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Karlsruher Institut für Technologie
MIKROTRIBOLOGIE CENTRUM µTC

Impact of alternative fuels on friction and wear in the ultra-low wear regime

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17.9.2024

Chapter 01

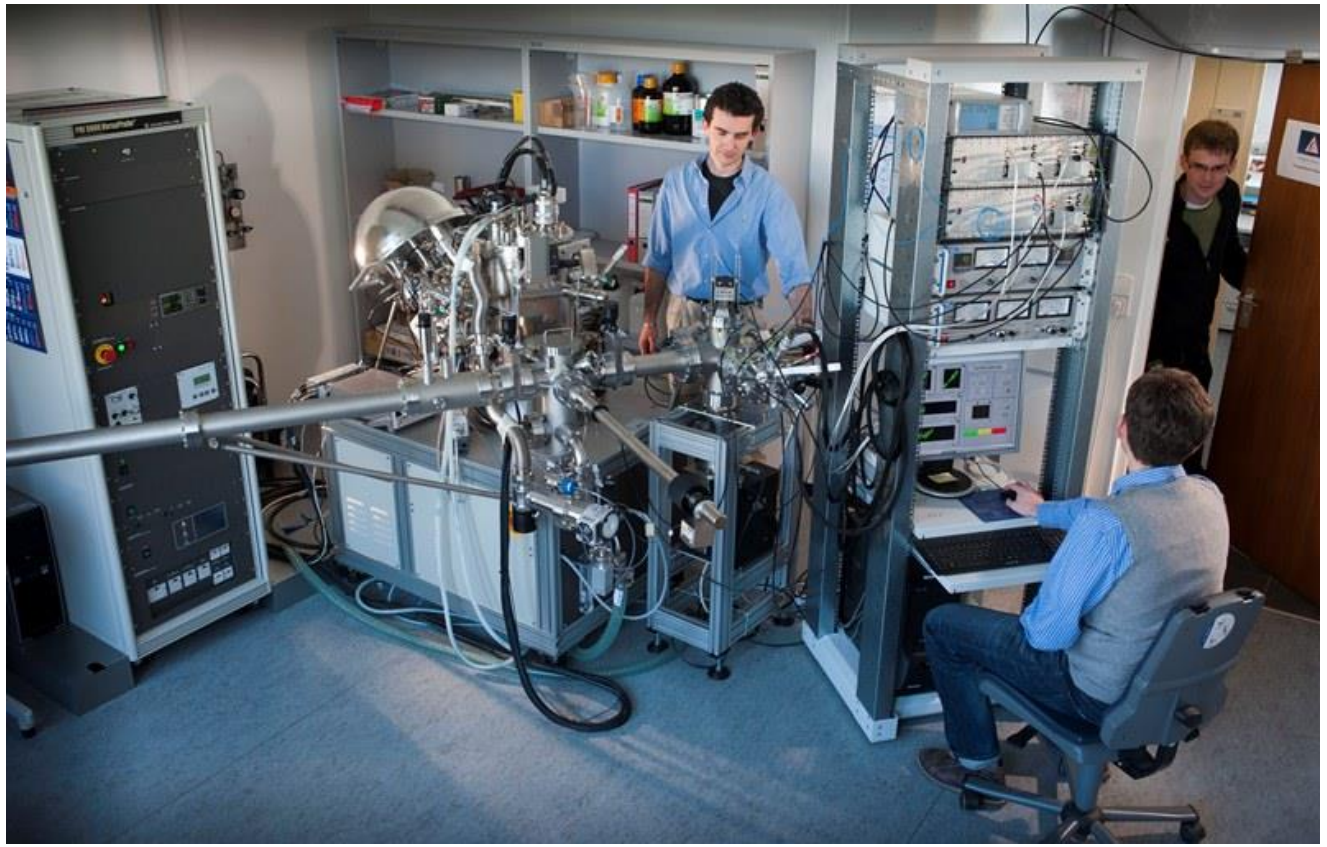
Introduction of µTC Microtribology Center

Mission

The MikroTribologie Centrum carries out **tribosystem evaluation**, **tribosystem optimization** and the development of **multifunctional tribological materials**.

µTC uses innovative approaches to make tribology calculable. The elucidation of friction and wear mechanisms on the micro and nano scale of materials and lubricants is the basis for **research and development services that are in demand in industry.**

Numbers



groups: 7
employees: 110
tribometers: 40+
gear tests rigs: 2
profilometers: 10
bearing test rigs: 5
annual turn over: 6 Mio.€
DLC/diamond coating machines: 10
infrastructural investments: 20 Mio. €
analytics: XPS, FTIR, ICP-OES, Raman, WLI, FIB, AFM
DFG and ERC Grants for Scientific Staff Development: 6 Mio. €

