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Modelling of two-scale contact - Investigation of leakage in polymer seals at cryogenic temperatures

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The prediction of leakage in polymer seals is still a particular challenge due to many dependencies: manufacturing inaccuracy, microparticles on the contact surface and surface asperity. Polymer seals, which are operated at cryogenic temperatures, undergo a material behaviour change at the so-called glass transition temperature. At this temperature, its behaviour changes from viscous/rubbery to glassy. There is a significant stiffening of the polymer material, which leads to a worse compensation of roughness in the contact surfaces. As a consequence the tightness of the valve may no longer be sufficiently given. The leakage through the valve is numerically investigated by a two-scale contact simulation, which is based on the concept of Representative Volume Elements, which are known in homogenization of microstructures. The deformations on the microstructure are prescribed by the macroscopic kinematics at the contact area. The mean microscopic contact forces are determined in Representative Contact Elements (RCE), which are node-wise linked to the macroscopic contact area. The RCEs surface texture is parameterized based on optical measurement data.

As the polymer seal is operated over a wide temperature range, a fully coupled thermo-viscoelastic material model at finite strains is used to simulate the material behaviour at both scales [1]. Due to the change from entropy to energy dominated behaviour over the glass transition temperature the model is extended to account for the transition from viscous/rubbery to glassy as the temperature is decreased. The surface asperity needs to be represent explicitly as the gap and volume between both contact surfaces and the fluid path through the seal are used to determine the leakage through the seal.

REFERENCES

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