

Time Dependent Sliding Performance of a Hyperelastic Seal

Presentation by

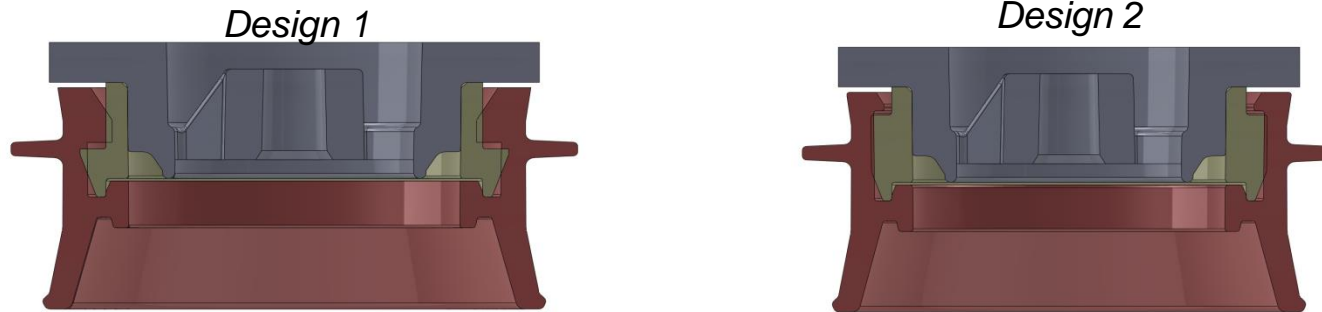
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COMSOL
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Introduction

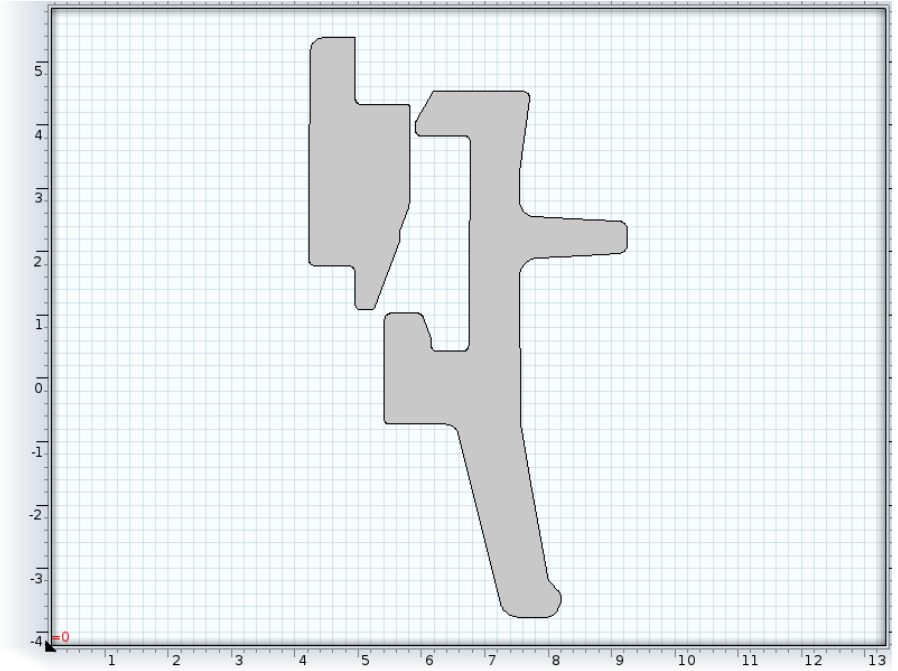
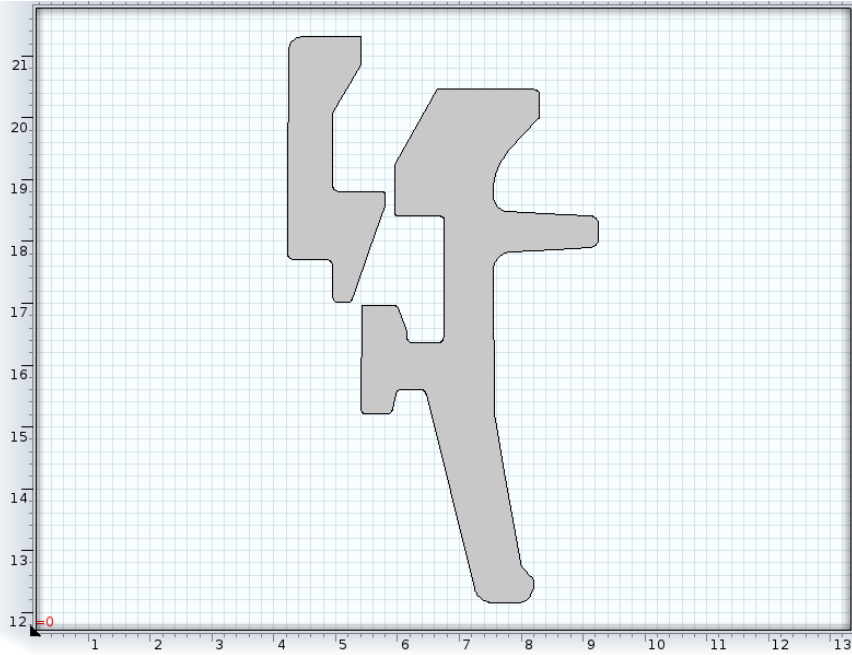
- For an automatic coffee machine a part inside is used for regular maintenance.
- The part consists of an hyper-elastic material and is attached to a metal ring.
- Use has been made of COMSOL, with mechanical module, hyper-elastic material is included in the model.
- Operator should apply a force between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

