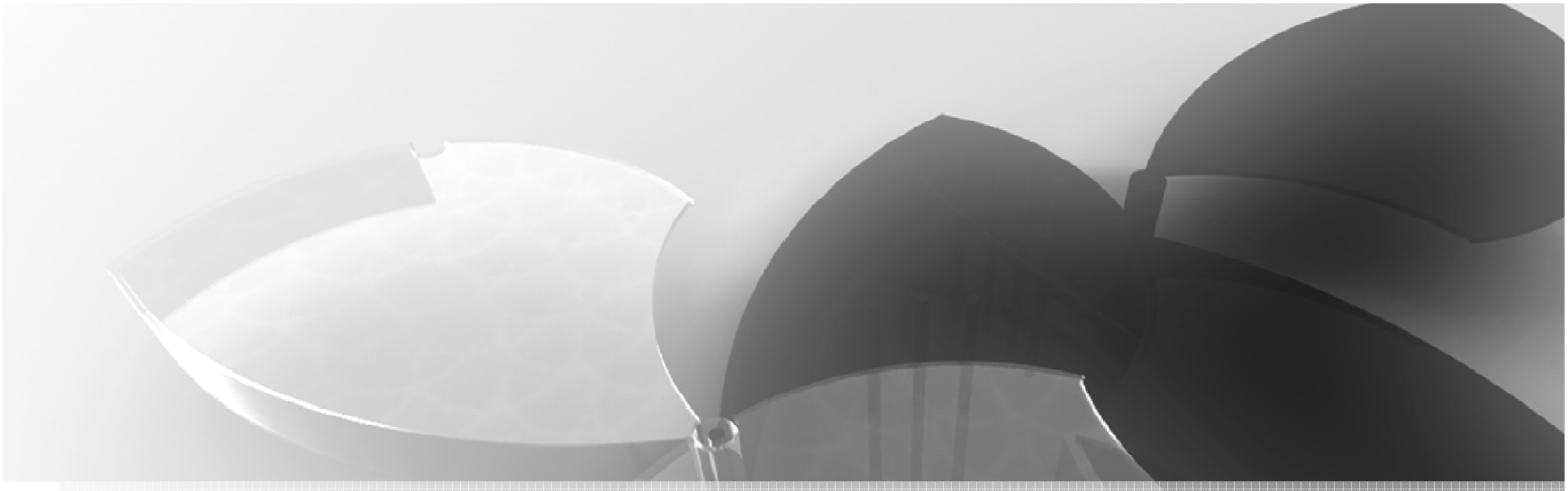

Effect of surface texturing on friction under starved lubrication conditions

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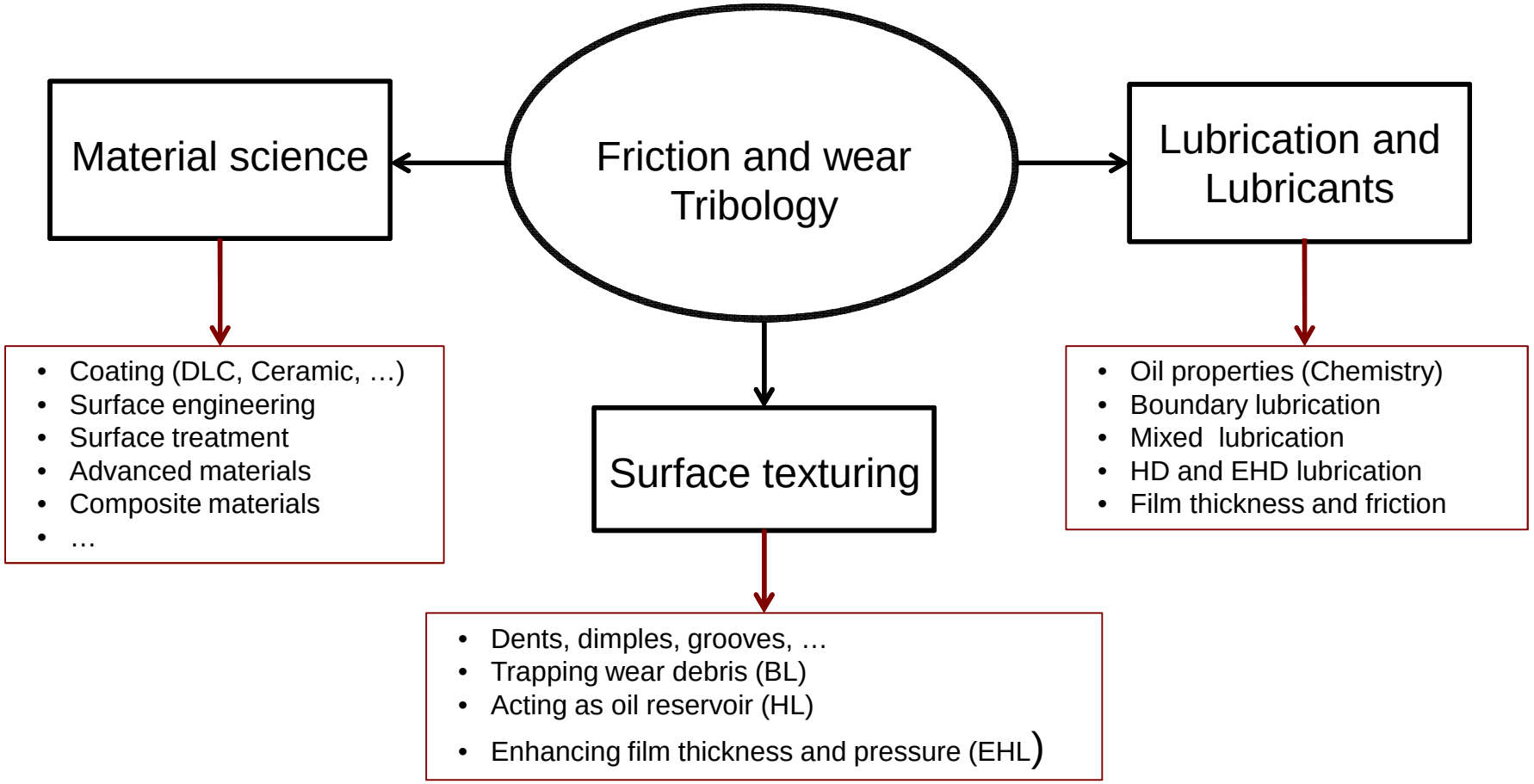
22.10.2103, FSI VUT v Brně, Česká republika