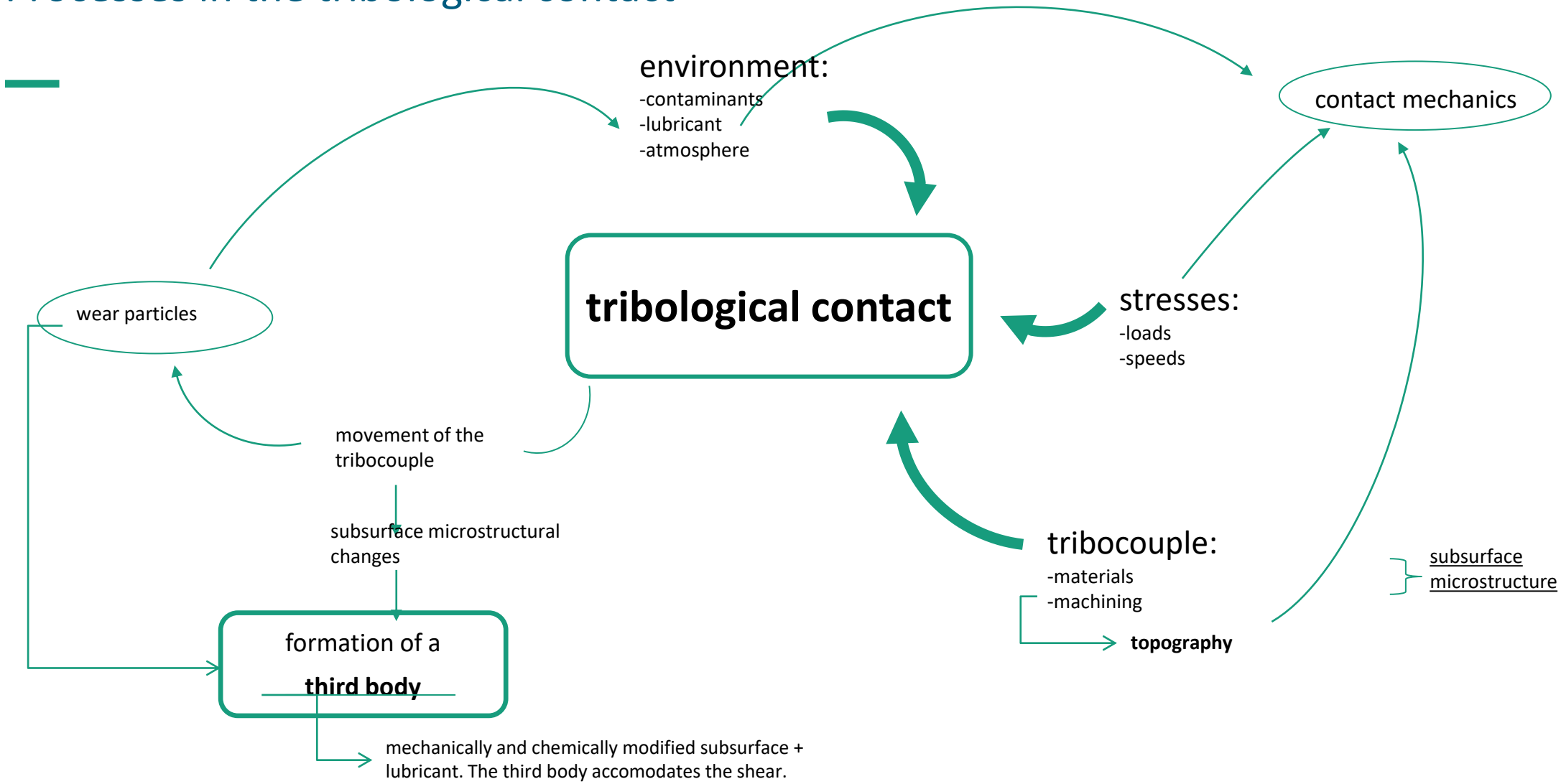
Agenda

- Processes in the tribological contact
- Examples – choice of tribosystems for Lubricant characterization
- Reduction of Scope 1 emissions – impact on tribology
- Example – impact of combustion by-products of ethanol
- Testing of Systems with Ammonia and Hydrogen

Chapter 02

Processes in the tribological contact

Processes in the tribological contact



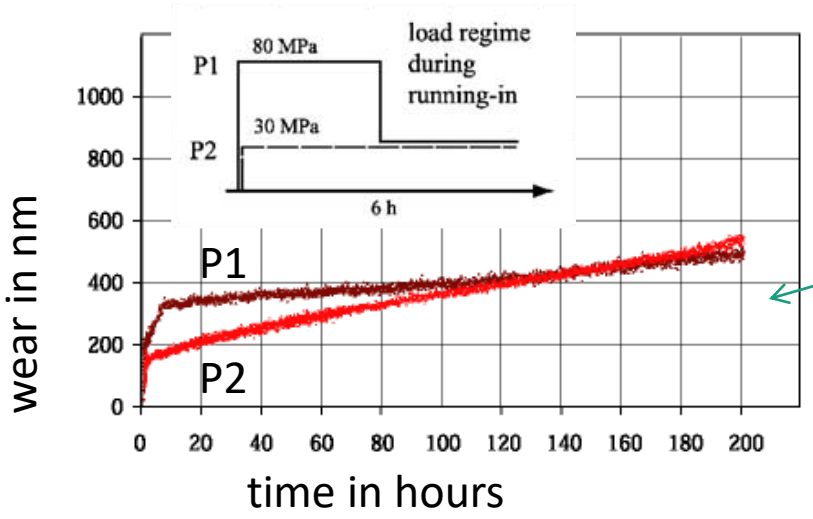
Running-in in the ultra-low wear regime

wear rates in the range of nm/h

topographic changes

third body

running-in behavior



changes of friction and wear rate over time

technically relevant for most mechanical engineering applications: ultra low wear regime with a few nm/h

