

## Reduced Finite Element Elastohydrodynamic Lubrication Model: Circular Contacts

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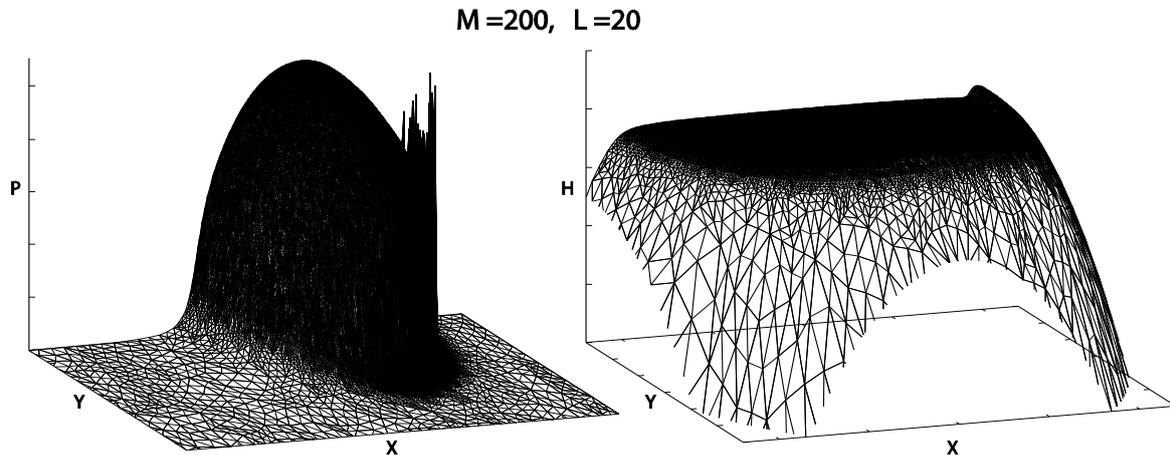


Fig. 1: Three-dimensional pressure (left) and film thickness (right) profiles for a typical EHL contact ( $M=200, L=20$ ) obtained using the reduced finite element model

### 1. Introduction

This paper presents a reduced finite element model for circular elastohydrodynamic lubricated (EHL) contacts. This model combines fast convergence rates with reduced memory requirements and negligible model reduction errors compared to the full model which makes it an attractive tool for EHL contact performance prediction.

### 2. Methodology

The reduced EHL line contact model was developed and validated in a previous work [1] [2] where it was shown that the elastic deformation of the contacting solids can be obtained using less than 30 degrees of freedom. This lead to a significant reduction in the size of the matrix system to solve leading to reduced memory usage and computational times. In fact, cpu times for the reduced line contact model were shown to be an order of magnitude smaller than for the full model. In addition, model reduction errors of the order of only 1‰ were obtained for both central and minimum film thicknesses. In this work, the model order reduction technique developed in [1] and [2] is extended to the case of circular contacts. It consists in defining the elastic deformation of the solid components as a linear combination of carefully selected and pre-computed EHL deformations called “basis functions”. The model is based on a finite element discretization of the EHL equations: Reynolds, linear elasticity and load balance. All equations are solved simultaneously in a

fully-coupled framework using a damped-Newton procedure allowing fast convergence rates for the global solution. The free boundary arising at the exit of the contact is handled by means of a penalty method. Fig. 1 shows typical pressure and film thickness profiles for a circular contact ( $M=200, L=20$ ) obtained using the reduced model. The elastic deformation of the contacting solids is also obtained using less than 30 degrees of freedom allowing a significant reduction in cpu time and memory requirements compared to the full model.

### 3. Conclusion

A reduced finite element fully-coupled model for the solution of EHL circular contacts is developed. Compared to the full model, it offers an order of magnitude reduction in cpu times with negligible model reduction errors. In addition, memory requirements are significantly reduced as the size of the obtained matrix system to solve at every iteration is considerably smaller.

### 4. References

- [1] Habchi W. and Issa J. - Model Order Reduction Techniques for the Solution of EHL Problems, Proceedings of the 38th Leeds- Lyon Symposium on Tribology, Lyon, 2011.
- [2] Habchi W. and Issa J. – Fast and Reduced Full-System Finite Element Solution of Elastohydrodynamic Lubrication Problems: Line Contacts, *Advances in Engineering Software*, 2013, vol. 56, pp. 51-62.