physixfactor R&D SOLUTIONS

Time Dependent Sliding Performance of a Hyperelastic Seal

Presentation by

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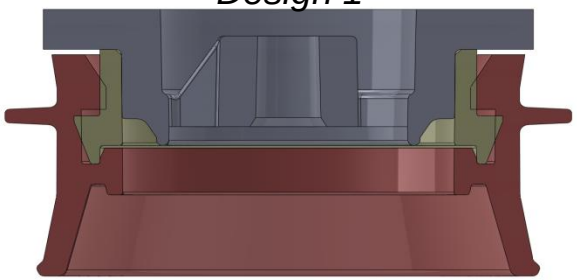
COMSOL CONFERENCE ROTTERDAM2013

Introduction

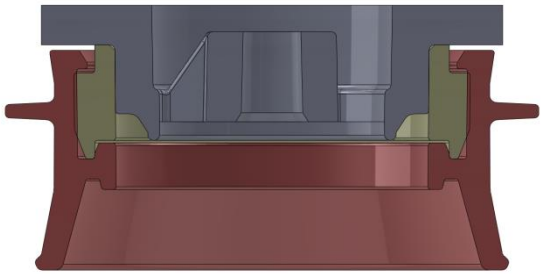
- For an automatic coffee machine a part inside is used for regular maitenance.
- The part consists of an hyper-elastic material and is attached to a metal ring.
- Use has been made of COMSOL, with mechanical module, hyper-elastic material is included in the model.
- Operator should apply a force between 10 – 14 N.

