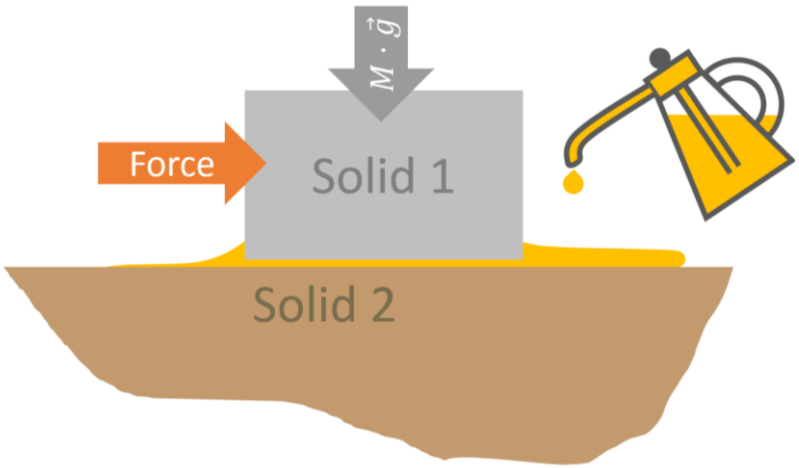
Modelling lubricated contact

04/10/2018



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Working with SIMTEC

Industry Challenges

- R&D sections: experts in their field
  → Expertise in numerical modelling?
- Lack of time
- FE modelling performed by a small group of people

SIMTEC's Solutions

- Numerical modelling project
  → SIMTEC's member as your colleague
  → Help improve your modelling knowledge!
  → Cost-effective outsourcing

Our team & Our clients

COMSOL
Certified Consultant

Numerical Modelling Consultants

6 Members all EngD + PhD

- Extensive research background
- Complex problems
- various fields of expertise

Successful Track Record:

- Big international compagnies
- Government laboratories

Involved in Research Consortia

- EU funded projects (REEcover / SHARK)
- PhD projects supervision.

Patrick Namy

Vincent Bruyère

Elise Chevallier

Jean-Marc Dedulle

Jean-David Wheeler

Maalek Mohamed-Said

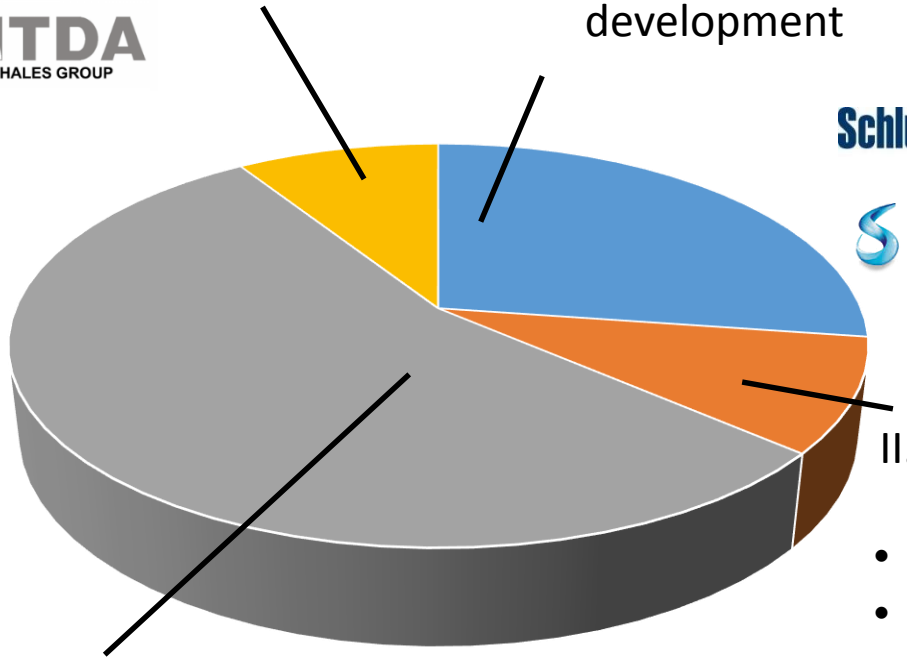
EUROPEAN COMMISSION
SEVENTH FRAMEWORK PROGRAMME
REEcover

