New and modified bearing surface layers incorporating interaction with lubricants for friction reduction in engine crank trains

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Presentation agenda

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1. Engine application and influencing parameters
    a. Influences on bearing system
    b. Crank train system influencing parameters
2. Friction reduction approach
    a. Base friction model and friction reduction approach
    b. Mixed friction area
        a. Investigation methods and parameters
        b. Friction - material and viscosity influences
        c. Robustness – oil chemistry and material interaction
3. Summary, outlook and support

Influences on bearing system

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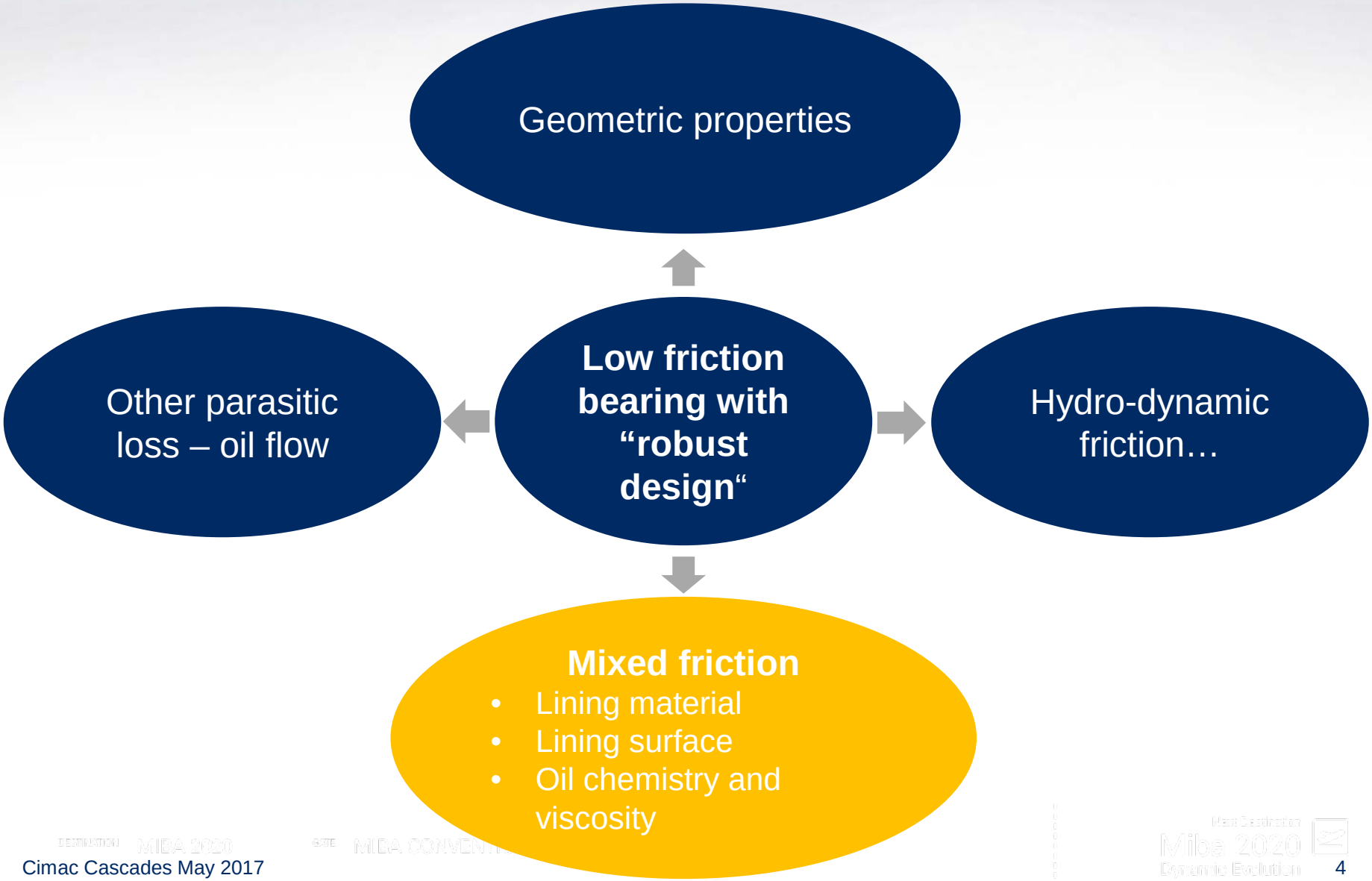
Changes in engine application and operating conditions influence the bearing system & design:

- Downspeeding
- Downsizing
- Robustness, operational risk
- Urban areas
  - Start/stop application
  - Fuel flexibility
  - Hybridization

	Load capability			Friction			Robustness		
Influence	low	med	high	low	med	high	low	med	high
Bearing lining			☑	☑				☑	
Bearing surface			☑			☑			☑
Oil viscosity			☑			☑			☑
Ash reduced oils		☑		☑					☑

Investigation root cause

Crank train system influencing parameters



Base model for friction reduction

Influence of friction reduction on bearing system

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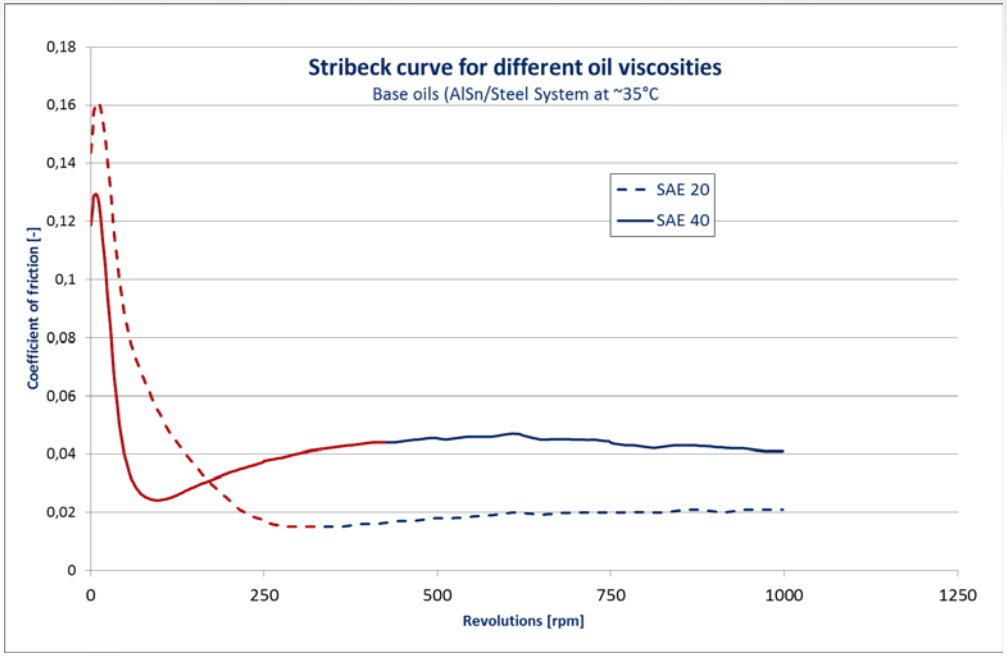
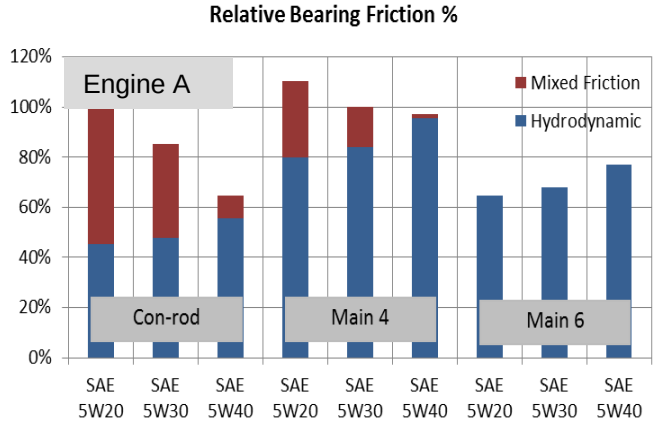
Trend to low viscosity oil with low ash forming components