Designs



- 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: $\mu = 2$.

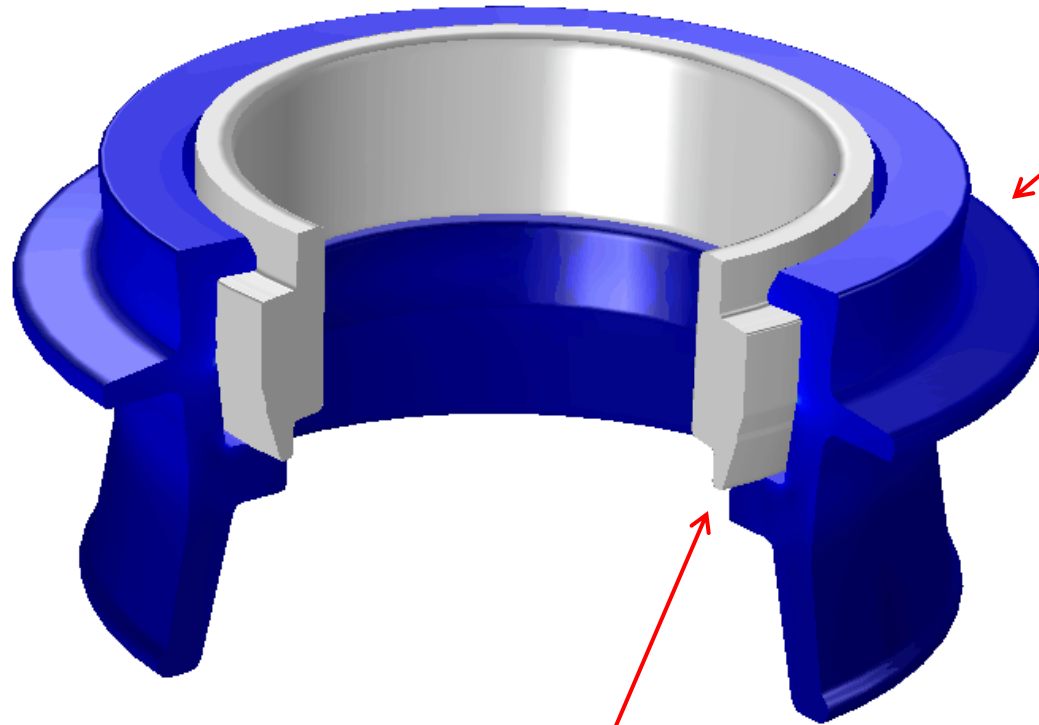
Design1 & 2



Overview of design 2



Hyper-elastic seal

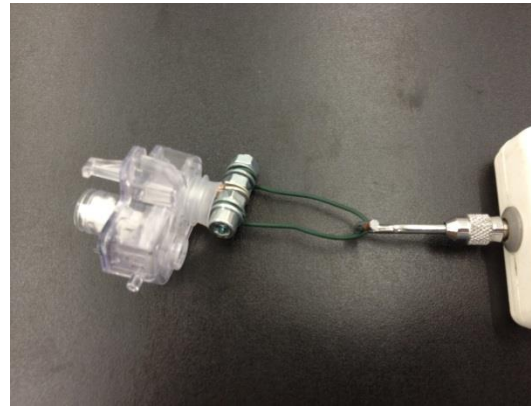


- Question:
- Simulate the friction force during dismantling of system.
- Complications :
 1. **Stick slip**
 2. **Pre-stressed**