Designs

Design 1

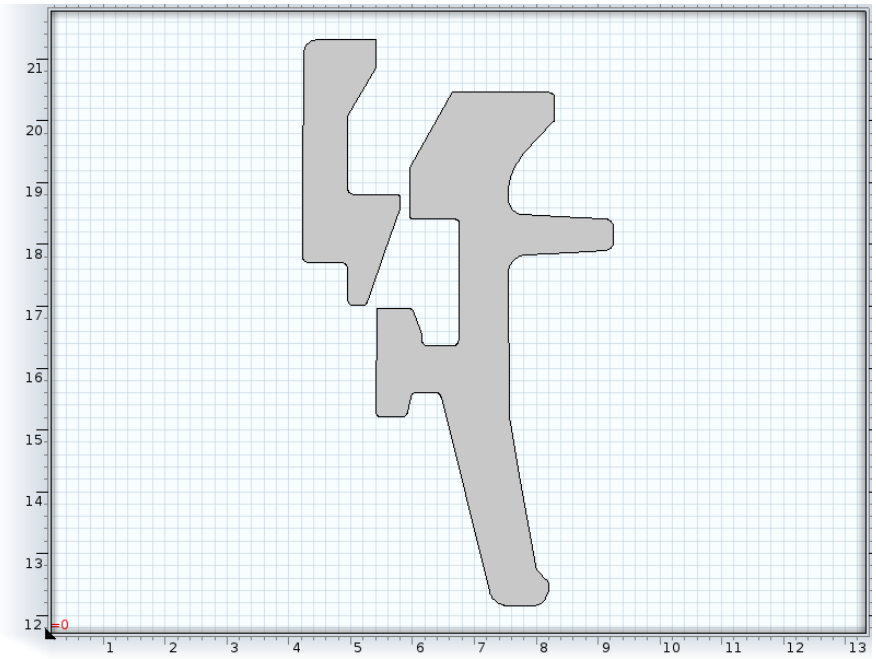


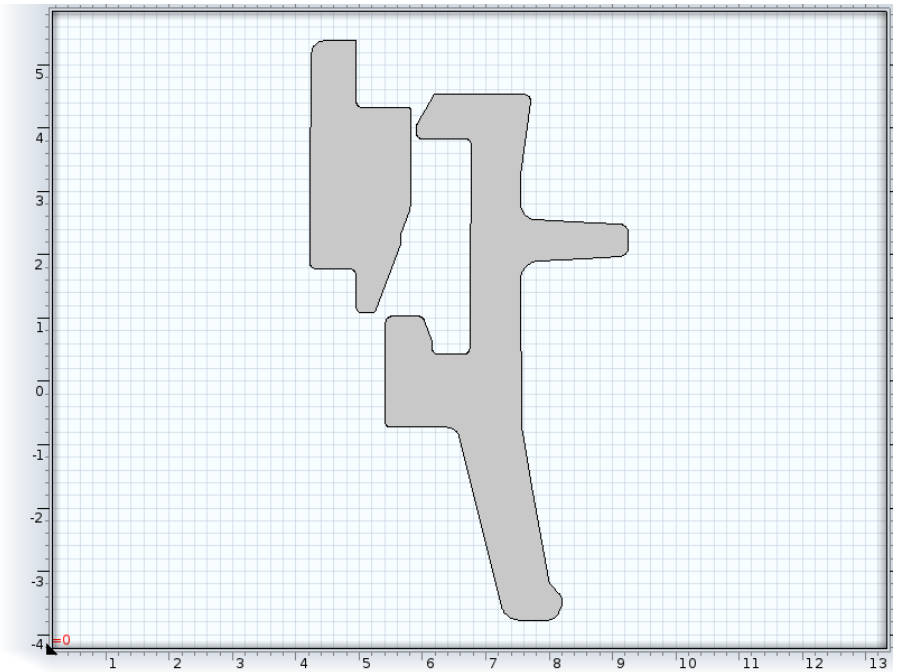
Design 2



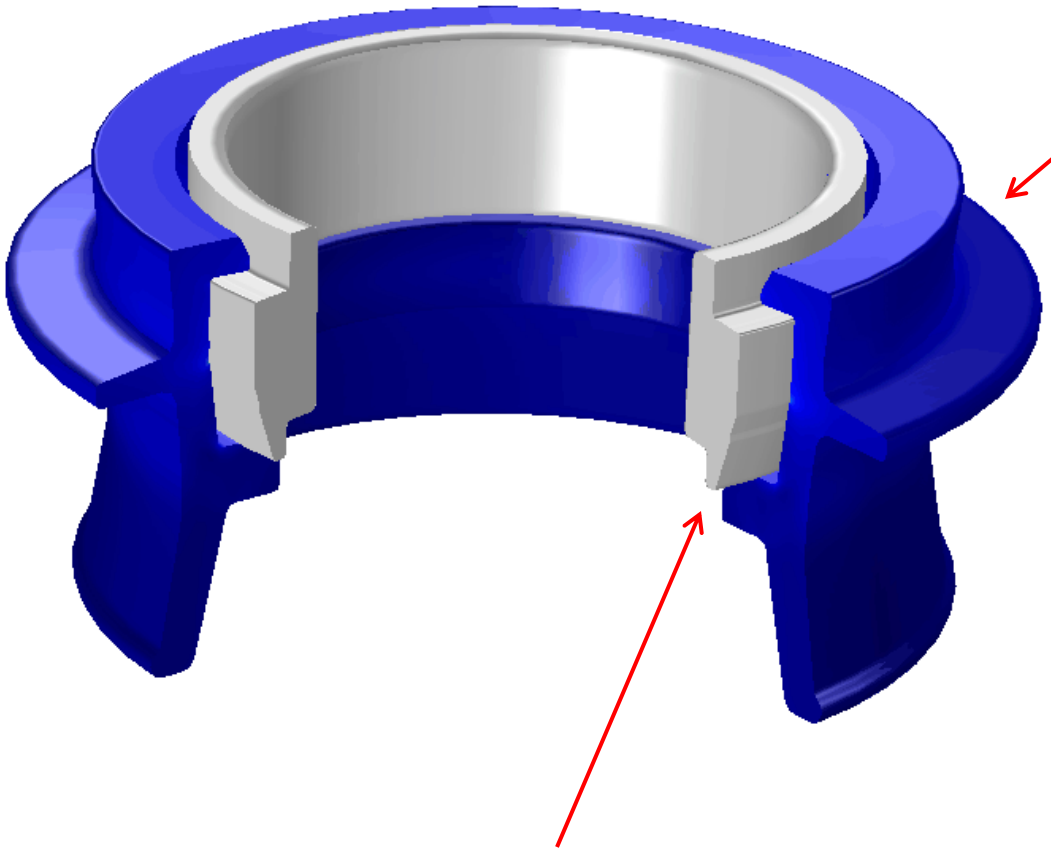
- Silicone ring can be pulled off the metal ring.
- Two designs should be simulated on force development during time.
- Force should be in the order of 10-14 N.
- Friction coefficient has been tested: $\mu = 2$.

Design1 & 2





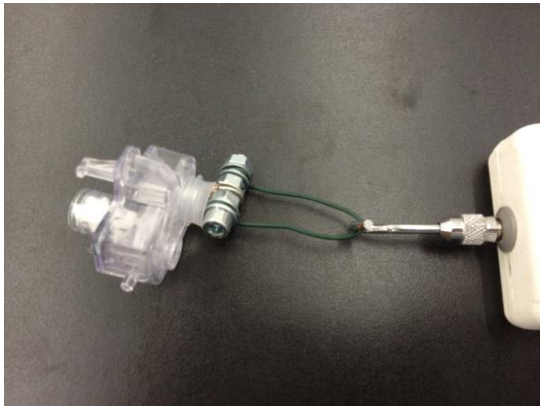
Overview of design 2



- Question:
- Simulate the firction force during dismantling of system.
- Complications :
  1. Stick slip
  2. Pre-stressed

Laboratory tests on friction

a) Slide pack on table: Should withstand sliding a pack of 5 kg on high friction surface (specify)



b) Tests reveal a friction coefficient of 2.