CONTENTS

- INTRODUCTION
- LITERATURE REVIEW
- TITLE AND AIM OF THESIS
- METHODS
- PRELIMINARY RESULTS
- PUBLICATIONS

INTRODUCTION

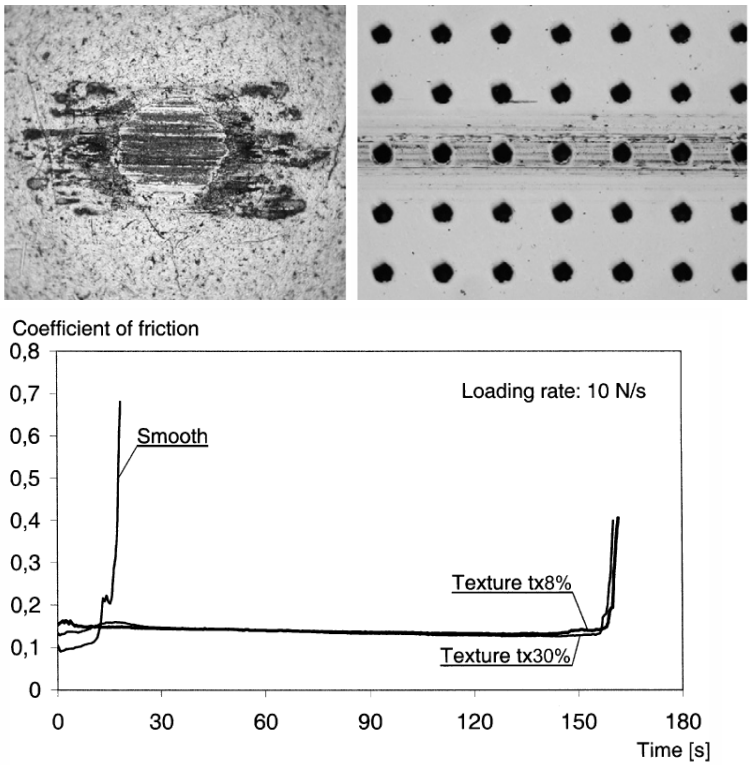


- **Effect of micro-textures on the coefficient of friction and wear**

RESULTS

- Reducing friction and wear under lubricated sliding conditions, in comparison with smooth surfaces.

Andersson et al. 2007



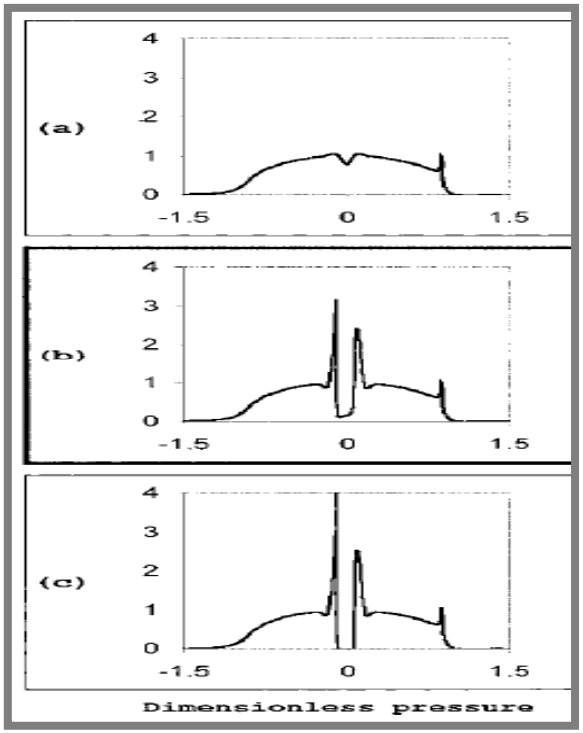
Friction graphs obtained with the SRV tribometer, for a smooth steel disc and for laser-textured discs

- **Effect of micro-textures size on the pressure distribution and film thickness profile in EHL contacts.**

RESULTS

- No effect for small size of micro-dents.
- Positive effect for intermediate size(no cavitations)
- Negative effect for large size due to the cavitations.

