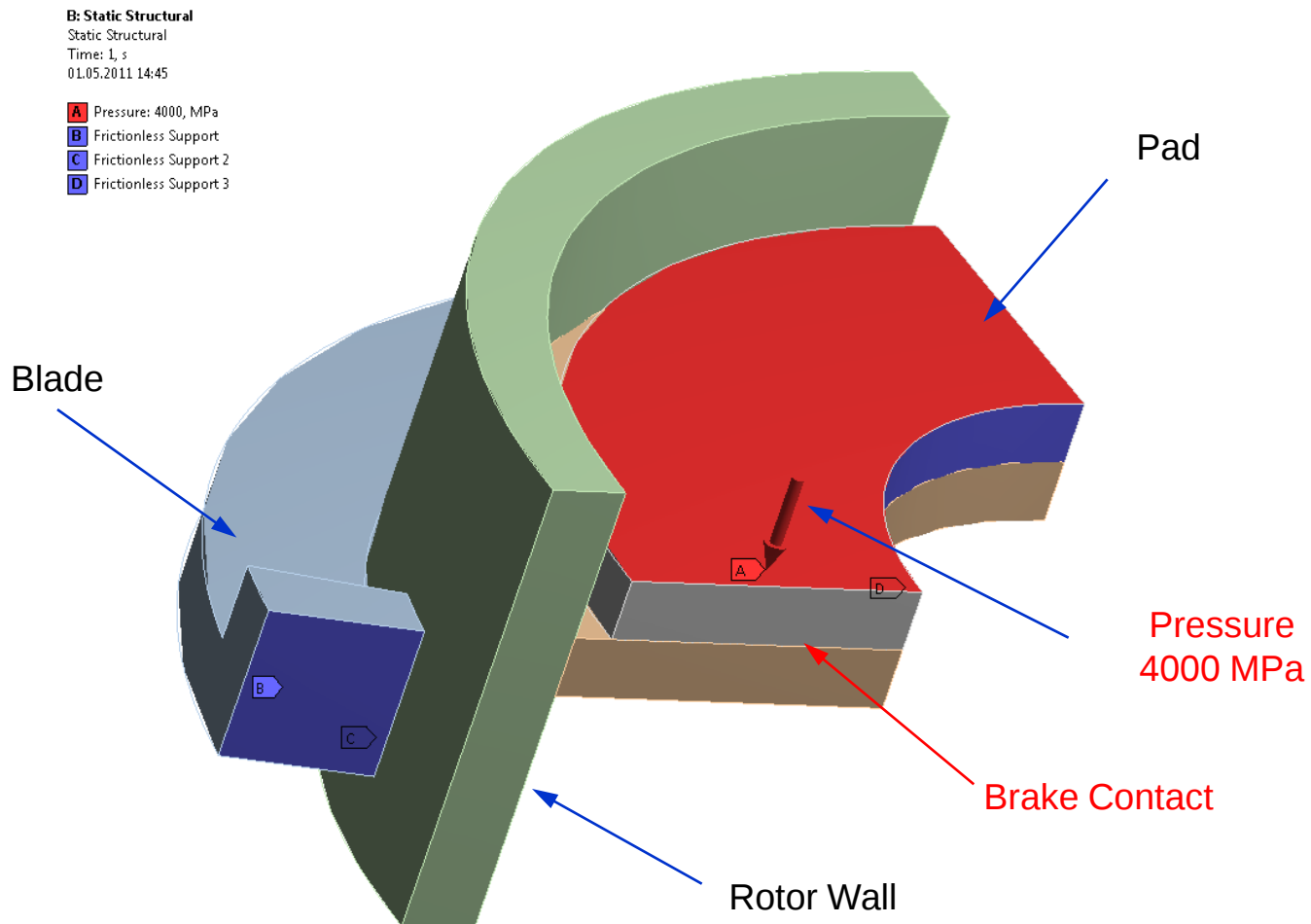


Sensitivity Study Design Optimization Probabilistic Analysis of a Rotor Brake System

OptiY GmbH - Germany

Rotor Brake System



Design Specifications

Design Parameter Space:

- Wall High = [6, 10] mm
- Pad Thickness = [0.8, 1.2] mm
- Brake Thickness = [0.8, 1.2] mm

Geometry Tolerances = 0.1 mm
With Normal Distribution

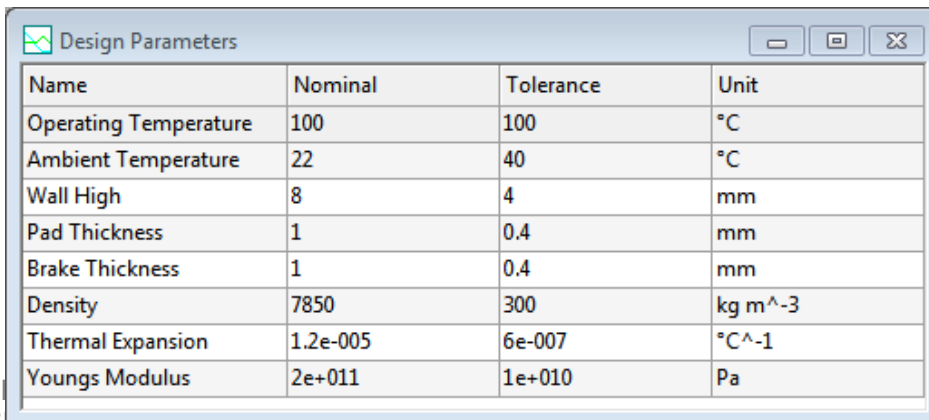
Initial Nominal Parameters

Fix Process or Environment Parameters:

- Operating Temperature = 100 ± 50 °C
- Ambient Temperature = 22 ± 20 °C
- Material Density = 7850 ± 150 kg m⁻³
- Thermal Expansion = $1.2\text{E-}5 \pm 3\text{E-}7$ °C⁻¹
- Young's Modulus = $2\text{E}11 \pm 5\text{E}9$ Pa

Functional Requirements:

- Contact Pressure = maximal as possible



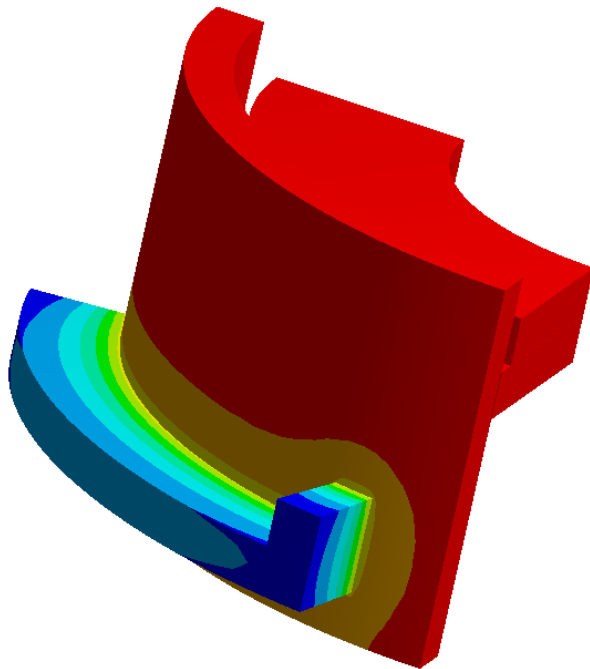
Name	Nominal	Tolerance	Unit
Operating Temperature	100	100	°C
Ambient Temperature	22	40	°C
Wall High	8	4	mm
Pad Thickness	1	0.4	mm
Brake Thickness	1	0.4	mm
Density	7850	300	kg m ⁻³
Thermal Expansion	1.2e-005	6e-007	°C ⁻¹
Youngs Modulus	2e+011	1e+010	Pa

Nominal FE-Simulation

Temperature
Operating Point = 100 °C

A: Steady-State Thermal
Temperature
Type: Temperature
Unit: °C
Time: 1
01.05.2011 16:54

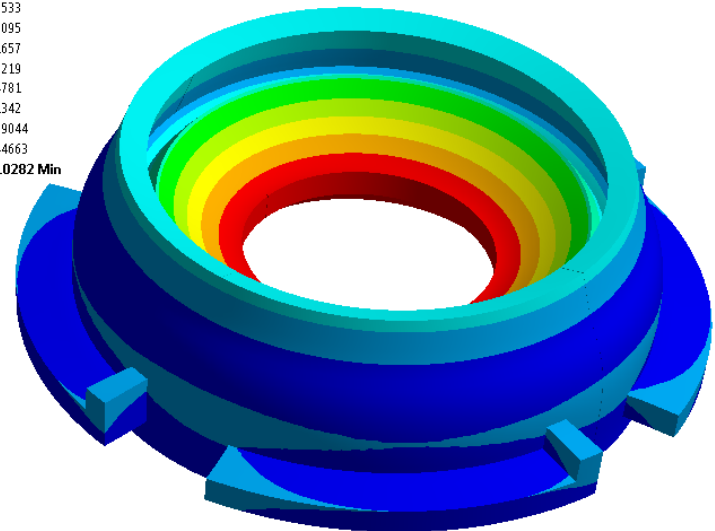
100 Max
99,993
99,987
99,98
99,974
99,967
99,961
99,954
99,947
99,941 Min



Total Deformation
Max = 3,19 mm

B: Static Structural
Total Deformation
Type: Total Deformation
Unit: mm
Time: 1
01.05.2011 16:56

3,1971 Max
2,8533
2,5095
2,1657
1,8219
1,4781
1,1342
0,79044
0,44663
0,10282 Min



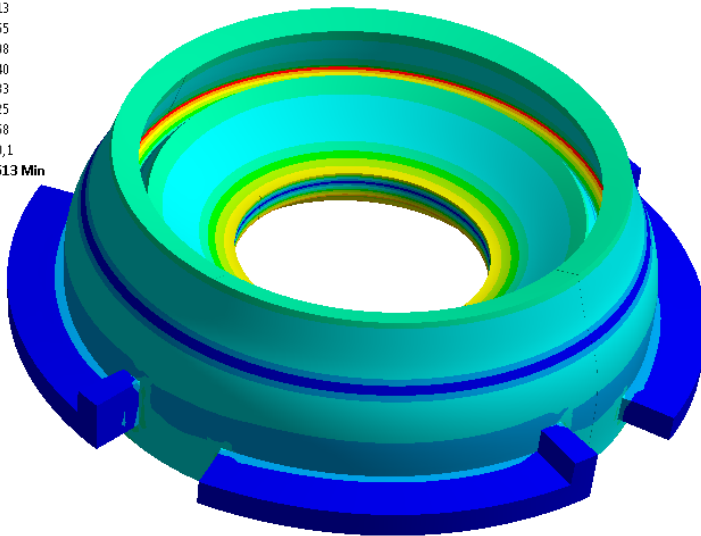
Nominal FE-Simulation

Equivalent Stress
Max = 50970 MPa

Equivalent Strain
Max = 0.24

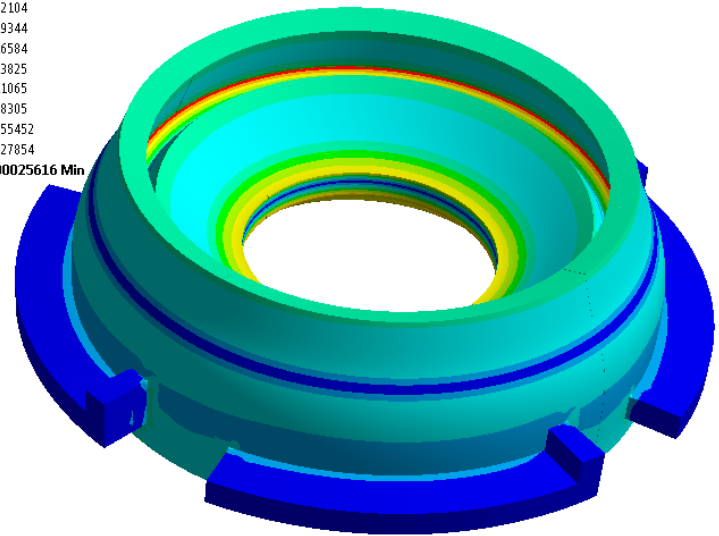
B: Static Structural
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 1
01.05.2011 16:59