COMSOL Solid mechanics module

- Use has been made of
  - Contact mechanics with friction.
  - Hyper-elastic node: Neo-Hookean.

- Study 1:
  - Assembly of system, in order to include the prestress.
- Study 2:
  - Move the elastic seal over the metal part, with friction.
  - Time dependant study.

Material data

DATA TABLE FOR: Polymers: Elastomers: Silicone Rubber

Mechanical Properties

Quantity	Value	Unit
Young's modulus	1 - 5	MPa
Tensile strength	5 - 8	MPa
Elongation	200 - 800	%

Physical Properties

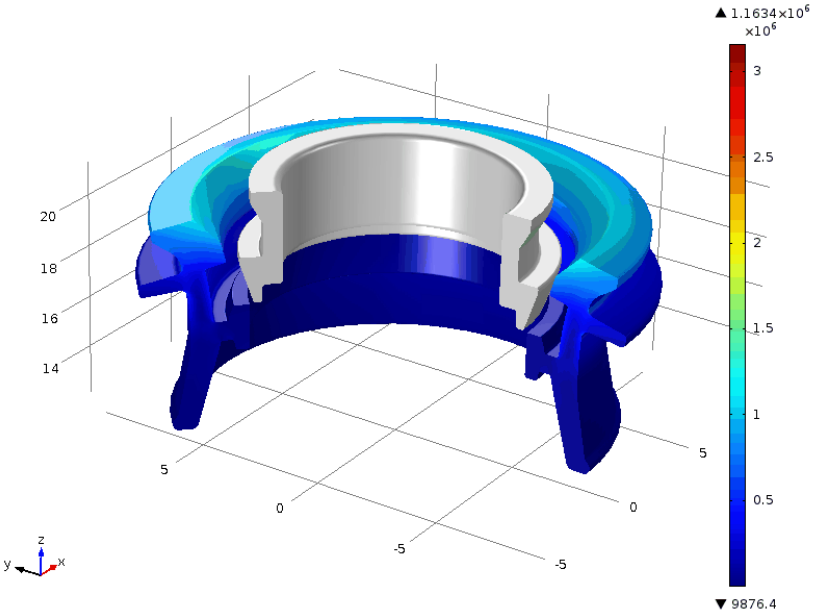
Quantity	Value	Unit
Thermal expansion	8.1 - 8.1	e-6/K
Thermal conductivity	0.22 - 0.22	W/m.K
Glass temperature	-120 - -123	°C
Service temperature	-70 - 250	°C
Density	1250 - 1250	kg/m^3
Resistivity	1e+19 - 1e+21	$Ohm.mm^2/m$
Dielectric loss factor	0.001 - 0.01	