Metal ring

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

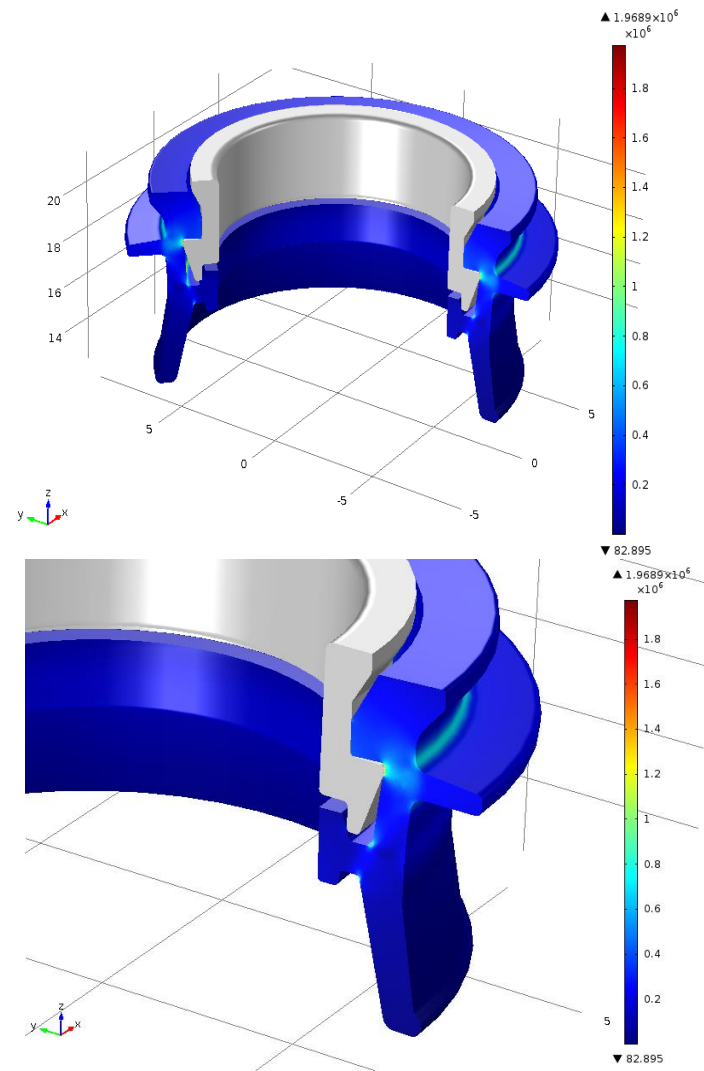
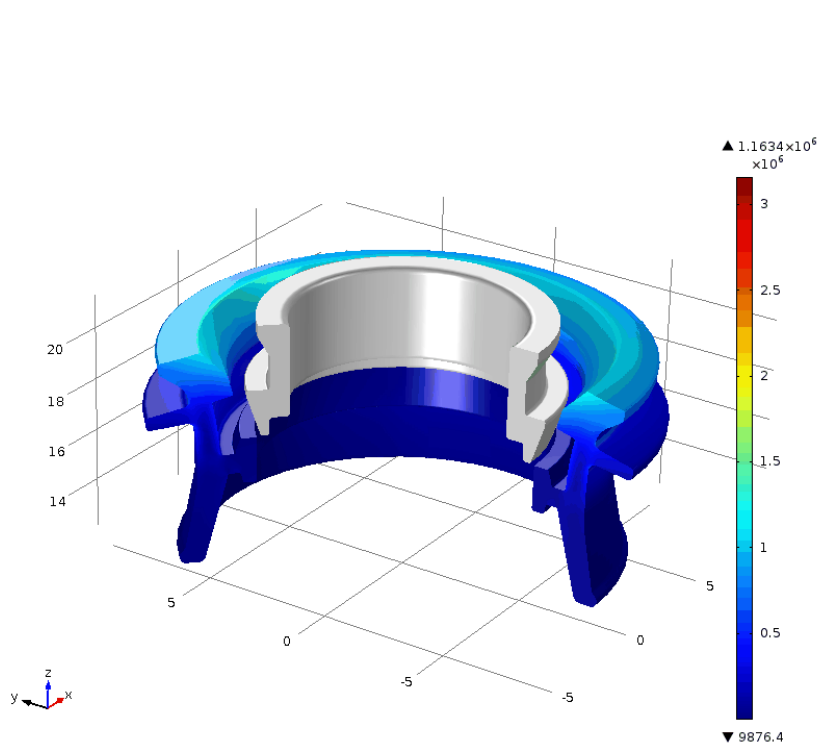
Quantity	Value	Unit
Thermal expansion	8.1 - 8.1	e-6/K
Thermal conductivity	0.22 - 0.22	W/m.K
Glass temperature	-120 - -123	°C
Service temperature	-70 - 250	°C
Density	1250 - 1250	kg/m ³
Resistivity	1e+19 - 1e+21	Ohm.mm ² /m
Dielectric loss factor	0.001 - 0.01	

