

Probabilistic Design of a Static Mixer

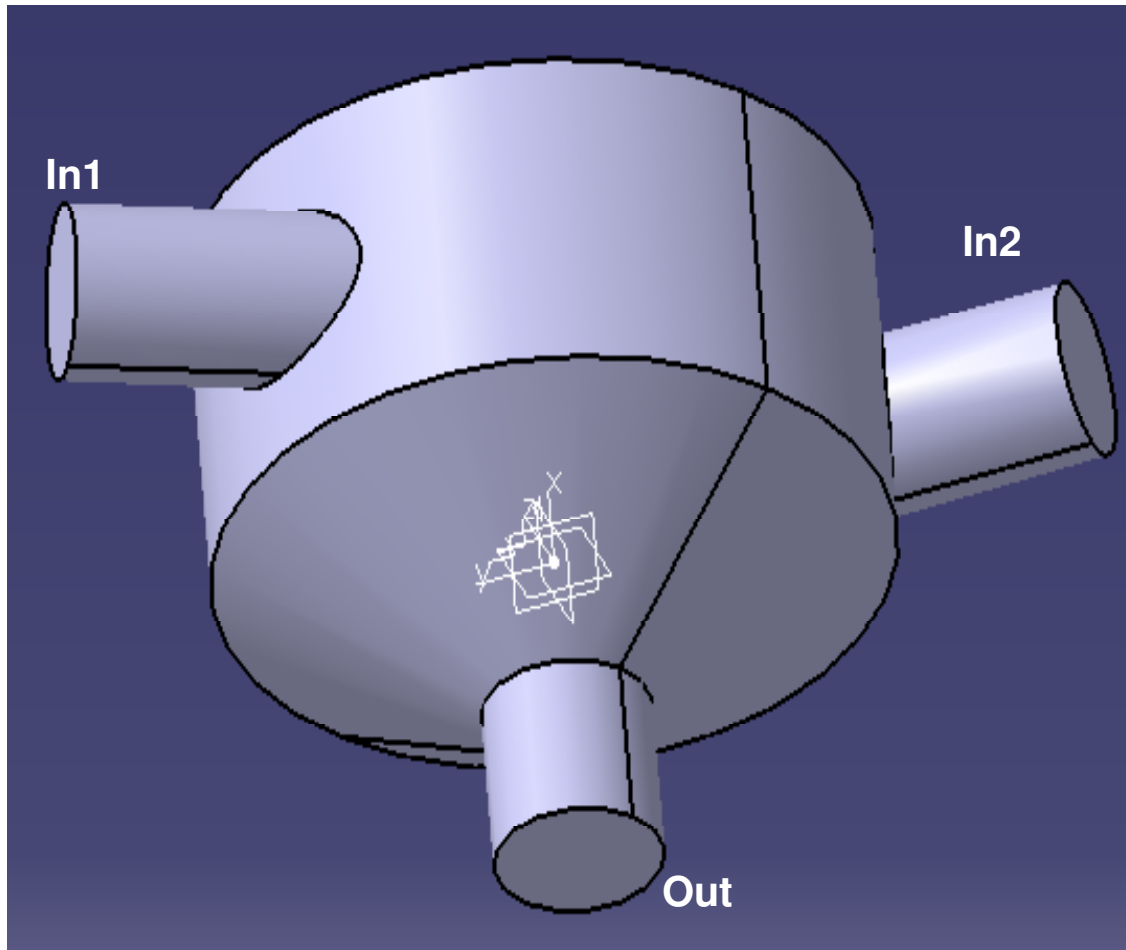
Challenges of the design process

- Create 3D-geometry with capable CAD-systems (e.g. CATIA, Pro/E) and mesh and simulation with other CAE-systems (e.g. ANSYS, NASTRAN)
- Simulation returns only accurate results for samples in the pre-design process. Realistic behaviours as variability, uncertainty and manufacturing tolerances cannot be realized until now
- Deterministic Simulation is computationally intensive. Monte-Carlo-Simulation is practically impossible

Specifications for the static mixer

- Mix two water streaming with different temperature and velocity
- Mass manufacturing with variability and uncertainty
 - Tolerances of input streaming (Angles and Radius)
 - Variability of input streaming velocities
- Customers requirements
 - Mixed temperature of input streaming and its variation should be minimal
 - Pressure of the mixer may not violate the given boundary