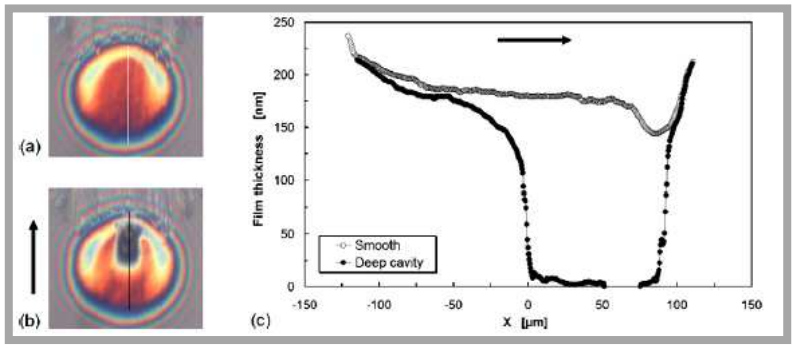
Nélias et al. 2000



Effect of micro-dimples size on the pressure distribution and film thickness profile

- **Effect of micro-dents depth**

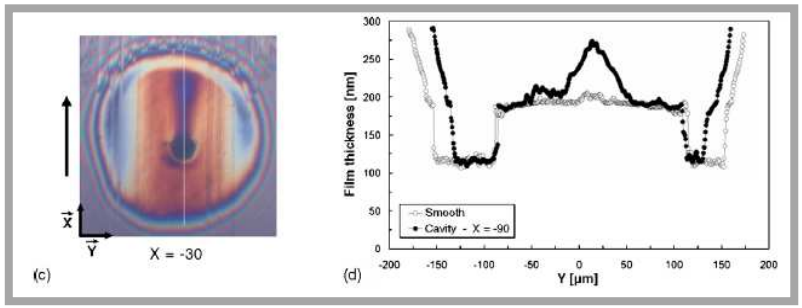
Mourier et al. 2008



Deep micro-cavities

RESULTS

- Deep micro-cavities cause a reduction in film thickness.
- Shallow micro-cavities enhance film thickness.



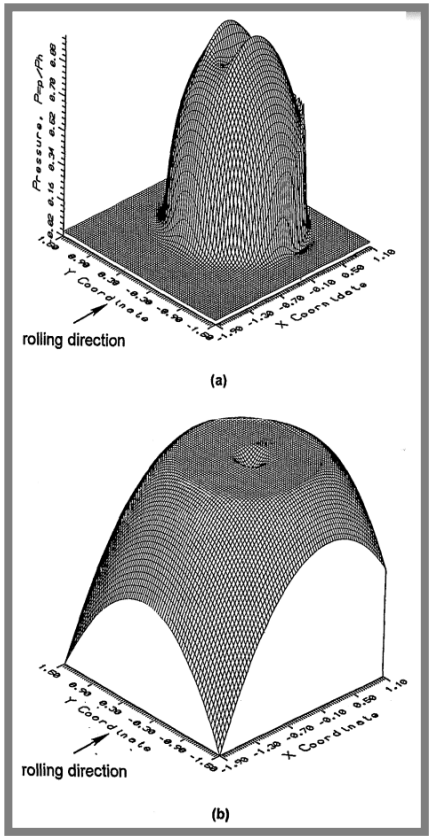
Shallow micro-cavities

- **Effect of slide-to-roll ratio (SRR)**

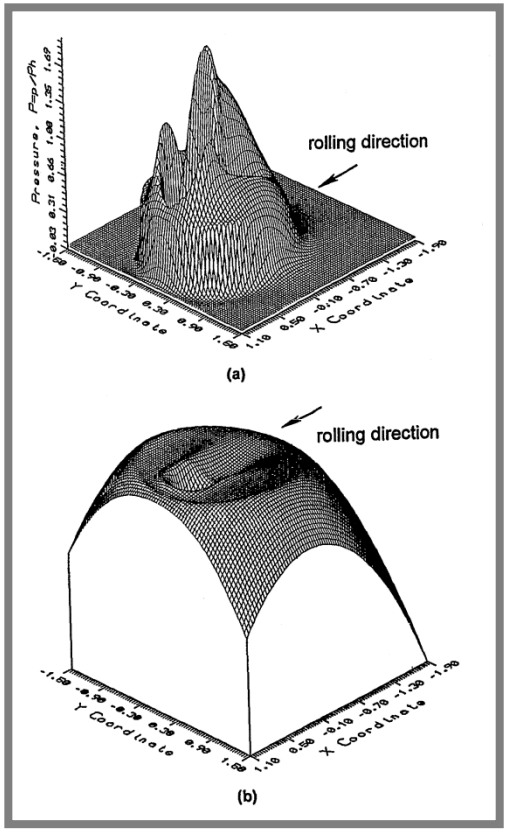
RESULTS

- Limited effect under pure rolling conditions.
- Positive effect when the sliding is introduced.

Ai et al. 1994



SRR=0



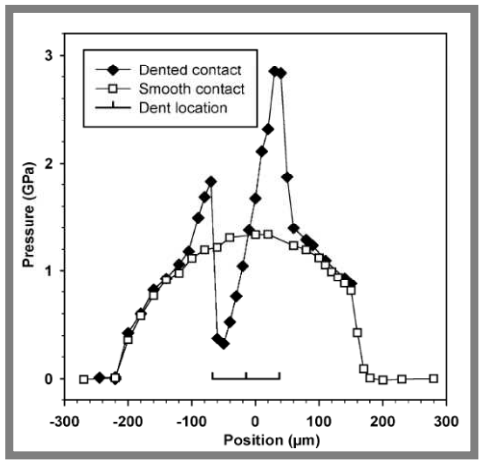
SRR=2

- **Effect of micro-dents on rolling contact fatigue (RCF)**

RESULTS

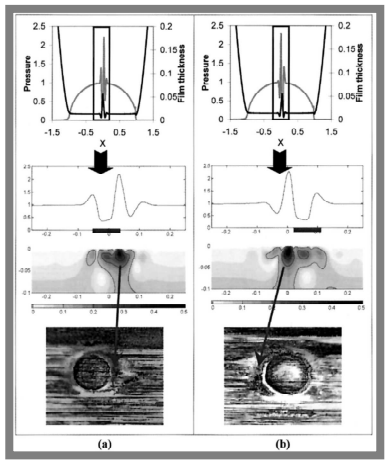
- Low stress concentration was found under pure rolling. Slide-to-roll ratio increases the stress level .
- Location of concentrated pressure depends on the direction of sliding.