SHARK
INDUSTRIALISING LASER FUNCTIONAL TEXTURING

SIMTEC: 15 years of building expertise…

IV. Remote computation

I. Numerical modelling development



III. Provide support in numerical modelling

II. Tailored training sessions on numerical modelling

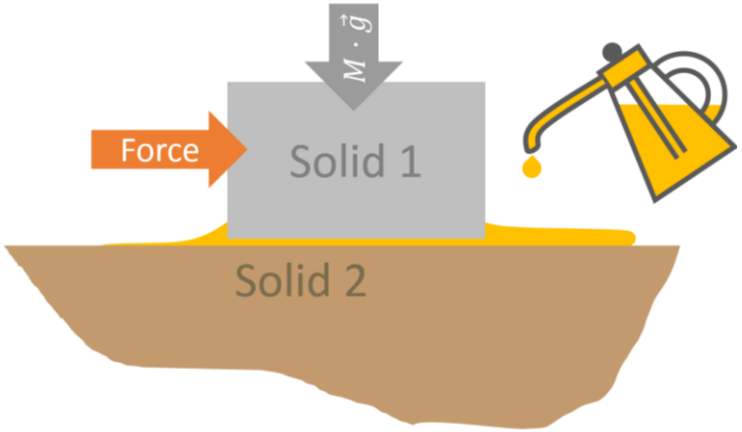
- FEM method training session
- Become an expert with solvers
- Two-phase flow modelling

→ Discover more about our successful modelling work with clients!

www.simtecsolution.fr

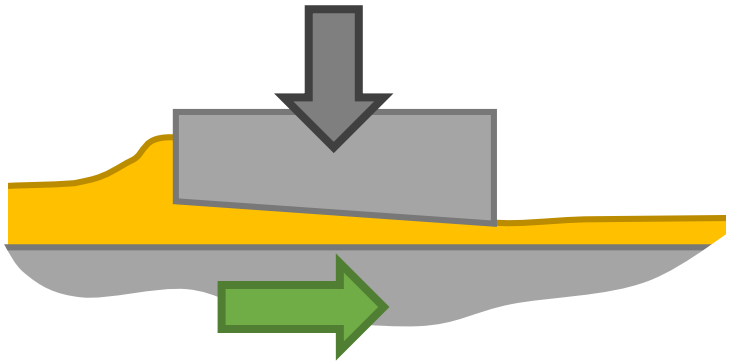
Summary

- Introduction
- Study Case with COMSOL Multiphysics®
- Application with COMSOL Server ™
- Conclusions

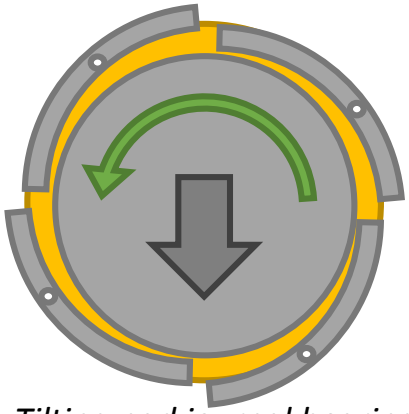


Introduction

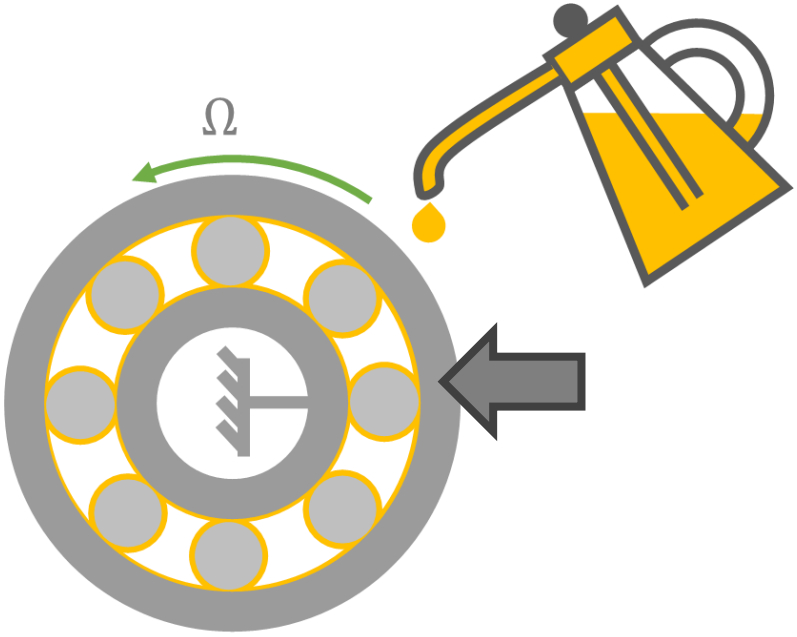
Wear?
Friction force $\overrightarrow{F_f}$?