3D-CAD Geometry in CATIA V5



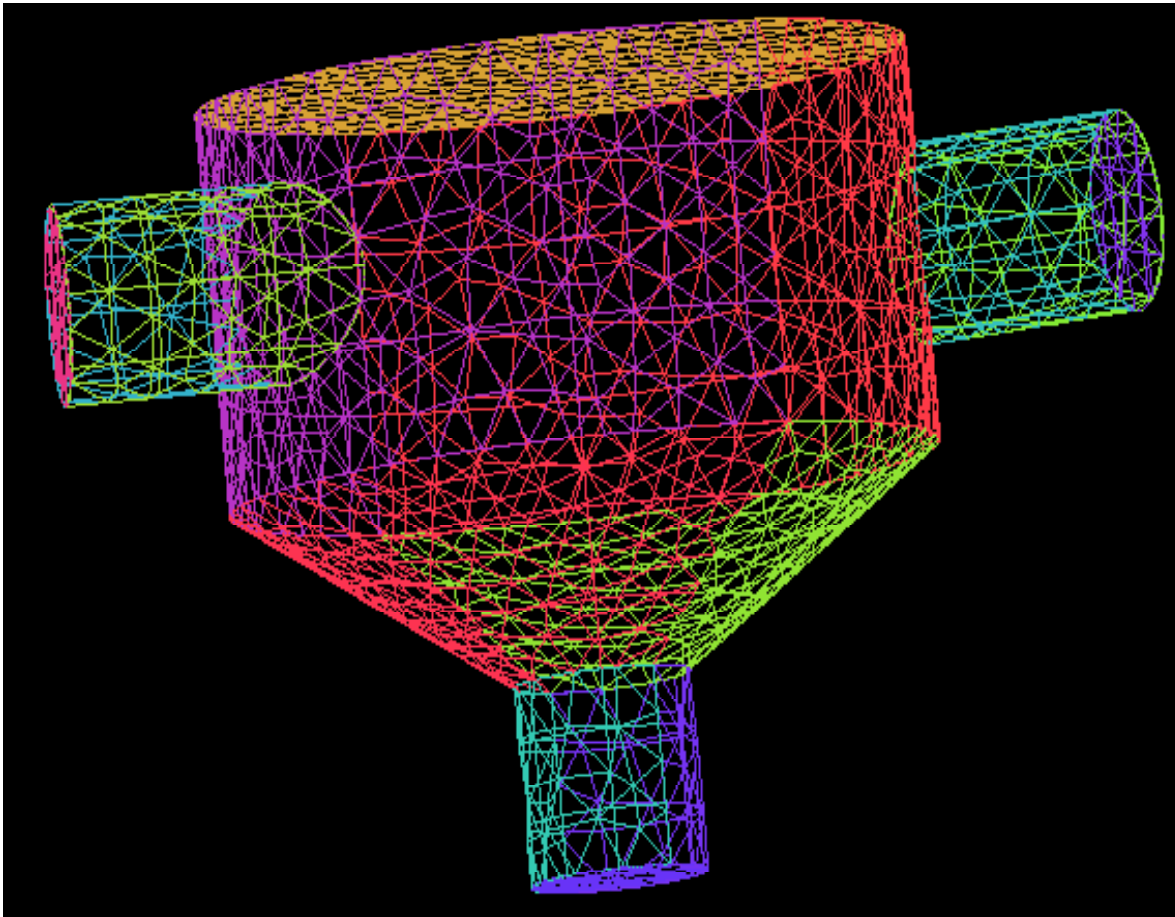
Creating Geometry in CATIA V5

- Inputs **In1** and **In2**
- Output **Out**
- Manufacturing tolerances of inputs:
 - Angles
 - Radius

Control of CATIA via COM-Interface with VBScript:

- Set Parameters
- Update Geometry
- Save as IGES-File

Meshing with ICEM CFD



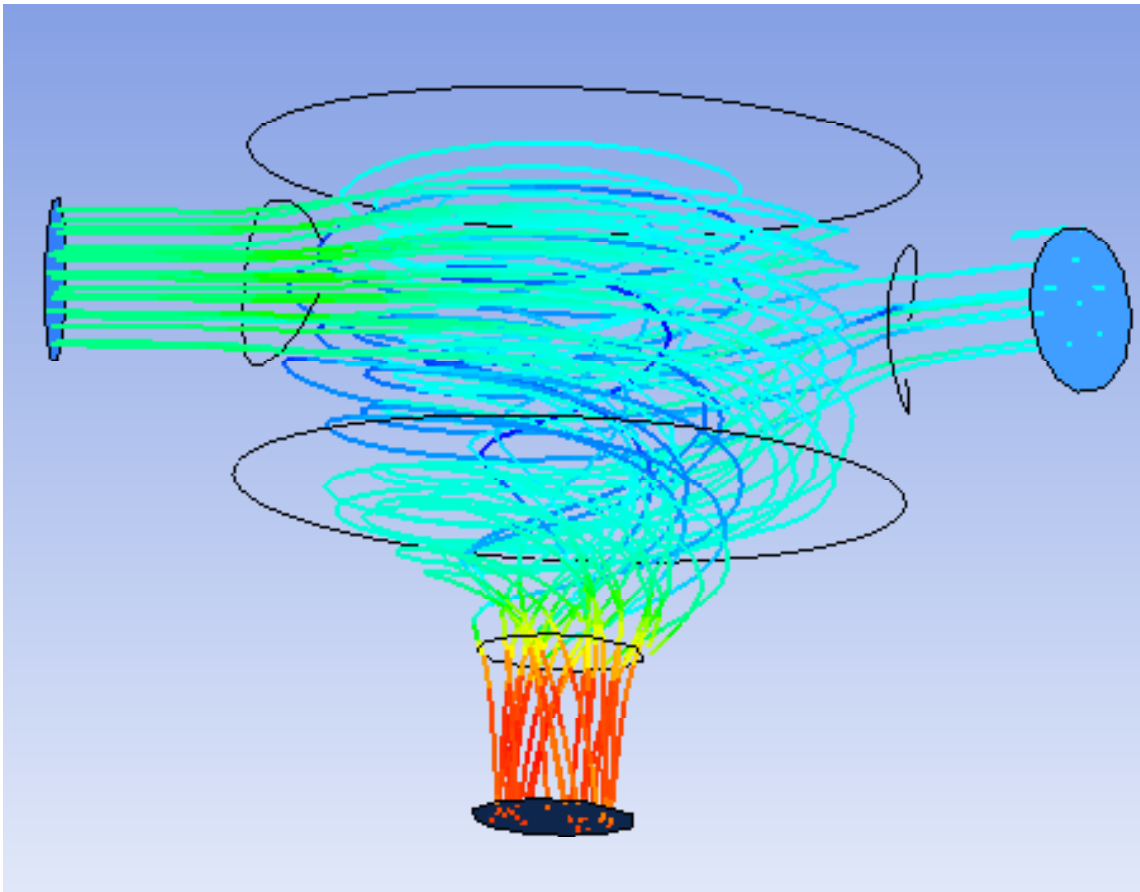
Meshing in ICEM CFD

- Meshing surfaces and volumes
- Create script file via recording of single working steps with GUI by a macro

Control of ICEM CFD via DOS-Batch-Script:

- Import IGES-File from CATIA
- Meshing Geometry
- Save the meshed model as cfx5-file for CFX-Pre