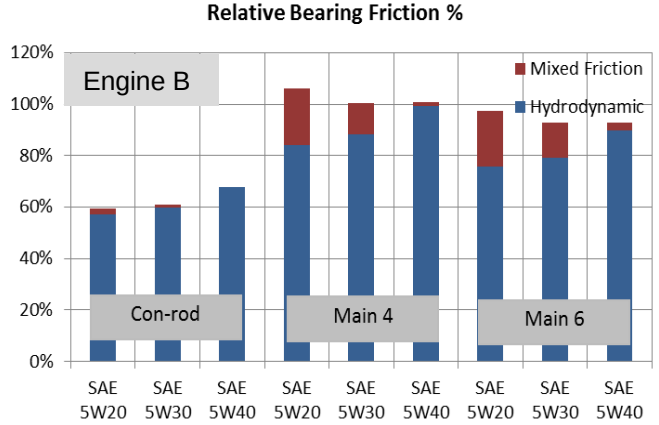
- ↓ Hydrodynamic friction
- ↑ Increasing mixed friction
- ↓ Loss of bearing robustness

↓

Different friction situation for each engine







Mixed friction area

Investigation methods to evaluate mixed friction

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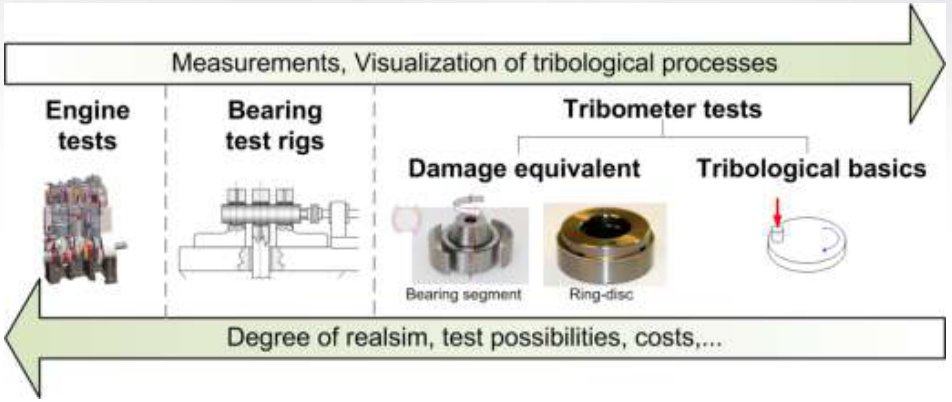
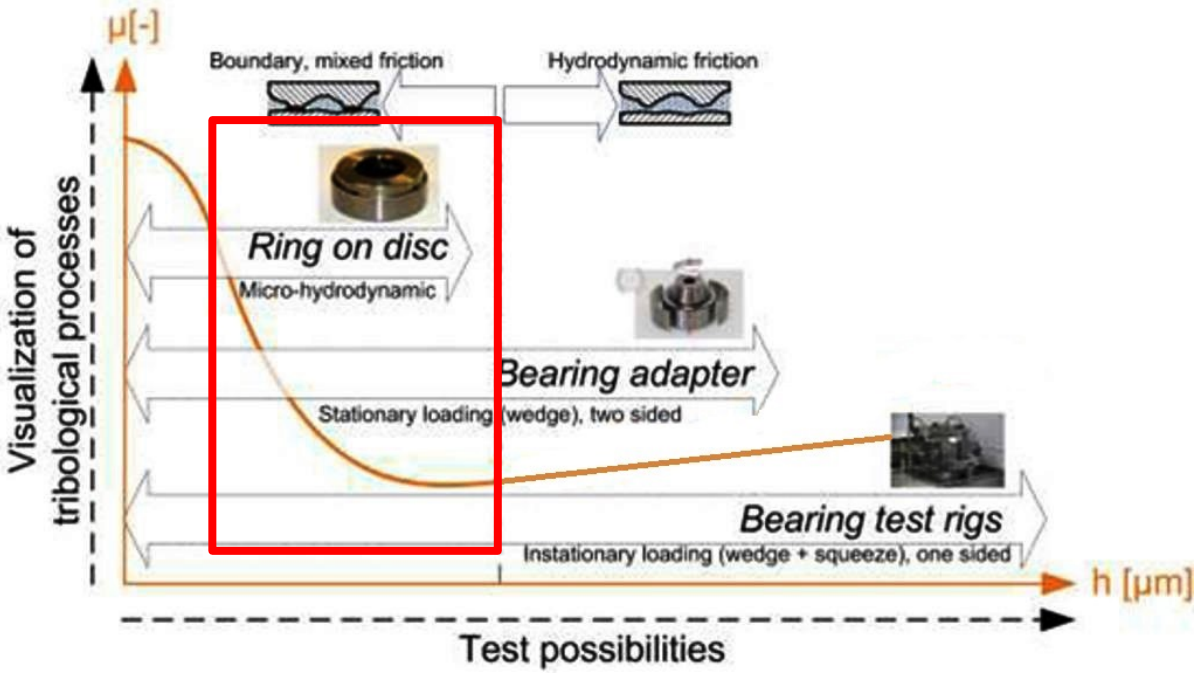
Investigation methods



- **Ring on disc method**
  - Friction coefficient determination
- **Bearing adapter**
  - Wear characterization
  - Seizure limits