Coulon et al. 2004



Pressure profiles for smooth and dented contact

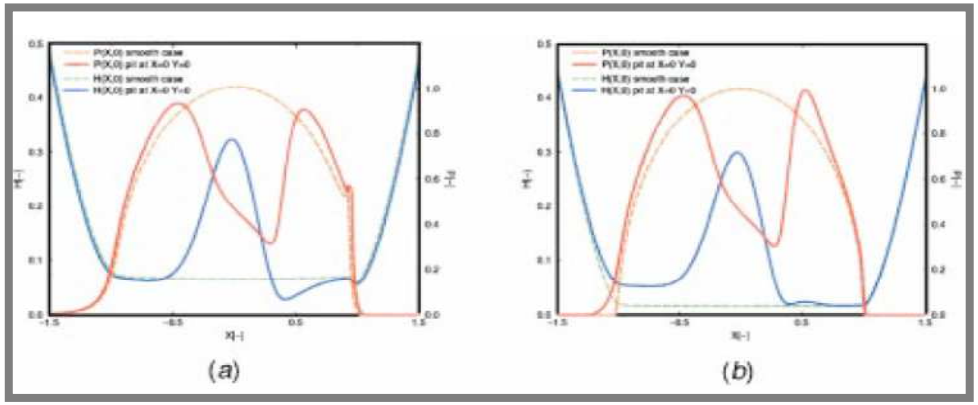
Nélias et al. 2000



stress field in the vicinity of micro-dent

- **Effect of micro-dents under starved conditions**

Dumont et al. 2002

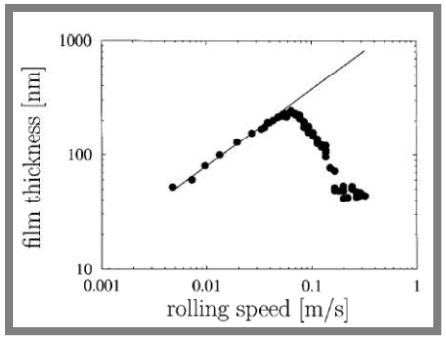


a) Fully flooded contact b) Starved contact

RESULTS

- The beneficial increase of film thickness is lost if the contact becomes fully flooded.

Damiens et al. 2004



Film thickness under starved lubrication

ANALYSIS OF LITERATURE

Problem	Status
Effect of micro-textures on friction and load carrying capacity for conformal contacts	Solved (Numerically and Experimentally)
Effect of micro-textures on pressure and film thickness in non-conformal contacts (EHL)	Solved (Numerically and Experimentally)
Effect of micro-textures on pressure and film thickness in starved EHL	Partially solved (Numerically)
Effect of micro-textures on friction in starved EHL	Not solved

ANALYSIS OF LITERATURE

Problem	Status
Effect of micro-textures on friction and load carrying capacity for conformal contacts	Solved (Num ally and mentally)

Etsion, I., “State of the Art in Laser Surface Texturing”, ASME

Pettersson, U. and Jacobson, S., "Influence of Surface Texture on Boundary Lubricated Sliding Contacts", Tribology International

Zhao, J., Sadeghi, F. and Nixon, H., “A Finite Element Analysis of Surface Pocket Effects in Hertzian Line Contact”, ASME Journal of Tribology

Kovalchenko, A., Ajayi, O., Erdemir, A., Fenske, G., Etsion, I., “The Effect of Laser Surface Texturing on Transitions in Lubrication Regimes During Unidirectional Sliding Contact”, Tribology International

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Effect of micro-textures on pressure and film thickness in non-conformal contacts (EHL)	Solved (Numerically and Experimentally)

Coulon S, Jubault I, Lubrech AA, Ville F, Vergne P (2004) Pressure profiles measured within lubricated contacts in presence of dented surfaces. Comparison with numericalmodels. Tribol Int

Nelias D, Ville F (2000) Detrimental effects of debris dents on rolling contact fatigue. Trans ASME J Tribol

Mourier L, Mazuyer D, Lubrecht AA, Donnet C (2006) Transient increase of film thickness in micro-textured EHL contacts. Tribol Int

Ai XL, Cheng HS (1994) The influence of moving dent on point EHL contacts. Tribol Trans

Krupka I, Hartl M (2007) The effect of surface texturing on thin EHD lubrication films. Tribol Int

ANALYSIS OF LITERATURE

Problem	Status
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Effect of micro-textures on pressure and film thickness in starved EHL	Partially solved (Numerically)
Effect of micro-textures on friction in starved EHL	Solved

Dumont M, Lugt PM, Tripp JH (2002) Surface feature effects in starved circular EHL contacts. Trans ASME J Tribol

ANALYSIS OF LITERATURE

Problem	Status
Effect of micro-textures on friction and load carrying capacity for conformal contacts	Solved (Numerically and Experimentally)
Effect of micro-textures on pressure and film thickness in non-conformal contacts (EHL)	Solved (Numerically and Experimentally)
Effect of micro-textures on pressure and film thickness in starved EHL	Partially solved (Numerically)
Effect of micro-textures on friction in starved EHL	Not solved