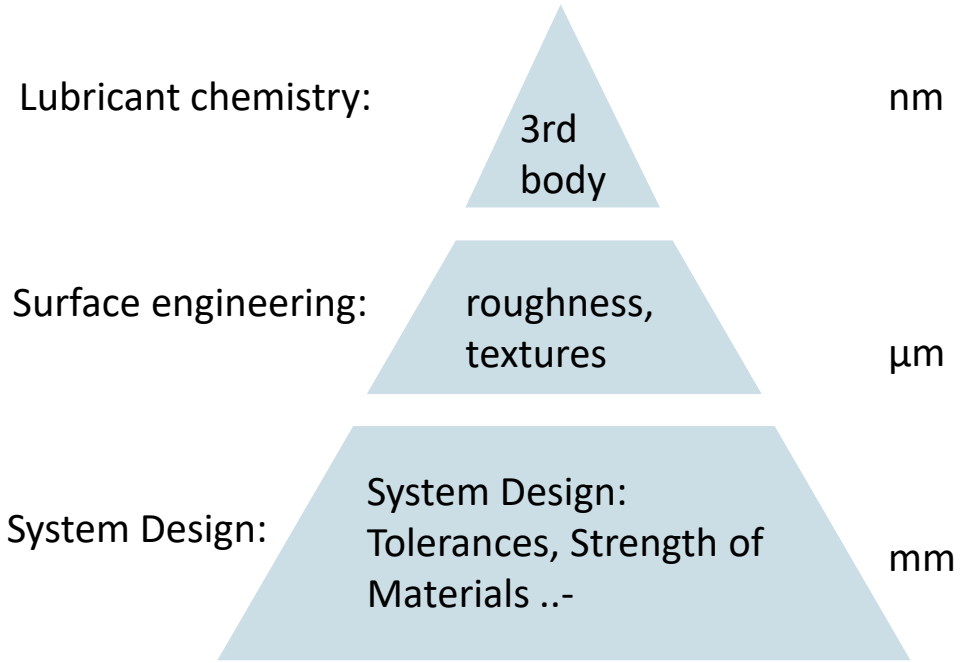
measurement with radionuclide technique:
+ online
+ highest resolution

Chapter 03

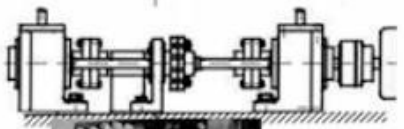
Examples – choice of tribosystem for lubricant characterization

Proper selection of boundary conditions

Load regimes, wear regimes, abstraction level



Level of abstraction

Kategorie	Mess- und Prüftechnik		System, Baugruppe, Modell
I	Betriebsversuche und betriebsähnliche Versuche: Original-System-struktur, Beanspruchung vereinfacht	Betriebsversuch	
II		Prüfstandsversuch	
III		Aggregatversuch	
IV		Bauteilversuch	
V	Modell-Struktur und einfache Beanspruchung	Probekörperversuch	
VI		Modellversuch	