50970 Max
45313
39655
33998
28340
22683
17025
11368
5710,1
52,513 Min



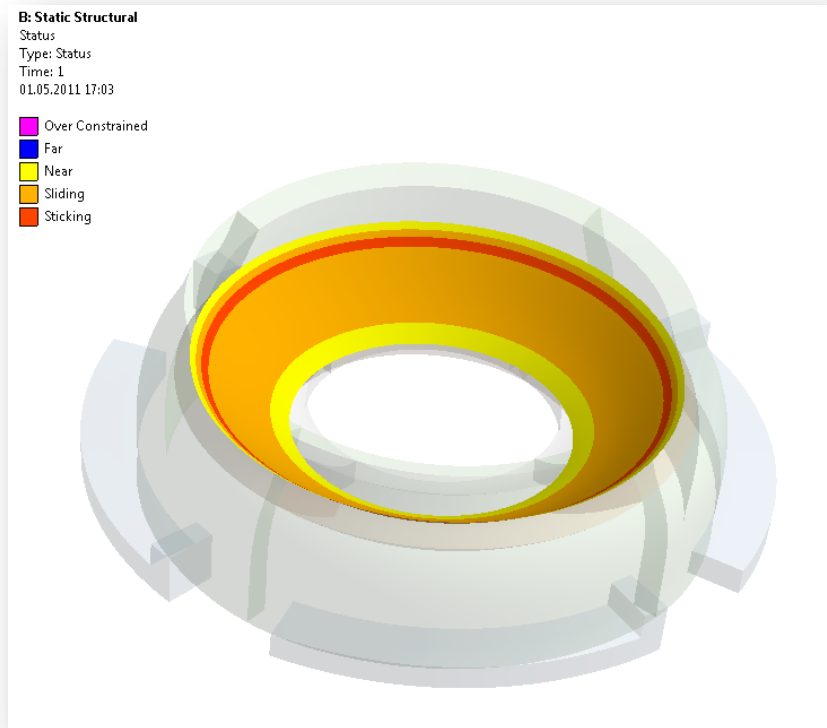
B: Static Structural
Equivalent Elastic Strain
Type: Equivalent (von-Mises) Elastic Strain
Unit: mm/mm
Time: 1
01.05.2011 17:00

0,24864 Max
0,22104
0,19344
0,16584
0,13825
0,11065
0,08305
0,055452
0,027854
0,00025616 Min

