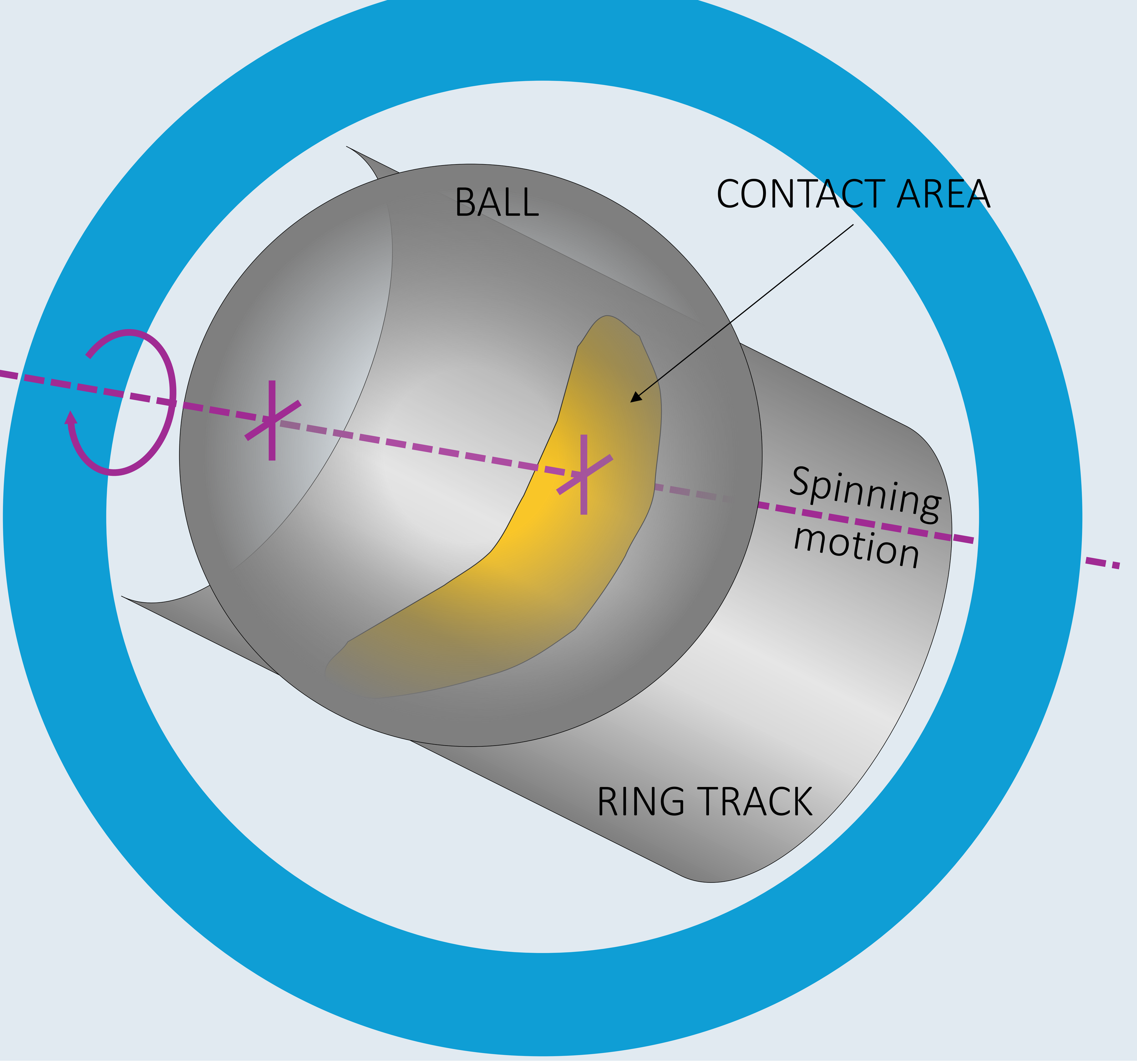

Thermal-Elastohydrodynamic Simulation of Angular Contact Ball Bearing Using COMSOL Multiphysics®

Thermal effects in lubricated contacts have a large influence on friction and power losses: for deep-groove ball bearing, it changes everything.

F. Zhang[1], J.-D. Wheeler[2], V. Bruyere[2], J. Raisin[1]
1. TotalEnergies OneTech, Solaize, France.
2. SIMTEC, Grenoble, France.

Introduction & Goals

Angular contact ball bearings (ACBB, see Figure 1, left) are rolling bearings designed to support both axial and radial loads. The rolling elements (balls in this case) significantly decrease the power losses associated with rotating load bearing by replacing sliding with rolling. However, both the specific kinematic of ACBB [1,2] and the depth of the ring grooves respectively generate high spinning and sliding between the balls and the rings. Together, they contribute to generate frictional power losses in the lubricated contacts.