From: Czichos, Habig: Tribologie-Handbuch

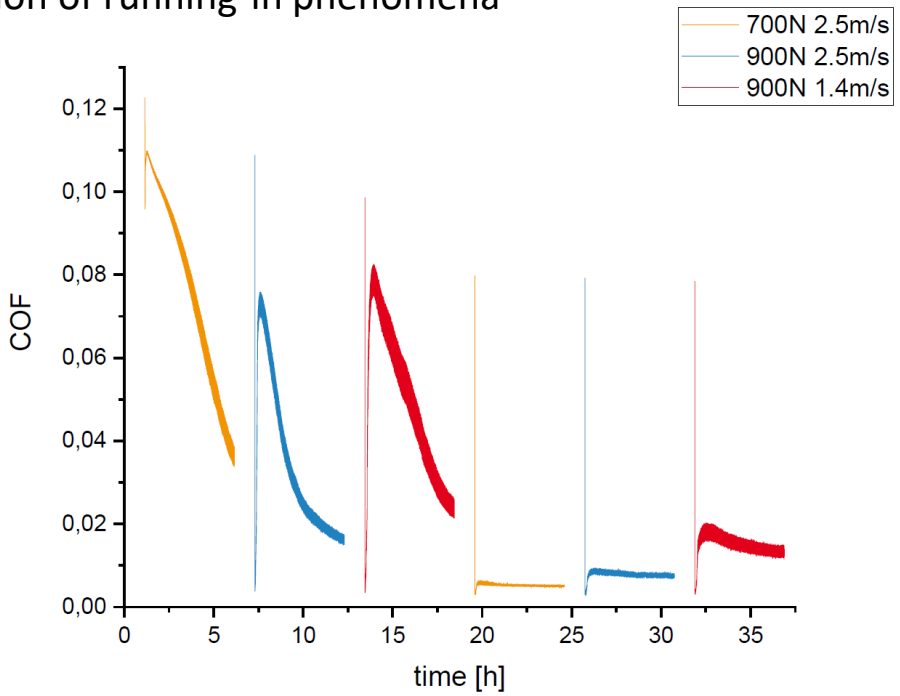
Proper selection of boundary conditions

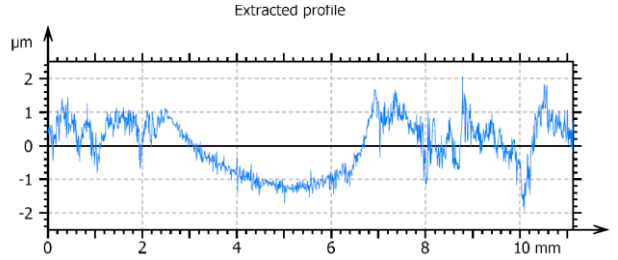
Load regimes and test program

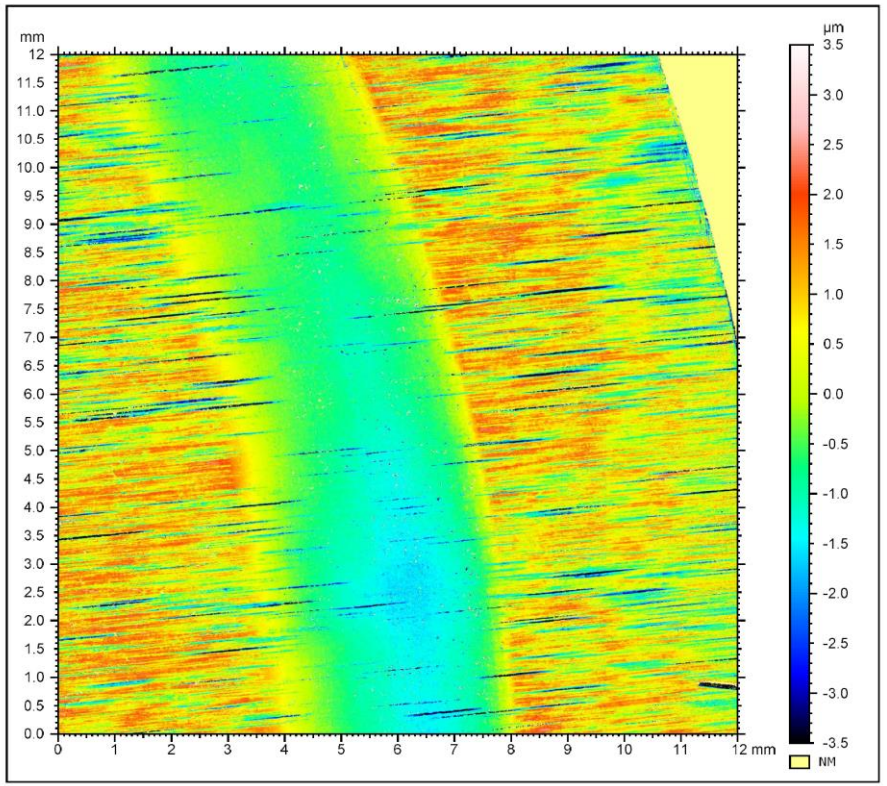
Pin-on-disk:

pressures in the MPa regime

consideration of running-in phenomena







Pin-on-disk: flat on flat

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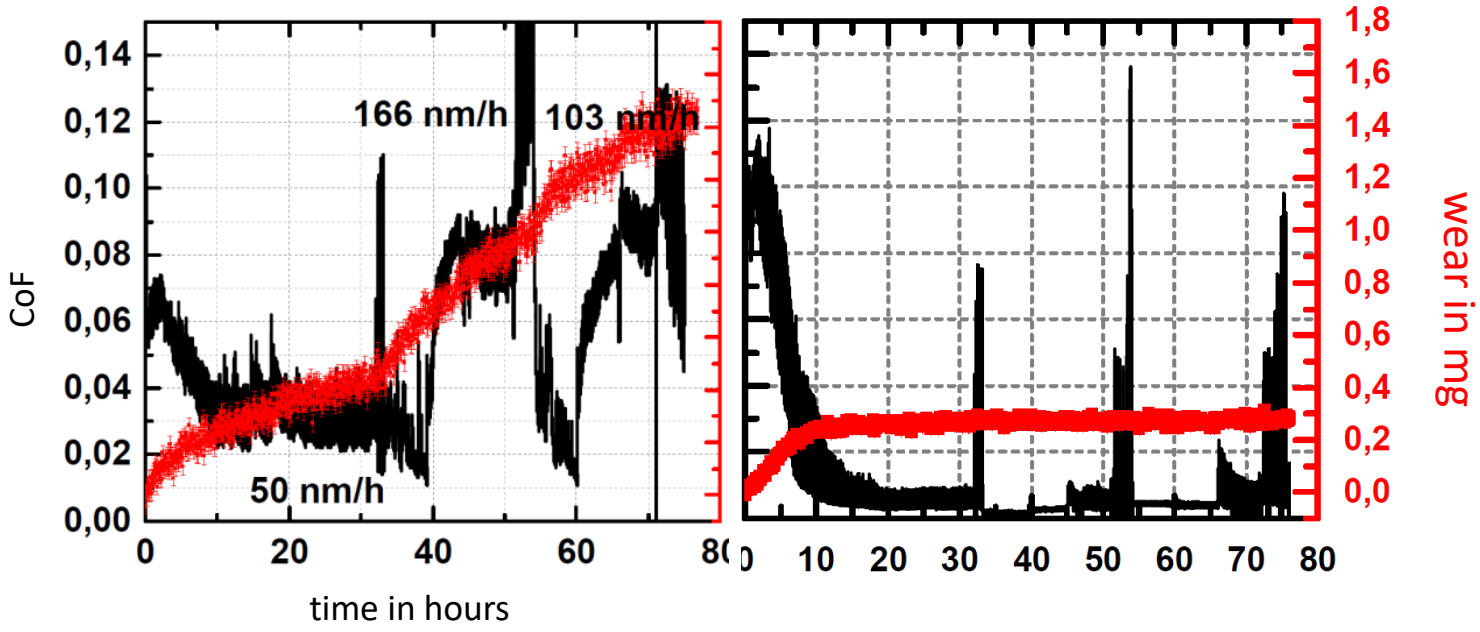
Proper selection of boundary conditions