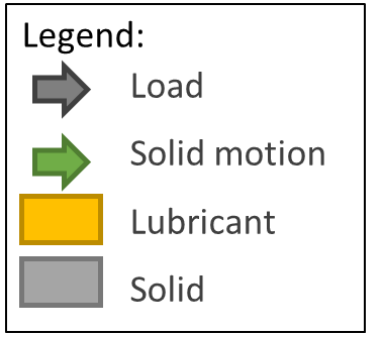
Sliding bearing



Tilting pad journal bearing



Side view of a rolling element bearing



Images from [Wheeler, Bruyère & Namy, COMSOL Conference Boston, 2018]

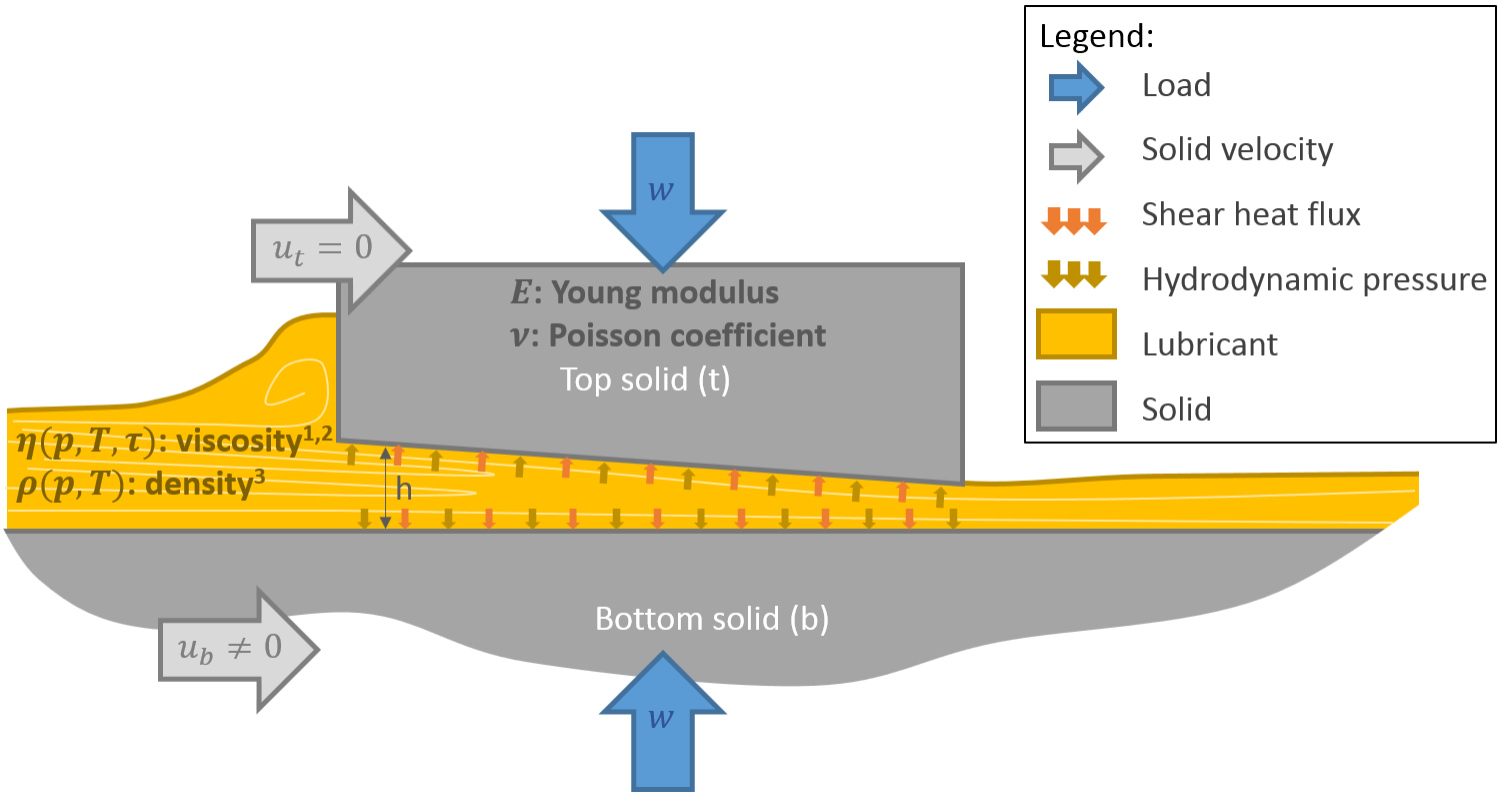
Introduction

- Typical physical phenomena

- **High pressure inside of the contact / at the inlet**
  - → Piezoviscous lubricant
  - → Compressible lubricant
  - → Non-Newtonian lubricant → lubricant thinning
