An Elastohydrodynamic Lubrication Model Considering Surface Roughness and Mixed Friction

Jakob Moder[1], Florian Grün[1]

[1]Chair of Mechanical Engineering, Montanuniversität, Leoben, Austria

Abstract

In mechanical engineering machine elements such as gears or camshafts are lubricated in order to ensure a safe operation. The elastohydrodynamic lubrication (EHL) theory describes phenomena taking place in the tribological system. Due to the very thin fluid film and the high deformation of the surfaces, the surface roughness plays an important role, because it significantly affects stresses arising in machine elements, which can cause fatigue and therefore system failure.
A model in COMSOL Multiphysics® has been set up, which allows do describe both surfaces, considering the macroscopic shape, as well as the microscopic surface roughness (Figure 1). The surface roughness profile is imported into COMSOL by employing the build-in interpolation function. The Reynolds Equation is implemented in the Boundary PDE interface, cavitation and time dependence are considered optionally. The Structural Mechanics Module is used to calculate the displacement field and compute stresses. Additionally, if the surfaces are very rough, the contact mechanics penalty method prevents overclosure, this way mixed friction situations can be depicted as well. Both physics are directly affecting each other and are therefore strongly coupled. Relevant physical properties of the fluid, such as viscosity or density, have been measured depending on pressure and temperature. Furthermore, a global equation is added to ensure force equilibrium. The problem itself is solved by a direct solver and linearized via the Newton-Raphson procedure. Usually 20 to 30 steps are necessary to achieve convergence.
The developed simulation methodology allows a detailed insight into physical phenomena taking place in highly loaded contacts. Different surface finishing technologies, coatings or special materials can be analyzed for their suitability in highly loaded contacts (Figure 2, Figure 3).

Figures used in the abstract

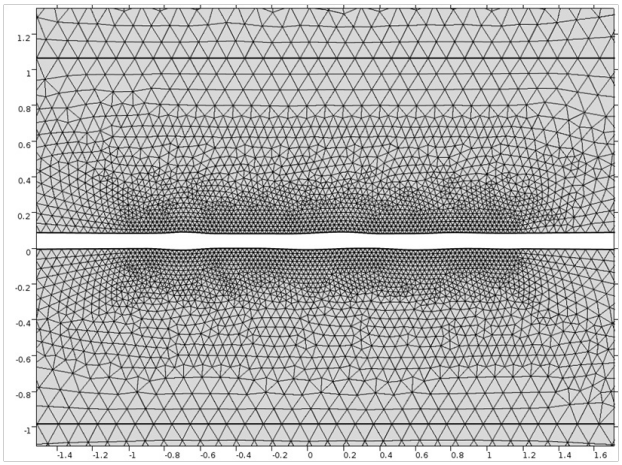

Figure 1: Meshed bodies with rough surface.

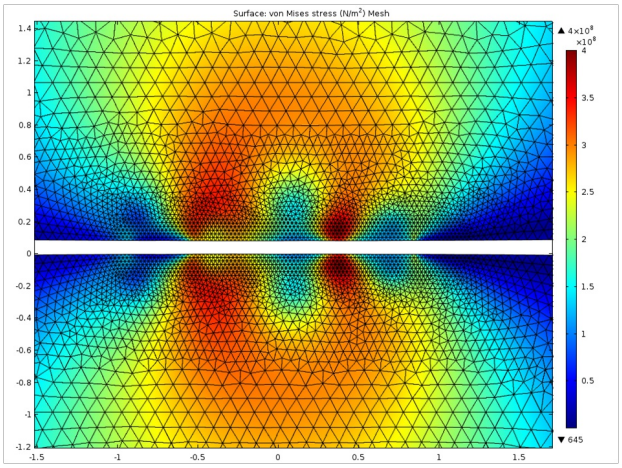

Figure 2: Von Mises stress for a fully lubricated situation.

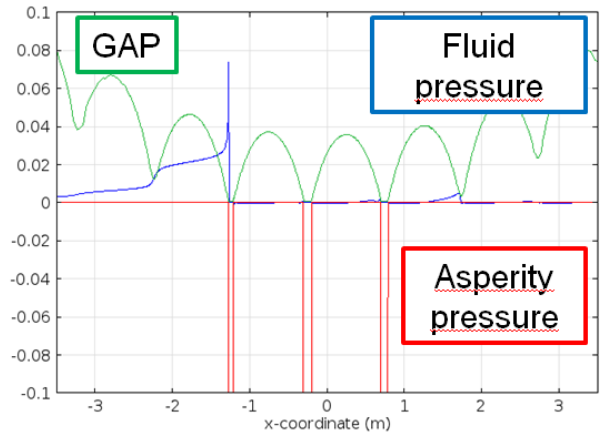

Figure 3: Fluid and asperity pressure for a mixed lubrication situation.