TITLE

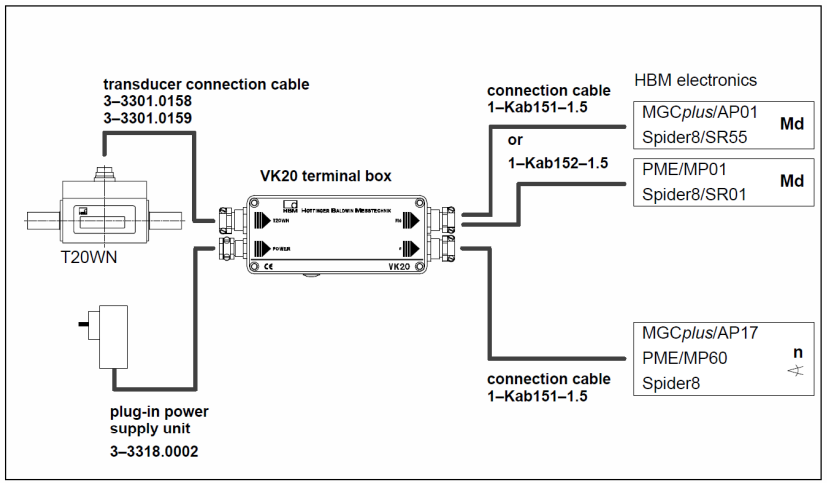
- Effect of surface texturing on friction under starved lubrication conditions.

AIM OF THESIS

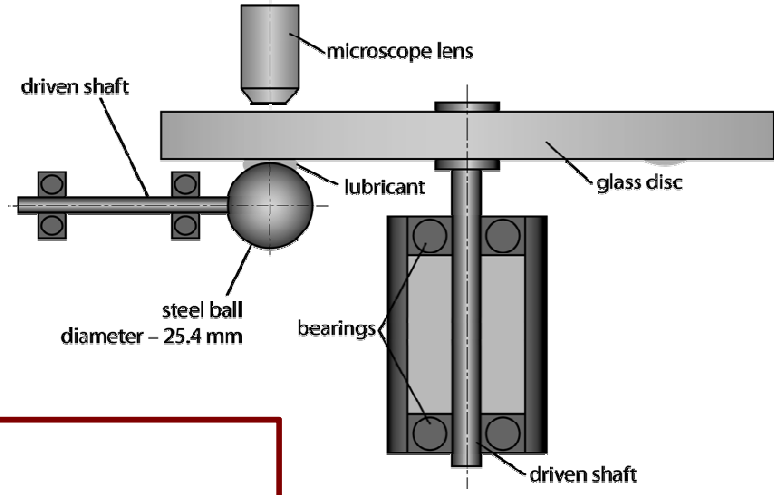
- Studying experimentally the effect of artificial micro-dents on reducing the coefficient of friction in sliding motion between non-conformal surfaces under starved lubrication
- Experimental investigation of micro-textures on pressure and film thickness in starved EHL
- Micro-textures in reciprocating motion with starved EHL
- Optimizing the distribution of micro-dents by means of experimental approach

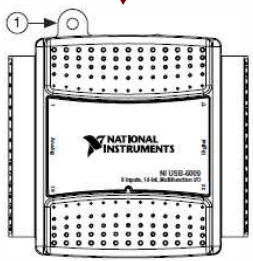
METHODS

Torque sensor with amplifier circuit



EHL contact





D/A Card

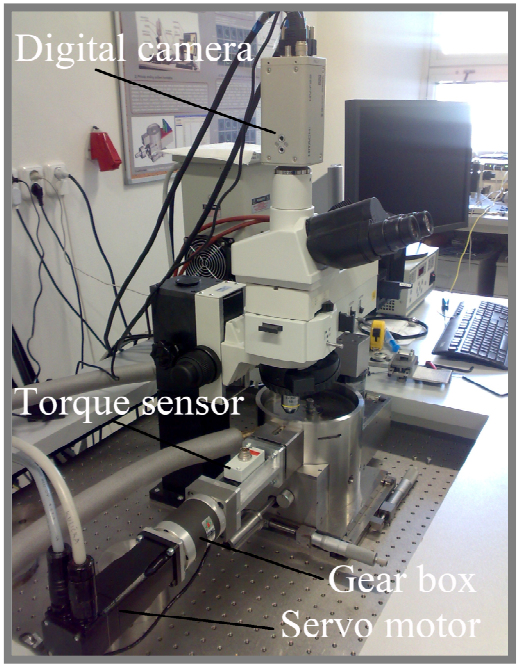
METHODS

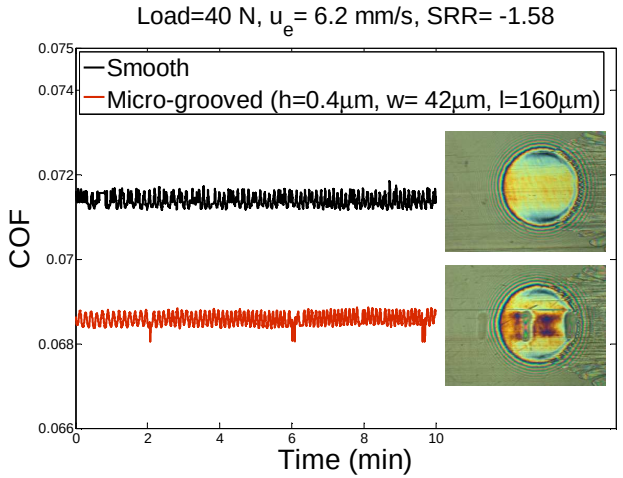
Advantage of setup:

•Possibility of measuring friction and film thickness simultaneously

Disadvantage of setup:

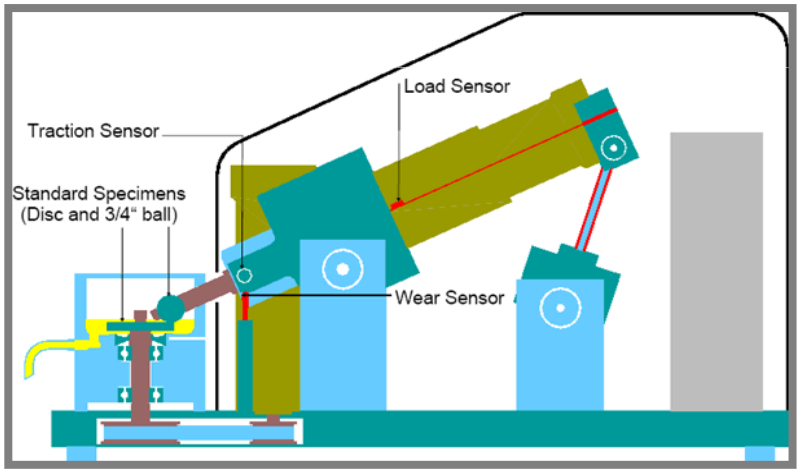
•Calibration for friction measurements
•Low sensitivity for low loads (W<10 N)





Disadvantage of MTM:

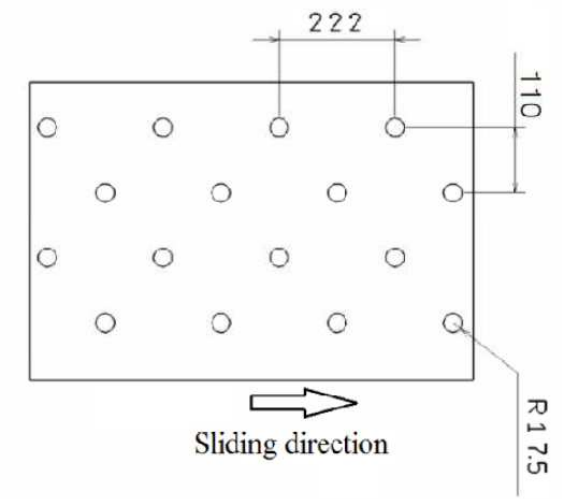
•No film thickness measurements

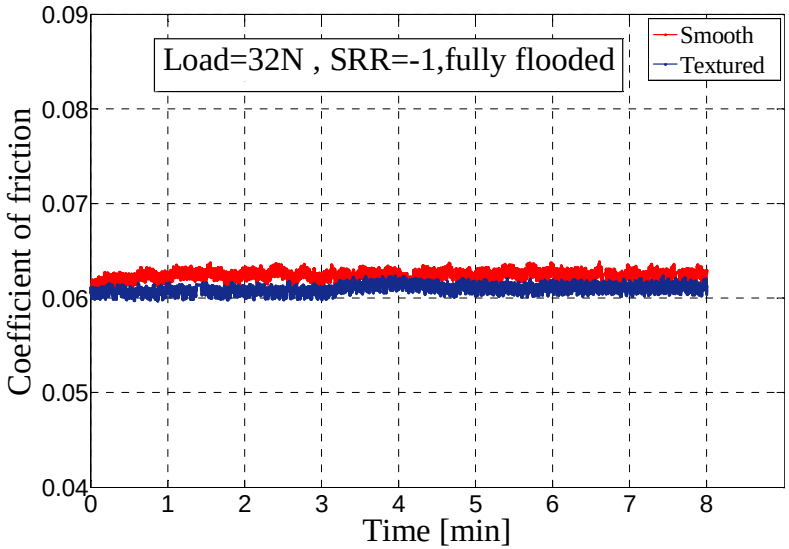


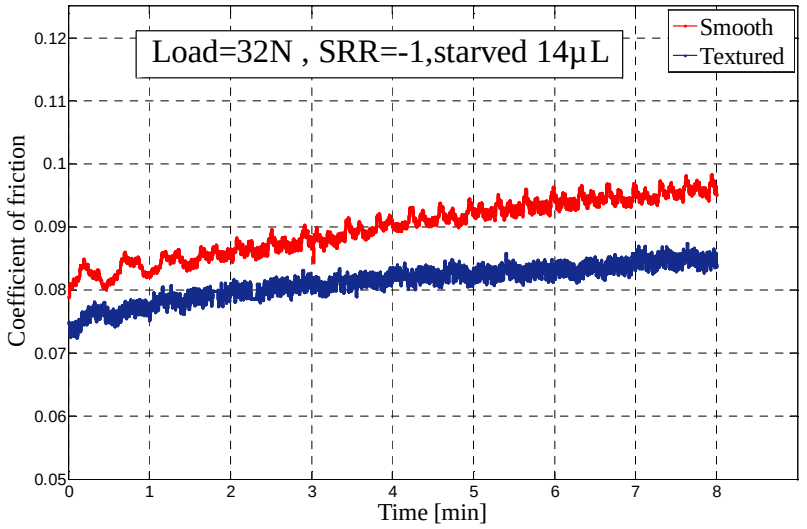
Mini Traction Machine (MTM)

Micro-dents in starved EHL

- Reducing friction under starved condition
- Negligible benefits under fully flooded