Materials

Impact of heat treatment – strength and microstructure

All results with the same lubricant

→ selection of tribosystem of significant importance



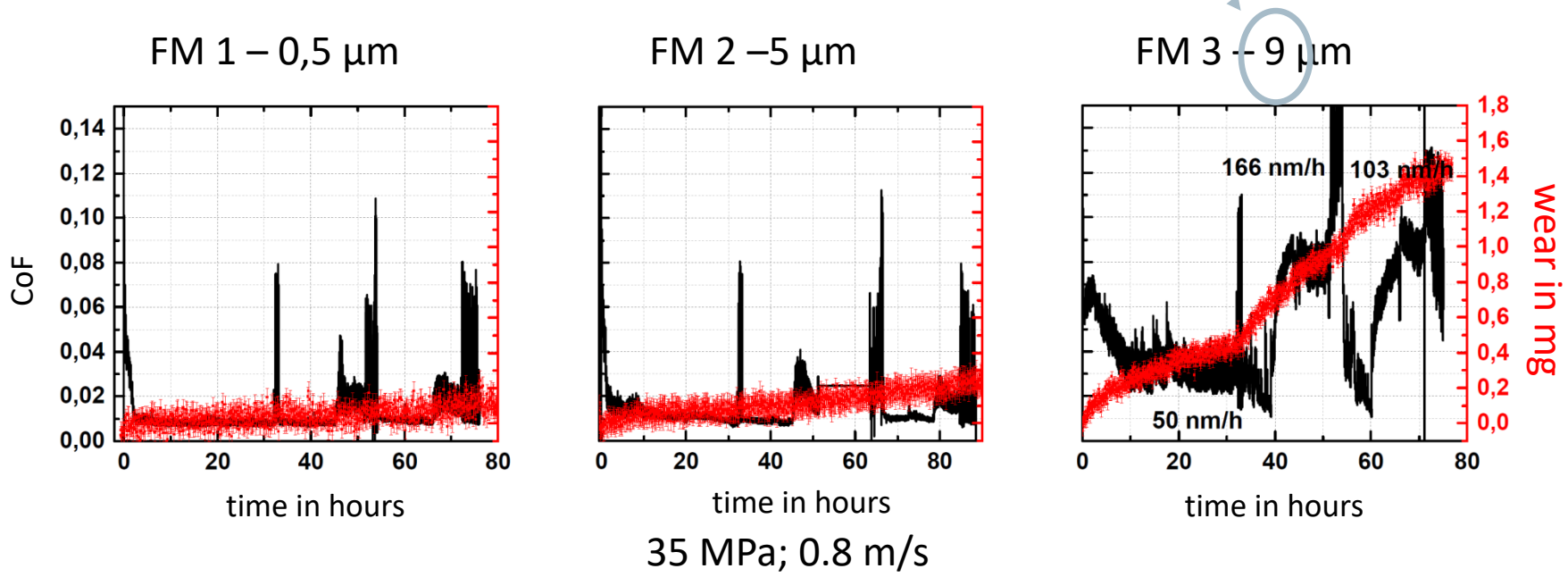
Proper selection of boundary conditions

subsurface microstructures

Materials reaction to tribological load:

- 3rd body formation
- indirect action of lubricant chemistry

depth of shear in subsurface by final machining (cutting)



35 MPa; 0.8 m/s

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Chapter 04

Reduction of Scope 1 emissions – Impact on tribology

Reduction of Scope-1 Emissions

Alternative fuels

Heavy Duty: different drive concepts

- Battery
- Fuel cell
- alternative fuels
  - Ethanol / Methanol
  - Hydrogen
  - Ammonia