  - → Shear and compression heating → lubricant thinning
  - → Limiting shear stress

- **Solids**
  - → Deformations
  - → Roughness
  - → Heat accumulation
  - → Tribofilm

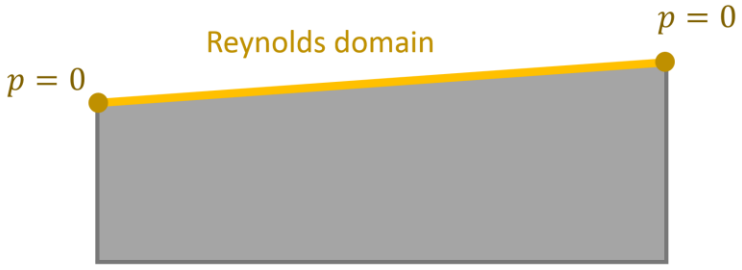
Study case with COMSOL Multiphysics®



Sliding bearing

Study case with COMSOL Multiphysics®

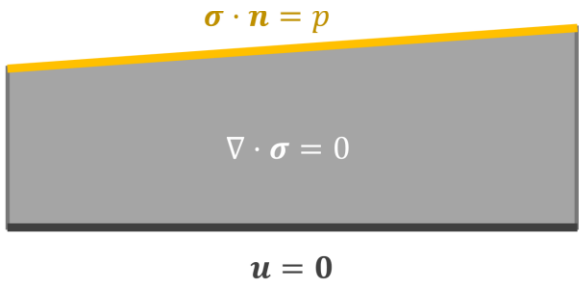
$$\frac{\partial}{\partial x}\left(\frac{\rho h^3}{12\eta}\frac{\partial p}{\partial x}\right) - u_e\frac{\partial(\rho h)}{\partial x} = 0$$