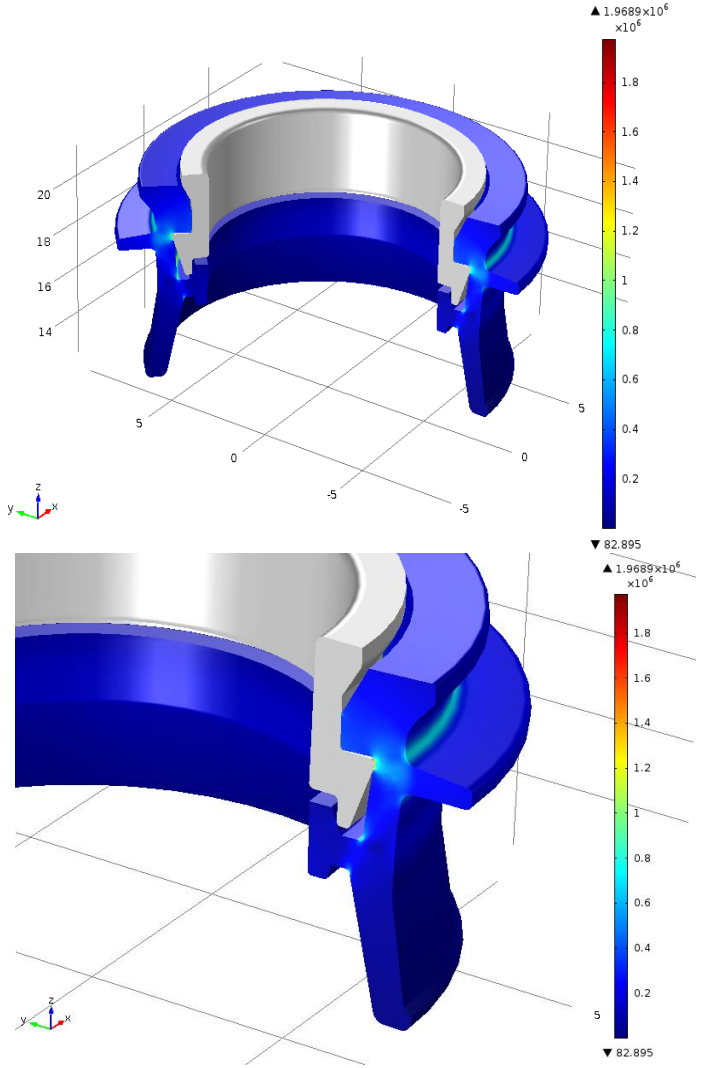
General

Remarks	Silicones are not or difficult to bond with an adhesive. Bonding is only possible with cyano-acrylaat after the application of a primer. With cyano-acrylaat it is not possible to bond with glass, stone and concrete.

