An elastohydrodynamic lubrication model considering surface roughness and mixed friction

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Introduction: Highly loaded lubricated machine elements such as gears or camshafts are an integral part in a wide variety of technical products. Due to higher efficiency requirements these machine elements have to be improved continuously, which leads to the necessity to investigate physical phenomena taking in place in the contact zone. Because of very low film thicknesses the surface microstructure plays an important role. High stress concentrations can occur and cause failure of the system.

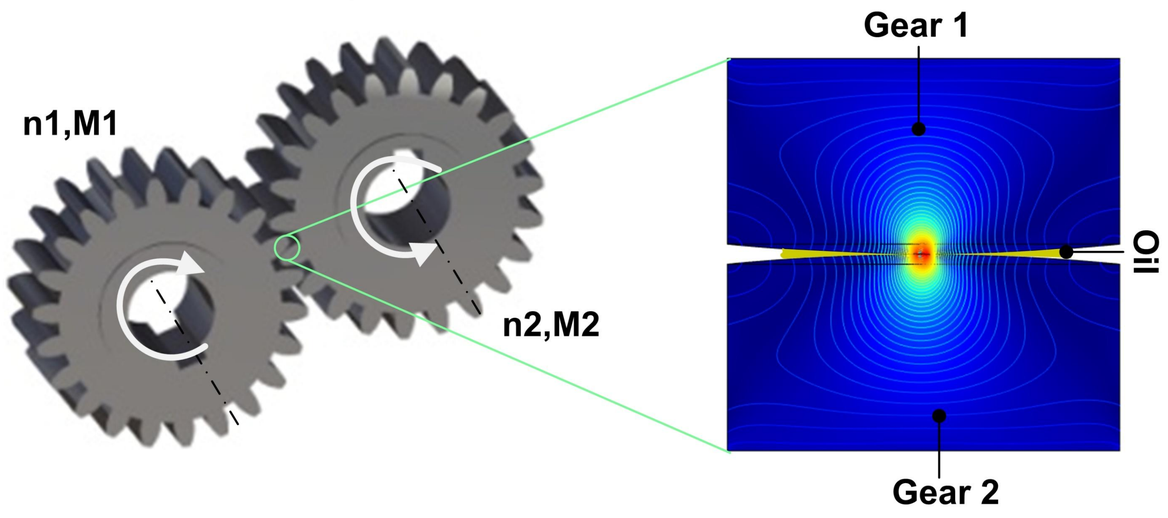

Figure 1. Gear pair and magnified view of the contact

Computational Methods: The lubrication problem is treated by employment of the Reynolds Equation (1). The deformations and stresses are computed by the Structural Mechanics Module (2), to prevent overclosure of the bodies, constraints are enforced by the Contact Mechanics Penalty Method (3). To ensure the force equilibrium, a Global Equation is added (GE) (4). The physics are fully coupled [1].

(1) $$\frac{\partial}{\partial x}\left[\frac{\rho h^3}{12\eta}\frac{\partial p}{\partial x}\right] = u_m \frac{\partial \rho h}{\partial x}$$

(2) $$-\nabla\sigma = F_V$$

(4) $$F = \iint_\Omega p(x,y)d\Omega + \iint_\Omega p_{Asp}d\Omega$$

(3) $$F_P(x) = F(x) + \varepsilon\langle -g(x)\rangle^2$$

The machine elements are only modeled in the vicinity of the contact to optimize computation effort.

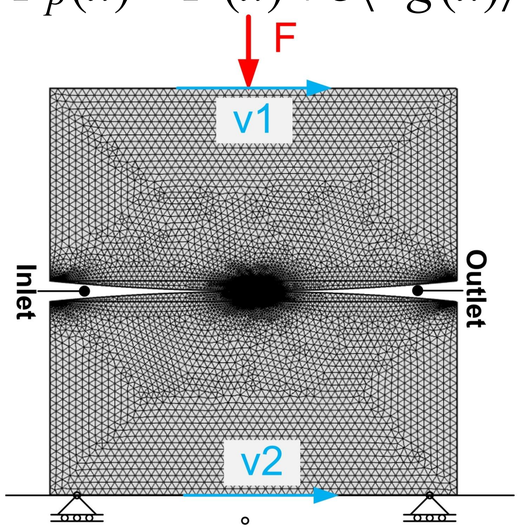

Figure 2. Model Setup in COMSOL

Results: To investigate the influence of surface roughness on the loading situation in the contact, a smooth system is compared to a rough system. A stress concentration factor K is introduced to relate the maximum EHD pressure to the corresponding dry Hertzian pressure [2].