General

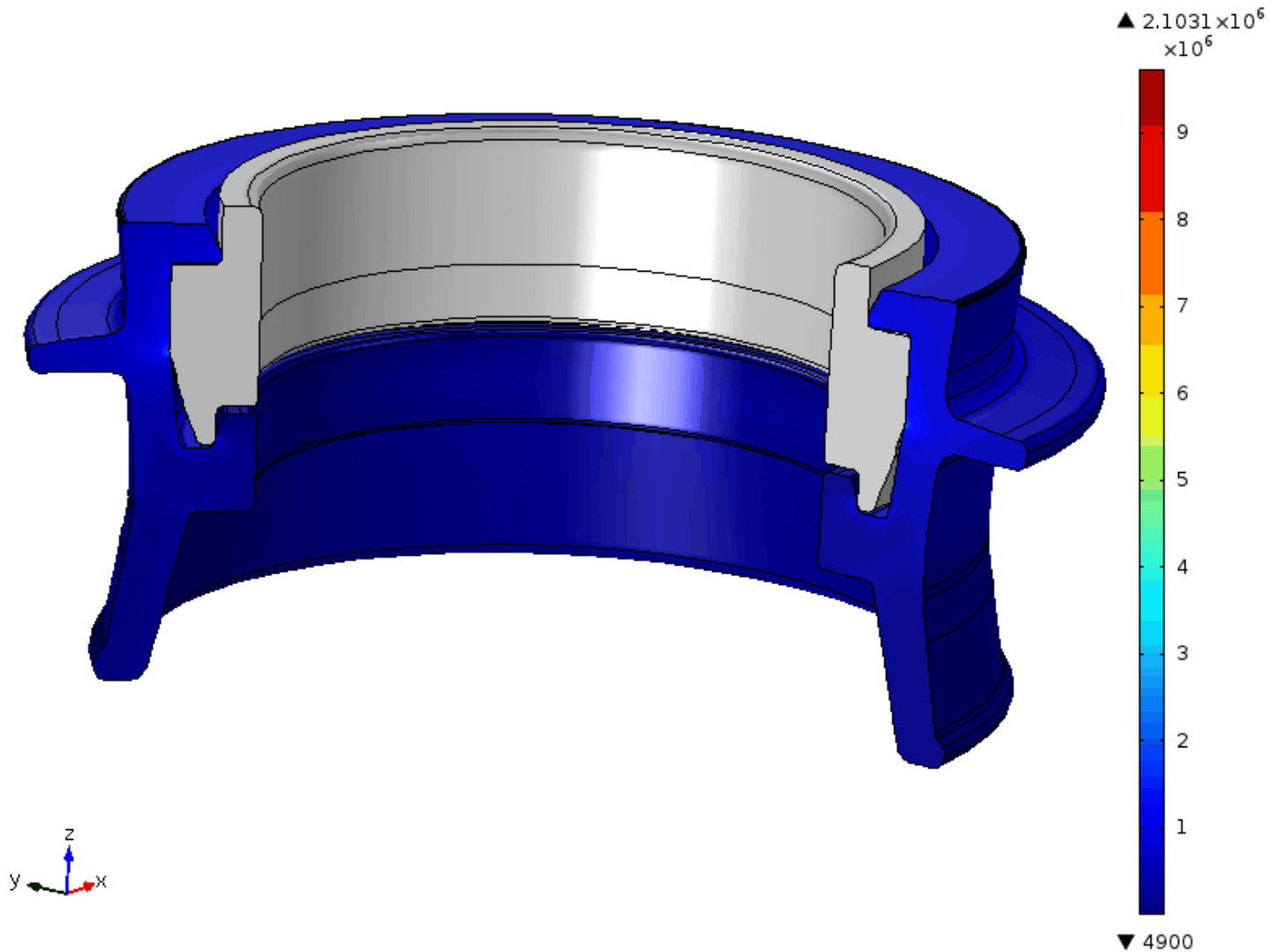
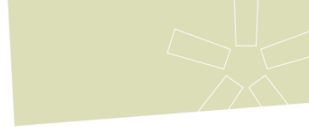
Remarks	Silicones are not or difficult to bond with an adhesive. Bonding is only possible with cyano-acrylaat after the application of a primer. With cyano-acrylaat it is not possible to bond with glass, stone and concrete.
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SAMPLE: ELASTOMERS

