Multi physics 1: solid in contact with large deformations

This exercise was adapted from an EPFL student project[1]. The idea is to model an artificial bladder, to test design hypotheses. We would like to predict the effect of an external compressive force on the deformation of the artificial bladder.

The artificial bladder is modeled by a sphere of silicon (e.g. Medical grade silicone rubber MED 4950), with an inner volume of 400 ml and a thickness of 5 mm. A rigid plate in contact with the sphere represents the external force. The model is of course axisymmetric. In addition, the symmetry plan can reduce the model by half.

Build the geometry of the sphere and the plate. In the geometry node, use the "Form assembly" option, to avoid linking the sphere and the plate. Assuming small deformations of the sphere, use linear elasticity for the silicon (Young's modulus = 3 MPa, Poisson's ratio = 0.4, density = 1250 kg/m^3). For sake of simplicity, assign the same properties to the plate.

Set the contact pair between the rigid plate and the deformable sphere. Pay attention to source and destination (see COMSOL documentation extracts below). Set the appropriate boundary condition at the symmetrical cut line. Prescribe a (rigid) displacement of the whole plate of 1 mm.

Plot the first principal strain, in percent. Evaluate the reaction force on the rigid plate (Results/derived values/surface integration).

When increasing the plate displacement force, and thus the sphere deformation, linear elasticity is not valid anymore. Use instead a hyperelastic model for the sphere. Choose Mooney-Rivlin (C01 = 0.5 MPa, C02 = 0.01 MPa, k = 60 MPa, and density = 1250 kg/m^3). Use "Parameter sweep" in the study node, to increase the plate displacement up to 10 mm, by steps of 1 mm. Select the Plot check box to allow plotting of results while solving. Compare with the linear elastic case. Evaluate the relationship between the reaction force and the plate displacement.

Extract from section "Contact Modeling" in Comsol documentation

COMSOL (Installation directory)/Multiphysics/doc/pdf/Structural_Mechanics_Module/StructuralMechanicsModuleUsersGuide.pdf

To decide which boundaries to assign as source and destination in a contact pair consider the following guideline: If one of the boundaries belongs to a part that is rigid, either since it is a rigid domain, or because of the constraints applied, it should be selected as the source boundary.

[1] *Diserens G, Herzog F, Kunze A, Neftel S. Artificial Bladder. Artificial Organs, EPFL, 2009.*