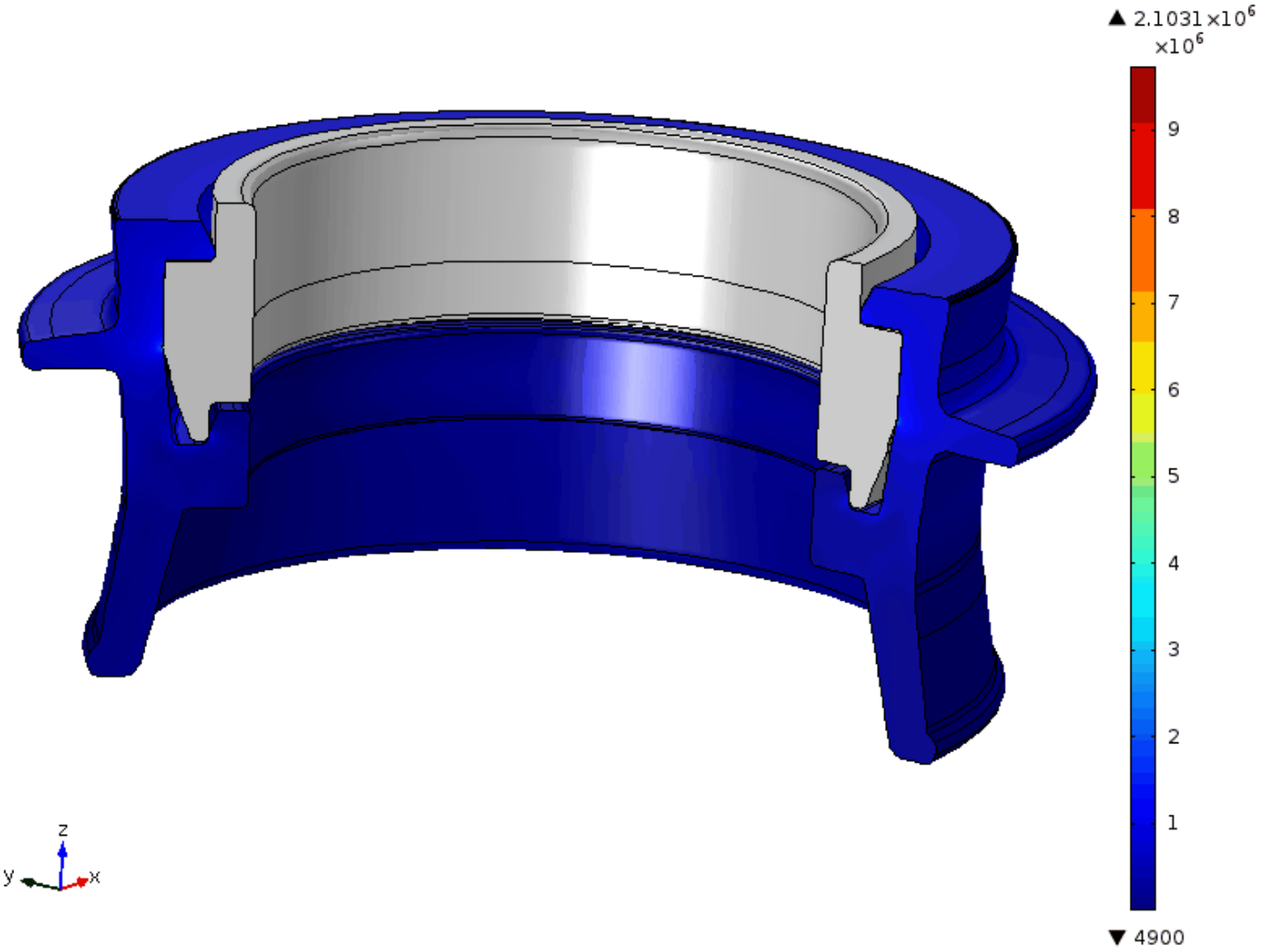
SAMPLE: ELASTOMERS

Preparation of simulation. Assembling Design 1

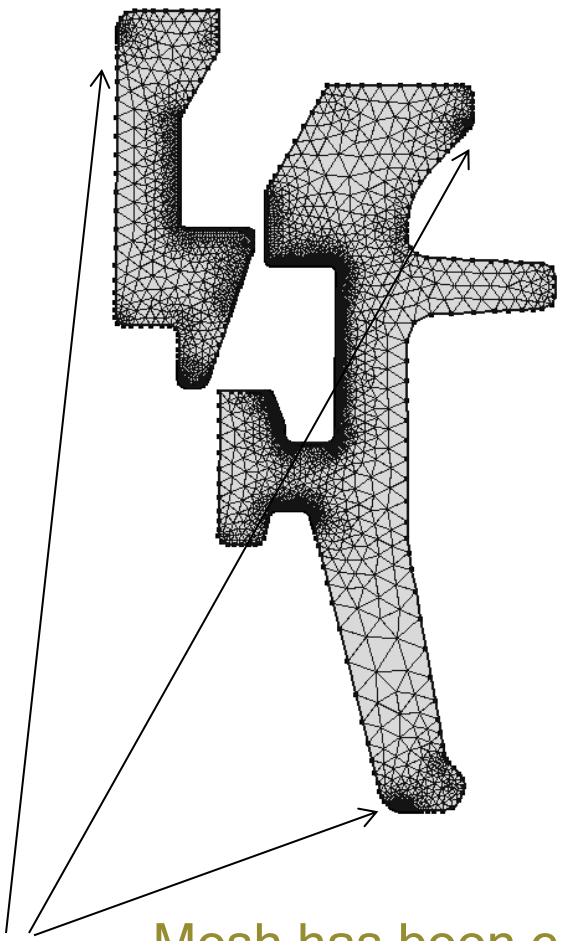




Stress development design 2



Some aspects of the mesh, design 1



Mesh has been cleaned prior to long runs.

Mesh

Geometric Entity Selection

Geometric entity level: Entire geometry

Statistics

Complete mesh

Element type: All elements

Triangular elements:	5415
Edge elements:	541
Vertex elements:	87

Domain element statistics

Number of elements:	5415
Minimum element quality:	0.6872
Average element quality:	0.9492
Element area ratio:	1.275E-4
Mesh area:	15.7 mm^2
Maximum growth rate:	2.328
Average growth rate:	1.352