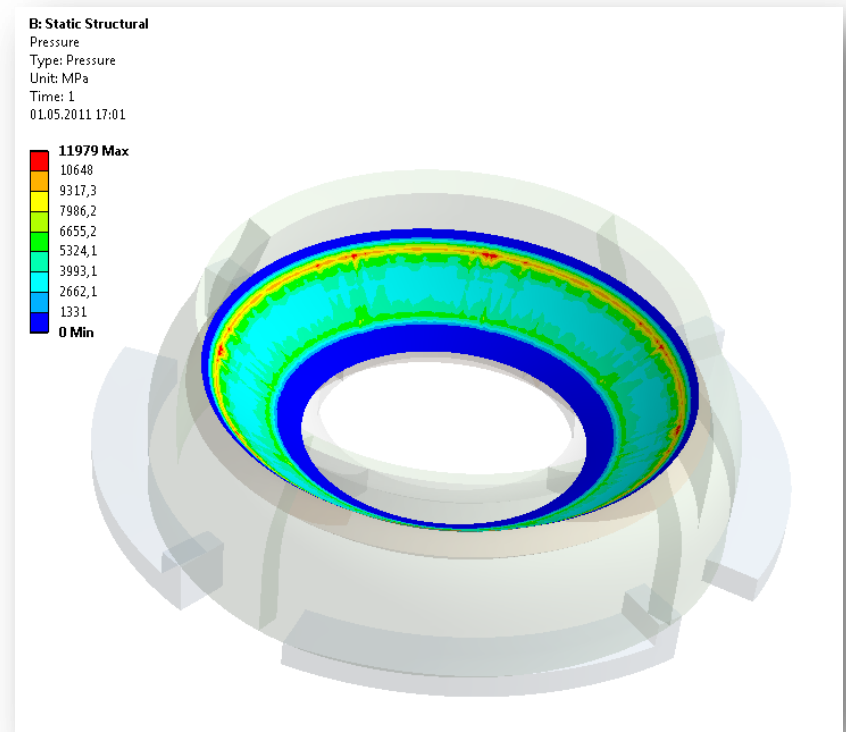


Nominal FE-Simulation

Contact Status

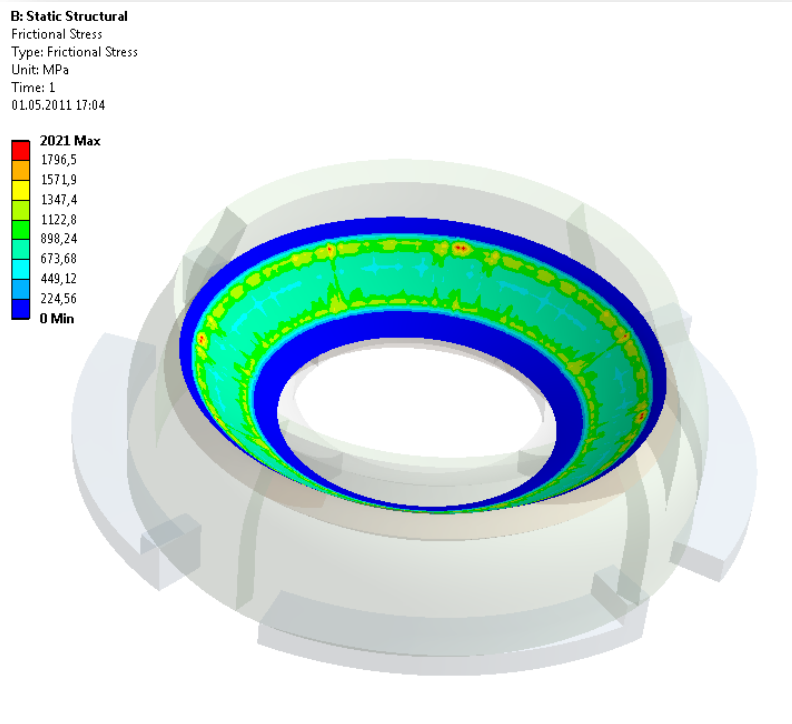


Contact Pressure
 Max = 11979 MPa

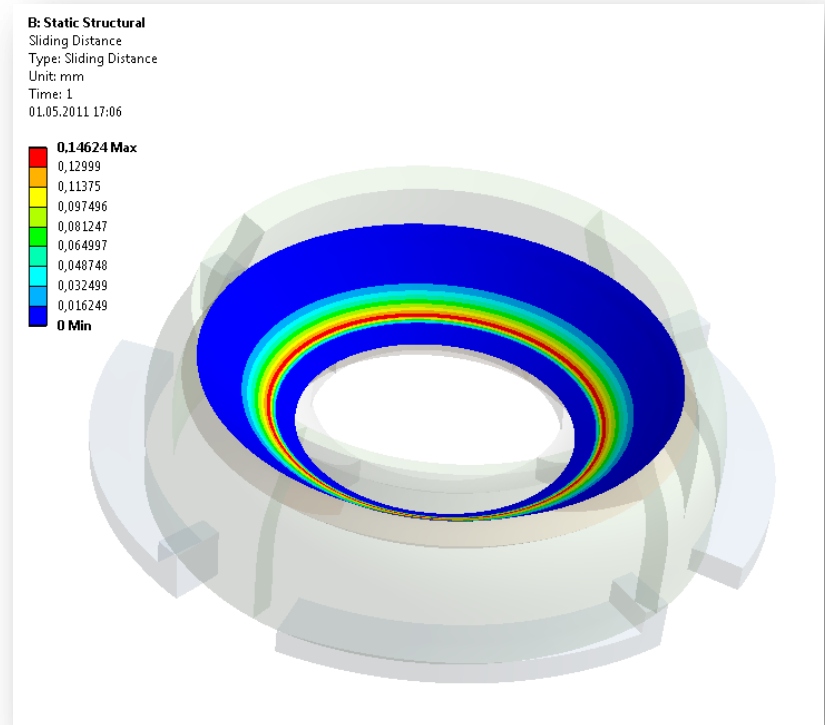


Nominal FE-Simulation

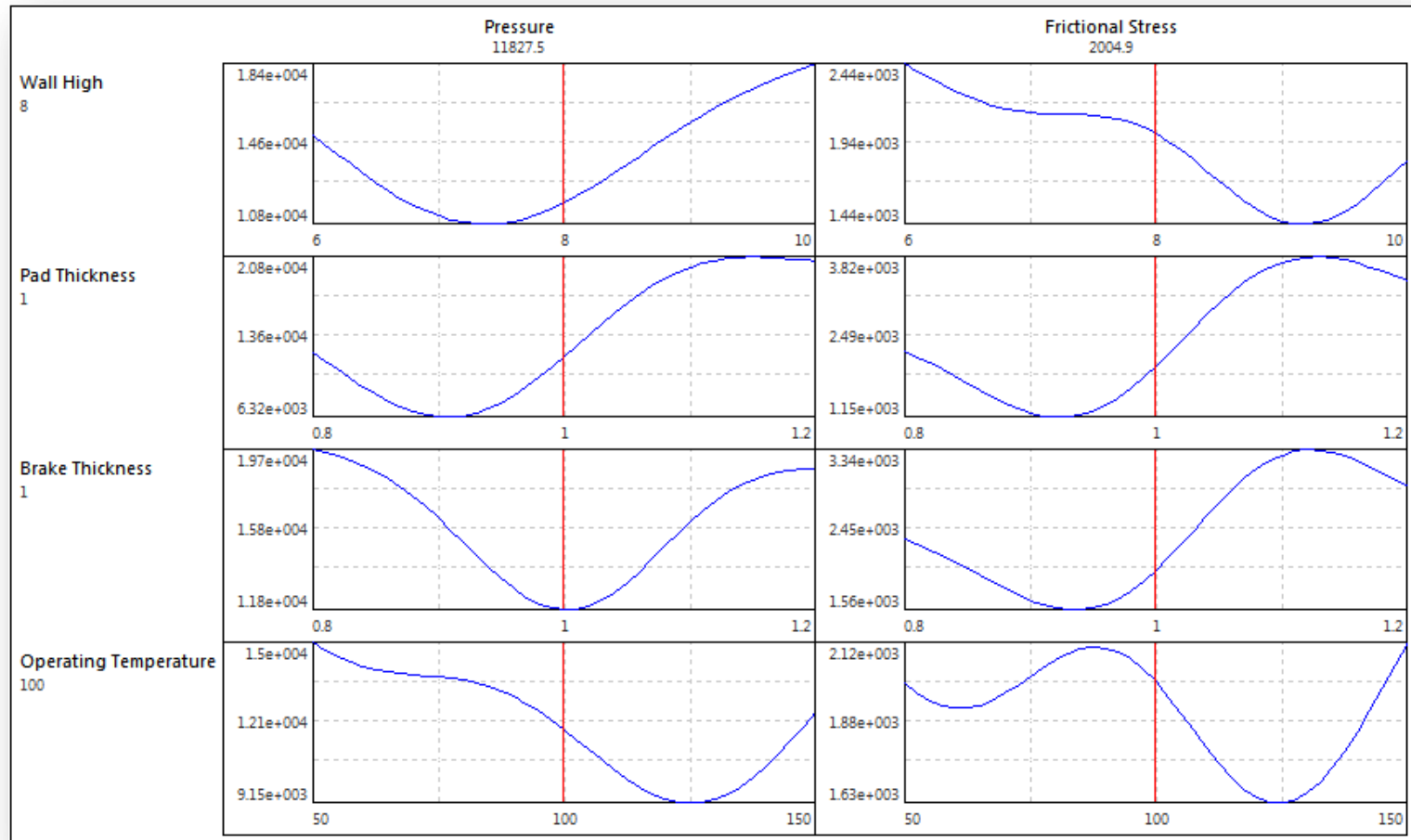
Frictional Stress
Max = 2021 MPa



Sliding Distance
Max = 0.146 mm