The goal of this work is to simulate the behavior of one of the lubricated elliptical contacts (represented in yellow in the introduction picture). It allows for quantifying the power losses and friction forces at play in this single contact. Such result can typically be used in a rolling bearing model or a rotor dynamics model.

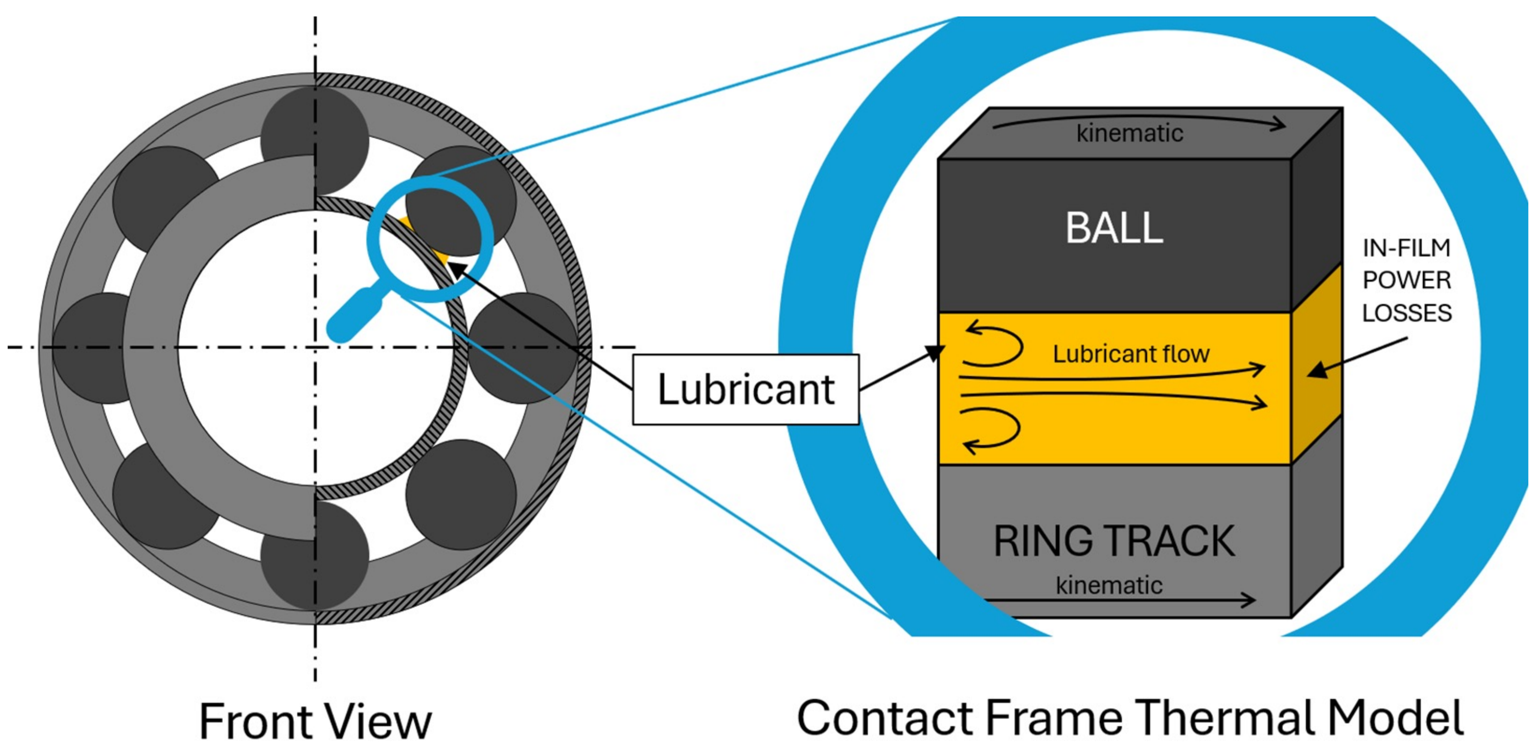

FIGURE 1. Angular contact bearing front view (left) and schematic description of the contact thermal model (right)

Methodology

The kinematic and geometry of the lubricated elliptical contact is computed using literature methods applied to ACBB [1,2].

Both are then applied to an ElastoHydrodynamic Lubrication (EHL) model [3]. It accounts for elastic deformation of the solids, and hydrodynamic lift generated by the lubricant flow in the contact in a contact. Coupled with a thermal model (see Figure 1, right), it also accounts for shear induced heating by solving the heat equation in the solids and the lubricant. The rheology of the lubricant integrates pressure, temperature and shear influence. Both models are strongly coupled together and constitute a Thermal-EHL model.

Parametric studies are run to simulate different operating conditions.

Results

Different key operational parameters, such as rotational speed, unloaded contact angle, and external loading are considered.

Quantitative estimations are made on local contact pressure and temperature profiles in the contact (see Figure 2), film thickness, velocity, viscosity (see Figure 2) and sliding roll ratio (SRR, see Figure 2).