Mixed friction area

Several parameters influence mixed friction

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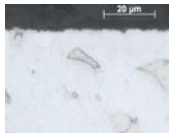
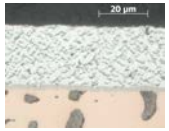
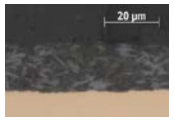
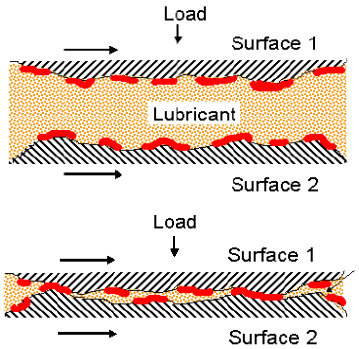
Parameters

- Bearing dimensions and design features
- Oil viscosity and especially additives
- Contact partners
  - o Materials
  - o Surface conditions and chemistry







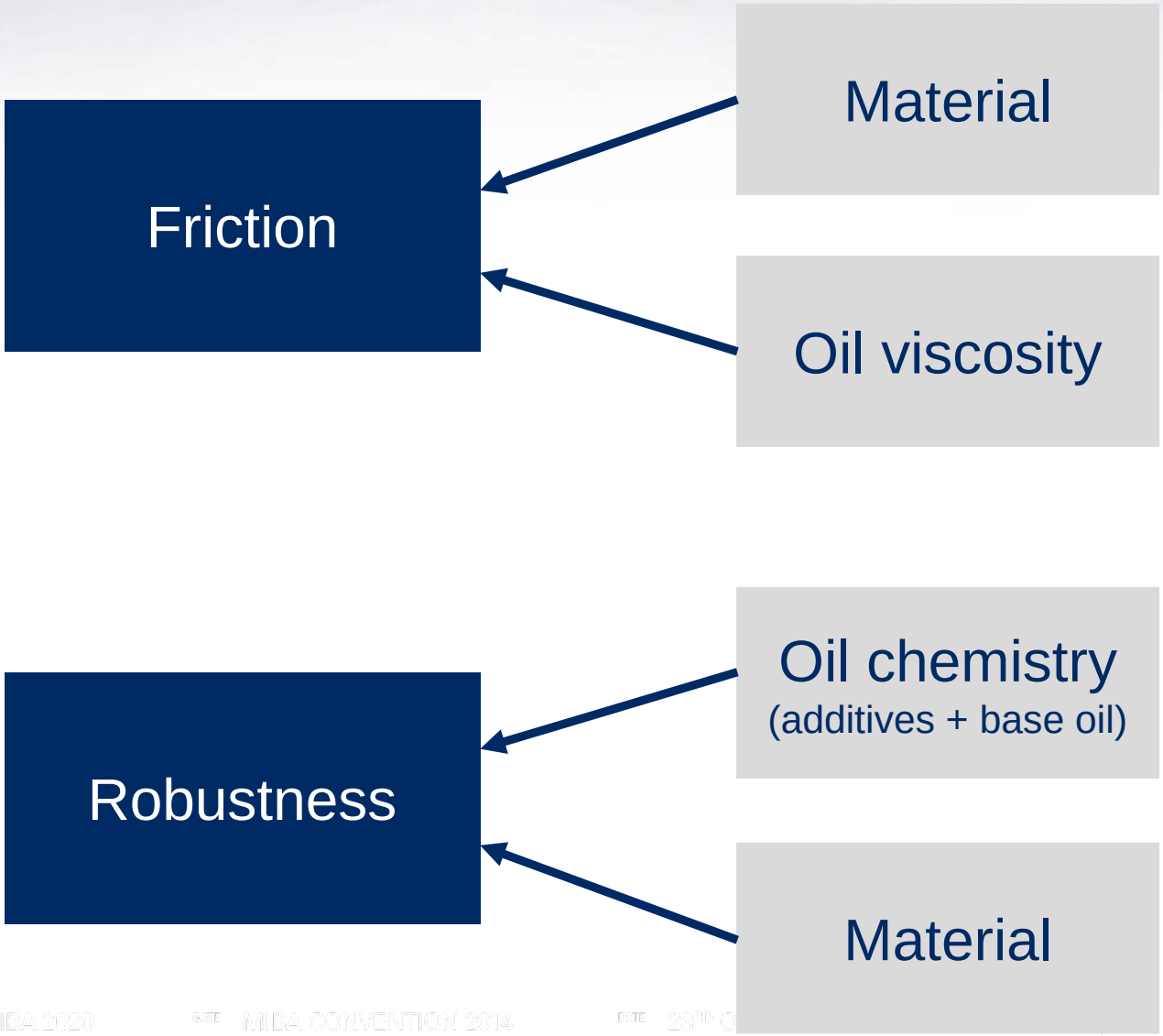


Boundary conditions for system optimization

- Design:
  - Engine and component dimensions
- Material properties:
  - Bearing load capability
  - Mixed friction and wear sensitivity

Mixed friction area

Friction and robustness are influenced by:



Friction

Influences of different lining materials and surfaces

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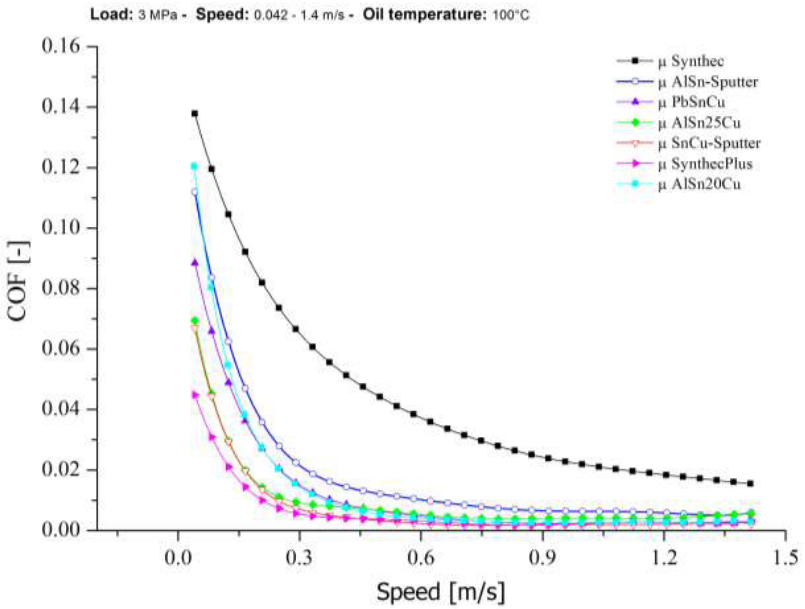
General bearing performance of different materials