Strömungssimulation mit ANSYS CFX



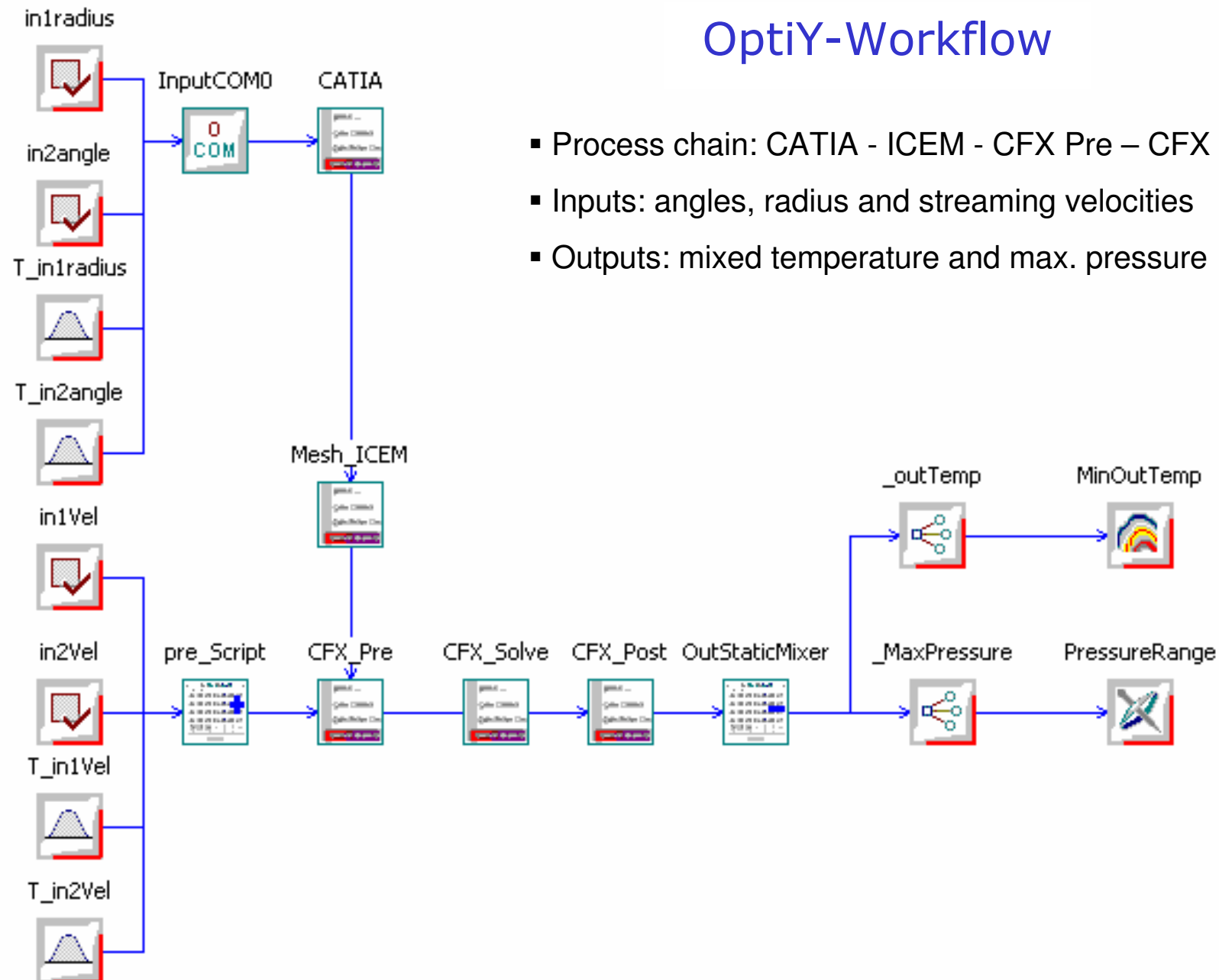
CFX-Pre + CFX-Solver + CFX-Post

- Read the cfx5-file
- Define constraints : Material, Temperature and streaming velocities **In1** and **In2**
- Solve with CFX-Solver
- Save results as ASCII-file with CFX-Post
- Dokumentation of working steps via Makro-Editor

Control of ANSYS CFX with DOS-Batch-Script:

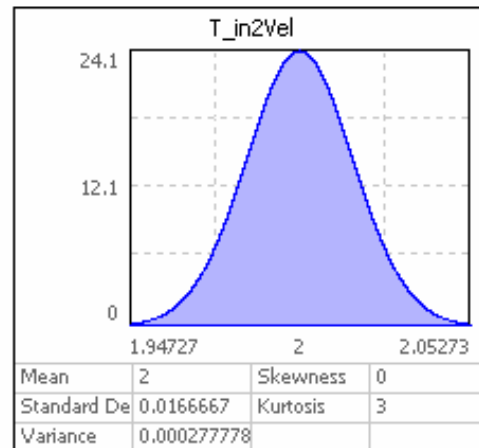
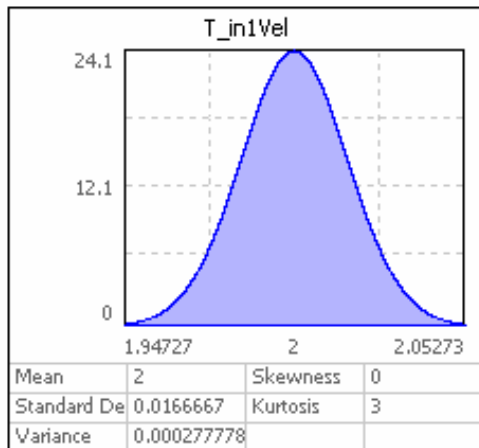
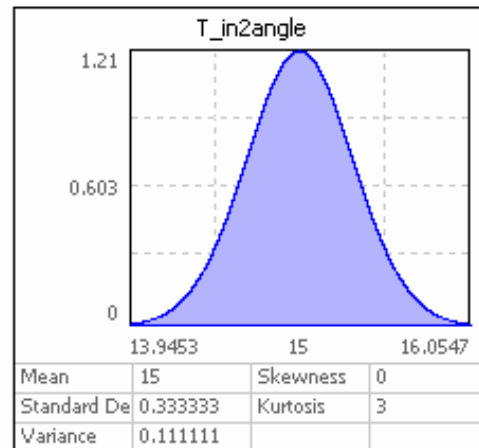
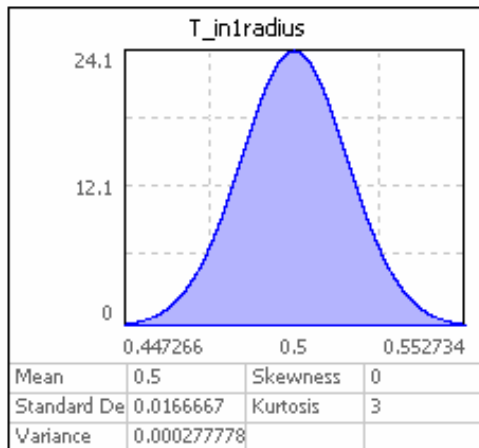
- Read Files
- Start Simulation
- Save results

OptiY-Workflow



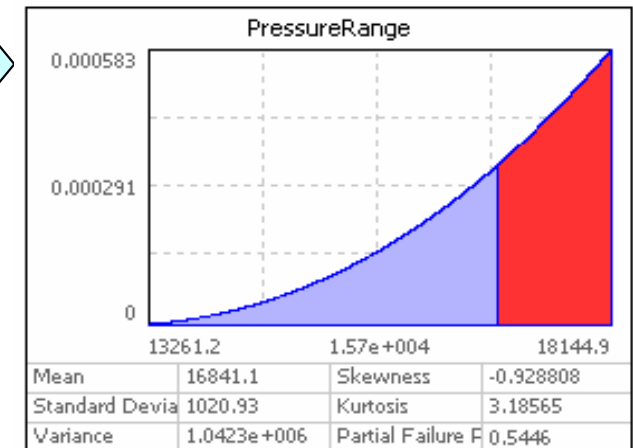
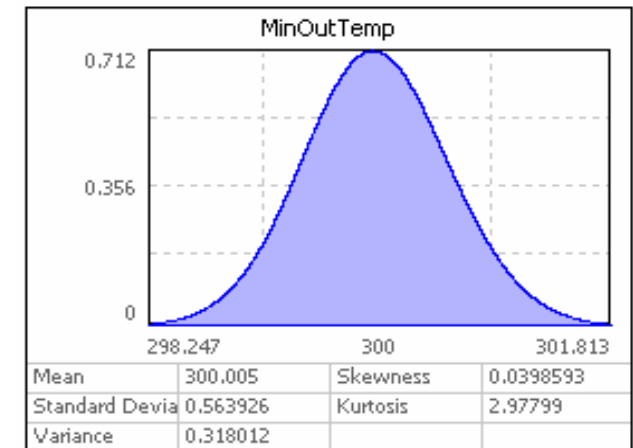
Tolerance and Reliability Analysis