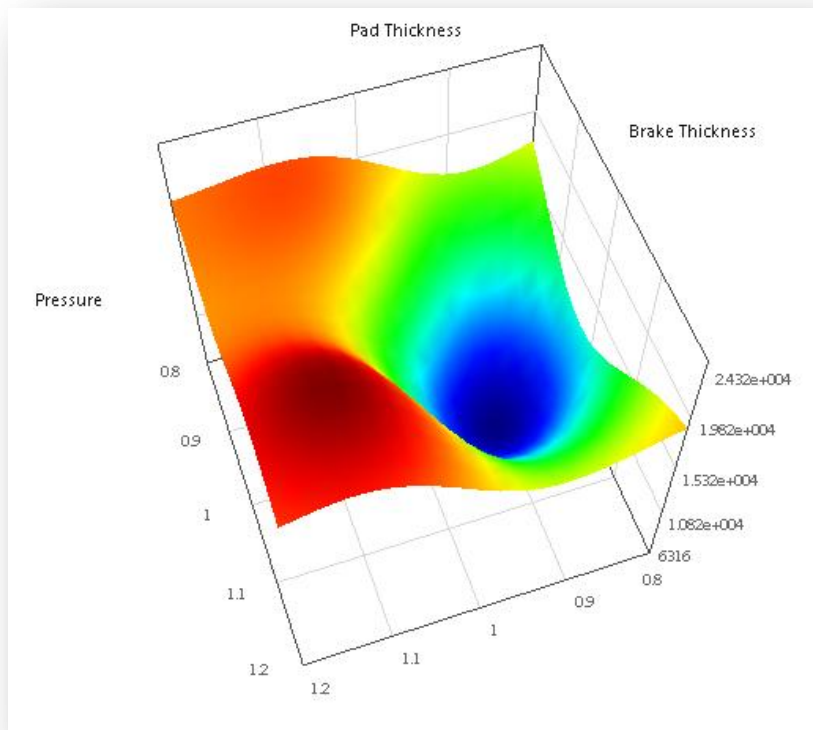


Design Space: 2D Section Diagrams

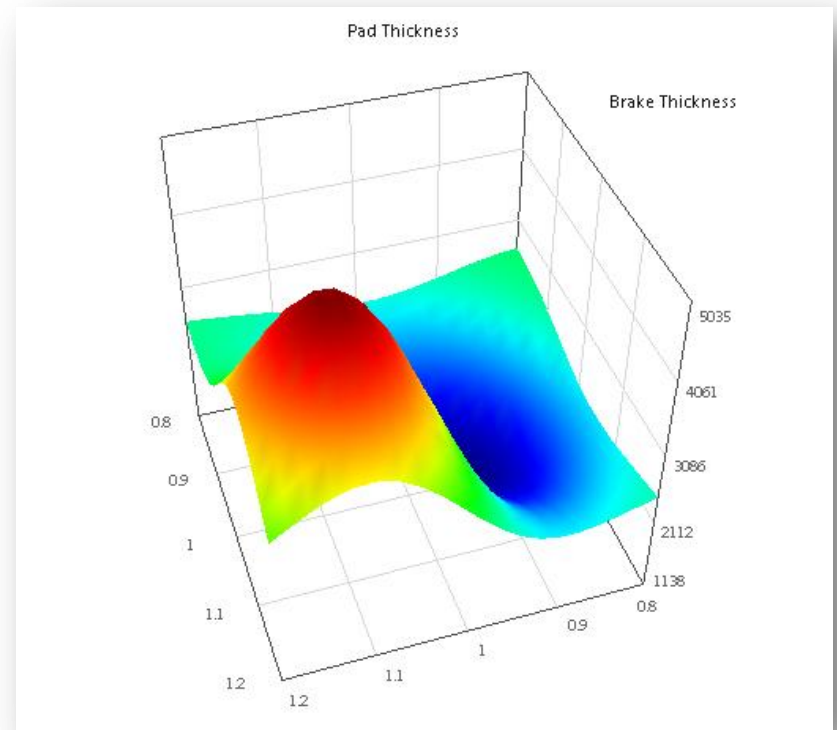


Design Space: 3D Graphics

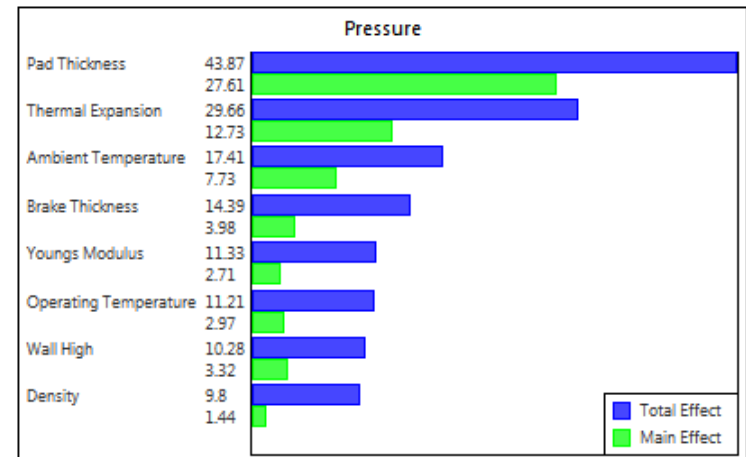
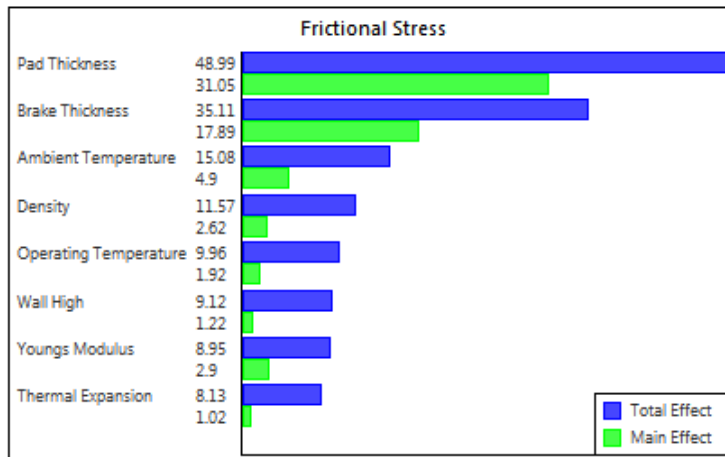
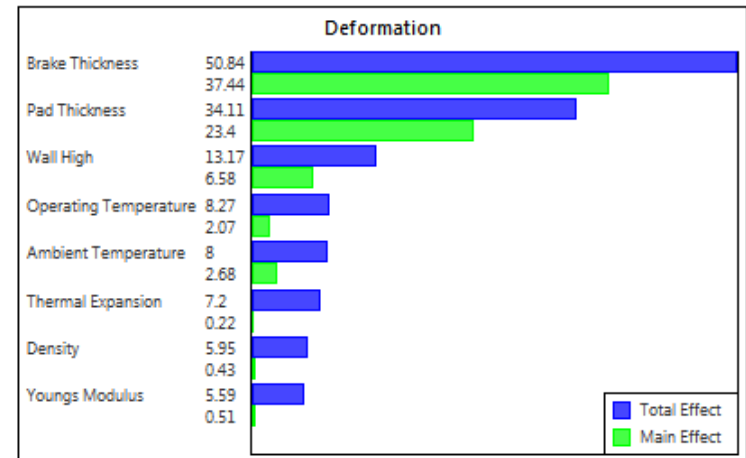
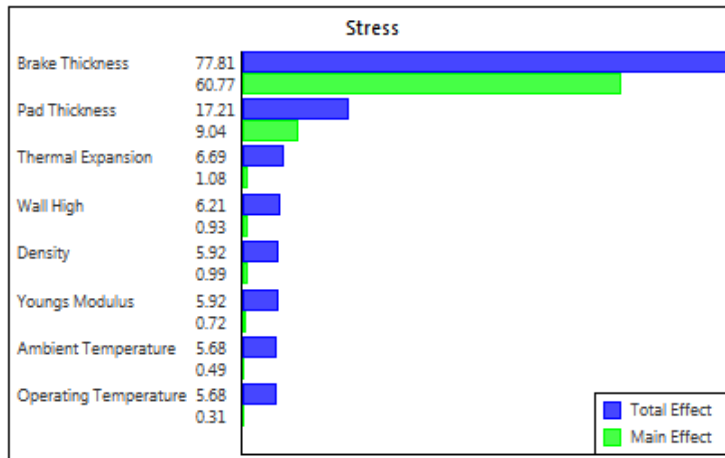
Contact Pressure



