The 9th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2024
3–7 June 2024, Lisbon, Portugal

A coupled finite element strategy for high-fidelity modelling of mechanical transmissions with non-isothermal lubrication

Sander Neeckx[*1,2], **Bart Blockmans**[1,2], **Régis Boukadia**[1,2], **Frank Naets**[1,2] **and Wim Desmet**[1,2]

[1] KU Leuven, Department of Mechanical Engineering
Celestijnenlaan 300, B-3001, Heverlee, Belgium
E-mail: sander.neeckx@kuleuven.be
[2] Flanders Make@KU Leuven

Keywords: *Finite Element Method (FEM), Reduced Order Model (ROM), Multibody dynamics, Thermo-ElastoHydrodynamic Lubrication (TEHL)*

Transmissions play a crucial role in power transfer between components in different applications. The main impact on loss in a transmission is friction, yielding power dissipation as heat, thereby limiting efficiency and performance. Optimal lubrication minimizes friction by separating the contact surfaces, promoting a more durable system by evacuating debris and excessive heat from the contact zone.

High-fidelity modelling of lubricated transmissions is established through coupling of isothermal Flexible MultiBody (FMB) dynamics [1] with Thermo-ElastoHydrodynamic Lubrication (TEHL) [2], both discretized using the Finite Element Method (FEM). Local deformations, accurately captured in the TEHL-model, are eliminated in the FMB-model by invoking global line-contact attachment modes in its reduced-order representation. The lubricant model's efficiency is improved through tensorization of its system matrices and scaling them based on the variable radii of curvature inherent in gear dynamics. Additionally, static condensation reduces the number of degrees of freedom to compute the lubricant film thickness, based on local deformation resulting from a local solid FE-model.

Steady-state simulations enable computation of the Transmission Error (TE), facilitating a comparison of the impact on gear dynamics when considering thermal effects in lubrication. In general, isothermal lubrication tends to overestimate the friction coefficient. However, it can be demonstrated that thermal effects only have a minor influence on the TE for a well-chosen initial temperature of the lubricant. This enables the use of the, less computationally demanding, EHL-model with a constant temperature in the lubricant.

REFERENCES

[1] B. Blockmans, T. Tamarozzi, F. Naets, and W. Desmet, "A nonlinear parametric model reduction method for efficient gear contact simulations," *International Journal for Numerical Methods in Engineering*, vol. 102, pp. 1162-1191, 2015.

[2] W. Habchi, D. Eyheramendy, S. Bair, P. Vergne, and G. Morales-Espejel, "Thermal Elastohydrodynamic Lubrication of Point Contacts Using a Newtonian/Generalized Newtonian Lubricant," *Tribology Letters*, vol. 30, pp. 41-52, 2008