	Load capability			Friction			Robustness		
	l	m	h	l	m	h	l	m	h
AlSn Bi-Metal	☑				☑				☑
Tri-Metal*		☑			☑				☑
Synthec®*		☑		☑				☑	
AlSn20 Sputter*			☑		☑		☑		
Sputter Synthec®*			☑	☑				☑	

l…. low m…. medium h… high

* Considering lining



Robustness

Basics of interaction between oil and surface material

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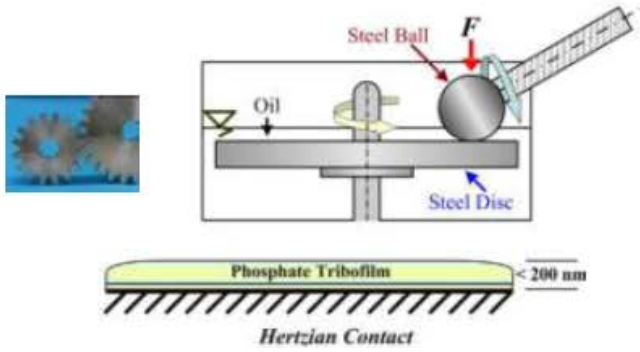
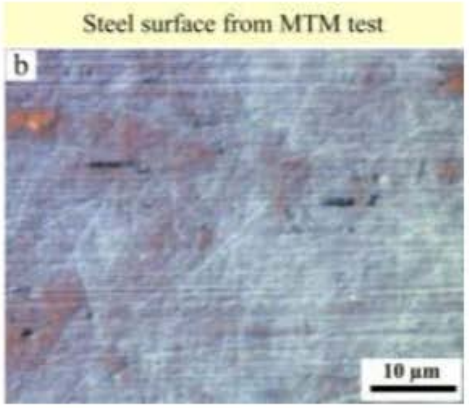
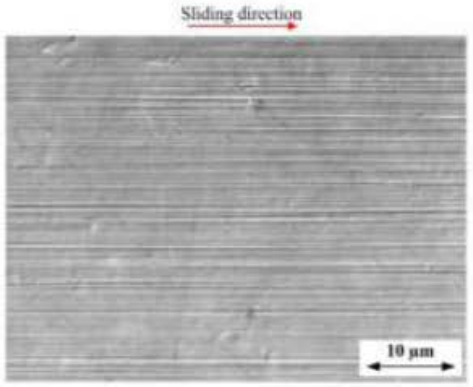
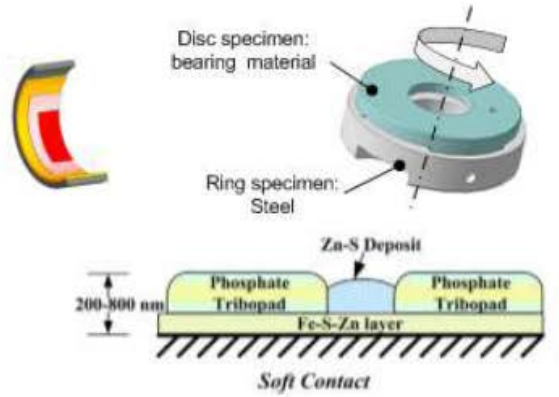
Hertzian contacts