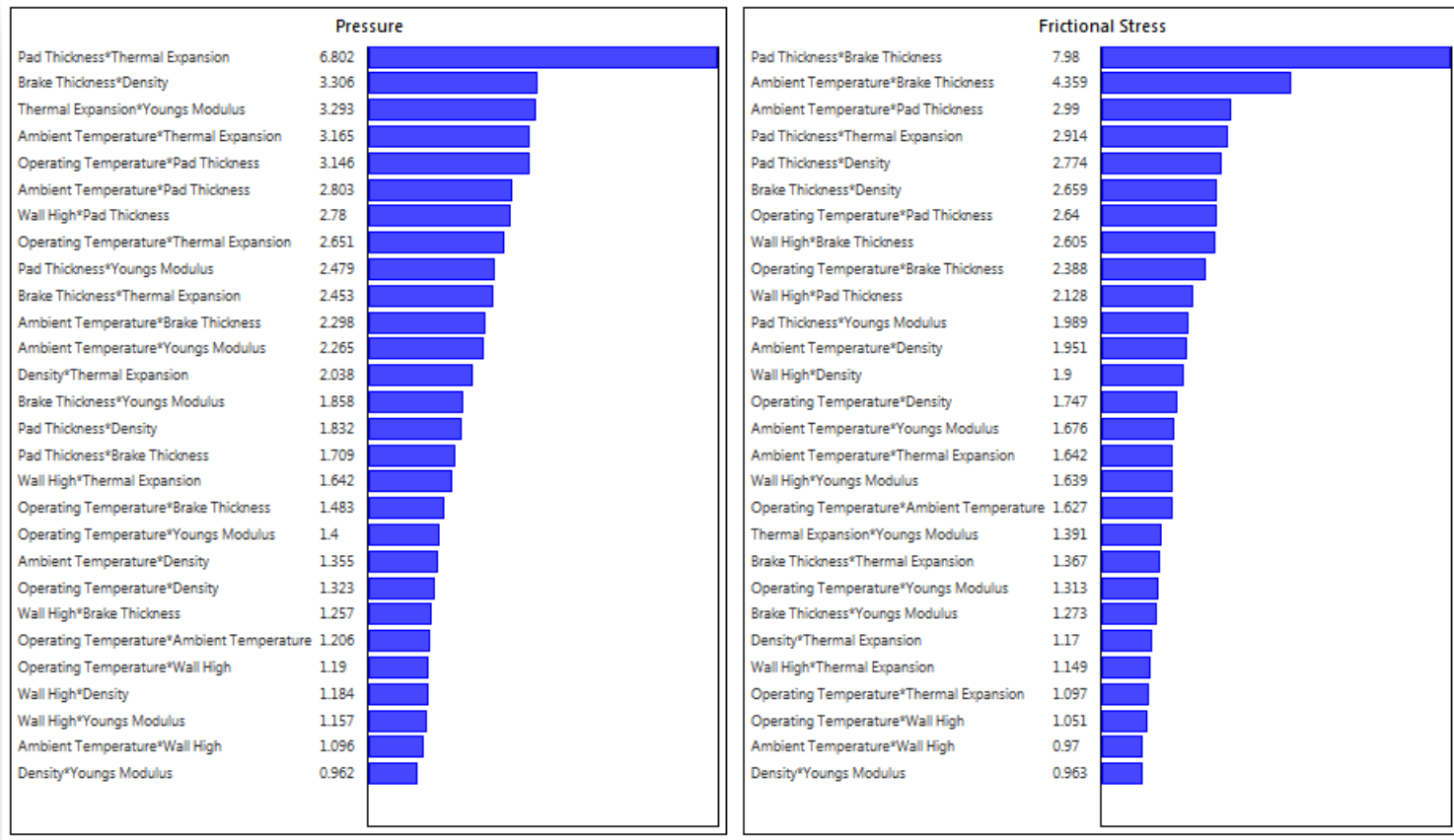
Contact Frictional Stress



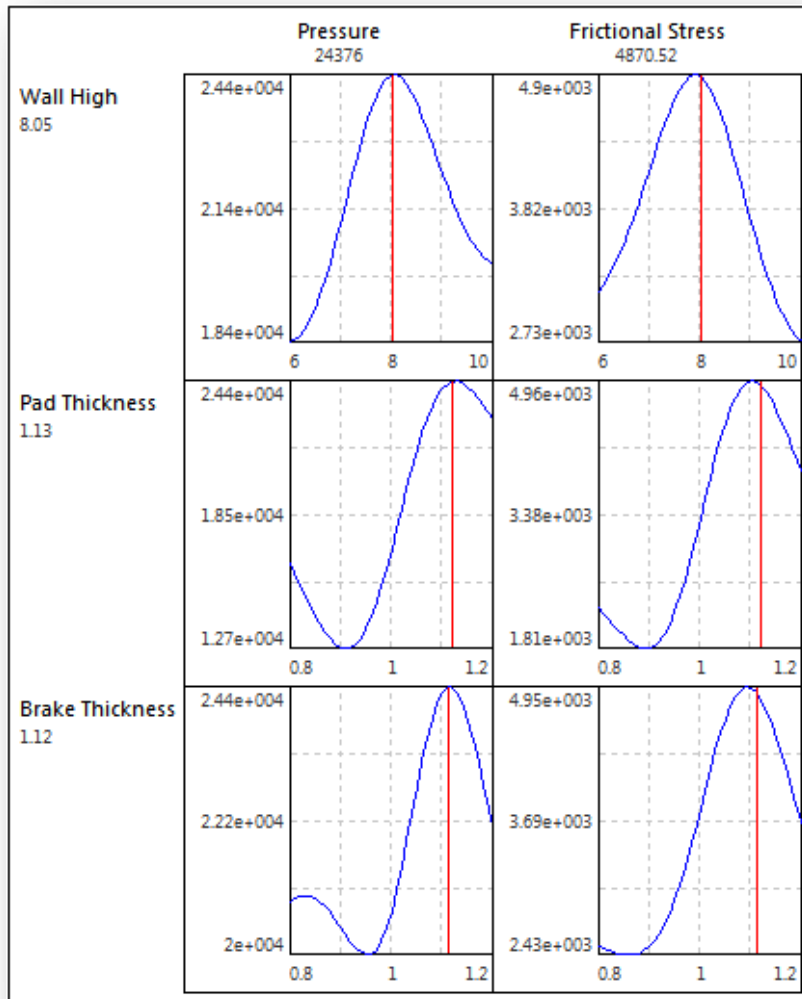
Global Sensitivity: Parameter Importance [%]



