University of Twente

Free Surface Thin Layer Flow Modelling of Contact Pressure Induced Lubricant Migration in Rolling Element Bearings

Ir. MT van Zoelen, dr. CH Venner, dr. PM Lugt

University of Twente
The Netherlands

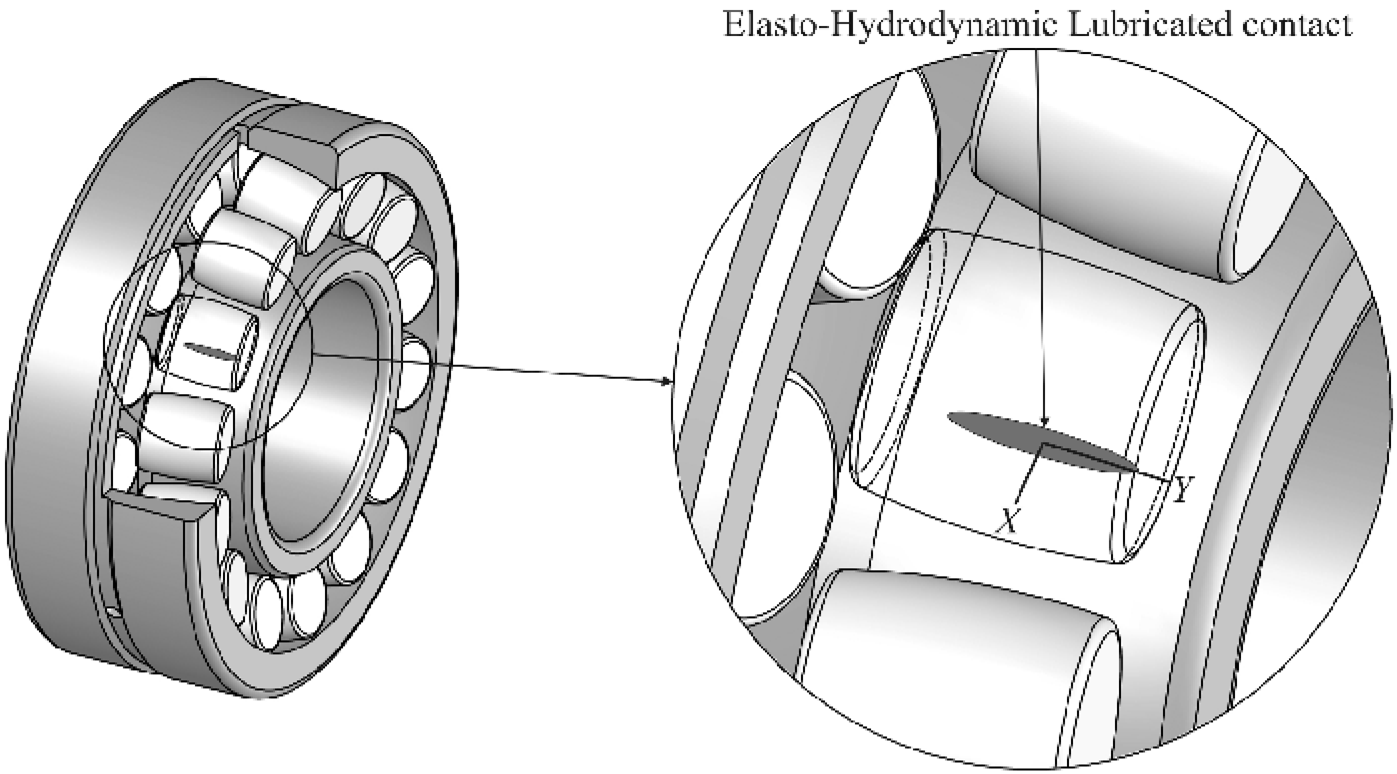
Content

- Introduction
- Theory
- Experimental validation
- Results
- Conclusions

Introduction

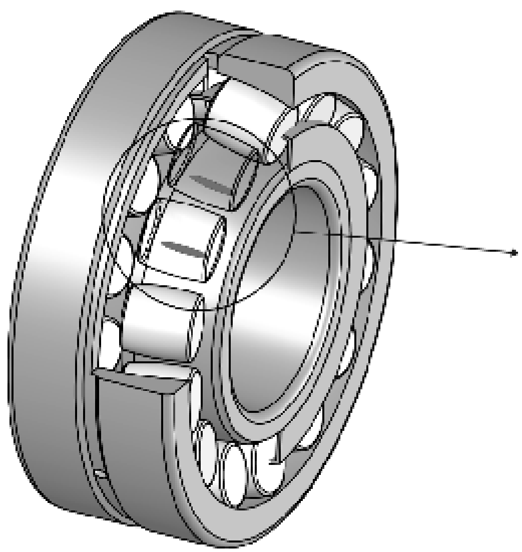
Background

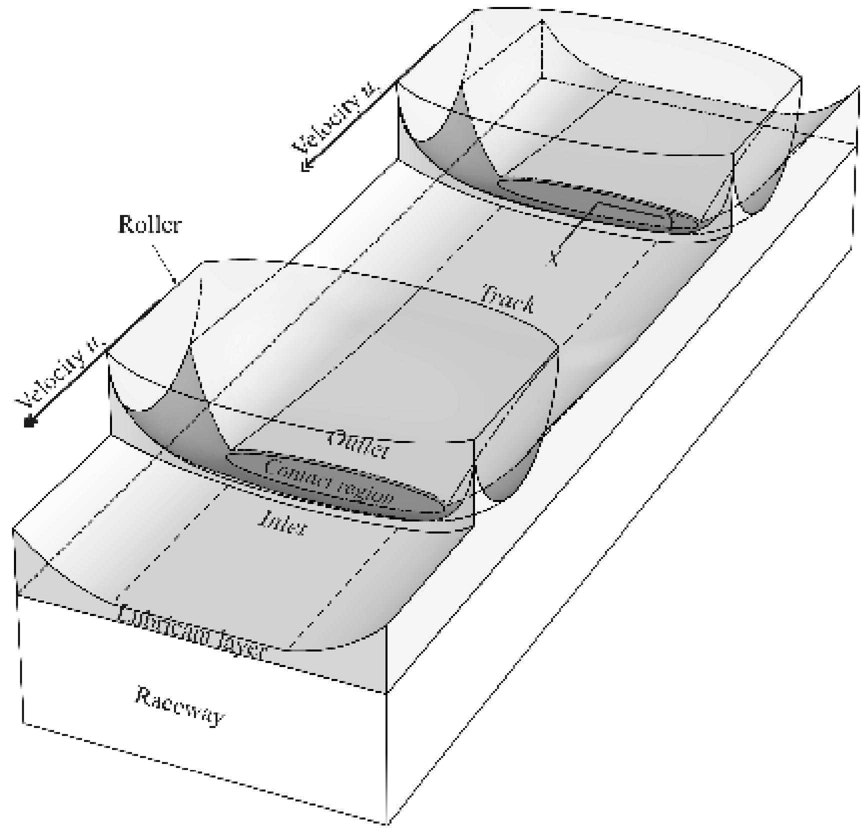
- *Bearing life:* Maintain a sufficiently thick lubricant film.