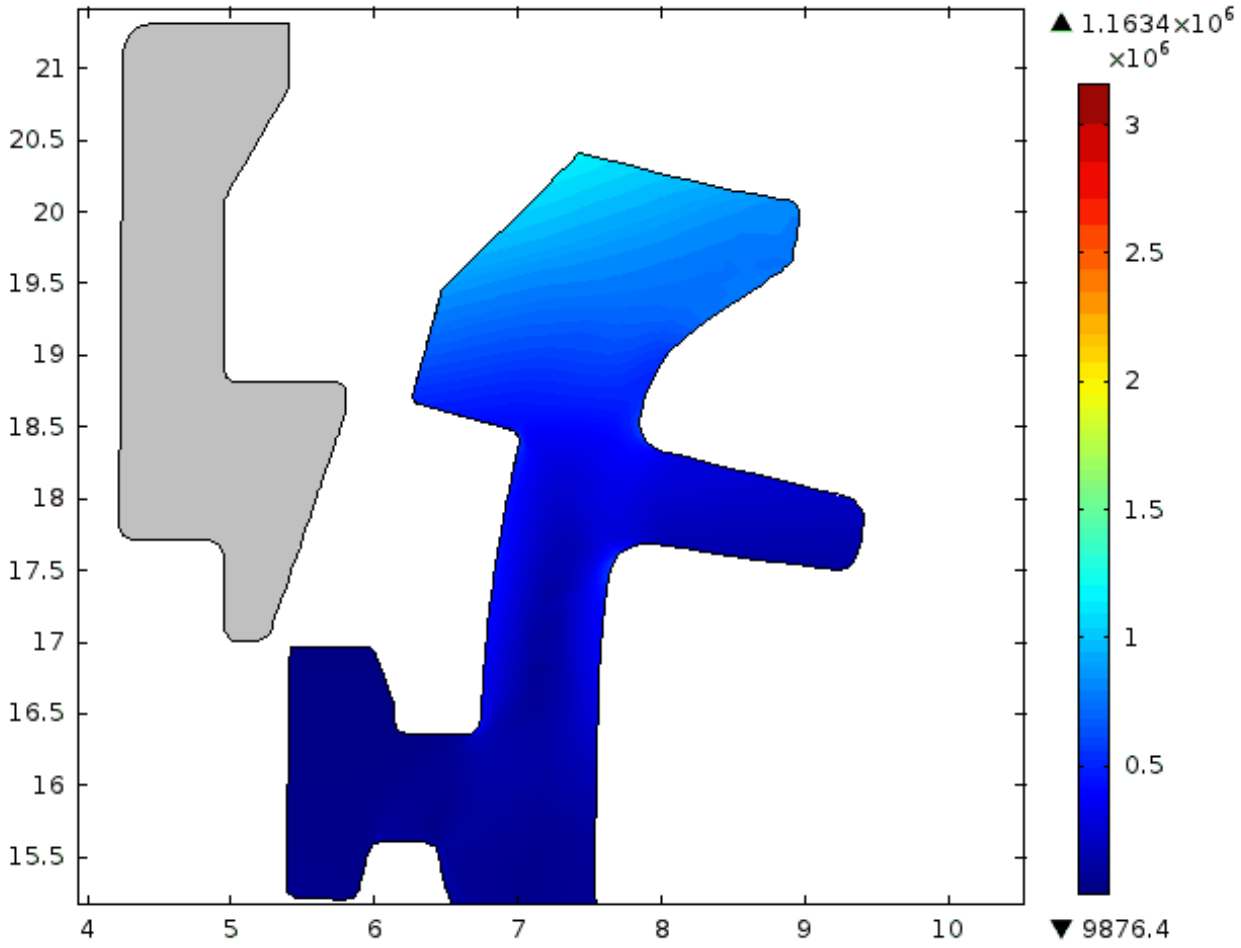
Element Quality Histogram

Final mesh properties.

Some remarks on simulation

- 2D axi-symmetric simulation.
- Mesh should be fine at contact points.
- Use small time steps, especially when stick slip occurs.
- Simulation time of 1 run approx. 1.5 hours
  - Can be optimised (Get the job done!)

Assembly Design 1



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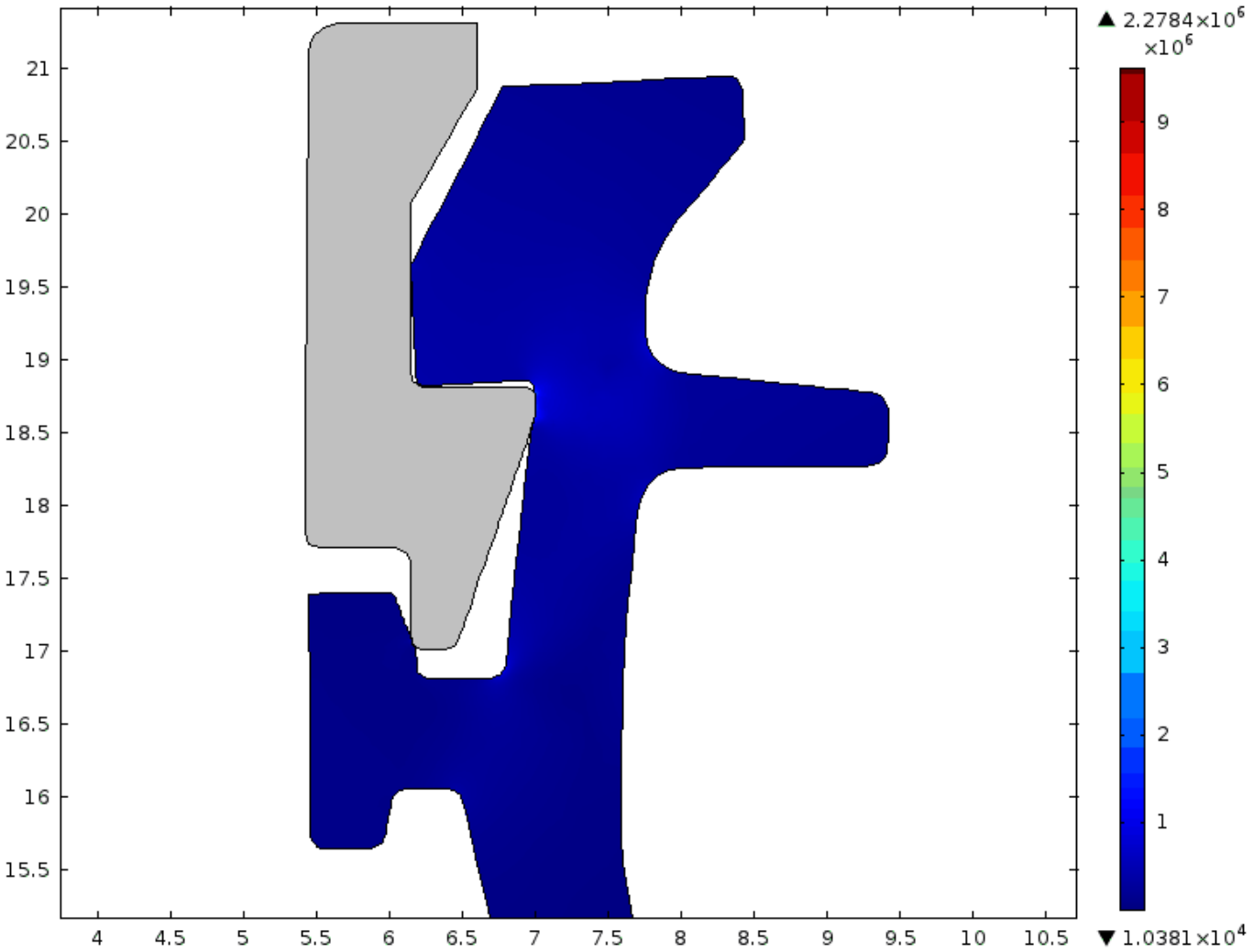
Peel off , Design 1