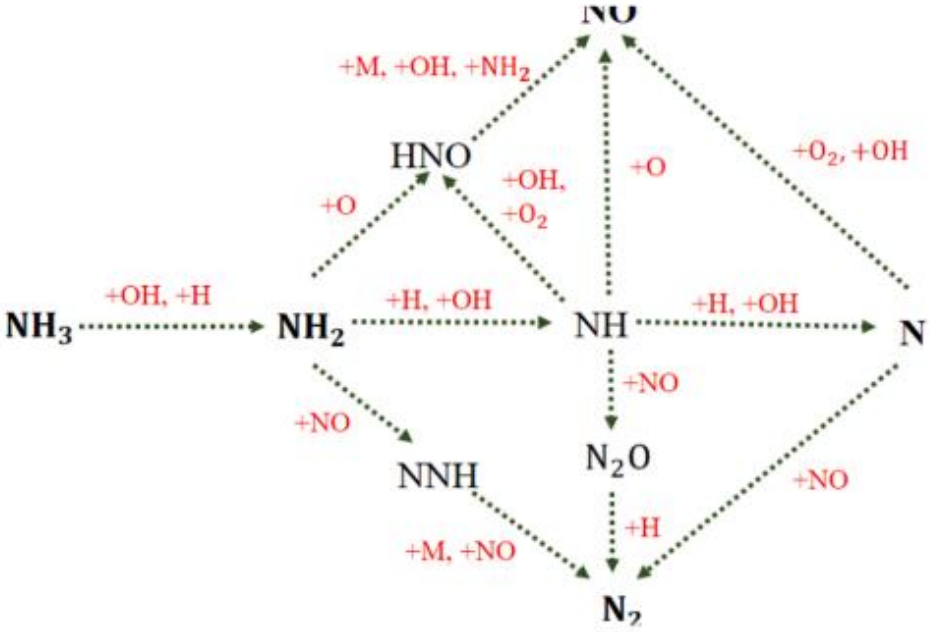

Fig. 4. Reaction pathways for ammonia combustion [90].

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Chapter 05

Example – impact of combustion by-products of ethanol

Insufficient combustion of ethanol
corrosive by-products

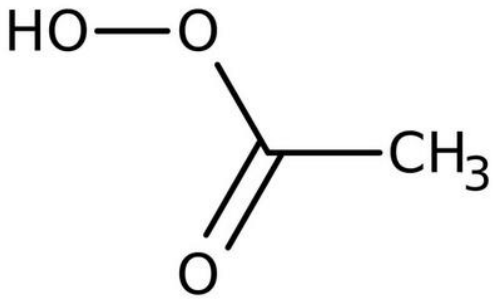
By-products during combustion

Water, peracetic acid, acetic acid, hydrogen peroxide

Experimental

- Pin-on-disk experiments with different concentrations of peracetic acid
- Tribocouple as used in ICE
  - Thermal spray coated disk (13Mn6)
  - Cr-plated pins
  - fully formulated lubricant (Fuchs Titan GT1 Flex5 0W20)

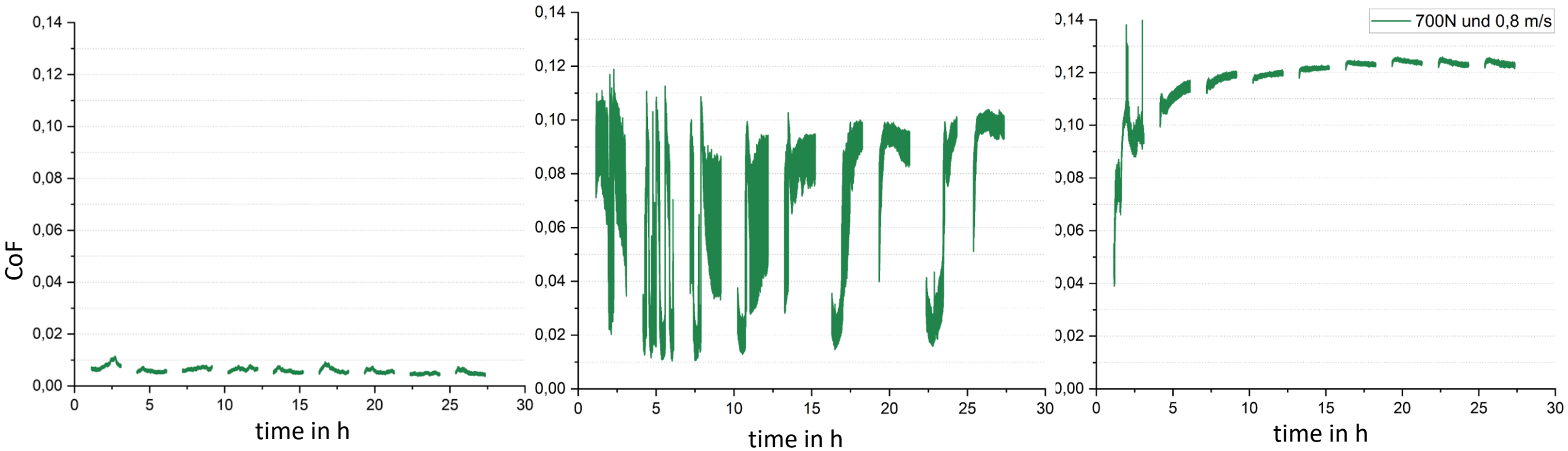
harvesting of sugar cane



*By: Hannes Grobe, Alfred-Wagner-Institut, Bremerhaven, Deutschland, https://commons.wikimedia.org/w/index.php?curid=5616625