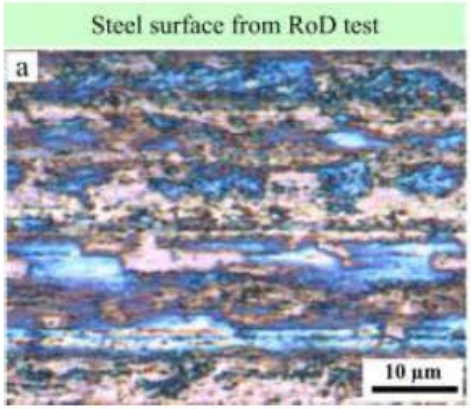


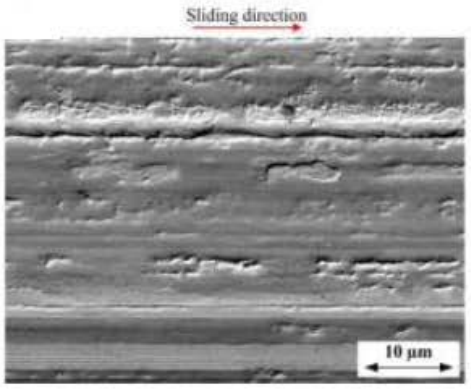




Soft contacts



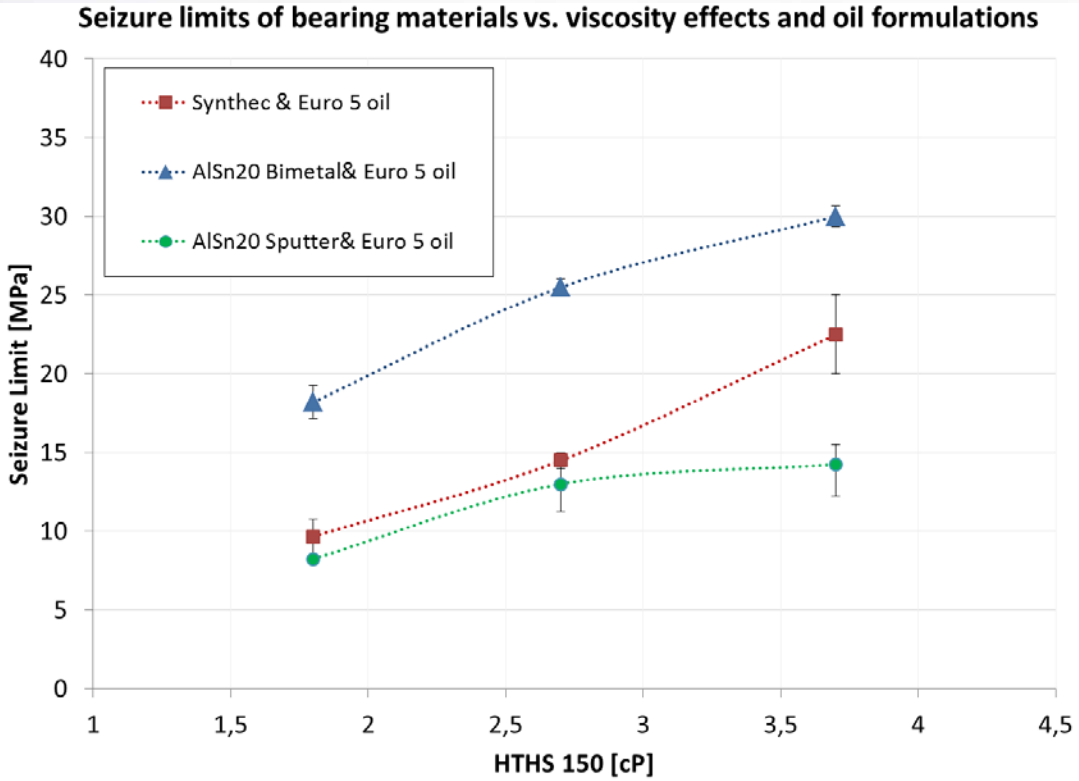




Pondicherry, et. Al, ECOTRIB 2011

Robustness

Influences of different viscosity grade

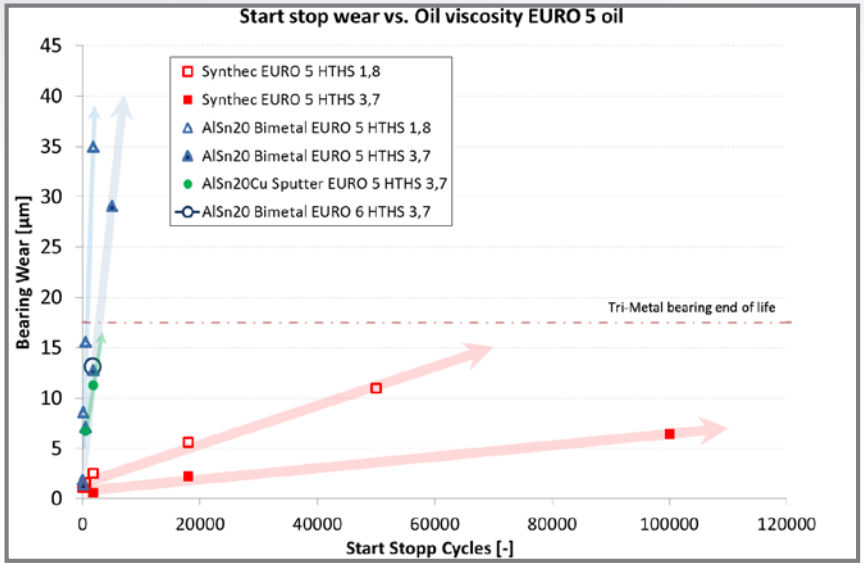


Low viscosity oils:

Bearing robustness

Robustness

Influences of different viscosity grade

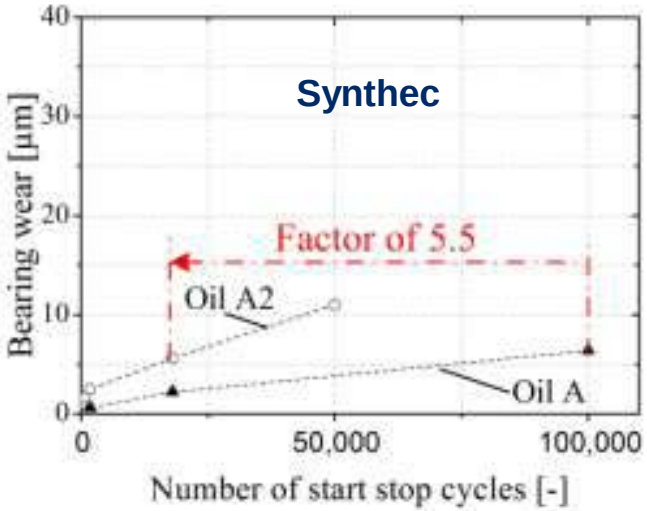


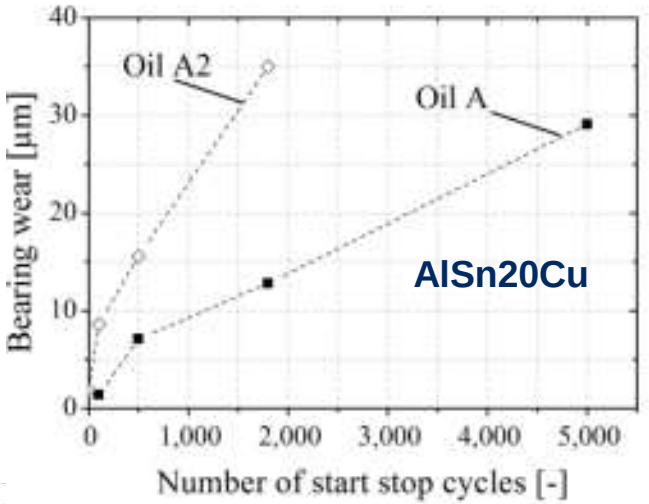
Low viscosity oils

↓ Bearing robustness

↑ Higher bearing wear

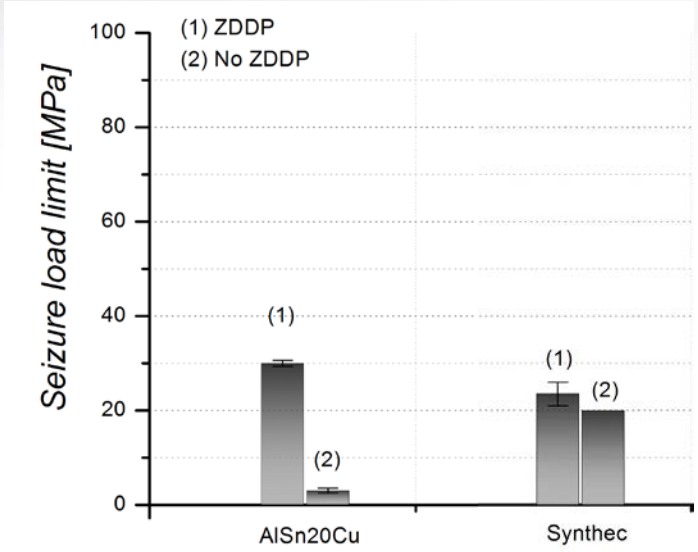
Synthec® superior wear properties @ Start-Stop
(factor 20x vs. metallic)

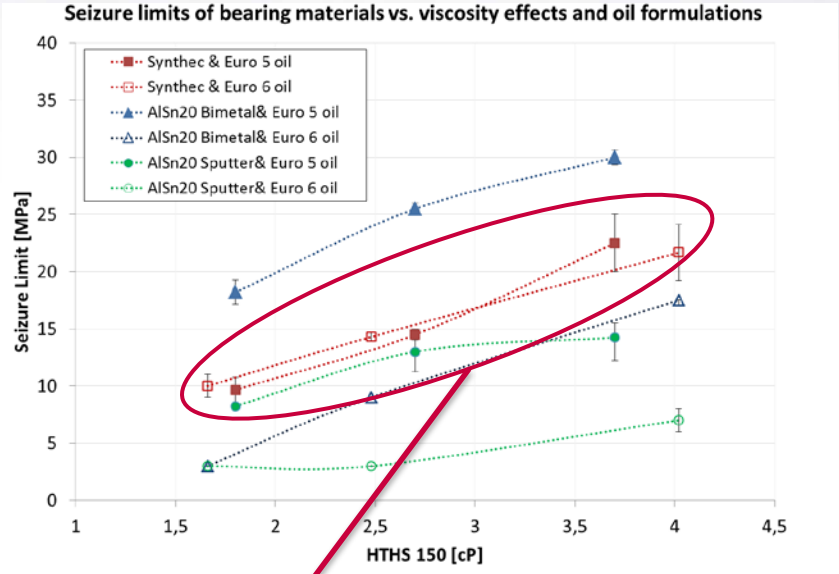




Robustness

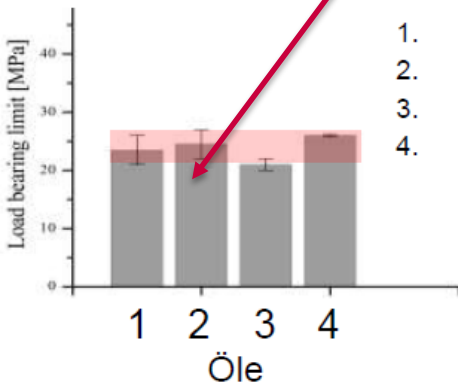
Influence of ZDDP in combination with different materials