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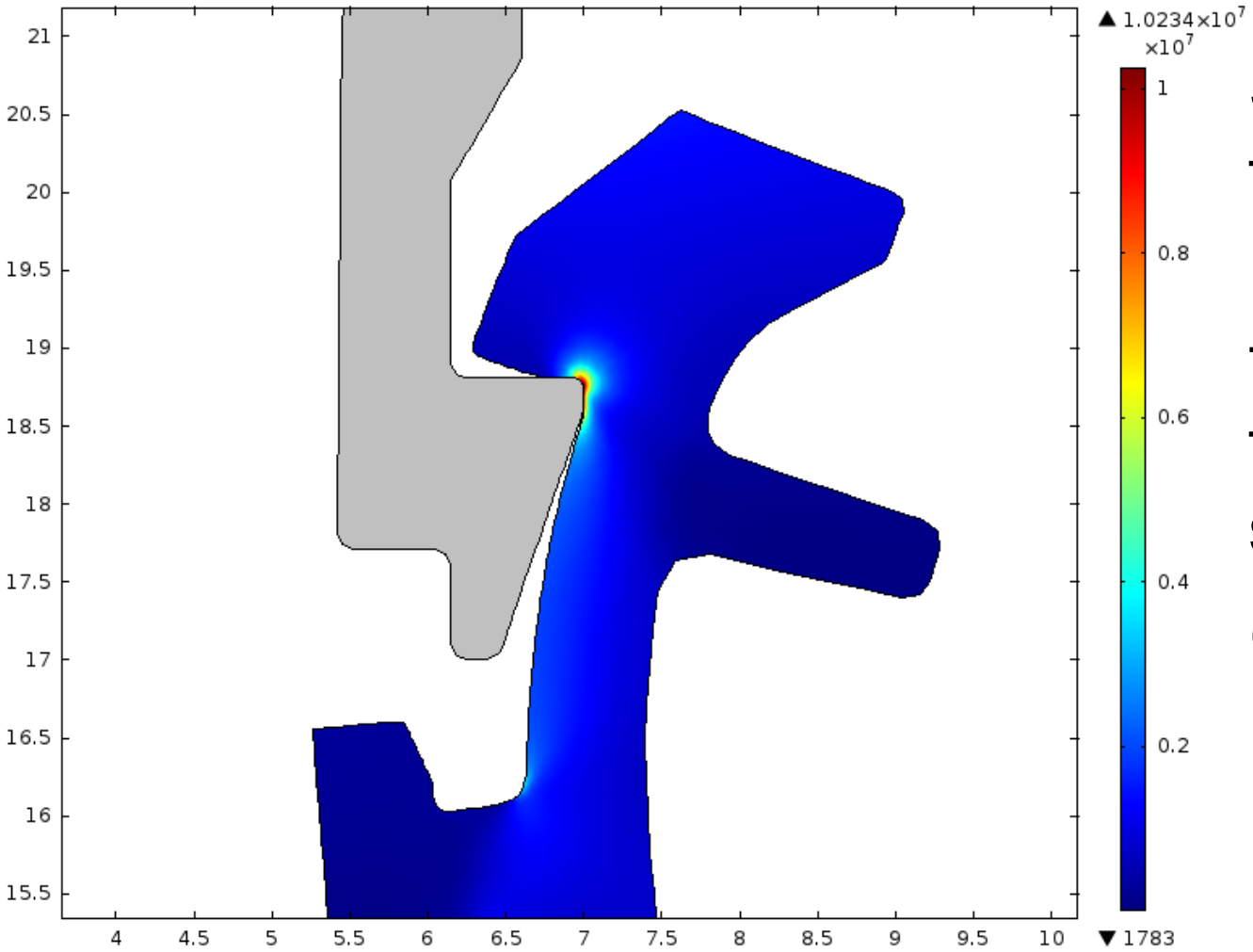
Design 1



Situation just for collapse.

