Tampereen yliopisto
Tampere University

Tribofilm evolution in simulated gear contact

13th TWC International Wear Seminar
Tribological Challenges in Industrial Applications

Reza Bayat

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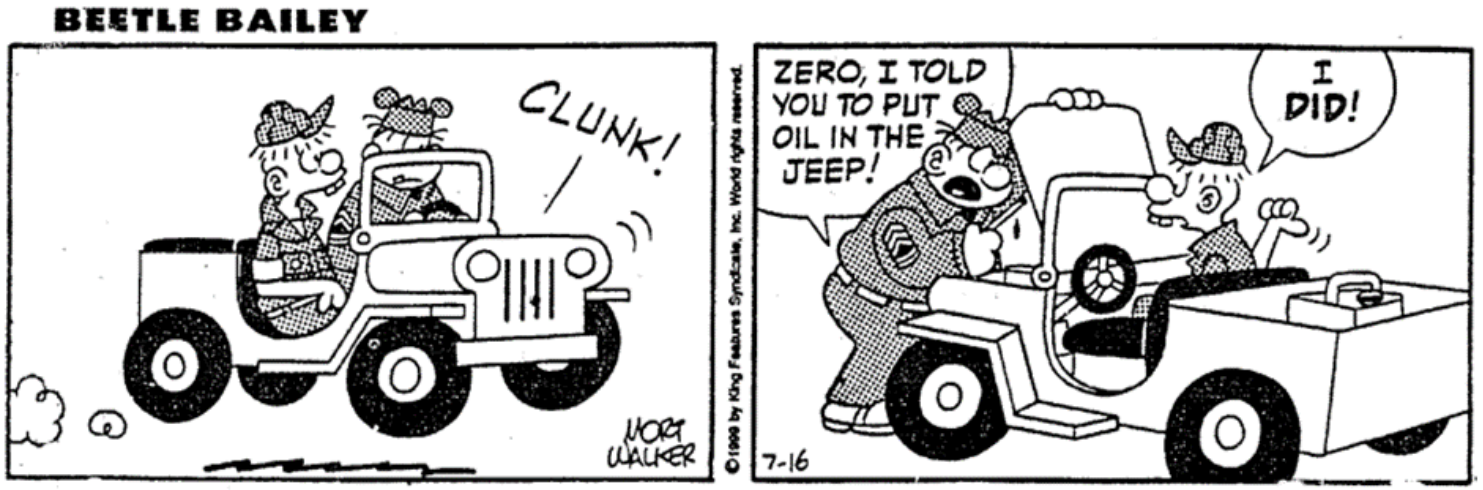
Gear lubrication

- Gears have been used for millennia as critical components of mechanisms and machines. The lubrication of gears aims to reduce friction, enhance cooling and prevent failures such as scuffing.