Results

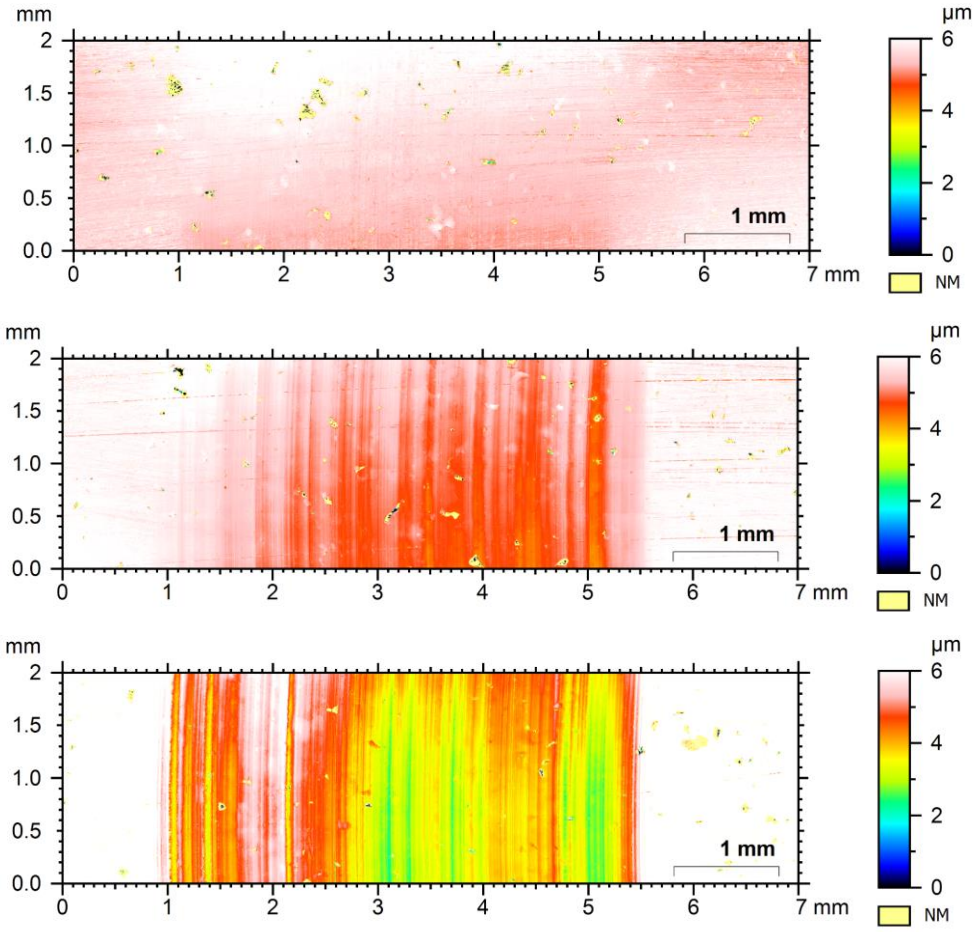
friction



0 % Peresal | 2 % Peresal | 8 % Peresal

Results

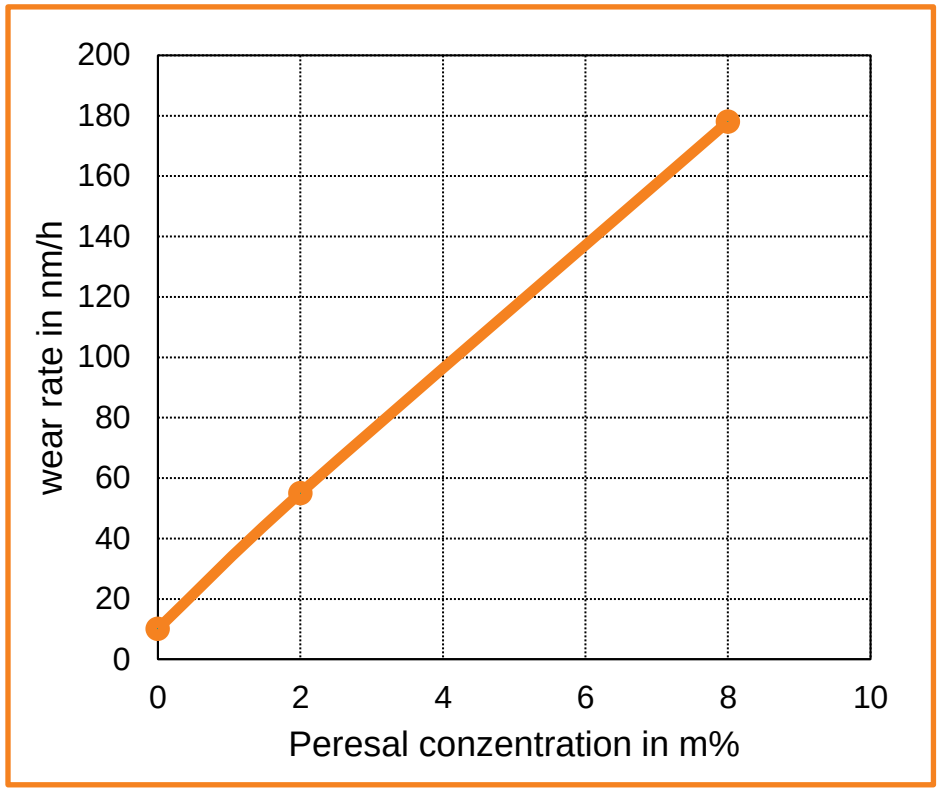
wear



0 % Peresal, < 10 nm/h

2 % Peresal, 55 nm/h

8 % Peresal, 178 nm/h



Chapter 06

Testing of tribosystems with Ammonia or Hydrogen

Testing under Ammonia atmosphere

Tribometer and research questions

ammonia and tribology

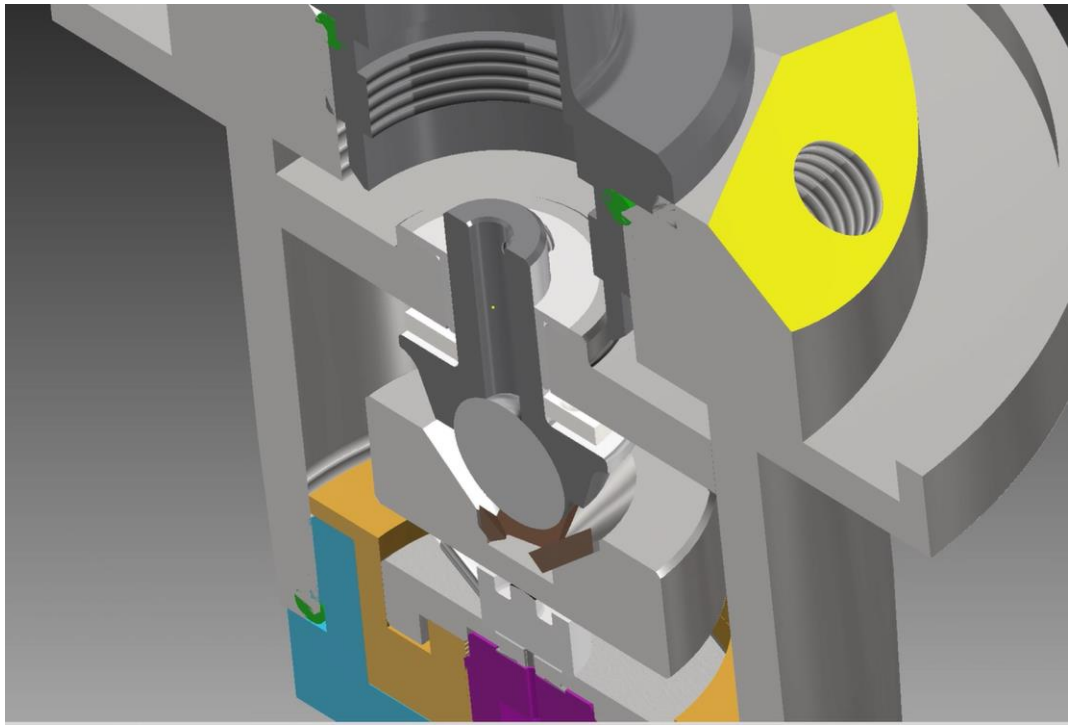
interaction ammonia – lubricant – surfaces under tribological load

challenges:

- health risk of ammonia
- ammonia corrosive to some materials
  → inert sensor design
- control of temperatures and pressures needed

approach:

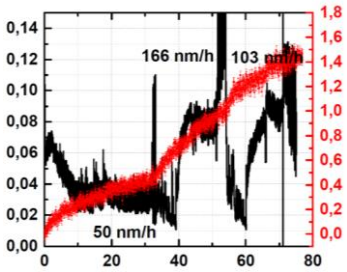
- setup of a tribometer in a pressure cell
  - control of temperature
  - control of pressure
    → defined fill with NH_3 possible
- magnetic coupling for torque transmission and –measurement
- ball-3-plate setup