The model is used to estimate the heat loss from lubricants' friction in angular contact bearings. The numerical approach in this study is used to predict and optimize lubricant performance in the bearings, especially for thermal aspects and lubrication.

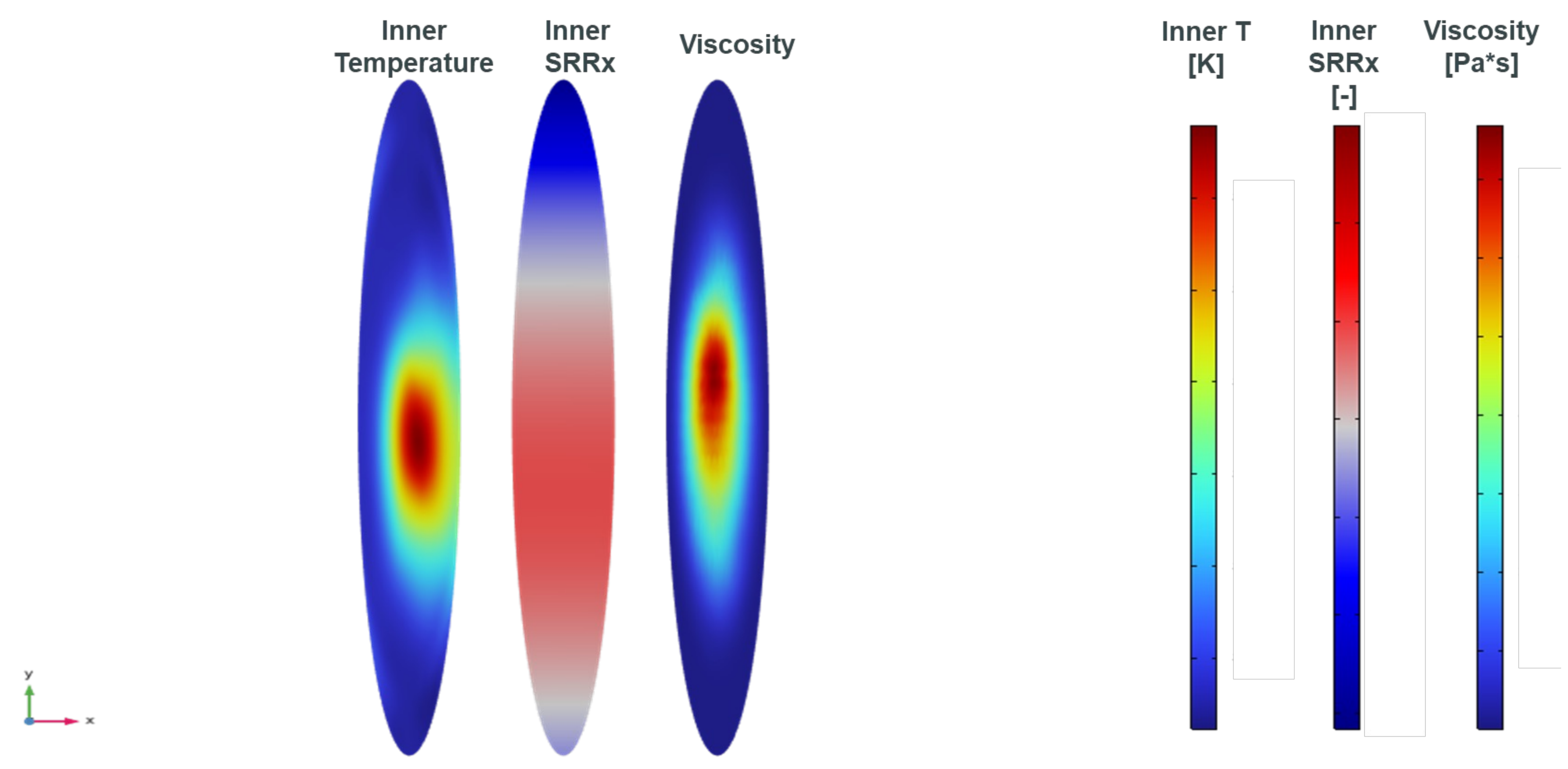

FIGURE 2. Temperature profile (left), SRR (middle) and viscosity profiles (right)

REFERENCES

1. A. Popescu, 2020. Four approaches for calculating power losses in an angular contact ball bearing. Mechanism and Machine Theory.
2. X.-J. Shi, 2015. Coupling study on dynamics and TEHL behavior of high-speed and heavy-load angular contact ball bearing with spinning. Tribology International.
3. W. Habchi, A full-system finite element approach to elastohydrodynamic lubrication problems: application to ultra-low-viscosity fluids, Thesis, INSA de Lyon, 2008.

TotalEnergies

Excerpt from the Proceedings of the COMSOL Conference 2024 Florence