Low ZDDP oils:

- Metallic bearings robustness
- Synthec® bearings robustness
- Wear @ Start-Stop



1. Oil with 0.12 wt% P
2. Oil with 0.08 wt% P
3. Oil without ZDDP
4. Baseoil

Conventional protective additive chemistry (ZDDP) has no effect for Synthec (polymer coating)

Robustness

Influence of oil formulation on seizure limits

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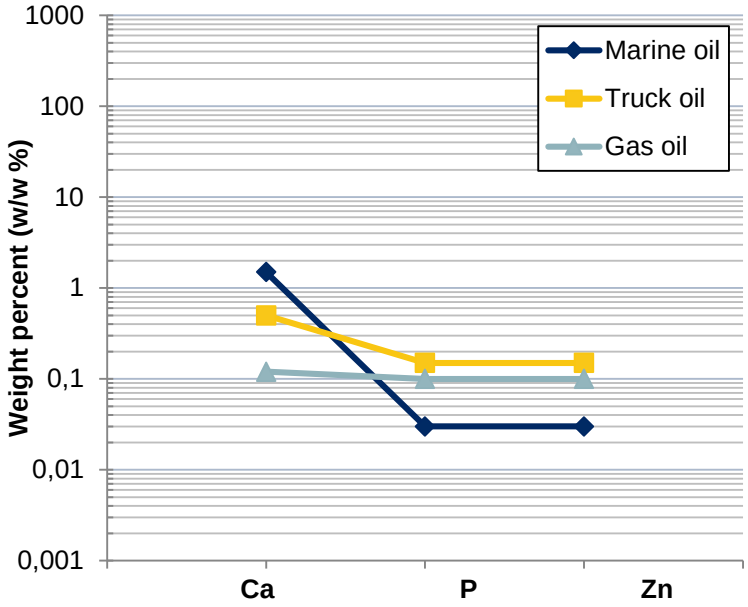
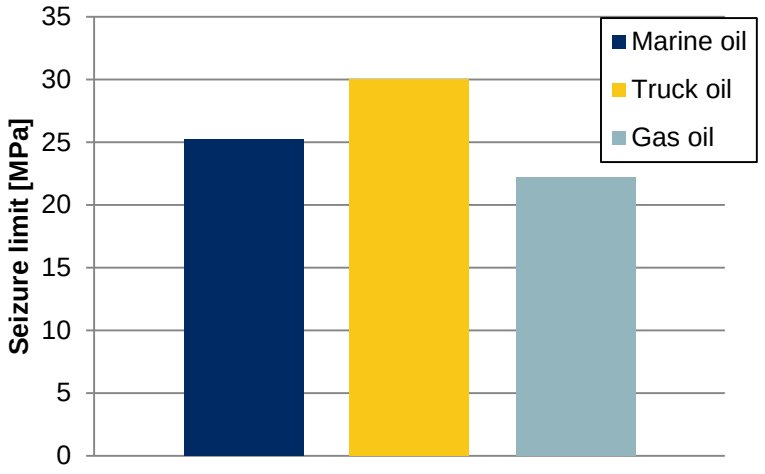
Different oil formulation shows different influence on robustness





Robustness

Different Oil Formulation leads to different tribofilms

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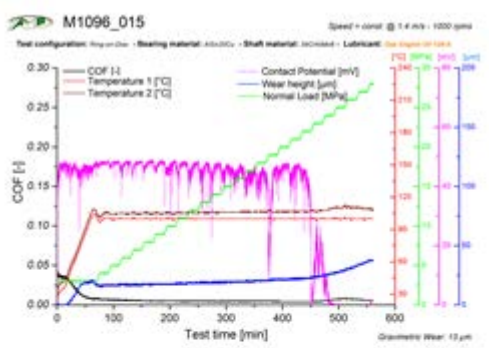
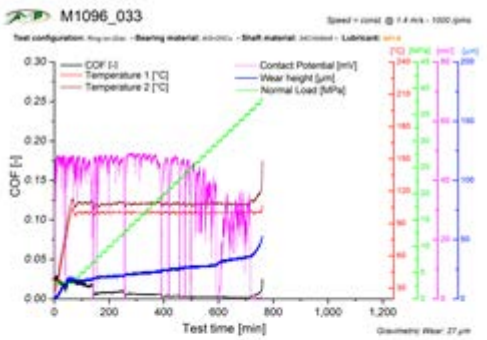
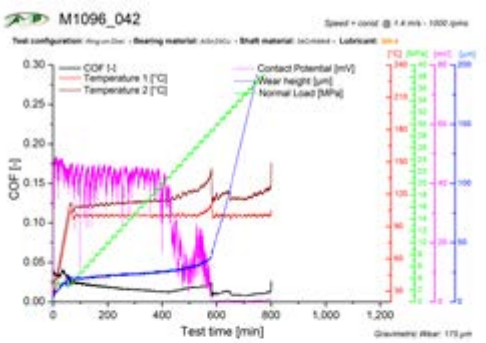
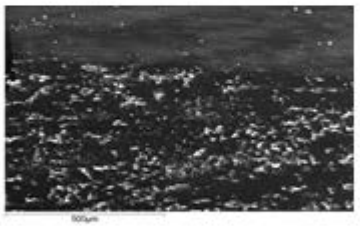
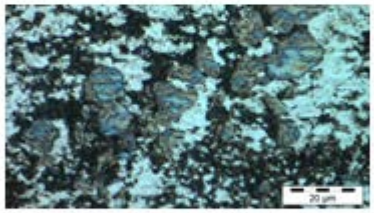
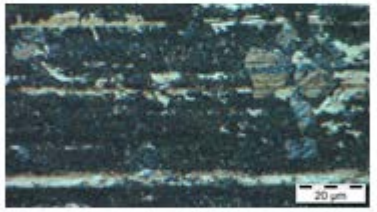
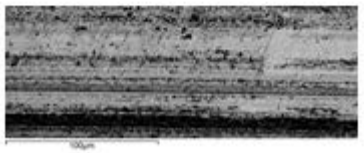
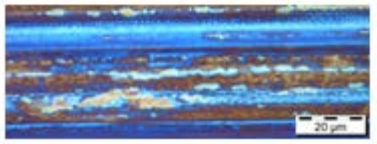
Comparison – Load bearing tests