Introduction

Starvation in bearings





Aim of the research:

- To develop a model that predicts change supply layer thickness.
- Use model to predict long term film thickness decay.

Content

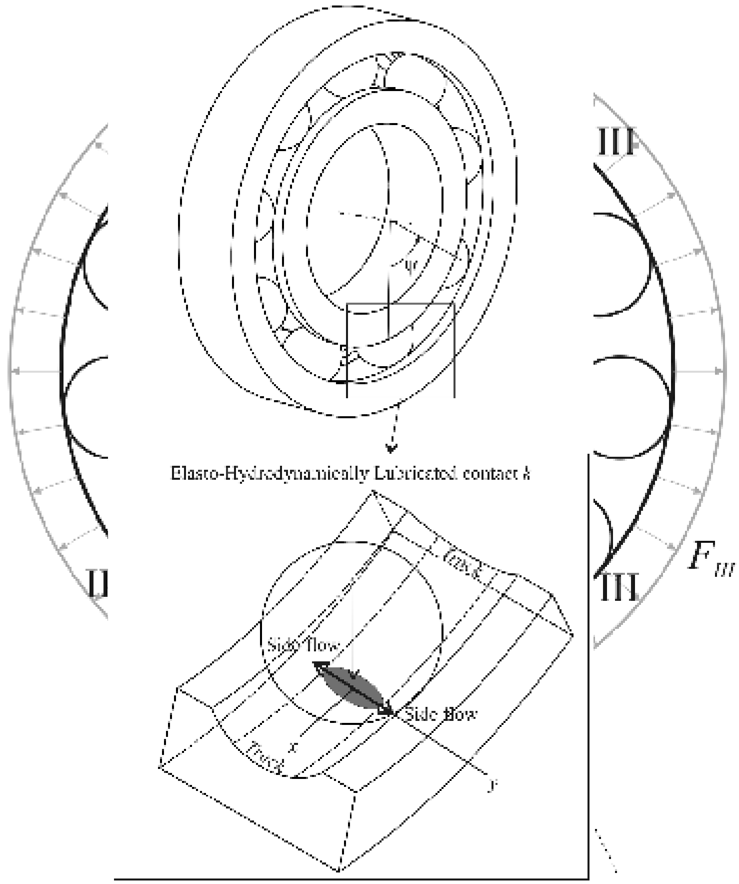
- Introduction
- Theory
  - Ingredients/assumptions
  - Equations
- Experimental validation
- Results
- Conclusions

Theory

Film thickness decay model for roller bearings

Ingredients:

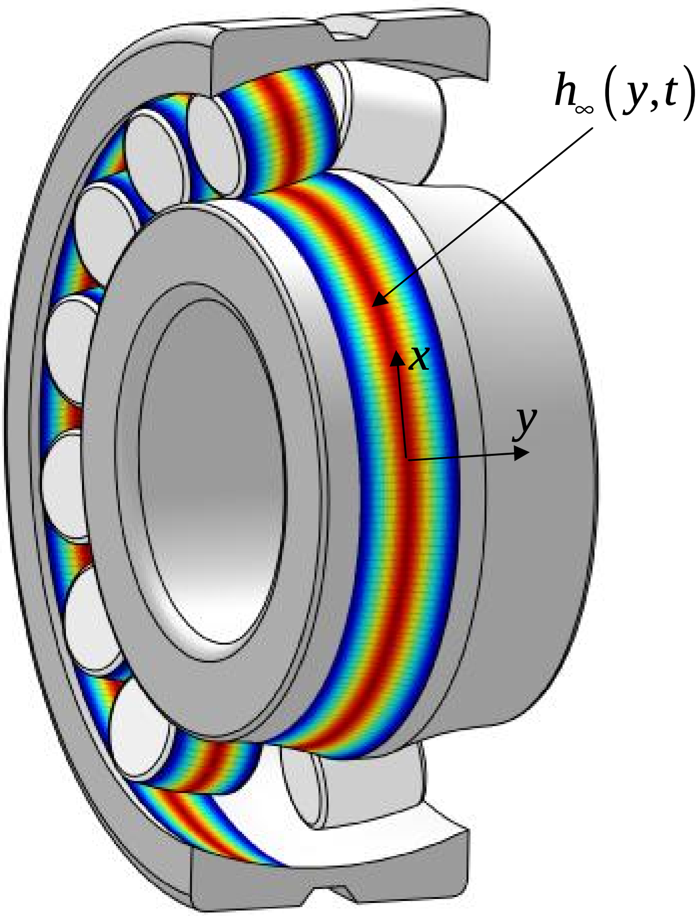
- Layer decay due to flow in the EHL contacts
- No lubricant supply
- Inner/outer raceway geometry
- Load distribution