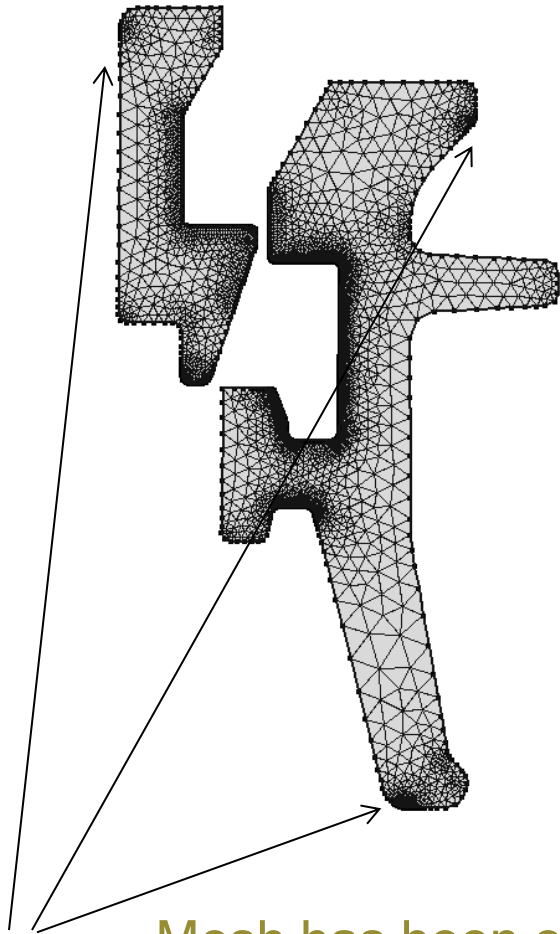
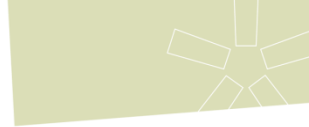
Preparation of simulation. Assembling Design 1



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 mm²
Maximum growth rate: 2.328
Average growth rate: 1.352