	Gas Oil 124-A	HDD Oil 441-A	Marine Oil 356-A
			
AlSn Disc			
Steel ring			
	Acting of Sn, Pad formation (P,Zn) on steel	Sn acting, Tribofilm/Ca deposits, Pad formation (P,Zn,Ca) on steel	Fe-S-Zn layer protecting, Ca-Pads on steel, Ca deposits on AlSn disc

Summary, outlook and support

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Oil viscosity reduction leads to:

- Lower hydrodynamic friction coefficient
- Critical changes in mixed friction area possible

Changes in oil chemistry lead to:

- New interactions between oil and material
- Metal surface
  → changes in system robustness
- Synthec surface
  → no changes in system robustness

Miba Bearing Group
provides support in friction simulation and optimization

Know How & Support → proper bearing choice
Know How & Support → Materials for all bearing applications

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Any Questions?

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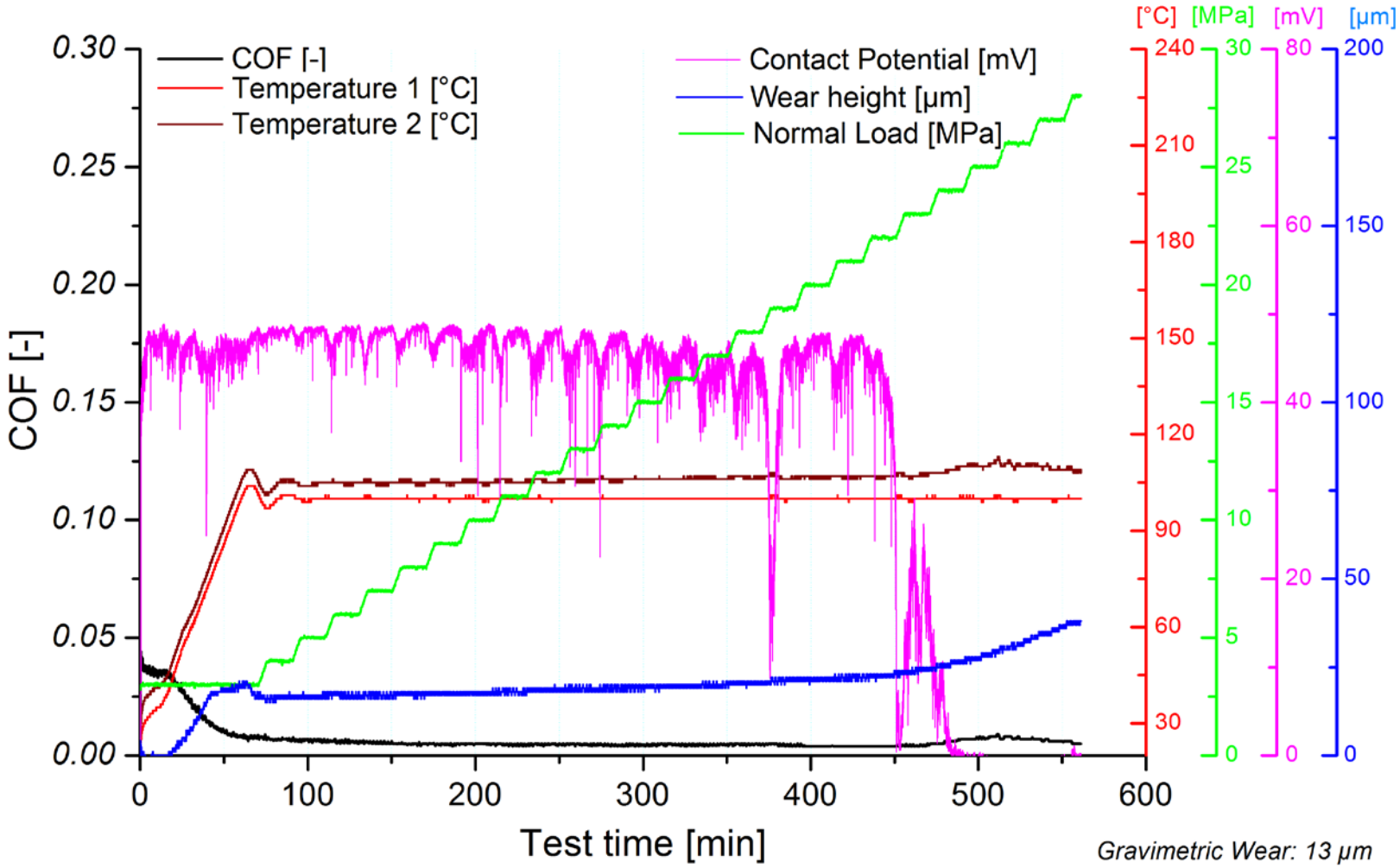
M1096_015

Speed = const. @ 1.4 m/s - 1000 rpms

Test configuration: *Ring-on-Disc* **- Bearing material:** *AlSn20Cu* **- Shaft material:** *34CrNiMo6* **- Lubricant:** *Gas Engine Oil 124-A*

