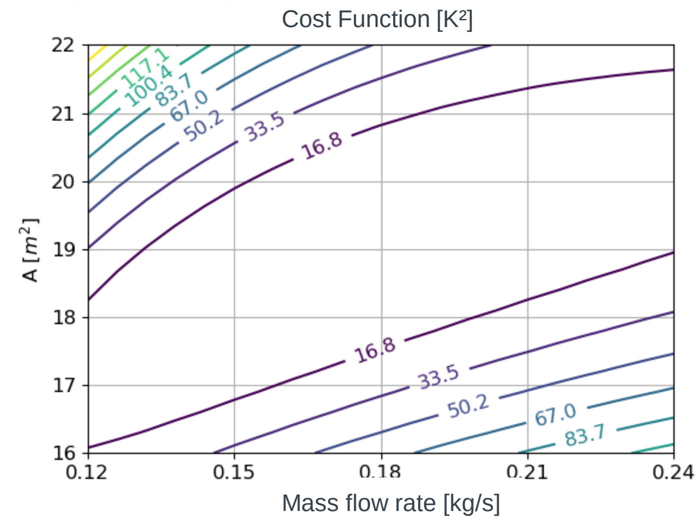
User Interfaces

- Python
- MoBA Automation
- ModelFitter (Excel)
- …

Optimization Suite

Simple Example Code of Python Interface






```python
from OptimizationProblem import SteadyStateOptimizationProblem
from scipy.optimize import minimize

sop = SteadyStateOptimizationProblem()
sop.loadModel("SteadyStateOptimization_D.fmu")

sop.addCostFunctionVariable_LSQ(name='T_t', LSQtarget=(273.15+45.0))
sop.addCostFunctionVariable_LSQ(name='T_c', LSQtarget=(273.15+60.0))
sop.addOptimizationParameter(name='mDot', lowerBound=0., nominalValue=.01, initialValue=0.05)
sop.addOptimizationParameter(name='A', lowerBound=0., nominalValue=1., initialValue=6.)

res = minimize(sop.getCostFunctionValue,
               x0=sop.getOptimizationParameterInitialValues(),
               method="SLSQP",
               bounds=sop.getOptimizationParameterBounds(),
               options={'eps': 0.01, 'disp': True, 'maxiter': 200})
```

Thank You

TLK-Thermo GmbH

If you have any questions,
please don’t hesitate to contact us at
optimization@tlk-thermo.com

Or your contact person
Andreas Varchmin
a.varchmin@tlk-thermo.com

TLK-Thermo GmbH
Hans-Sommer-Str. 5
38106 Braunschweig
www.tlk-thermo.com

Tel.: +49/531/390 76 - 263
Fax: +49/531/390 76 - 29