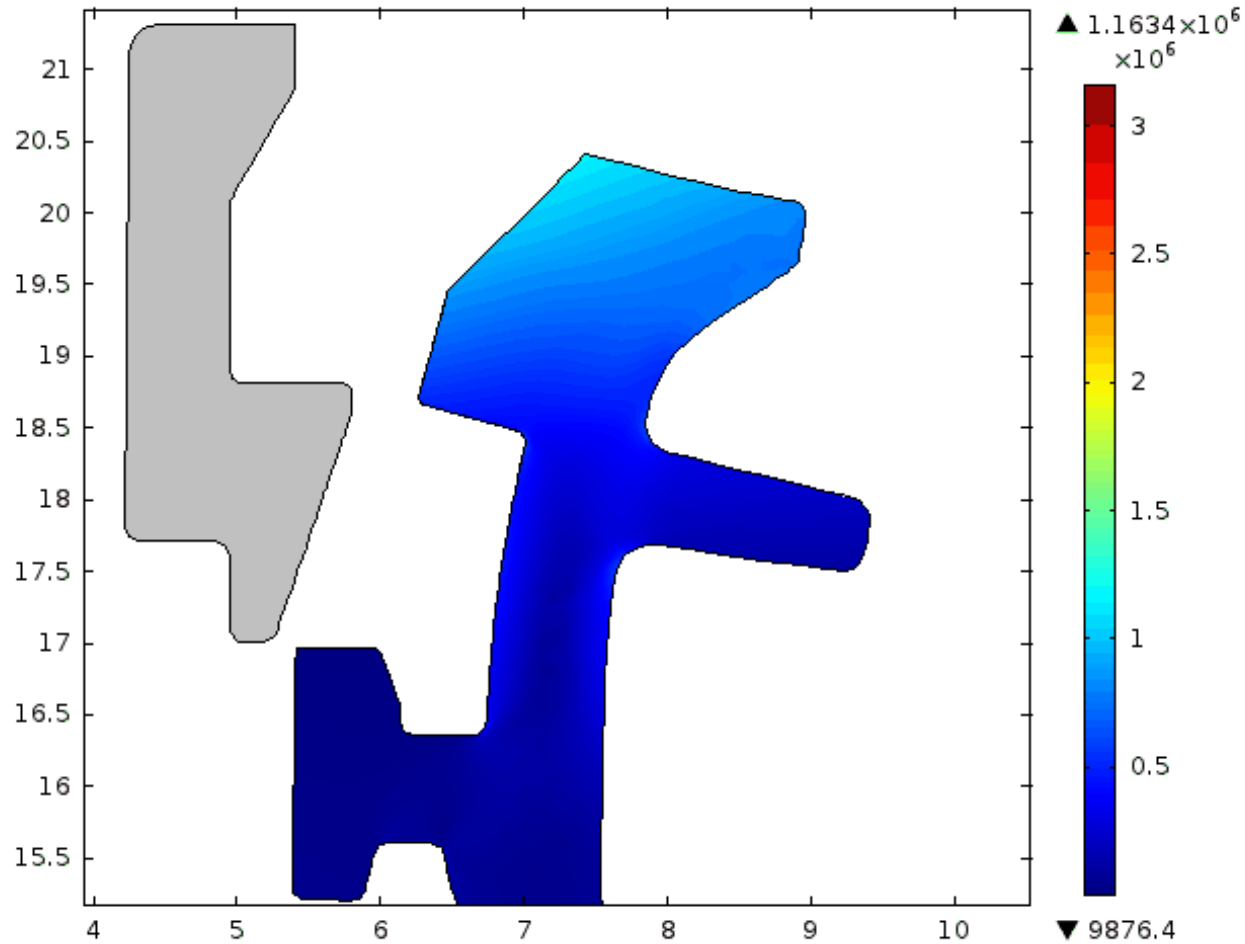
Element Quality Histogram

Final mesh properties.