Theory

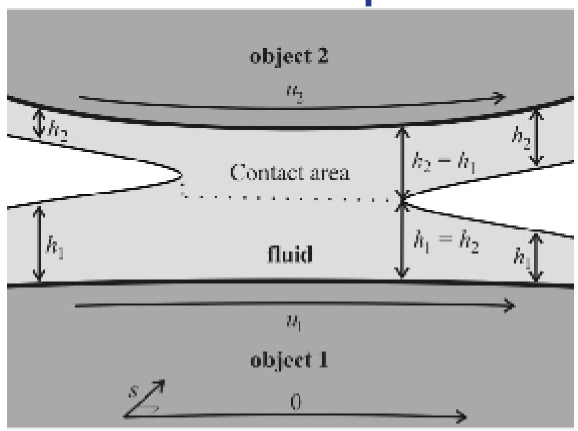
2D à 1D:

- Equipartition
- Contact pressure smoothening
- Surface tension

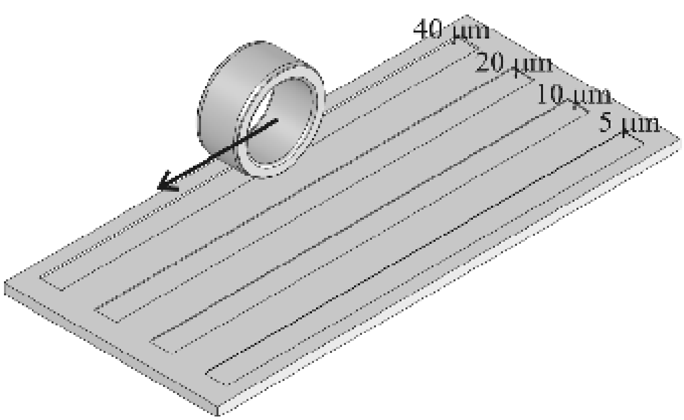


Theory - Equipartition

The concept

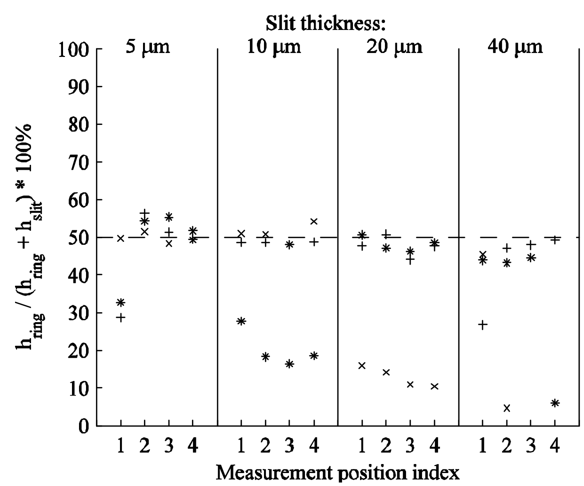


Measurement setup



Measurements have been carried out by H. de Ruig and R. Meeuwenoord at SKF ERC

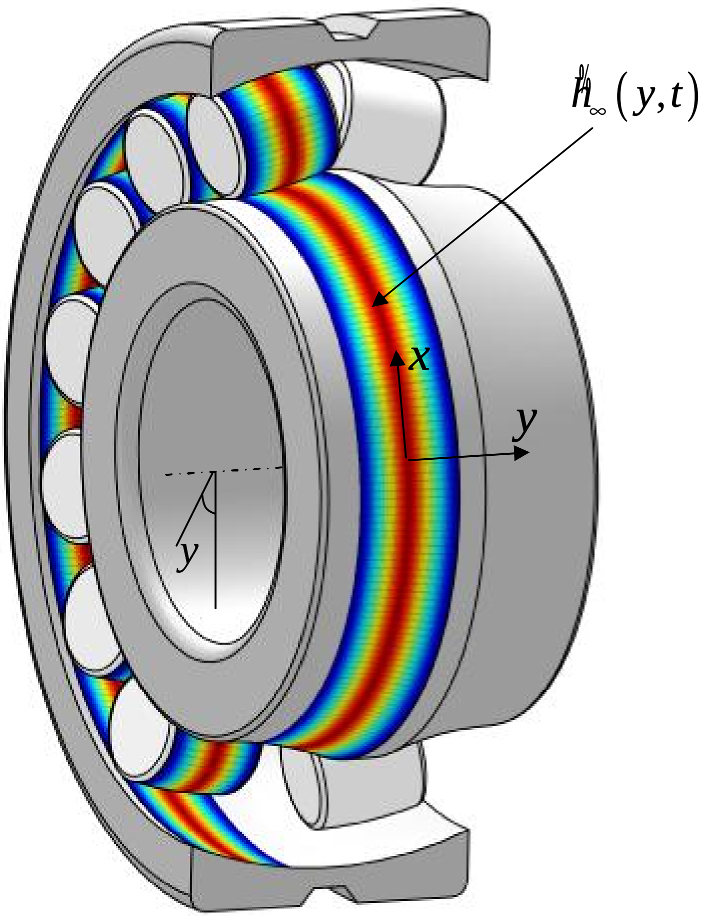
Measurement Results



Theory

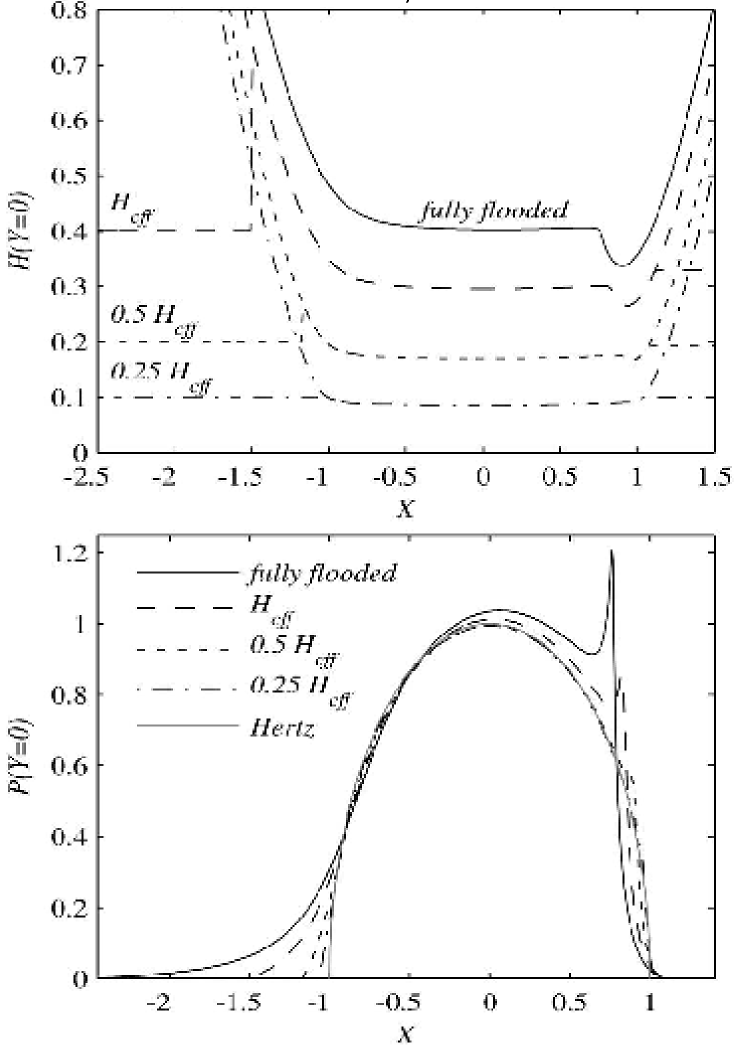
Mass conservation

$$\frac{\partial \tilde{h}_{\infty}}{\partial t} = -\frac{1}{r_0 l_t} \frac{\partial \hat{q}_y}{\partial y}$$