Input Distributions



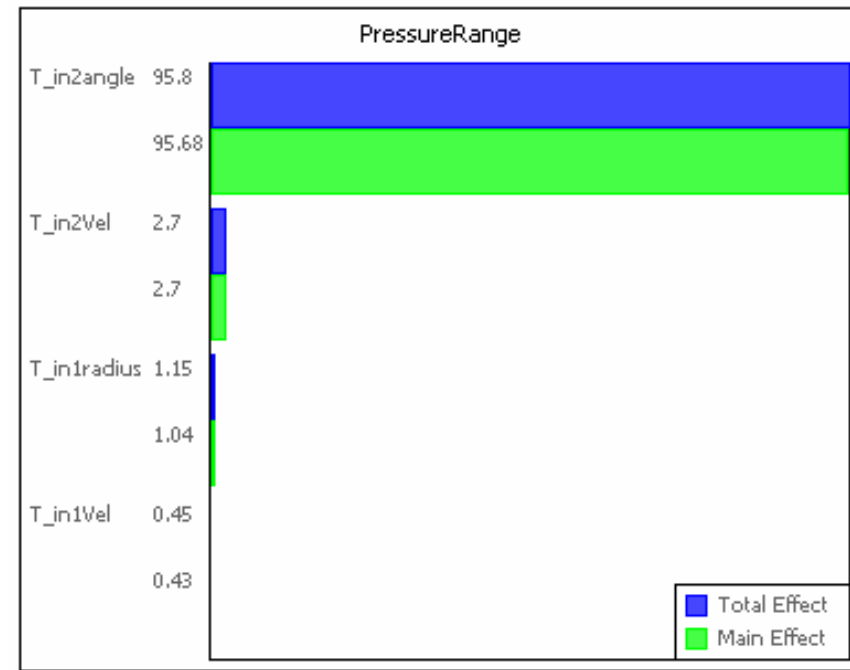
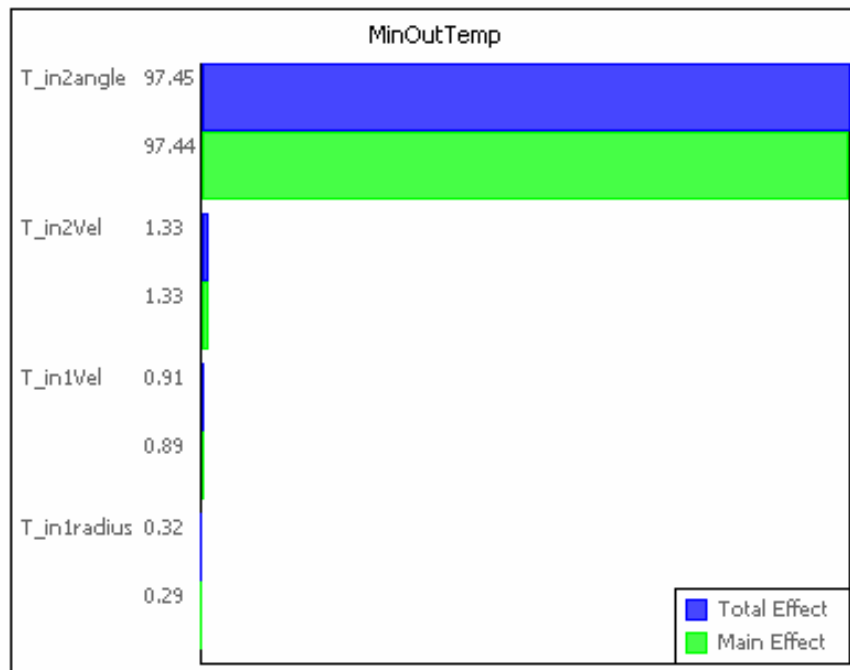
OptiY
Analysis