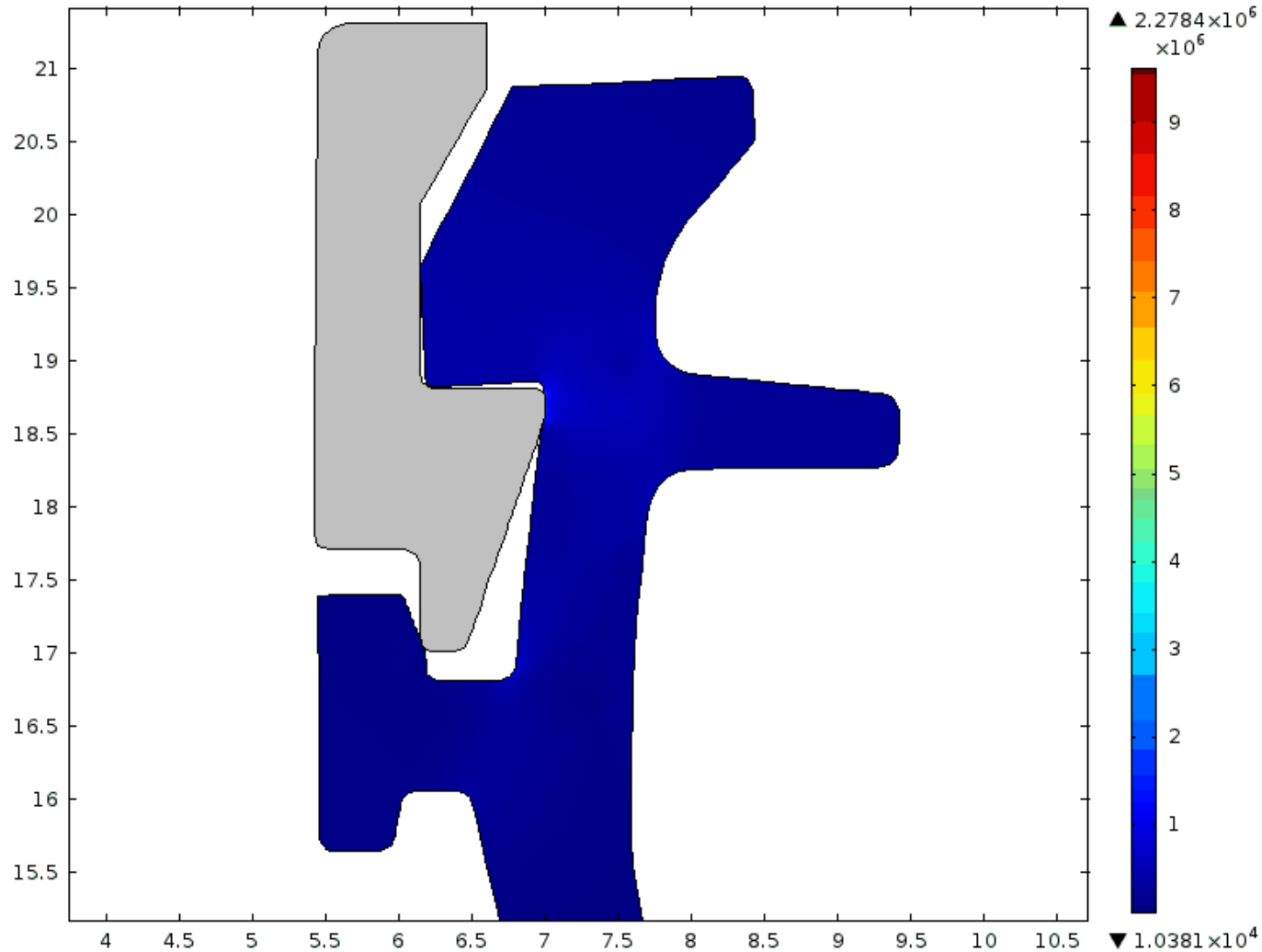
Some remarks on simulation

- 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!)