Impression is that the hook function is significant.

(Maybe too much)

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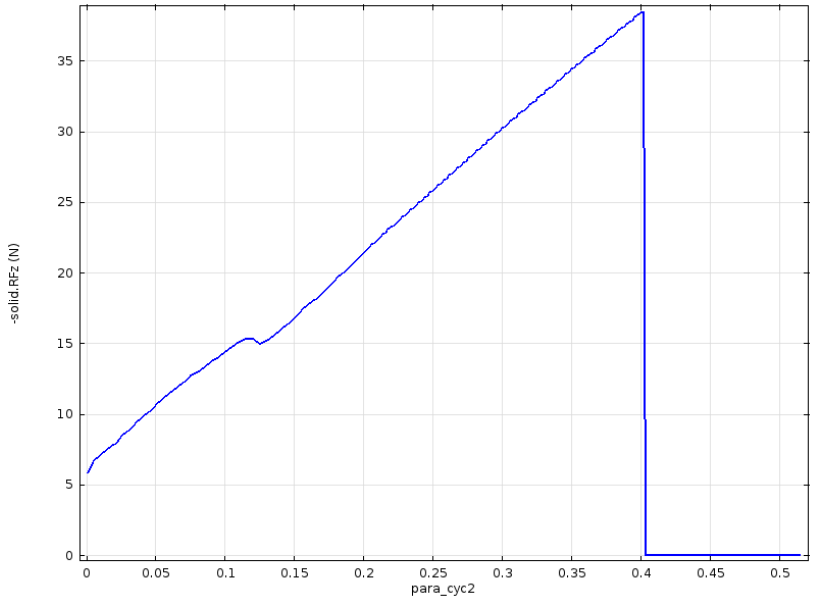
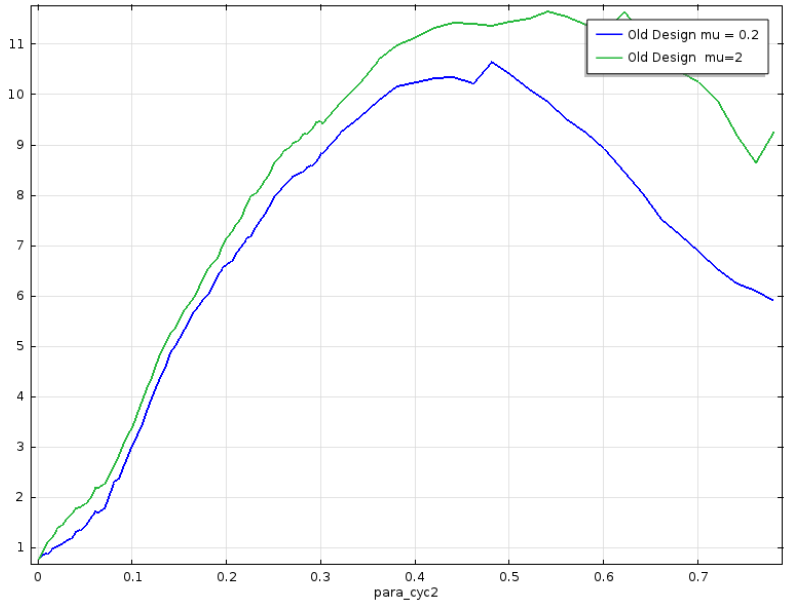
Force on seal during peel off. Design 1 & 2

Design 1



Design 2



- Left design 1, Peak force can be seen.(μ=0.4!)
- Right design 2, Peak stress around 11- 14 N.

An overview of the two simulations

Solver time	Design 1	Design 2
Study 1: Assembly	52 sec	60 sec
Study 2: Pull off	70 min	87 min
	75 kDOF Axi symmetric	95 kDOF Axi symmetric
Mesh size		

Some remarks

- With the friction coefficient of 2 (Laboratory measurements), the predicted maximum value of 11- 14N was measured in practice.
- A slight modification of the rounding of the metal ring was suggested for a smoother performance.
- Hyper-elastic module works well.
- Stick slip simulations are delicate, and take some time to study the behavior and tuning to get a stable solution.

People Creating Value

I would like to thank the support and measurements done by People Creating Value.

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People creating **value** through the **implementation** of new **ideas**

- Thanks to the People Creating Value
- Thanks for your attention.