Fundamentals of EHL film thickness formation and prediction

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Abstract
Elastohydrodynamic lubrication (EHL) is not really a new domain since Osborne Reynolds (18421912) first laid the foundations for it and published his famous equation in 1886, more than a century ago. Nevertheless, EHL in general and prediction of EHD contacts in particular are still facing unresolved questions, some of which concern film thickness. Knowledge of this parameter is of crucial importance, for example to develop efficient and long-lasting lubricated mechanisms.

The first solution of the EHL pressure profile was proposed by Petrusevich (1951) and, some years later, Dowson and Higginson published the first elastohydrodynamic (EHD) film thickness equation based on 1-D dimensionless parameters (1966). Then, Dowson and Hamrock published a series of papers in 1976 which provide analytical models to predict the minimum and central film thicknesses in EHD contacts, circular or elliptical, this time based on 2-D dimensionless parameters. These formulas have since been used extensively, including to validate experimental approaches or more advanced models. Following the development of numerical techniques and computing possibilities, a large collection of EHD analytical expressions have been published in the last 40 years.

However, the accuracy and validity of all these formulae have rarely been investigated. The purpose of this presentation is to provide a realistic perspective on the use of all these EHD film thickness models.

First, it is necessary to recall the basic notions and equations of lubrication, with a focus on the important physical quantities and on the use of dimensionless parameters in EHL.
Then, it will be shown by example that film thickness predictions can be confirmed by experiments or not, based on a wide choice of operating conditions and lubricants, leading us to explore a wide range of dimensionless parameters.

Finally, an evaluation of the most widespread analytical formulae to define whether they can be used as qualitative or quantitative predictions will be proposed. The methodology is based on comparisons with a numerical model for two configurations, circular and elliptical, considering both central and minimum film thicknesses.

Keywords
Elastohydrodynamic lubrication (EHL); Film thickness prediction; EHD analytical equation; Central film thickness; Minimum film thickness; Circular contacts; Elliptical contacts

CURRICULUM VITAE

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Professional experience

2002 - CNRS Senior Scientist (Directeur de Recherche) at LaMCoS, INSA Lyon
1998 - STLE member, now STLE Fellow

Current responsibilities

2019 - 2021 7th World Tribology Congress, Chairman of the Organizing Committee
2013 - 2019 Academic leader of the SKF Research Chair "Lubricated Interfaces for the Future"
2010 - Chair of the Leeds-Lyon Symposia on Tribology in Lyon: 2011, 2013, 2015, 2017, 2019 External opponent in PhD committees, including abroad (Sweden, The Netherlands, Portugal, Australia).
Expert for the evaluation research projects (Sweden, USA, The Netherlands, Czech Republic, and Japan).

Regular reviewer for Tribology International (Elsevier), Tribology Letters (Springer), JET (IMechE Part J, Sage), Journal of Tribology (ASME), Tribology Transactions (STLE, Taylor & Francis), Lubrication Science (Wiley), Friction (Springer) and occasionally for many others JET (IMechE Part J, Sage): editorial board member and editor for special issues (also for Tribology International)

Paper solicitor and reviewer for international conferences (Leeds-Lyon, World Tribology Congress, ICFD, Bearing World, International Tribology Congress, DGM, International Colloquium Esslingen…)

Research areas and context

Tribology & Lubrication are by nature multidisciplinary fields. In this context, I have been interested in several topics:

- Rheological and tribological behavior of multi-phase or complex fluids (i.e. real lubricants!) under various conditions, including high-pressure, high shear rate, high confinement …,

- Development of numerical models in the context of lubrication (multiphysics & multiscale modeling, from FEM to Molecular Dynamics), exploration of new features by numerical experiments,

- *In situ* optical techniques (interferometry, spectrometry, fluorescence…) to map tribological/physical parameters within highly confined thin films.