Output Distribution



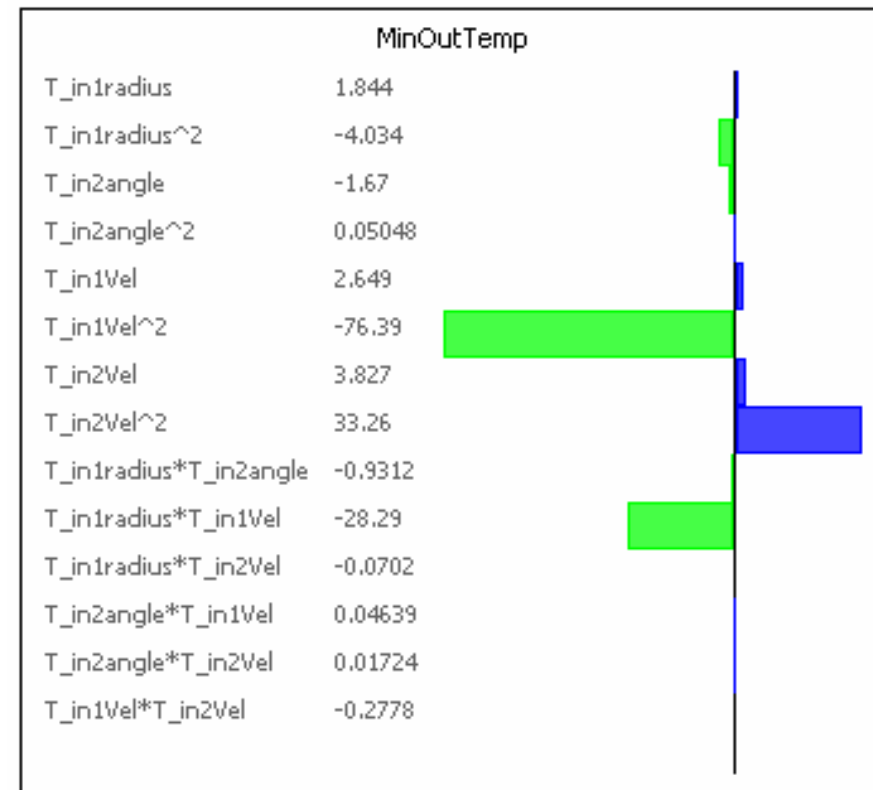
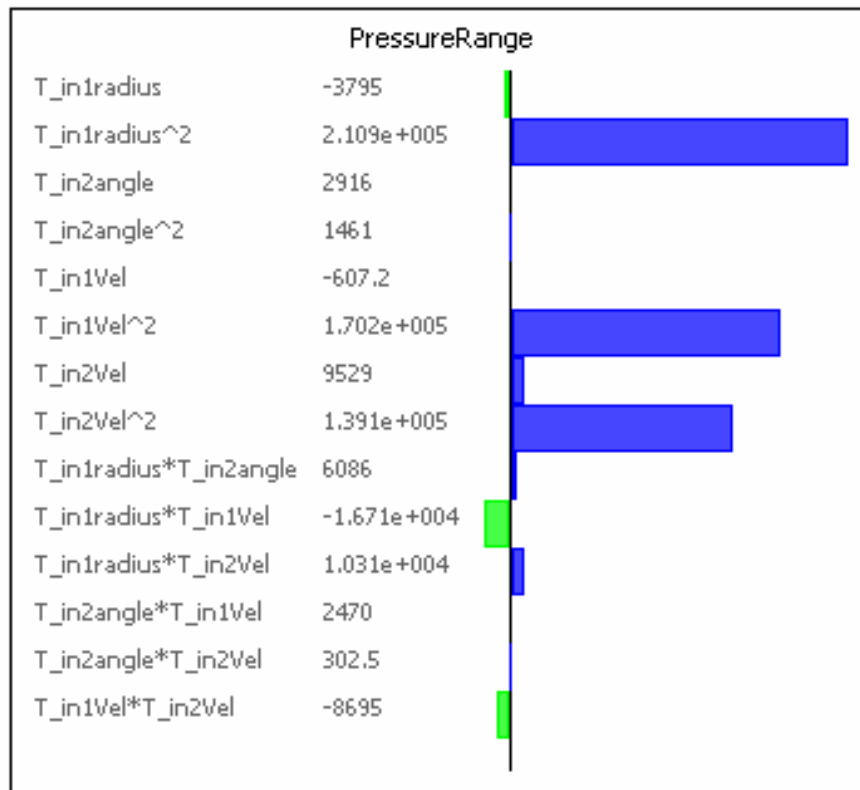
Global Sensitivity Analysis

- The output variability of mixed temperture and max. pressure depend mainly on the input angle 2
- The other tolerances can be neglected
- There is no interaction between inputs (total effect = main effect).



Local Sensitivity Analysis

- Coefficients of the Taylor series as bar chart
- Local sensitivities and interactions between inputs



Response Surface

- Quadratic correlation between inputs and outputs in the tolerance space
- 2D-diagrams or 3D-response surface available
- Enter values of inputs to get values of outputs without a new simulation