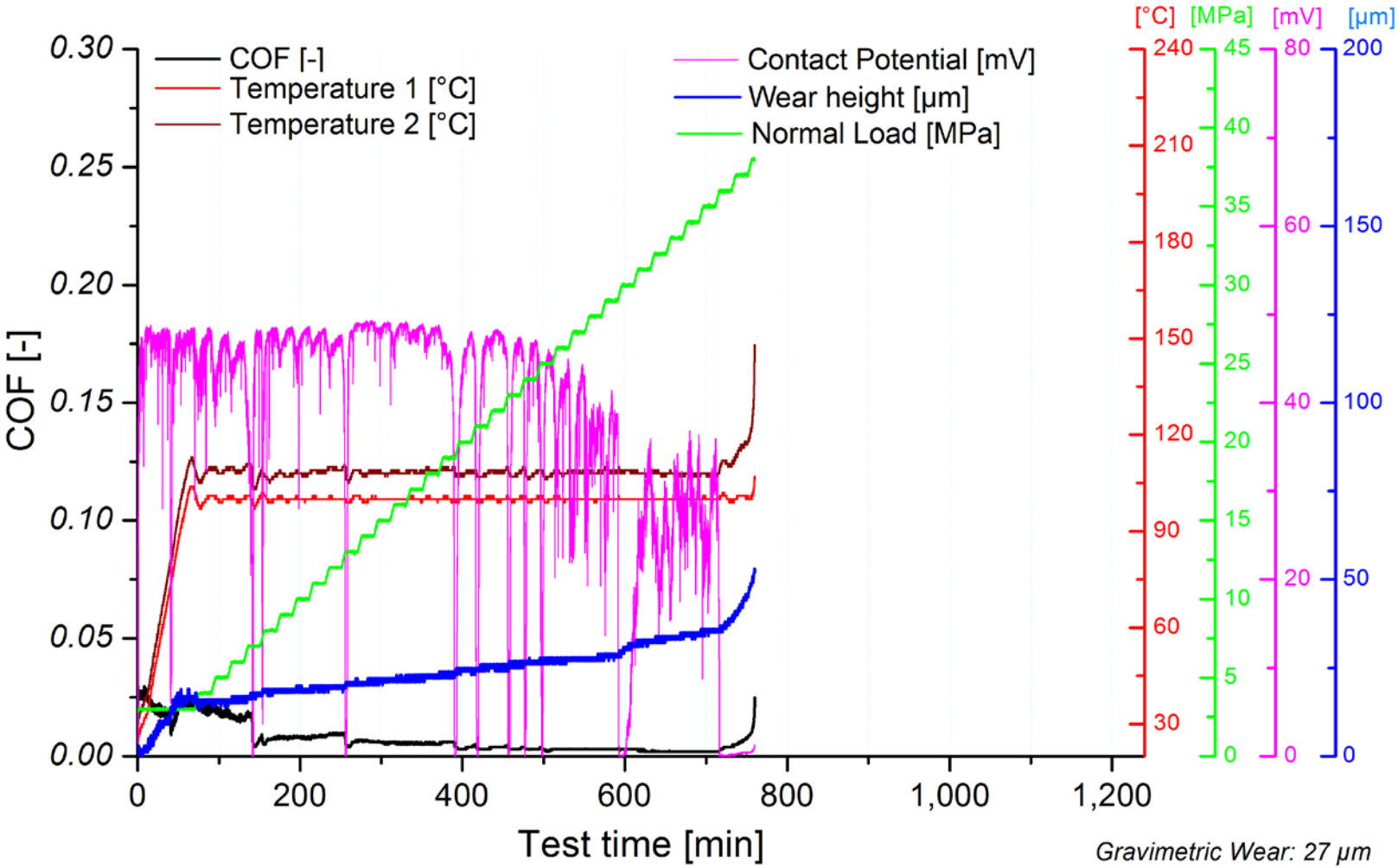


Gravimetric Wear: 13 µm

M1096_033

Speed = const. @ 1.4 m/s - 1000 rpms

Test configuration: *Ring-on-Disc* **- Bearing material:** *AlSn20Cu* **- Shaft material:** *34CrNiMo6* **- Lubricant:** *441-A*

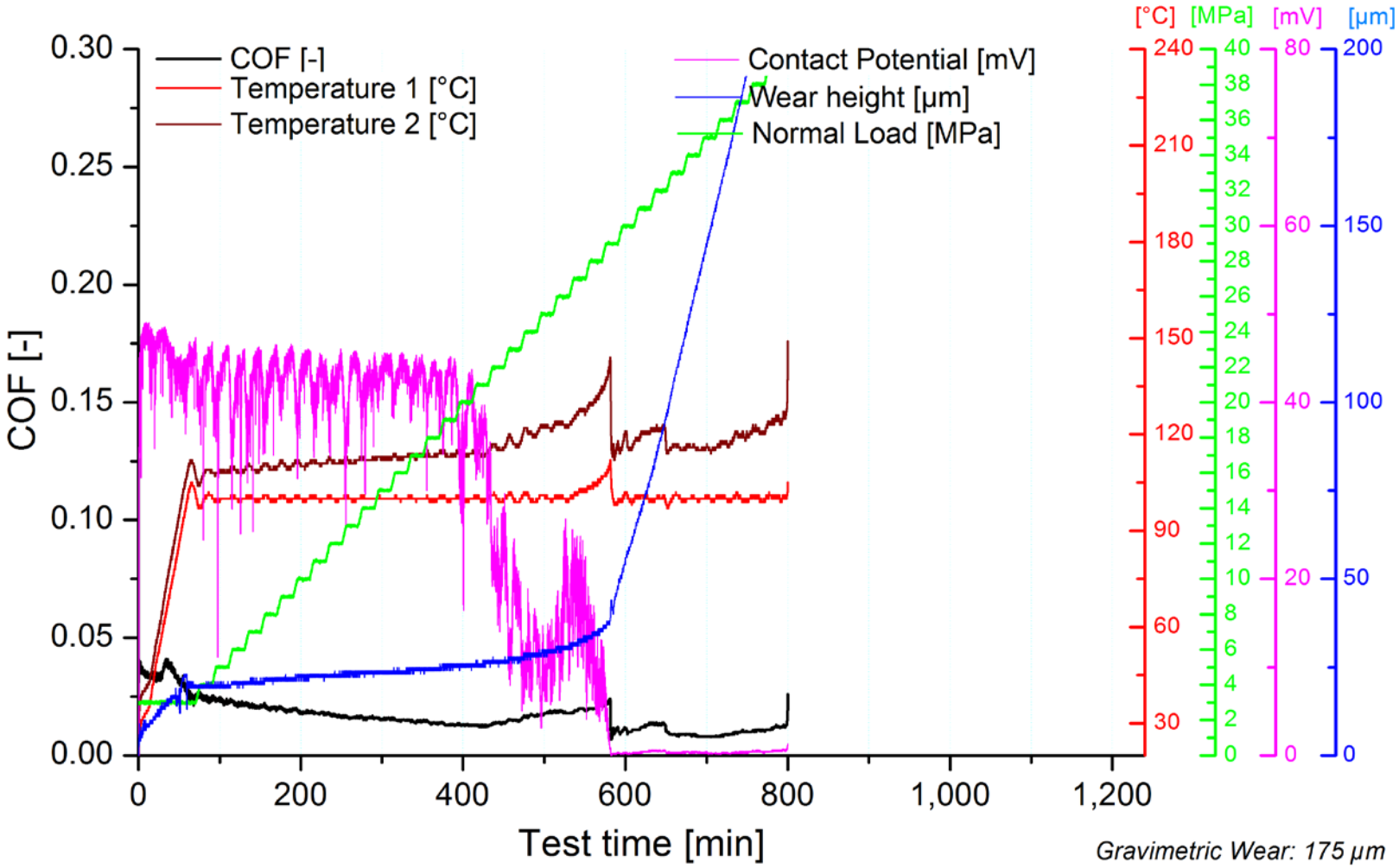


Gravimetric Wear: 27 µm

M1096_042

Speed = const. @ 1.4 m/s - 1000 rpms

Test configuration: *Ring-on-Disc* **- Bearing material:** *AlSn20Cu* **- Shaft material:** *34CrNiMo6* **- Lubricant:** *356-A*



Gravimetric Wear: 175 µm