Global Sensitivity: Parameter Interaction [%]



Nominal Design Optimization



Optimization Goal:

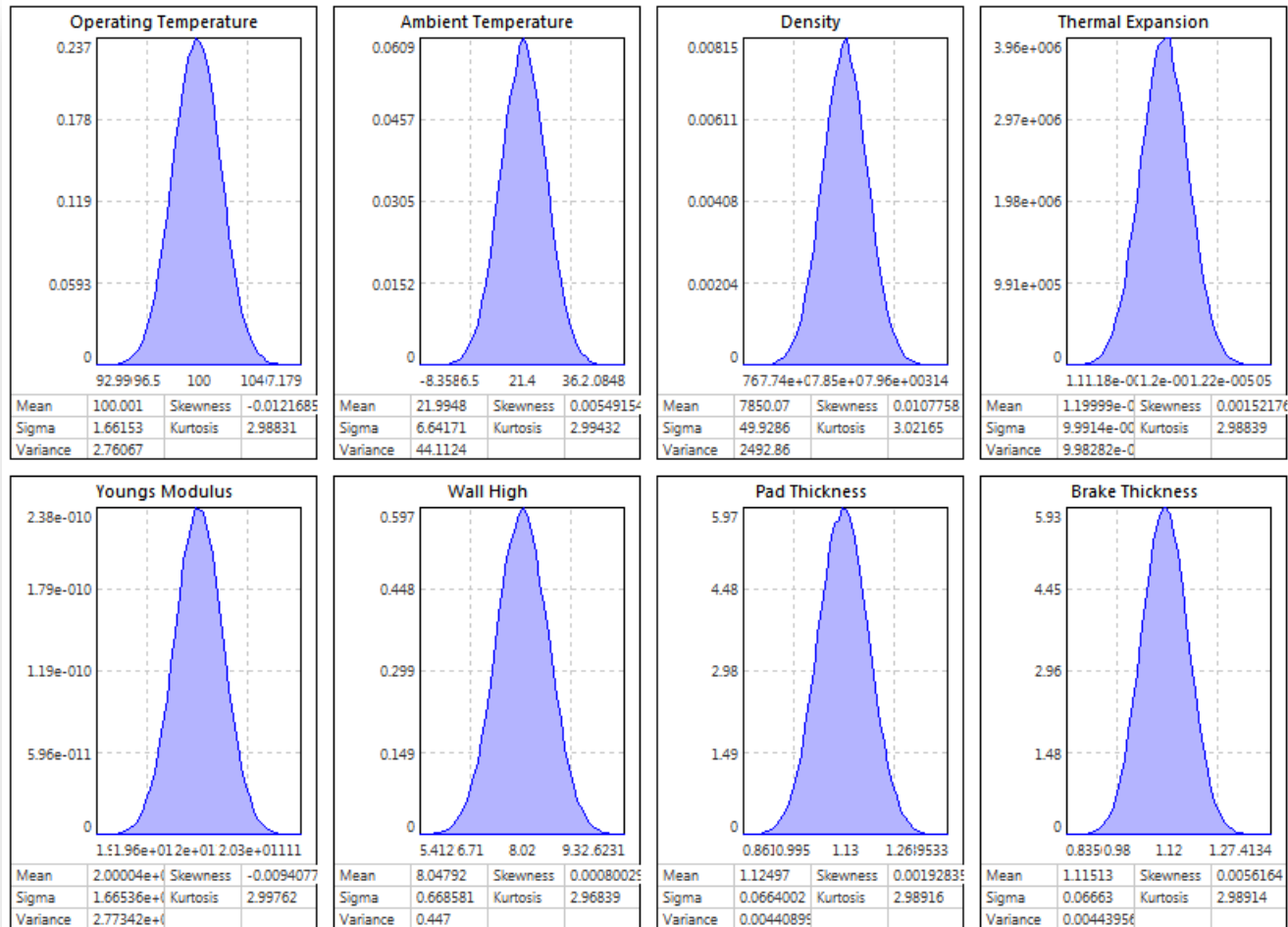
- Criteria: Maximize the Contact Pressure

Nominal Design:

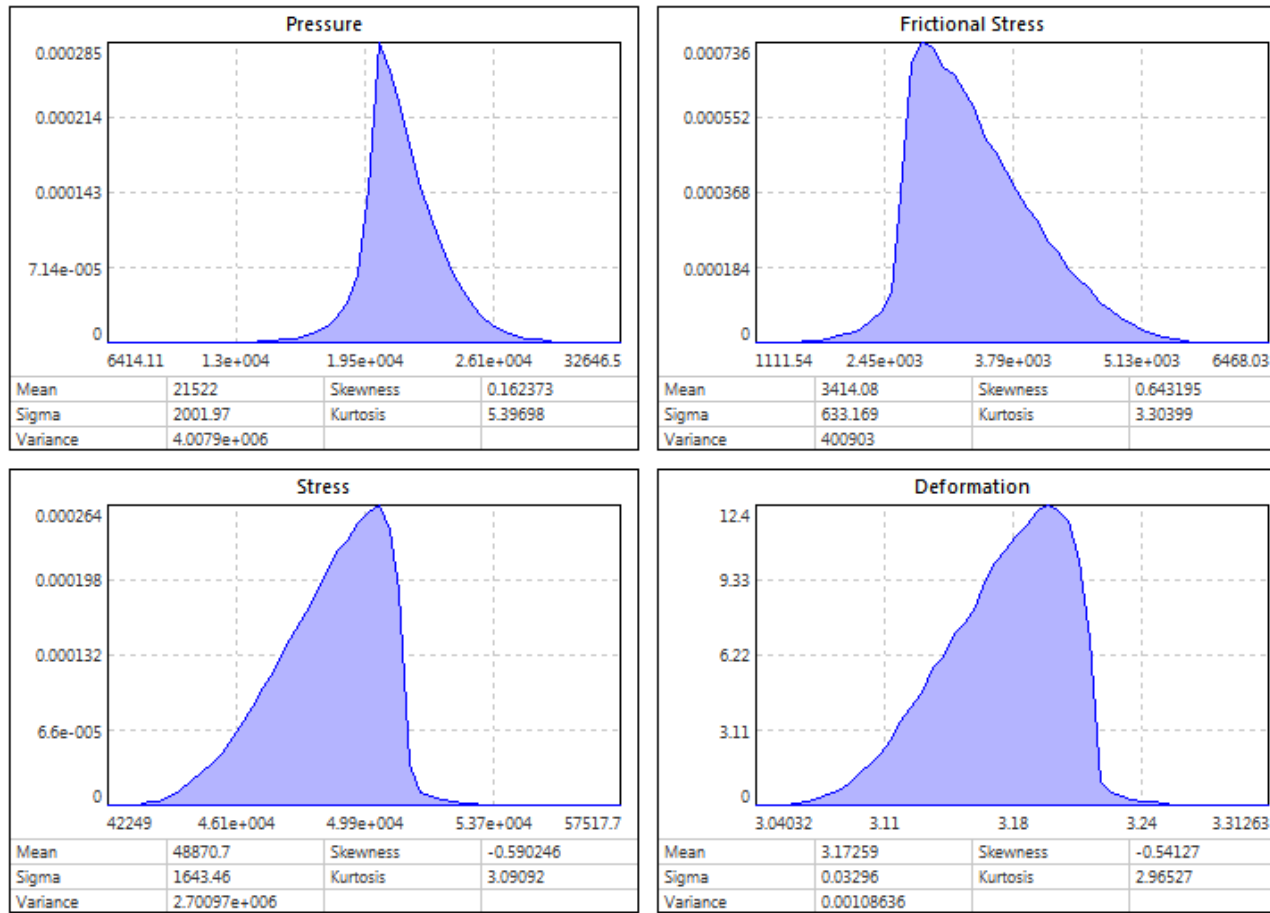
- Contact Pressure = 24376 MPa
- Contact Frictional Stress = 4870 MPa