Theory

M=20.1, L = 10.4



Layer thickness

$$\lim_{h_{oil} \to 0} h = \frac{2\bar{h}_\infty}{\bar{r}}$$

Pressure

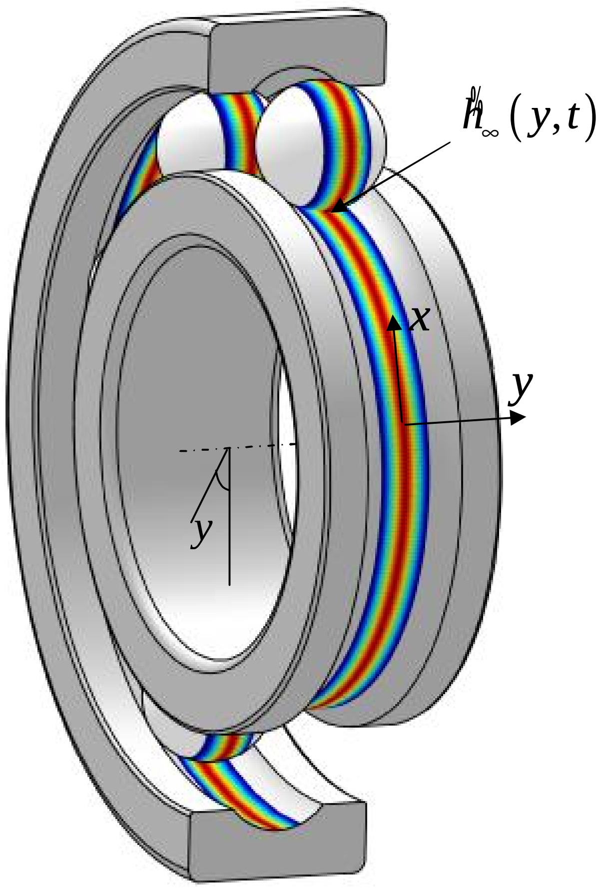
$$\lim_{h_{oil} \to 0} p = p_h \sqrt{1 - \left(\frac{x}{a}\right)^2 - \left(\frac{y}{b}\right)^2}$$

Theory

Central film thickness – bearing

Layer thickness distribution

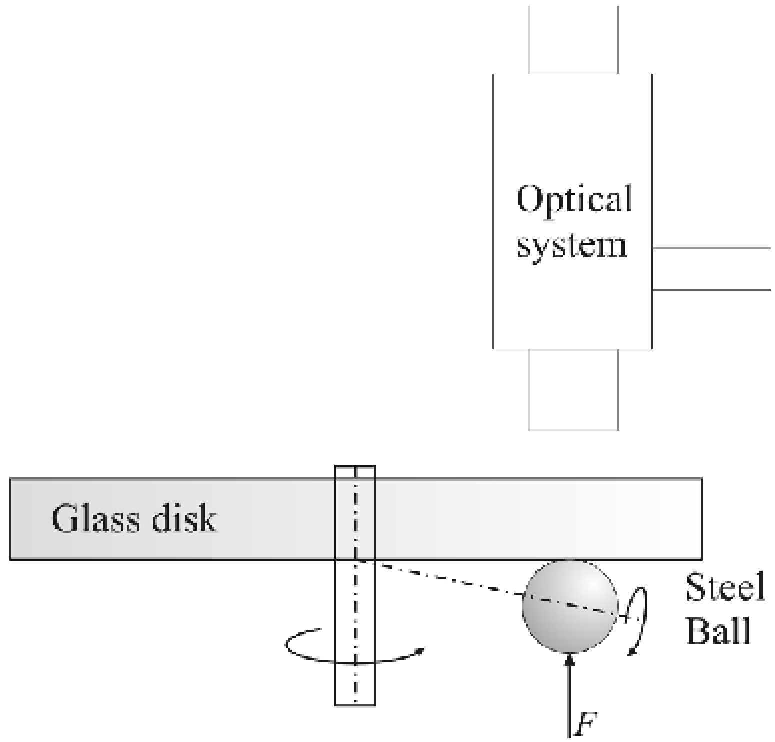
$$\frac{\partial \tilde{h}_\infty}{\partial t} = -\frac{\partial}{\partial y}\left(\tilde{h}_\infty^3\, y\, f(y)\right)$$