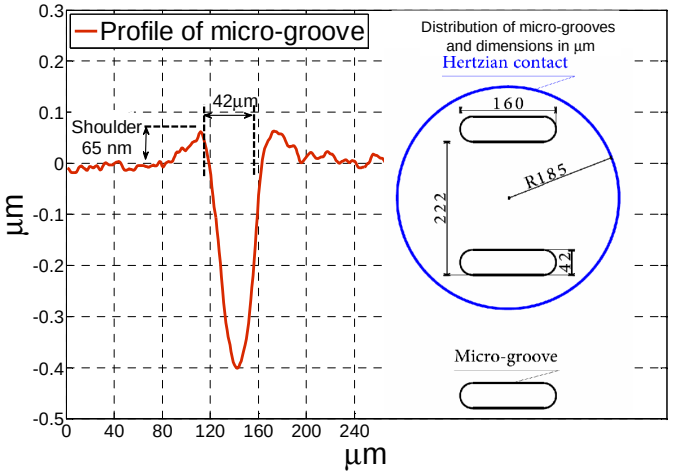




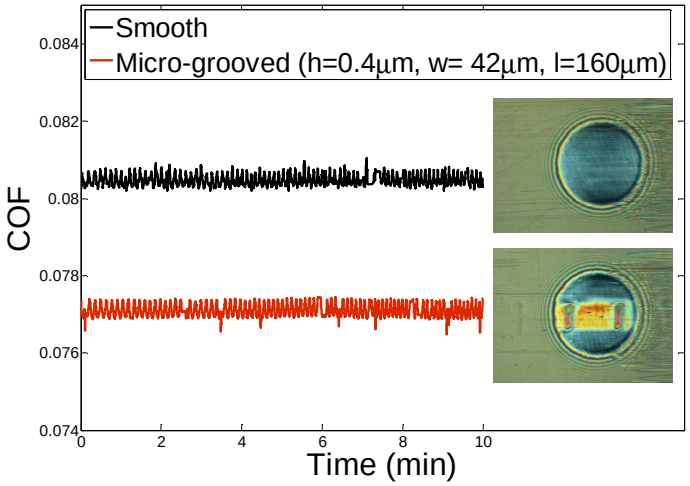


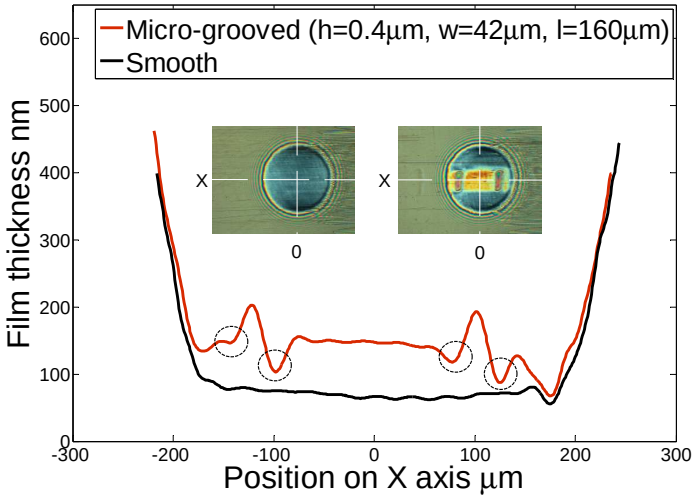
Transverse micro-grooves in starved EHL

- Reducing friction under starved condition
- Enhancing film thickness



Load=40 N, u_e= 2.9 mm/s, SRR= -5.6 (Reverse motion)





Publications

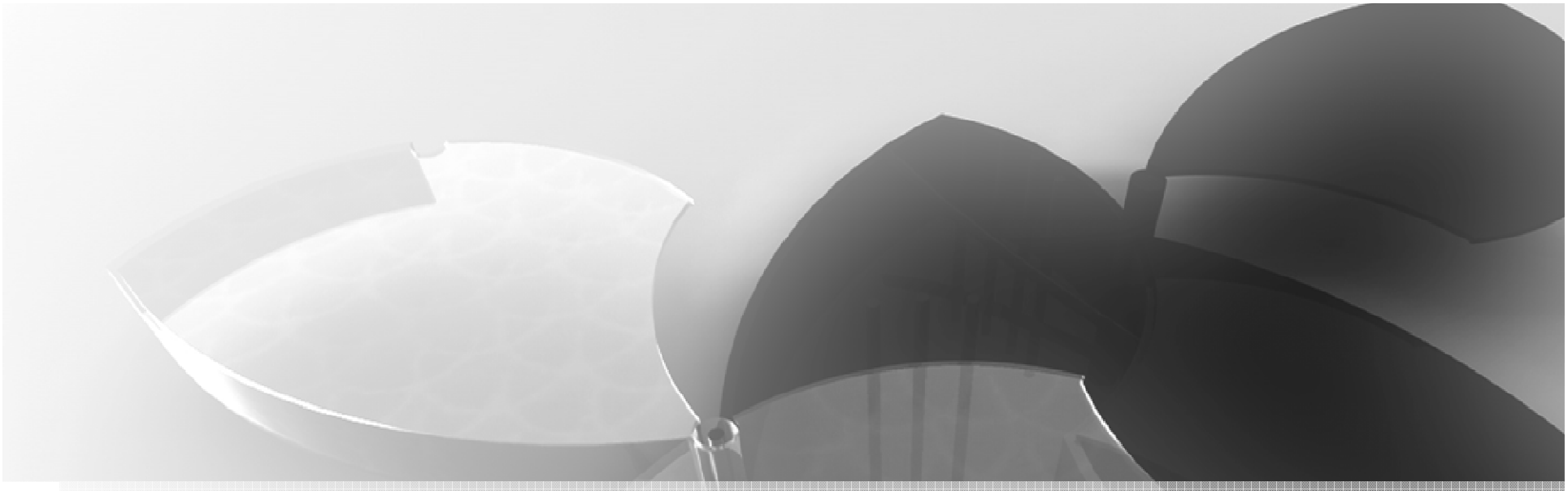
•ALI, F.; KRUPKA, I.; HARTL, M.:
Enhancing the parameters of starved EHL point conjunctions by artificially induced replenishment,
Tribology International, Vol.66, (2013), No.1, pp.134-142,ISSN 0301-679X, Elsevier
journal article