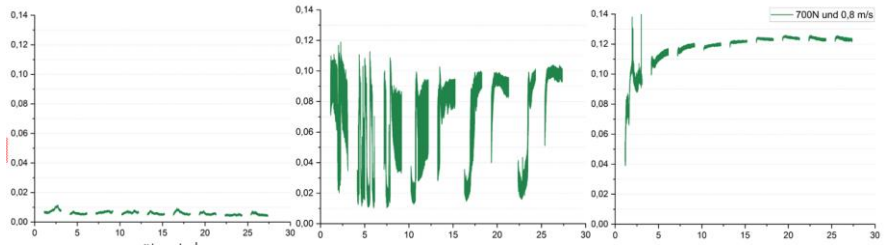
enables

- good trade-off
  model system ⇔ testing under gas atmosphere
- testing of different materials and lubricants under different atmospheres possible
- test program: allows for running-in analysis

conclusion



Alternative fuels:
modified boundary conditions / harsh environment for lubricants

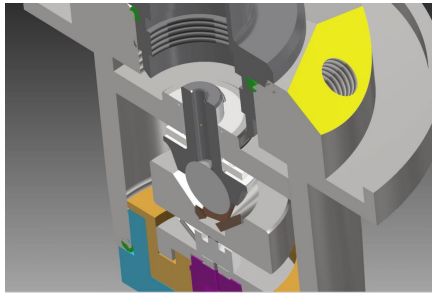


Advanced lubricant characterization

- running-in behavior and appropriate wear regime
  - → wear mechanisms comparable to the real system
  - for many mechanical engineering applications: ultra-low wear regime
- dedicated selection of materials
- appropriate design of tribo-experments
- combination with analytical methods

} understanding of tribosystems (lubricant is part of it)

Lubricated testing under various atmospheres possible



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Thank you for your attention!

Questions?