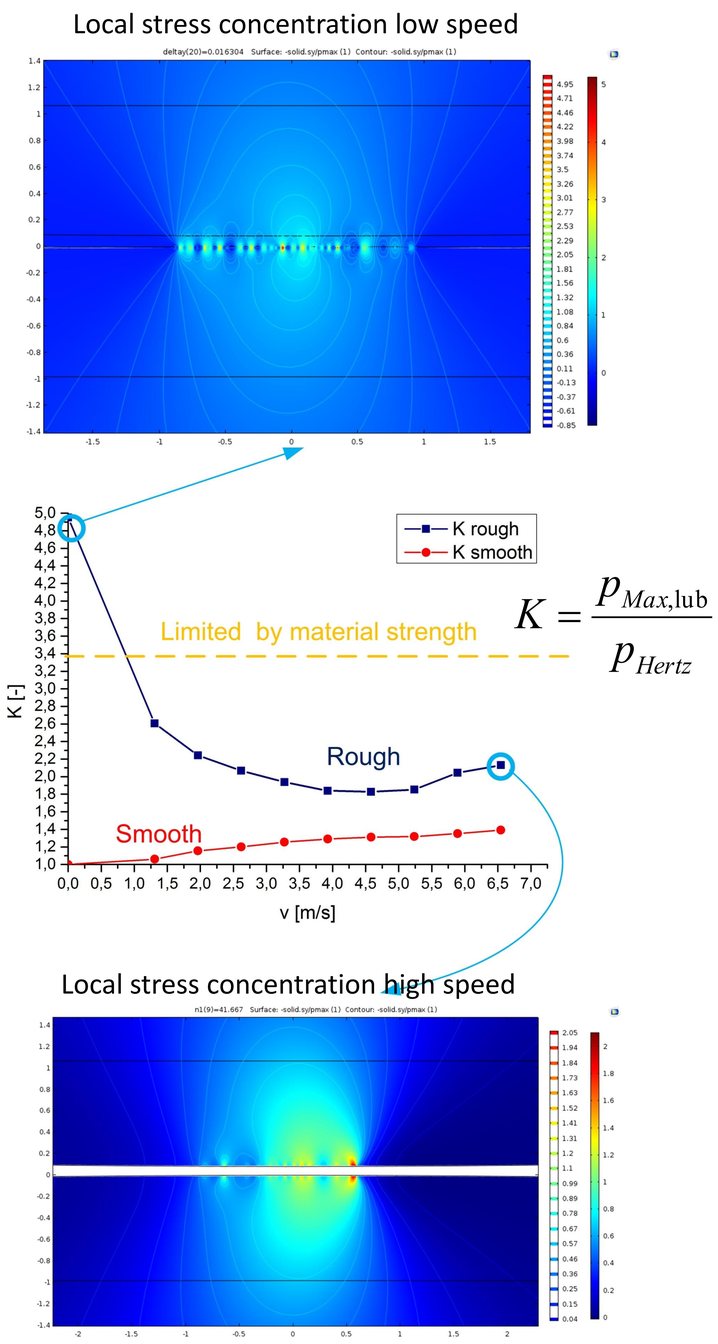

Figure 3. Stress concentration factors

Especially at low speed stress concentrations due to roughness effects are high. At higher speed macroscopic effects and the Petrusevich peak are responsible for stress concentrations.

Conclusions: An EHD model which considers the microstructure of surfaces has been developed. Stress concentration factors are computed in order to evaluate the suitability of different surface finishing processes for highly loaded contacts.

References:

1. H. Krampl, Numerical and experimental investigation of non-conformal lubricated contacts, Proceedings of the 15th Nordic Symposium on Tribology, 2012
2. H. Hertz, Über die Berührung fester elastischer Körper, Journal für die reine und angewandte Mathematik, 1881