Reynolds domain and boundary conditions

$$h = h_0 + h_{rigid} + deformations$$

Film thickness expression



Equivalent elastic solid deformation equation and boundary conditions

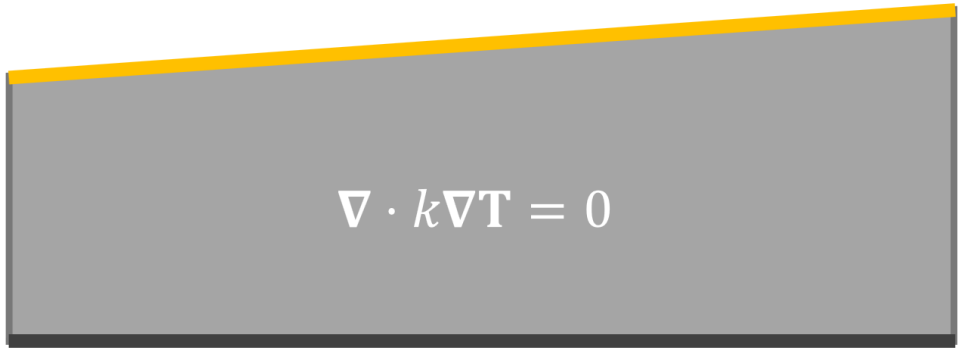
$$\int p = w$$

Load balance equation

Habchi W, Eyheramendy D, Vergne P, Morales-Espejel GE. A full-system approach to the elastohydrodynamic line/point contact problem. J Tribol. 2008;130(2):21501–10

Study case with COMSOL Multiphysics®

$$Q_s = h \cdot \eta \cdot \dot{\gamma}^2$$

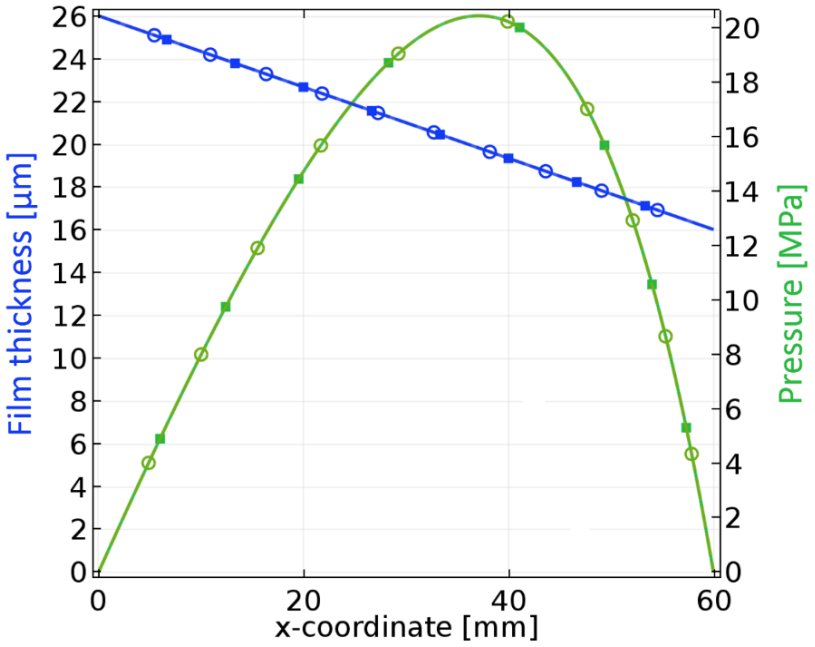


$$T = T_0$$

*Heat transfer equation and boundary conditions on an equivalent solid**

** Yes, it is a bit oversimplified!*

Study case with COMSOL Multiphysics®



Isothermal rigid contact with an isoviscous and incompressible Newtonian lubricant - comparison between analytical[1] (··o··) and numerical (—▪—) results

Solid model	
Deformations	None
Surface roughness	None

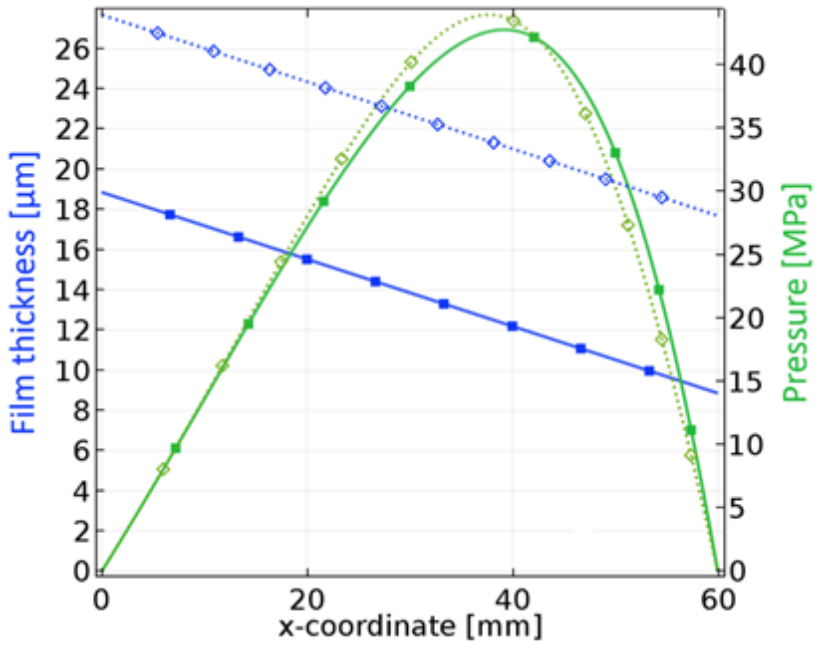
Lubricant density dependence	
Temperature	No
Pressure	No

