Comparison of Traction in Dry and Lubricated Contacts - A Review

Contact Mechanics and Lubricant Rheology

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The traction-creep resp. traction-slip characteristic in rolling contacts describes the relation between slide to roll ratio and tangential friction forces. The physics behind it are often regarded as entirely different for dry contacts such as between railway wheels and rails and for lubricated contacts such as between gear flanges, or rolling elements and rings in bearings resp. traction drives.

In dry contacts, slip is known to be the result of elastic deformations of the contacting solid bodies when subject to tangential forces. The Coulomb friction law is commonly applied to determine the maximum traction as a function of normal forces, assuming a strictly linear relationship. Thus, solid contact mechanics are governing the traction characteristics.

In lubricated contacts, slip is regarded as a consequence of viscous shear in fluids subject to shear stresses according to the Newtonian law which yields a linear relationship between shear rate and shear stress. Viscosity depends on temperature and pressure. With increasing pressure and shear stress, non-Newtonian effects may come into effect and the maximum traction is either limited by mechanical resp. thermal shear thinning or by the limiting shear stress. The limiting shear stress, like Coulomb friction, increases with pressure, albeit, as is known today, in a different way. Thus, fluid rheology is thought to govern the traction characteristics.

In reality, solid body elastic deformations as a result of tangential forces also exist in lubricated contacts and may not be neglected at small slide to roll ratios and high contact pressures. The more, the lubricant fluids tend to solidify into a glassy state with increasing pressure and then need to be regarded as solid interfacial layers with elastic properties. On the other hand, the surfaces in dry contacts are often not “clean” and covered by layers with specific rheological properties.

Like many other researchers, the authors of this abstract have conducted research in both fields – dry and lubricated rolling contacts and applied it to different applications: wheel/rail systems, rolling element bearings as well as traction drives. Given the fact that discussions in the scientific community have re-intensified recently, the authors intend to review the state of research regarding this topic.

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