•ALI, F.; KŘUPKA, I.; HARTL, M.:
An Approximate Approach to Predict the Degree of Starvation in Ball–Disk Machine Based on the Relative Friction,
TRIBOLOGY TRANSACTIONS, Vol.56, (2013), No.4, pp.681-686,ISSN 1040-2004, Taylor & Francis
journal article

•ALI, F.; KŘUPKA, I.; HARTL, M.:
Friction of smooth and textured non-conformal surfaces under starved conditions,
Tribology and Design II, pp.29-40, ISBN 978-1-84564-610-3, (2013), WIT Transactions on Engineering Sciences
conference paper

•ALI, F.; KŘUPKA, I.; HARTL, M.:
Analytical and experimental investigation on friction of non-conformal point contacts under starved lubrication,
MECCANICA, Vol.45, (2012), No.1, pp.1-9, ISSN 0025-6455, Springer
journal article

•ALI, F.; HARTL, M.:
FRICTION OF NON-CONFORMAL CONTACTS UNDER STARVED EHD LUBRICATION,
MM Science Journal, Vol.2012, (2012), No.12, pp.374-377,ISSN 1803-1269, (MM) Science Journal
journal article



THANK YOU FOR LISTENING

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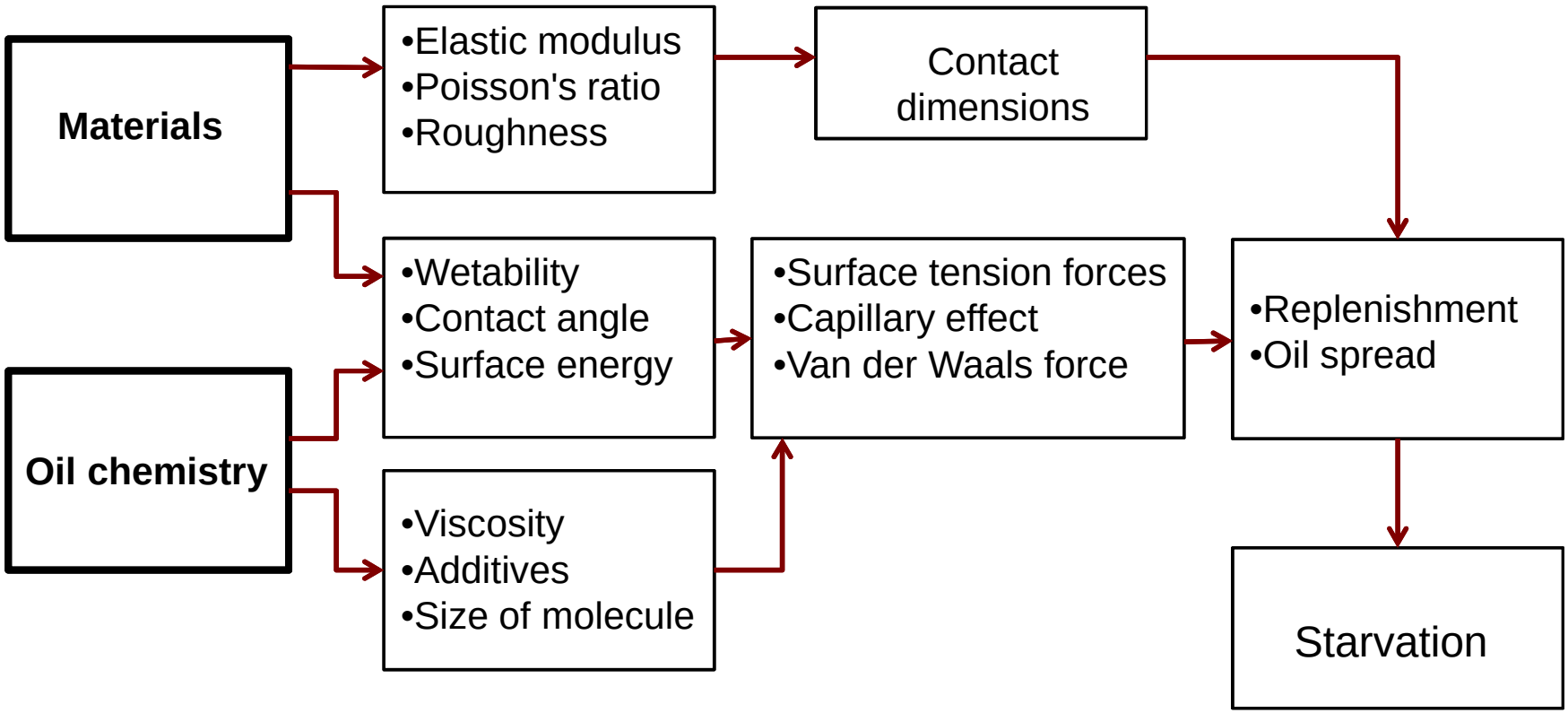
Questions:

1- what is the role of materials and oil chemistry on starvation?



Questions:

1- what is the role of material and oil chemistry on starvation?

Priority of parameters after introducing sliding from starvation point of view

1. Viscosity
2. Oil amount
3. Operating conditions (speed)
4. Temperature

→ Considered In my thesis

5. Surface tension forces
6. Capillary effect
7. Contact geometry
8. Van der Waals force
9. Surface energy
10. Contact angle
11. …
12. …

Questions:

2- Is there any algorithm to optimize the distribution of micro-textures? What is the optimum distribution?

- In EHL contacts (even in the starved regime) wear is minimum since separation is larger than the scale of roughness (adhesive wear is minimum)

- The optimum distribution of micro-textures results in the lowest friction (not wear) for given operating conditions.

- Distribution of micro-textures can be optimized by modifying the density of textured area and dimensions (**a**, **b**) between dents. This approach is experimental but it could be also mathematical.