Lubricant viscosity dependence	
Temperature	No
Pressure	No
Shear stress	No

Parameter	Value [Unit]
Slider velocity u_b	$10\ [m/s]$
Load w	$8 \cdot 10^5\ [N/m]$
Slider length	$60\ [mm]$

[1] Hamrock, B. J., Schmid, S. R. & Jacobson, B. O. Fundamentals of Fluid Film Lubrication. (2004)
Wheeler, J.-D., Bruyere, V., Namy, P., COMSOL Conference, Boston (2018) – to be published

Study case with COMSOL Multiphysics®



Influence of the lubricant temperature on the contact behaviour - comparison between isothermal (··o··) and thermal (—▪—) results

Solid model	
Deformations	None
Surface roughness	None

Lubricant density dependence	
Temperature	Yes
Pressure	No

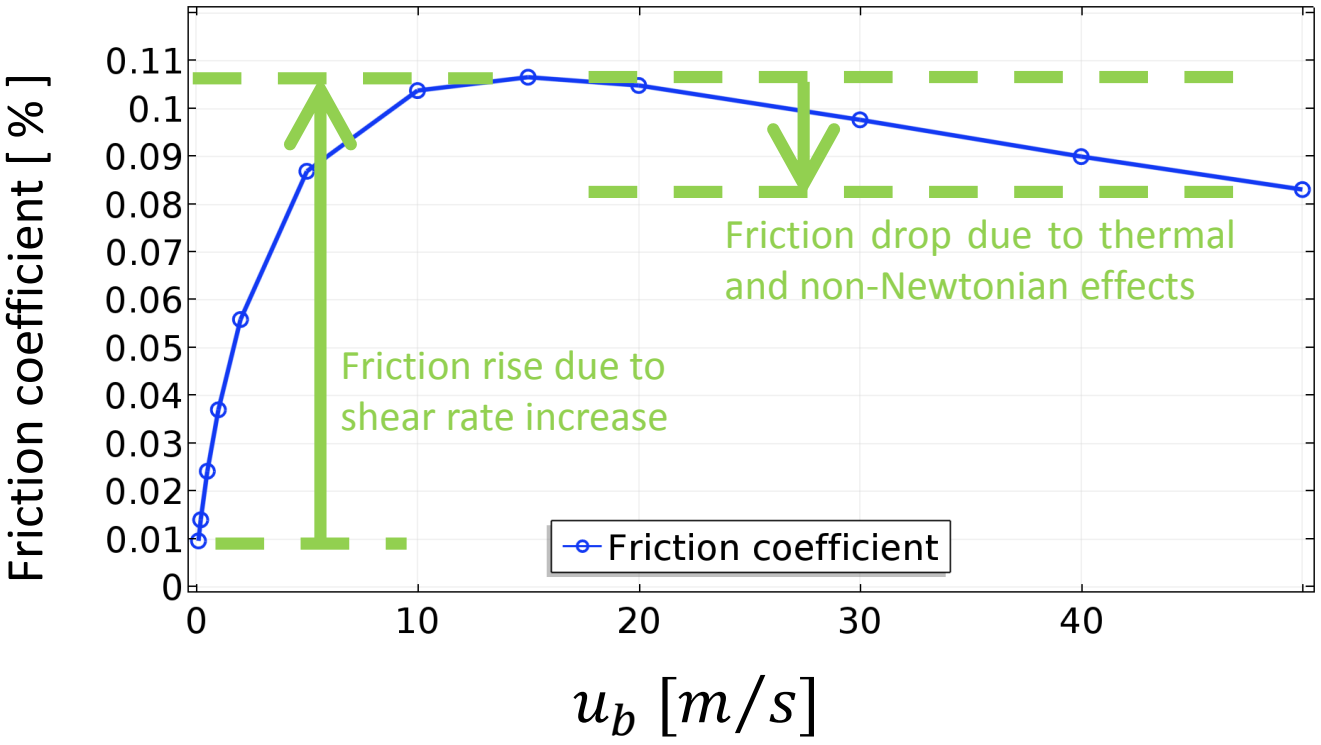
Lubricant viscosity dependence	
Temperature	Yes
Pressure	No
Shear stress	No