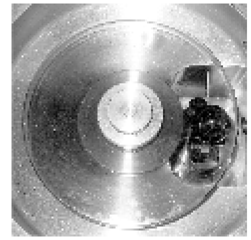
Content

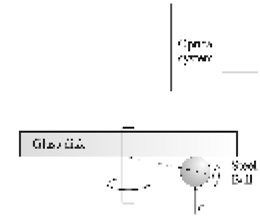
- Introduction
- Theory
- Experimental validation
- Results
- Conclusions

Experimental validation

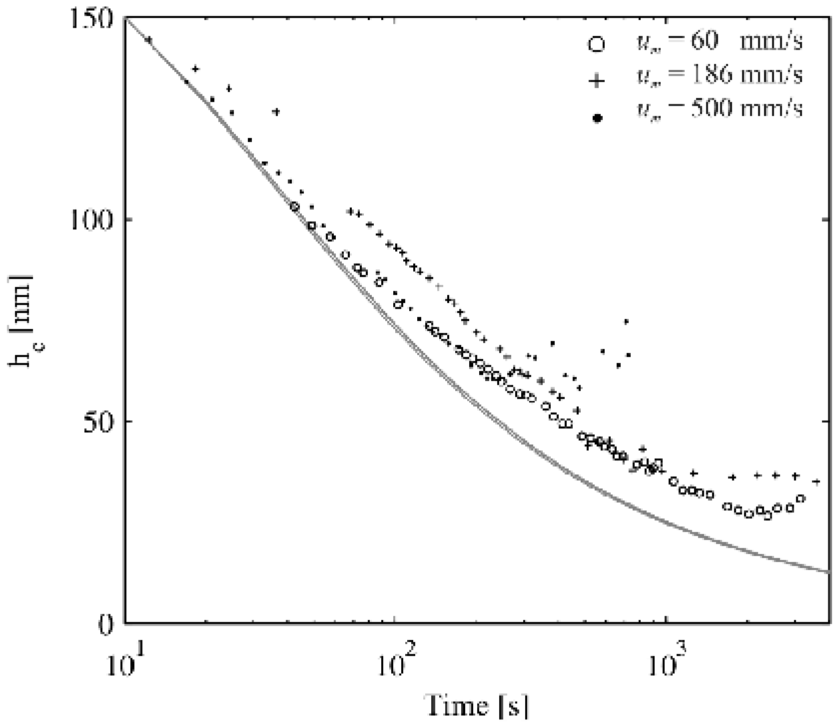


Experimental validation



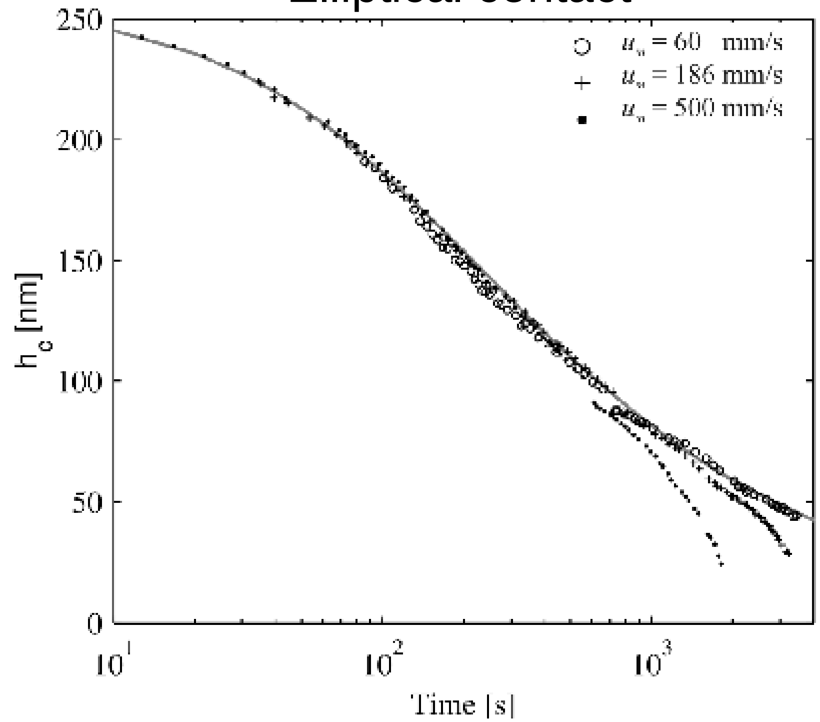


Circular contact



F = 20 N, p_h = 0.5 GPa, $\eta_0 \approx$ 0.8 Pa.s

Elliptical contact



F = 30 N, p_h = 0.33 GPa, $\eta_0 \approx$ 0.85 Pa.s

van Zoelen, M. T.; Venner, C. H. & Lugt, P. M. “Prediction of Film Thickness Decay in Starved EHL Contacts using a Thin Layer Flow Model,” *Journal of Engineering Tribology, ImechE,* **2009**, *223*, In Press.