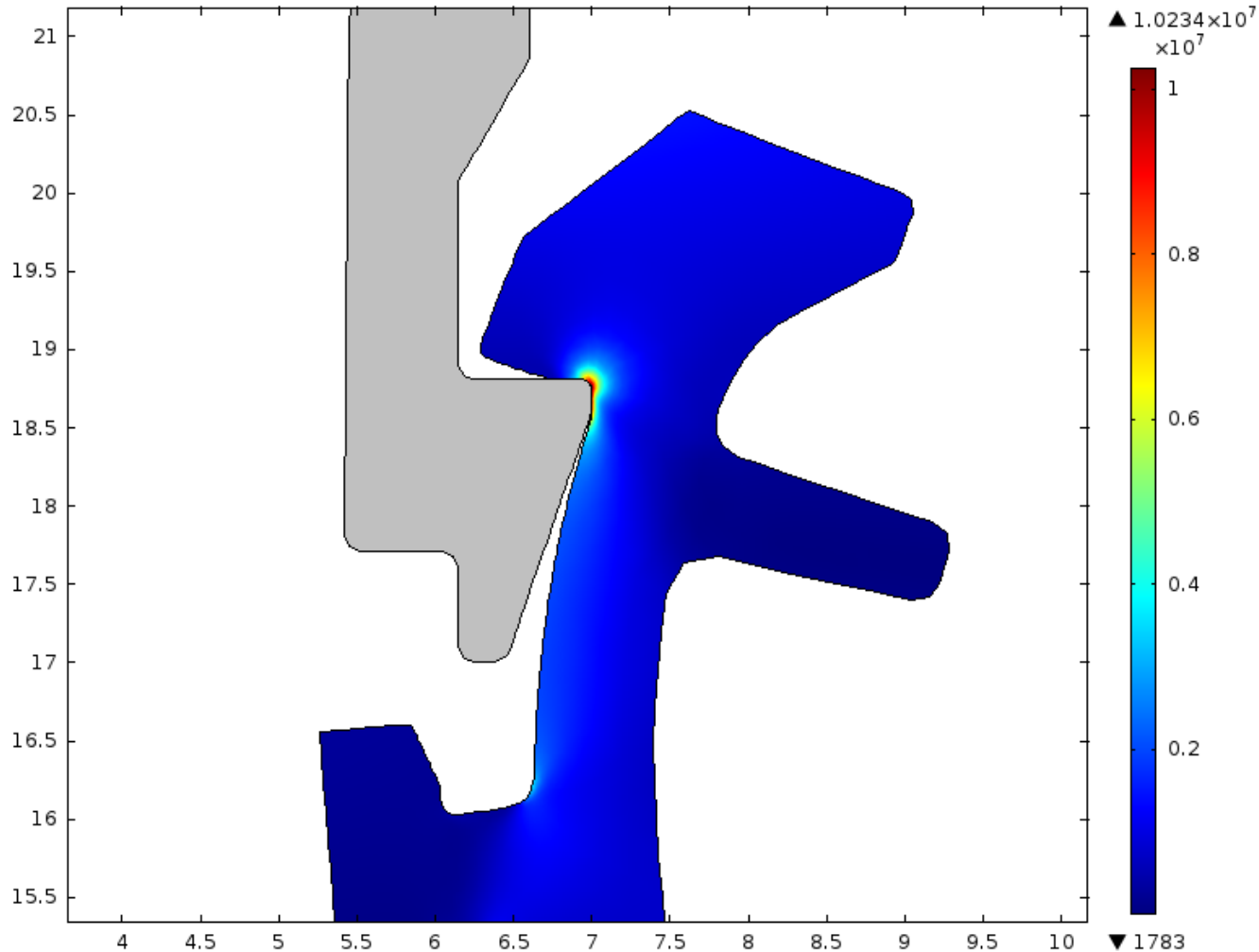
Assembly Design 1



Peel off , Design 1



Design 1

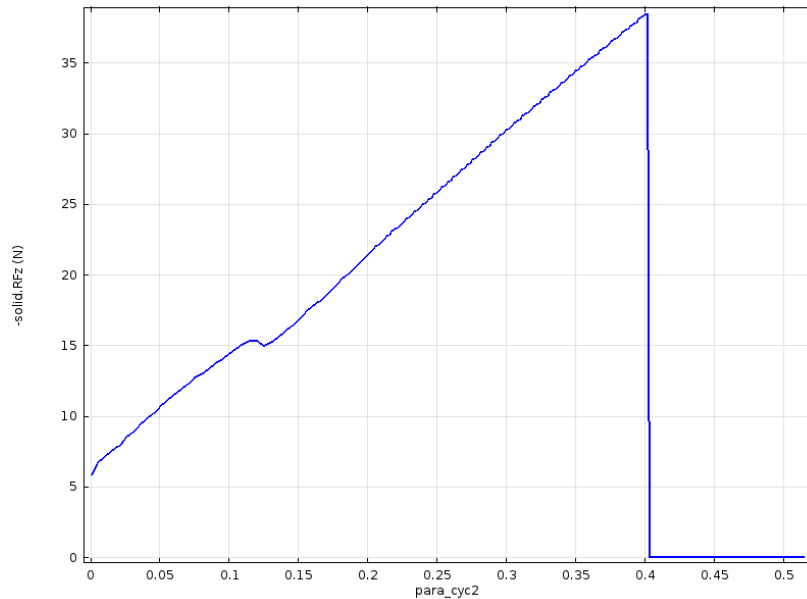


Situation just for collapse. Impression is that the hook function is significant. (Maybe too much)

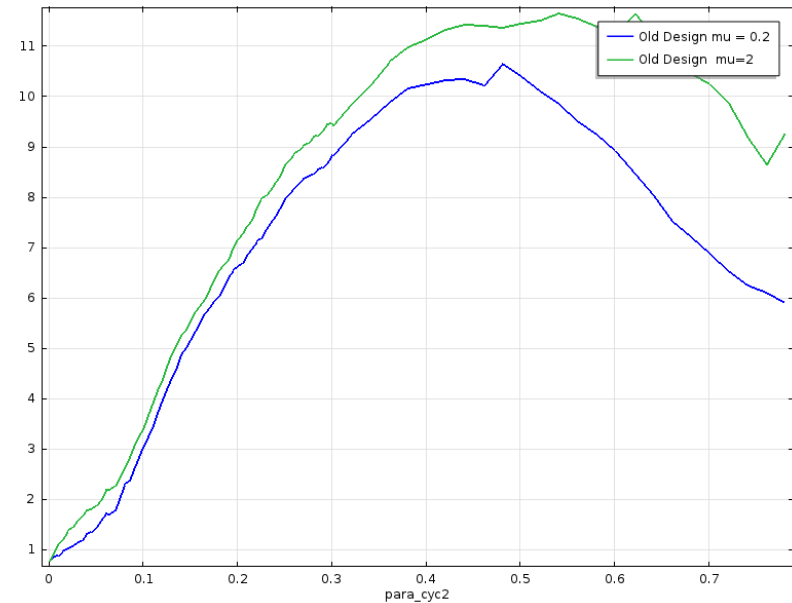
Force on seal during peel off. Design 1 & 2



Design 1



Design 2



- Left design 1, Peak force can be seen. ($\mu=0.4$!)
- 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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- Thanks to the People Creating Value
- Thanks for your attention.