Parameter	Value [Unit]
Slider velocity u_b	$10\ [m/s]$
Load w	$8 \cdot 10^5\ [N/m]$
Slider length	$60\ [mm]$

Wheeler, J.-D., Bruyere, V., Namy, P., COMSOL Conference, Boston (2018) – to be published

Study case with COMSOL Multiphysics®

FRICTION PREDICTIONS:



Solid model	
Deformations	Yes
Surface roughness	None

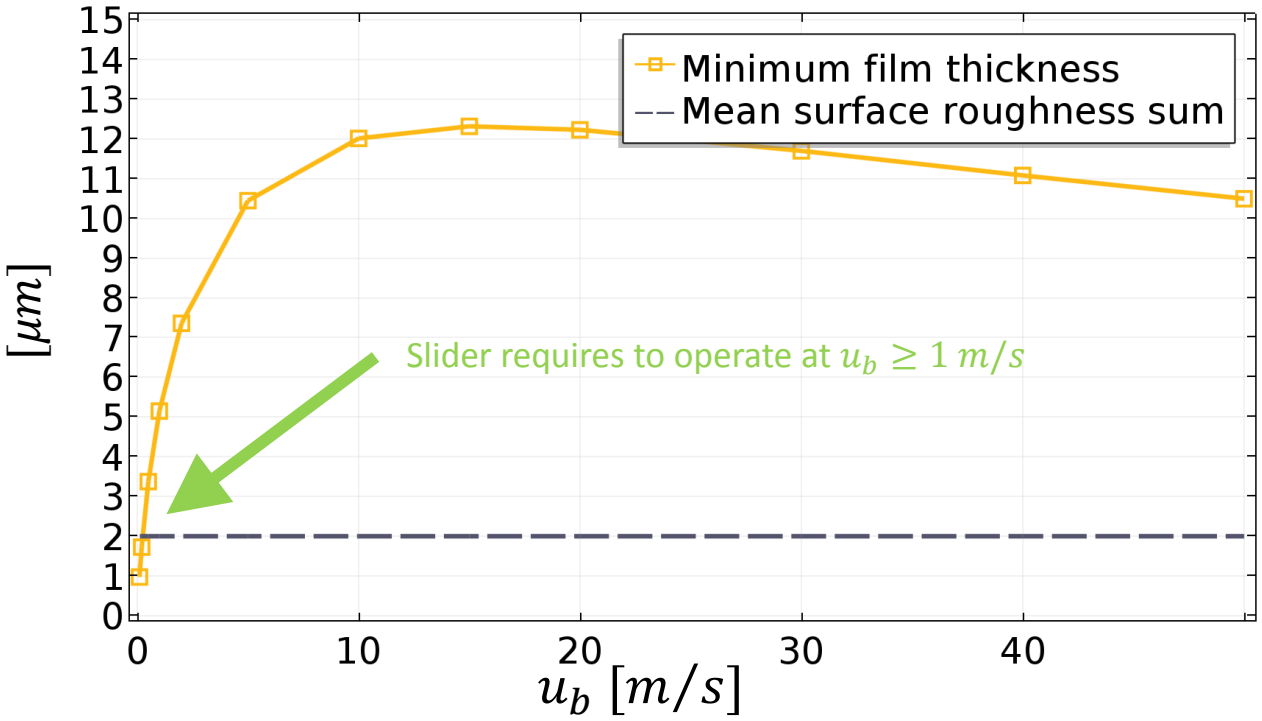
Lubricant density dependence	
Temperature	Yes
Pressure	Yes