Design Parameters			
Name	Nominal	Tolerance	Unit
Operating Temperature	100	10	°C
Ambient Temperature	22	40	°C
Wall High	8.05	4	mm
Pad Thickness	1.125	0.4	mm
Brake Thickness	1.115	0.4	mm
Density	7850	300	kg m ⁻³
Thermal Expansion	1.2e-005	6e-007	°C ⁻¹
Youngs Modulus	2e+011	1e+010	Pa

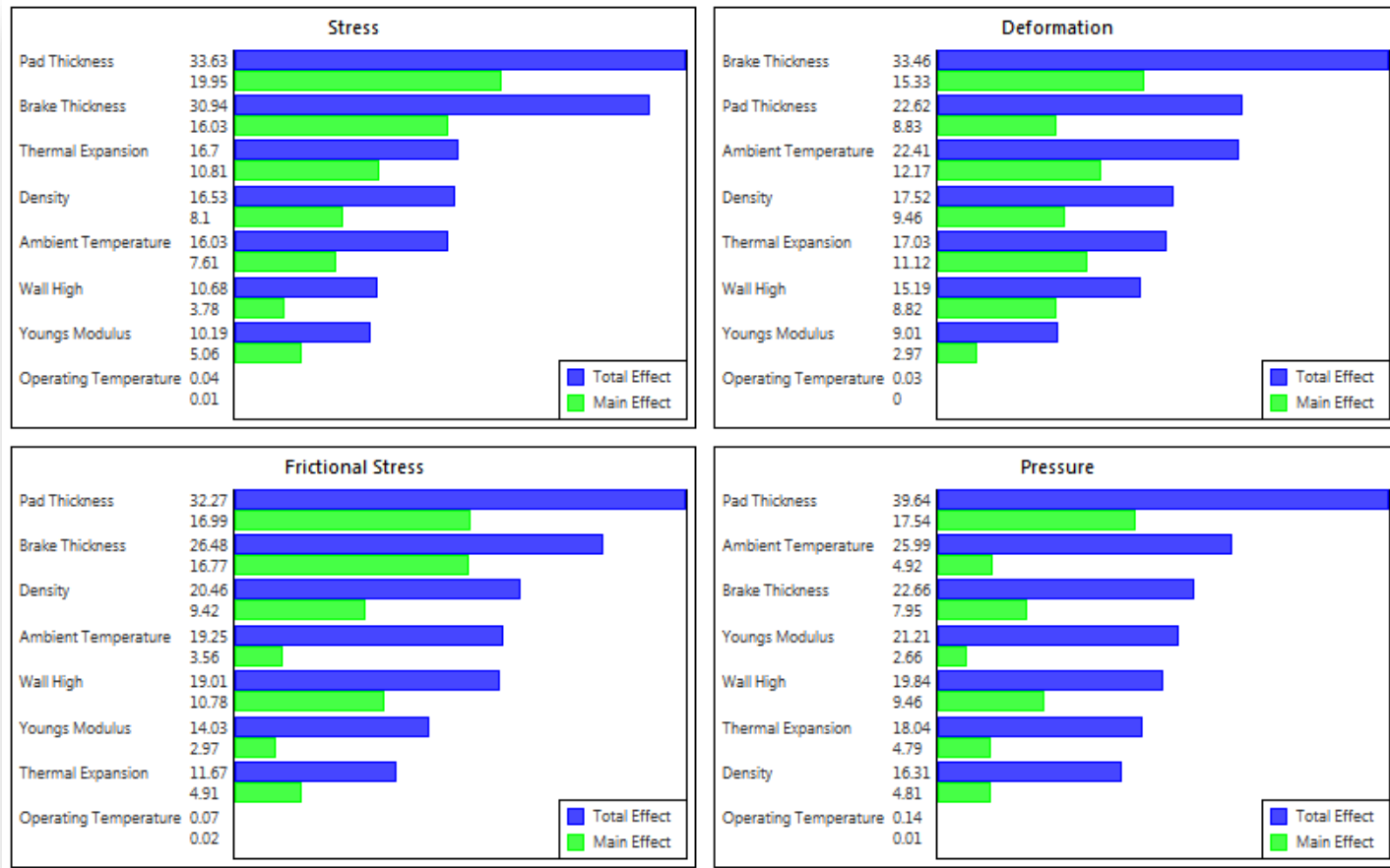
Uncertainty Parameters and Tolerances



Probabilistic Analysis



Design Sensitivity



Conclusion

Global sensitivity study based on the nonlinear meta model identifies significant design, environment or process parameters and its interactions.

Design optimization based on the meta model using adaptive Gaussian process is very fast and efficient.

Considering uncertainty parameters and tolerances, probabilistic analysis computes the stochastic distributions of the design goals. The design sensitivity shows the cause-effect-chain for the variability of the contact pressure.

OptiY® is the leading software platform for design optimization of all engineering fields using different commercial CAD/CAE-software or in-house codes.