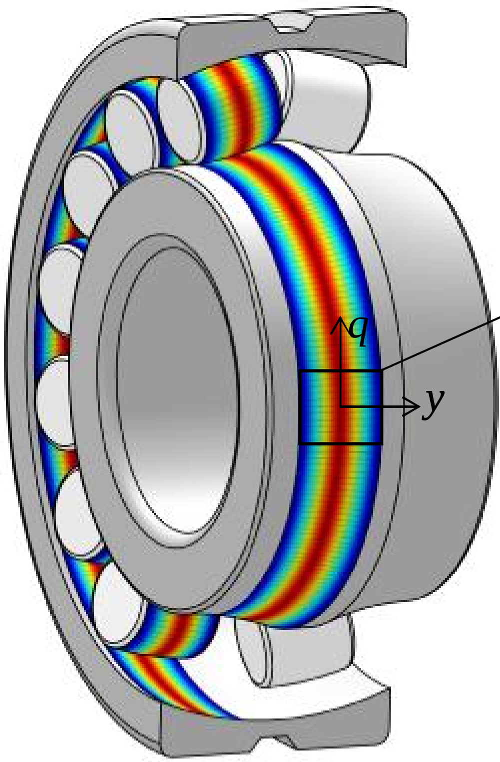
Content

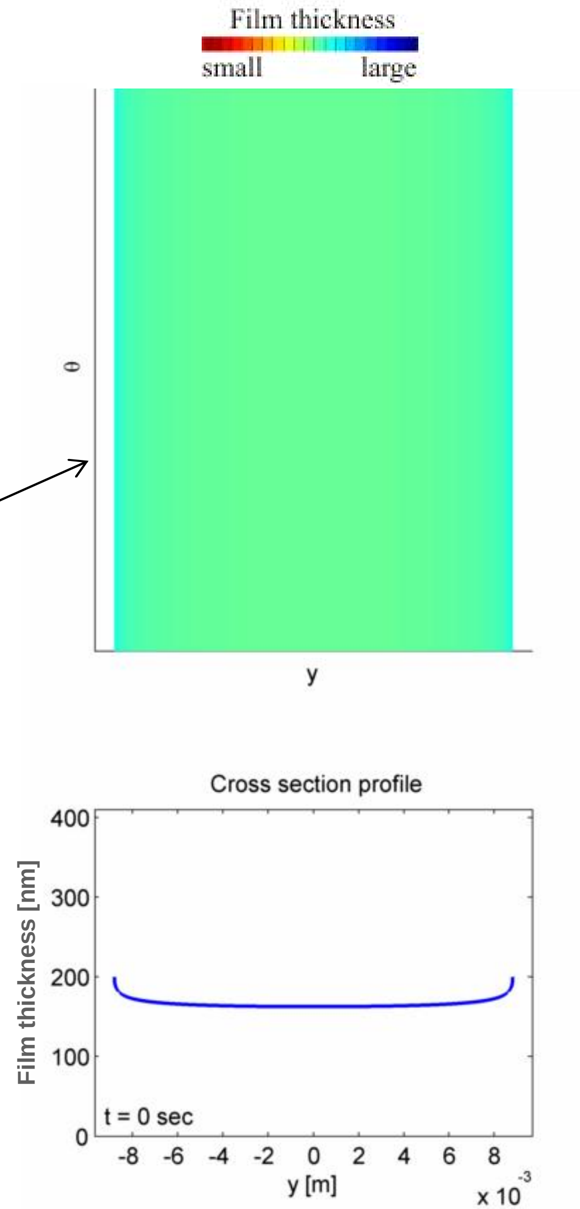
- Introduction
- Theory
- Experimental validation
- Results
  - Film thickness distribution
  - Central film thickness
- Conclusions