Lubricant viscosity dependence	
Temperature	Yes
Pressure	Yes
Shear stress	Yes

Parameter	Value [Unit]
Load w	$8 \cdot 10^5$ $[N/m]$
Slider length	60 $[mm]$

Study case with COMSOL Multiphysics®

WEAR: required operating conditions



Solid model	
Deformations	Yes
Surface roughness	None

Lubricant density dependence	
Temperature	Yes
Pressure	Yes

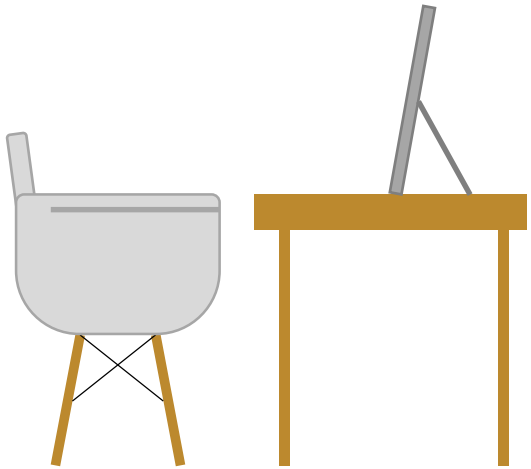
Lubricant viscosity dependence	
Temperature	Yes
Pressure	Yes
Shear stress	Yes

Parameter	Value [Unit]
Load w	$8 \cdot 10^5\ [N/m]$
Slider length	$60\ [mm]$

Application with COMSOL Server™

Application with COMSOL Server™

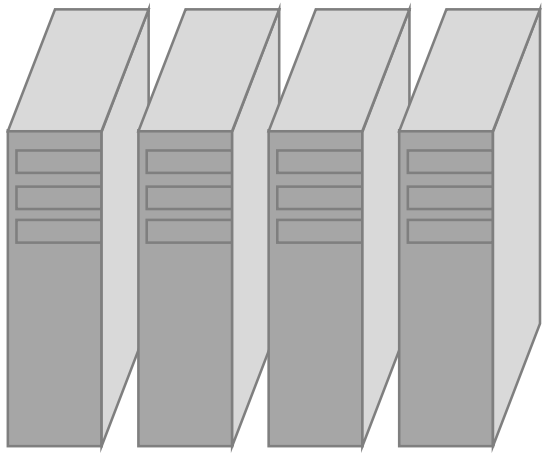
You only need a web browser!



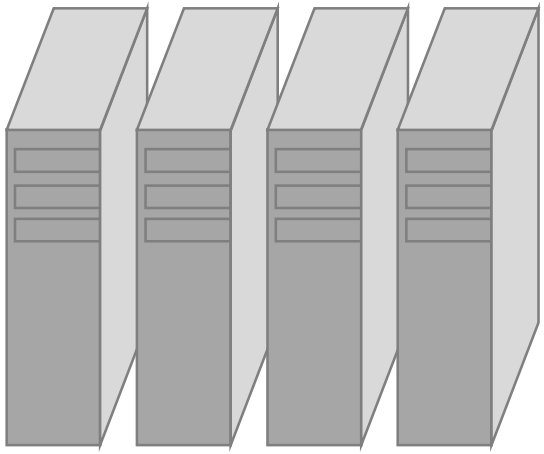
https

High speed secured connexion

SIMTEC



Application with COMSOL Server™



SIMTEC provides:

- New generation workstations
- Hardware maintenance
- Software maintenance
- Scientific validation at the updates
- COMSOL Server™ licence management
- Hotline
- Confidentiality

You:

- **focus only on your topic!**

Application with COMSOL Server™

Ask for a free secured access to the
slider bearing app

to test the SIMTEC modelling skills!

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vincent.bruyere@simtecsolution.fr

Conclusions

- Modelling lubrication is not an easy task!
- However, the tribology research field provides quantitative understanding on some topics
- SIMTEC develops physical models for quantitative predictions
- SIMTEC provides apps to make these models more accessible