Sliding Performance of a Hyperelastic Seal

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Abstract

A hyperelastic seal is pulled over a metal ring in an industrial coffee machine for maintenance reasons. The force needed to pull the hyper elastic seal over the part is too high and should be reduced in such a way that a maintenance technician can remove the part without applying too much force, and consequently preventing the chance of spoiling liquids.
Using the COMSOL Multiphysics® Structural Mechanics Module, and using the non-linear hyperelastic application mode, a geometry was set up of the complete system. Careful measurements of the material properties of the non-linear material resulted in reliable input parameters for the solver. The simulations are divided in two parts. The first part was a preparation to join two different parts together, and in this situation the assembly resulted in a pre-stressed situation for the seal material. In the second part of the simulation a force is gradually applied to the hyperelastic seal and a movement is induced over the metal ring. A stick slip movement is the result because of a friction coefficient of 0.4. Stick slip simulations are always delicate and a careful tuning of the mesh, the initial conditions and the time dependent steps are necessary. The generated movement in time which covers a time span long enough to extract the data needed to optimize the sliding with the desired forces. The geometry of the assembly is very important for the force development of the system. Some force plots will be discussed, including the stick slip effects and the time dependent steps needed to generate a smooth, stable and reliable response. An overview will be given of two hyperelastic seal models. The first model is the existing situation where the pull forces are too high. As a result the hyperelastic material will be over-stressed and deteriorate the properties of the material during use over time. The second model is an improved model with the desired pull forces. The shape of the metal ring is modified, and the force plot indicates a significant improvement of the sliding forces. These simulations resulted in an improved assembly for the coffee machine, and a maximum pulling force of about 11.5 N. Laboratory tests showed maximum pulling forces between 10 and 14 N, on many pulling tests. The conclusion is that COMSOL Multiphysics® was able to predict the forces with high enough accuracy. The project members were delighted with the predictability of this software method, and some other projects are now under investigation.

It is clear that non-linear modelling is feasible. If the input parameters can be measured with an high enough accuracy the response of the FEM software will be reliable, and can be predictive to a very high level. In this project we were able to speed up project results and reduce the amount laboratory tests.

Figures used in the abstract

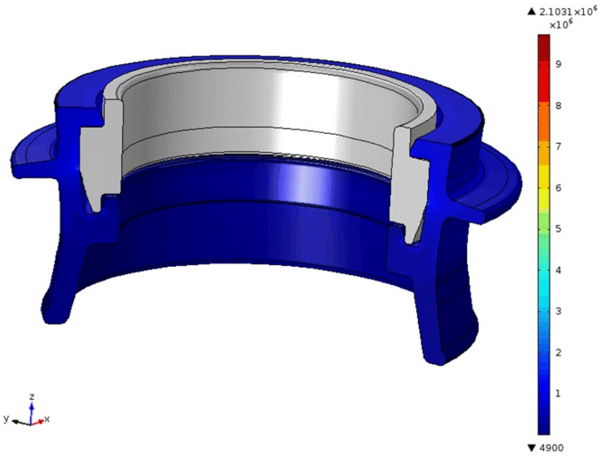

Figure 1: Assembly of the hyper-elastic seal with metal ring.

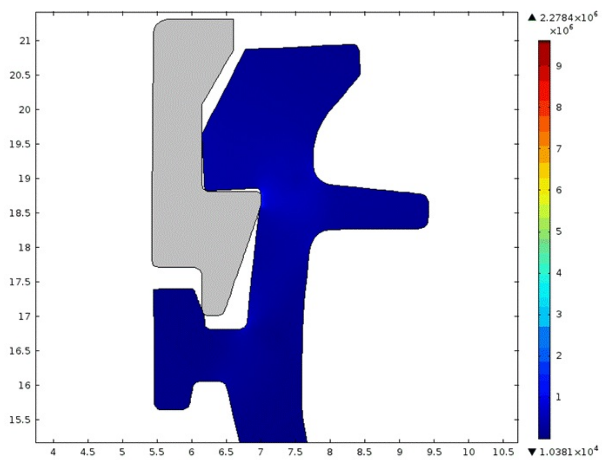

Figure 2: Start position for second simulation