Results

Film thickness distribution

Spherical Roller Bearing 22317



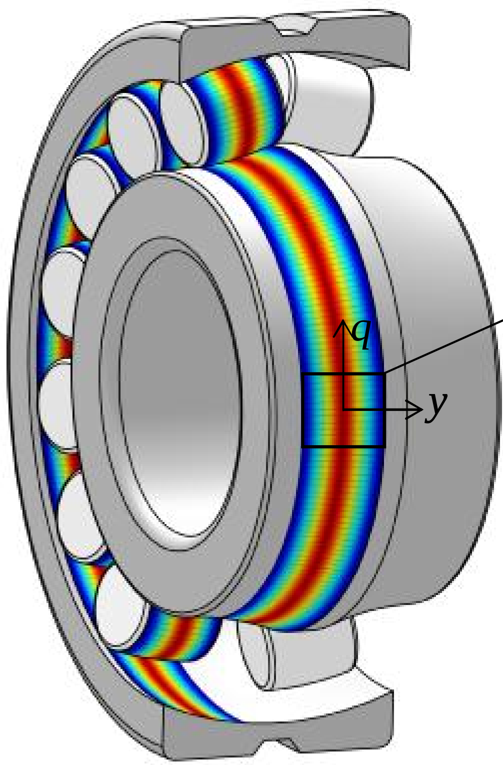


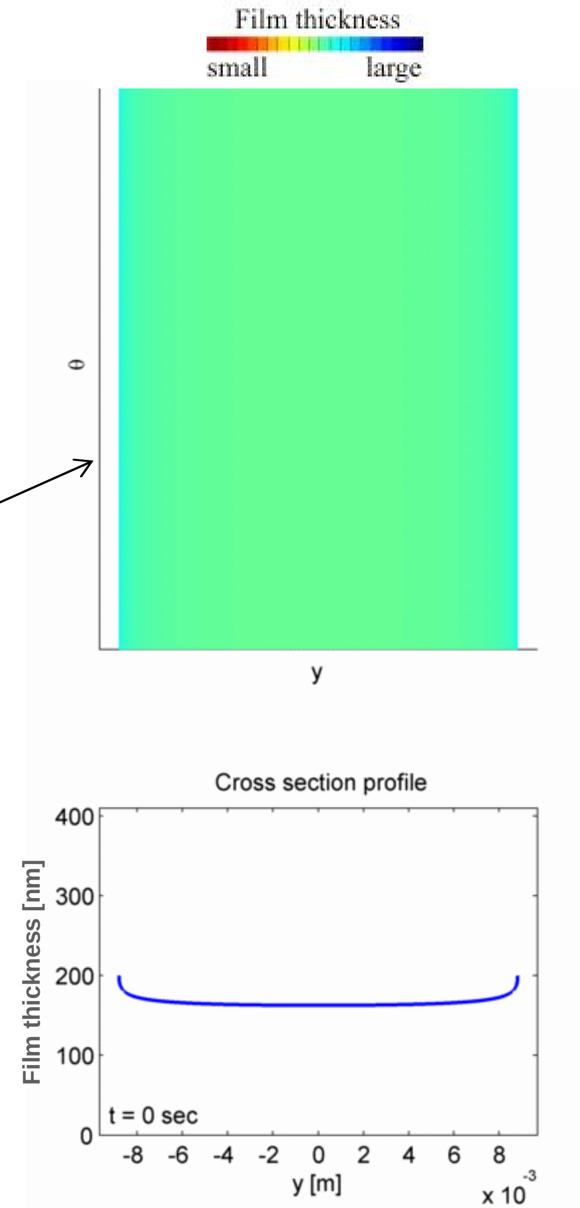
Fr = 10kN, Ω = 3000 rpm

Results

Film thickness distribution

Spherical Roller Bearing 22317



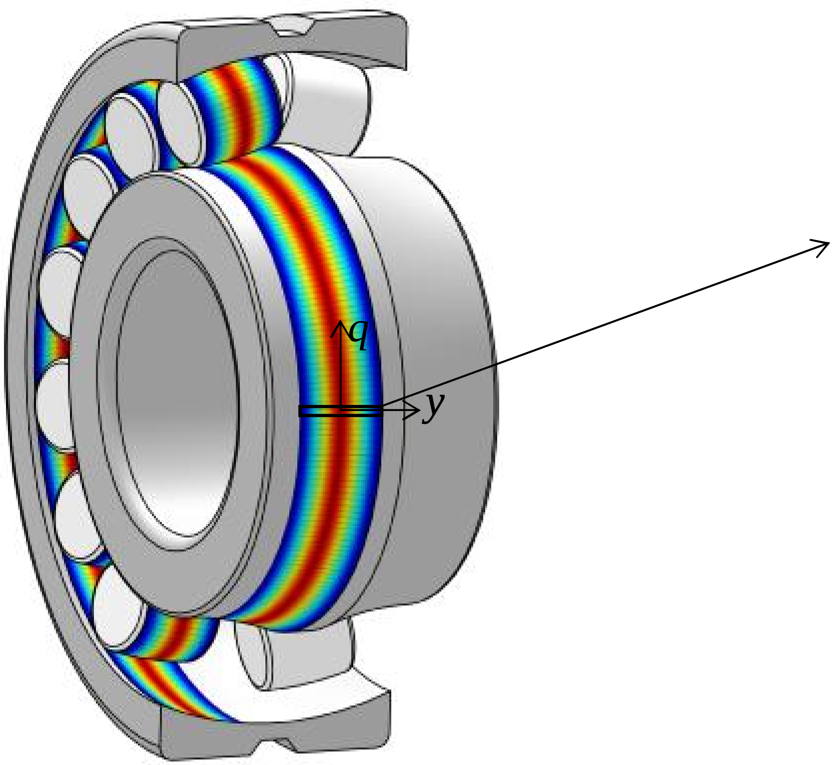


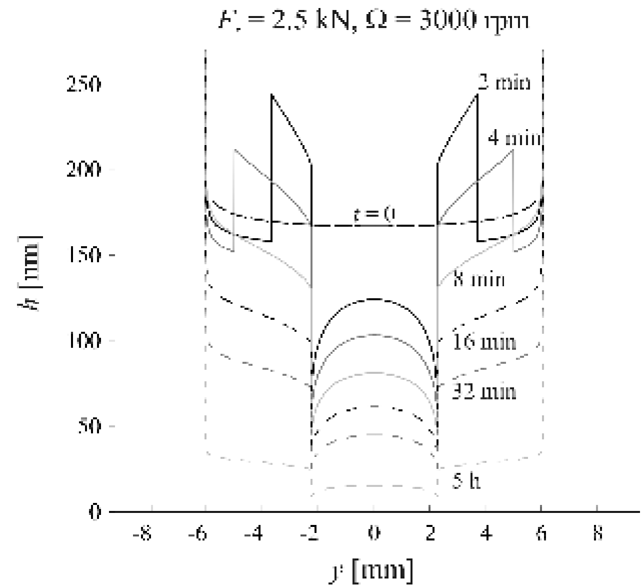
Fr = 10kN, Ω = 3000 rpm

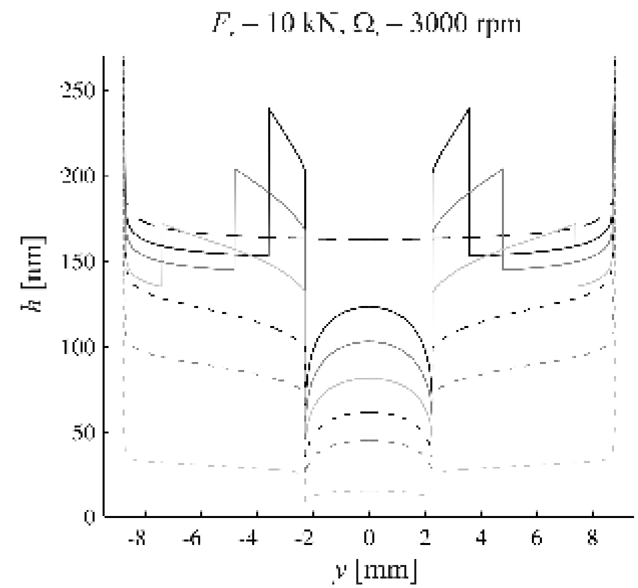
Results

Film thickness distribution

Influence of load



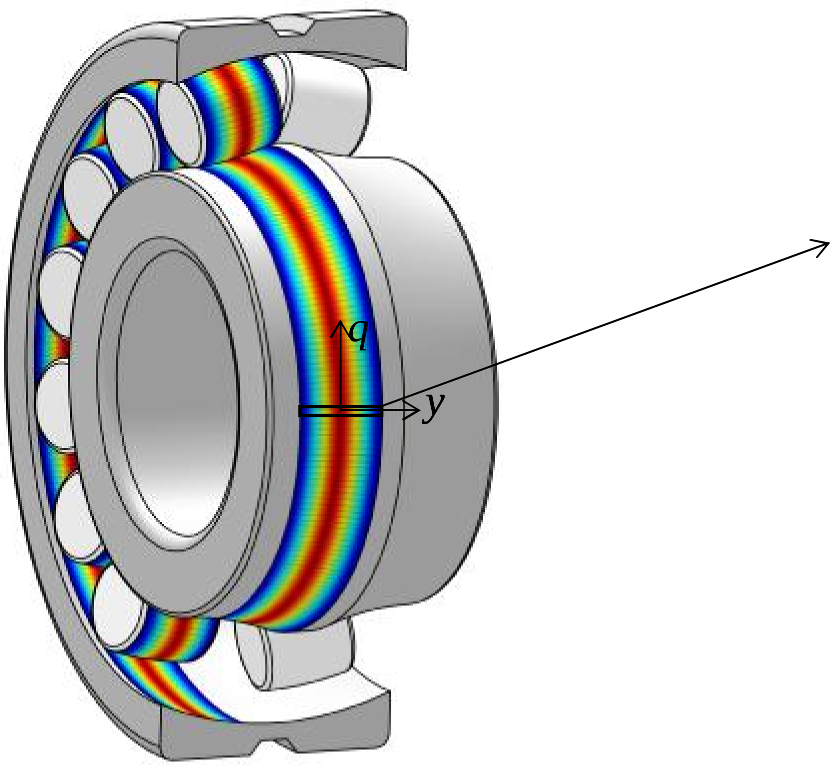


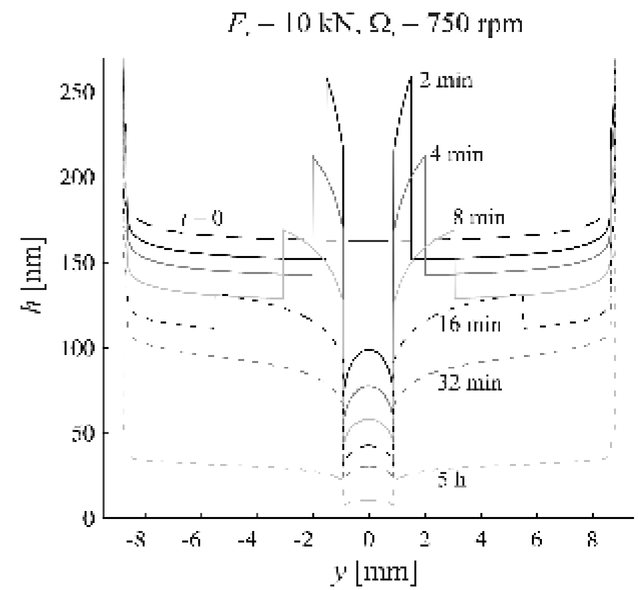


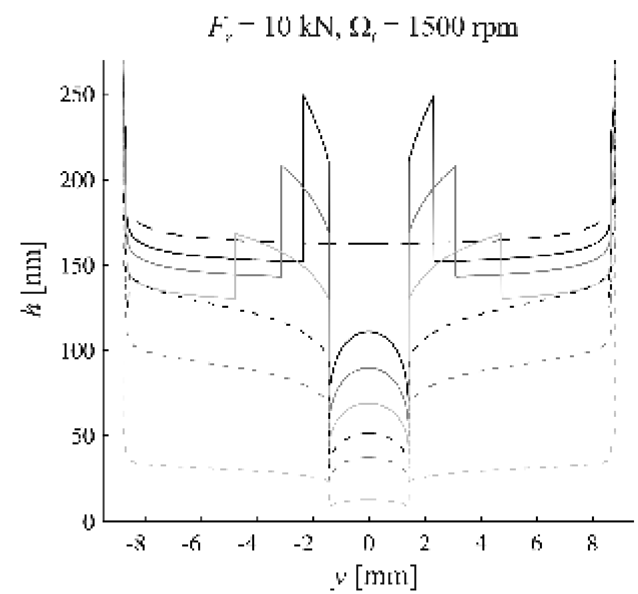
Results

Film thickness distribution

Influence of speed

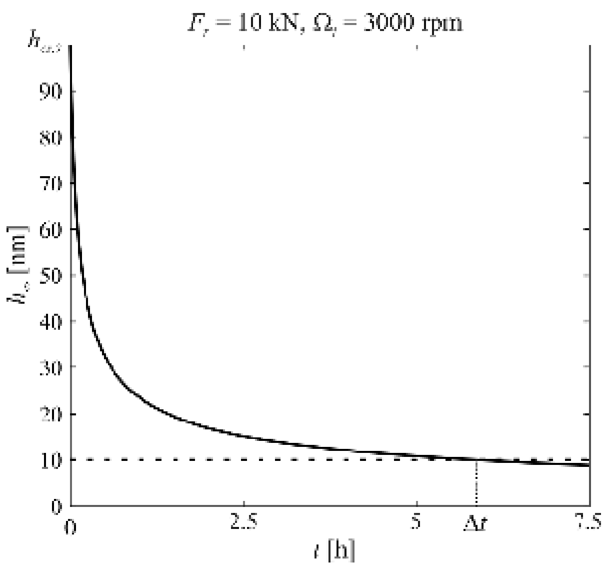




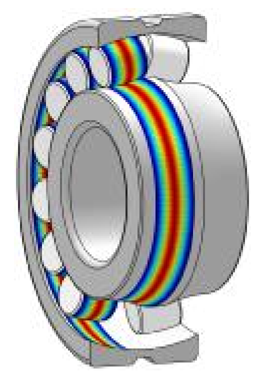


Results

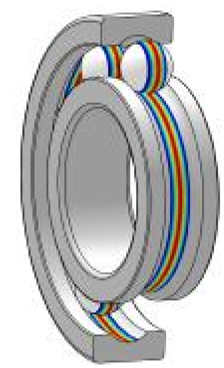
Central film thickness



Spherical Roller Bearing 22317	Deep groove Ball Bearing 209



$$\frac{k^2}{R}$$



Spherical Roller Bearing 22317:

Load [kN]	Speed [rpm]	Δt [h]
10	*750*	**2.5**
10	*1500*	**3.8**
10	*3000*	**5.8**
5	*3000*	**5.7**
2.5	*3000*	**5.6**

Deep groove Ball Bearing 209:

Load [kN]	Speed [rpm]	Δt [h]
10	*750*	**0.048**
10	*1500*	**0.072**
10	*3000*	**0.109**
5	*3000*	**0.105**
2.5	*3000*	**0.100**

Conclusions

- Larger layer thickness decay for ball bearing
- Decay depends on speed.
- Decay depends weakly on the load
- Decay periods are short **à** significant supply of lubricant to the track.

Future work

- Include lubricant supply mechanisms.
- Layer smoothening.
- Comparison with bearing tests: qualitative/quantitative

End