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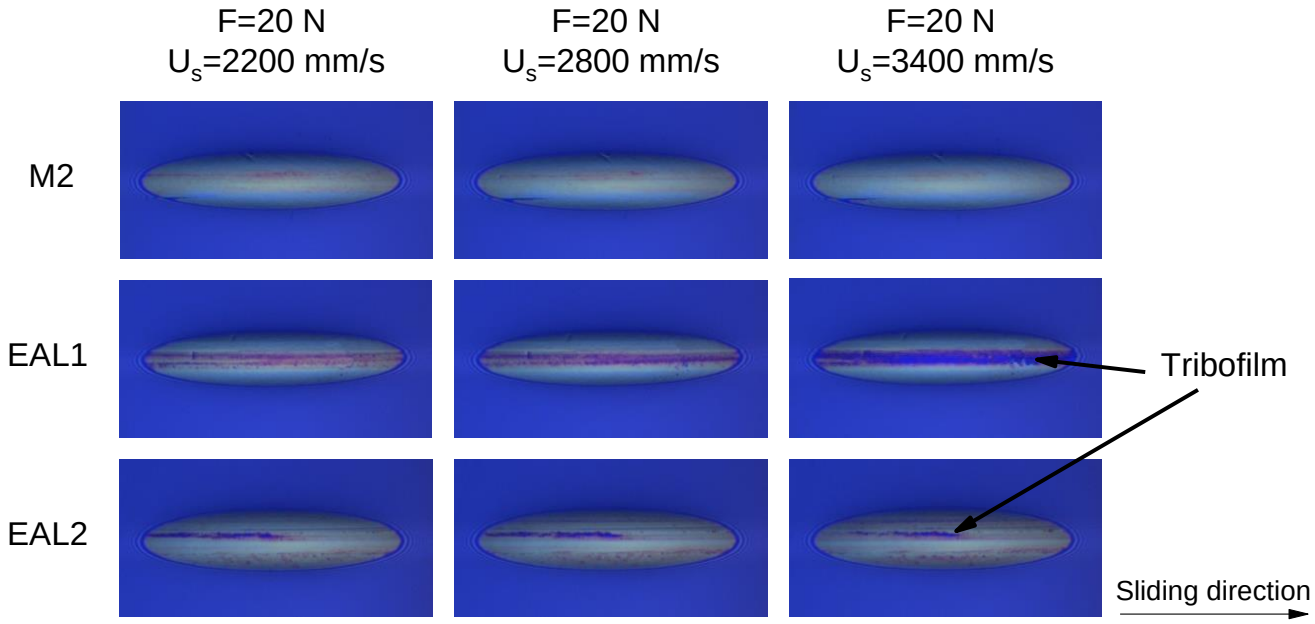
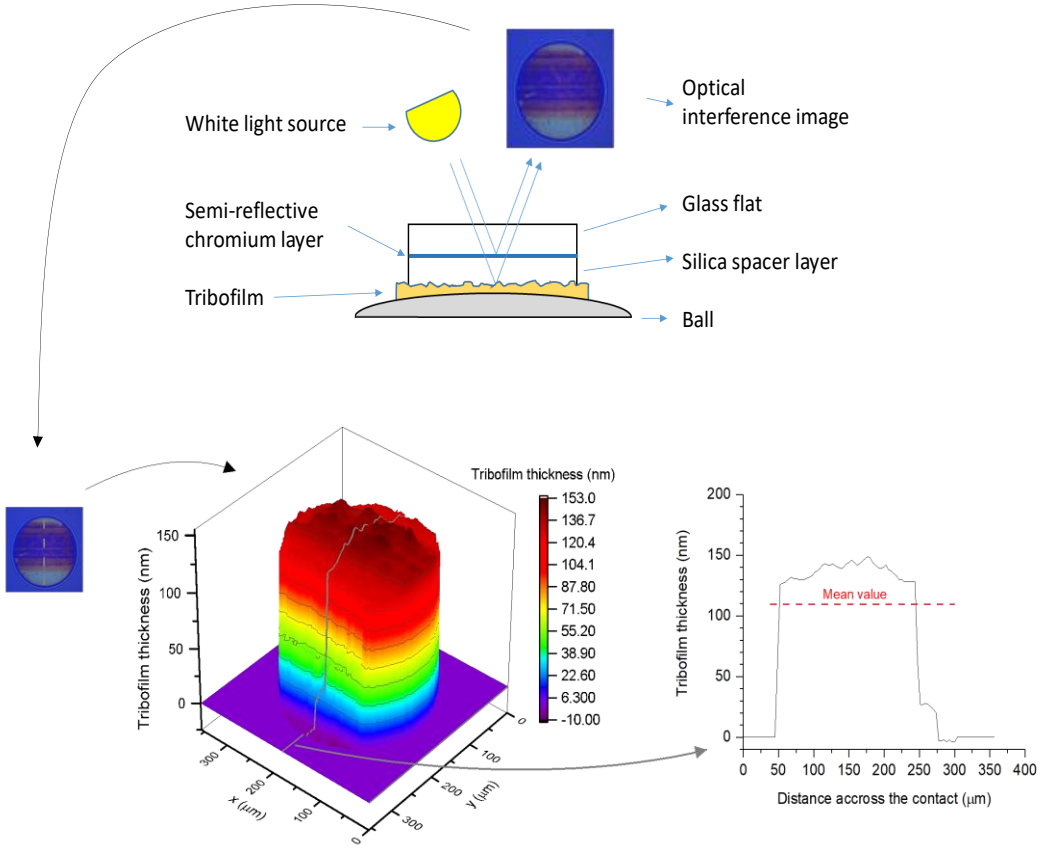
Tribofilm

One important factor in gear lubrication is the functionality of tribofilm. Tribofilm is defined as “a thin solid film generated as a consequence of sliding contact, which is adhered on its parent worn surface but has different chemical composition, structure, and tribological behavior”. Tribofilms exist in many tribological contacts where they act as a “third body” playing an important role in friction and wear.

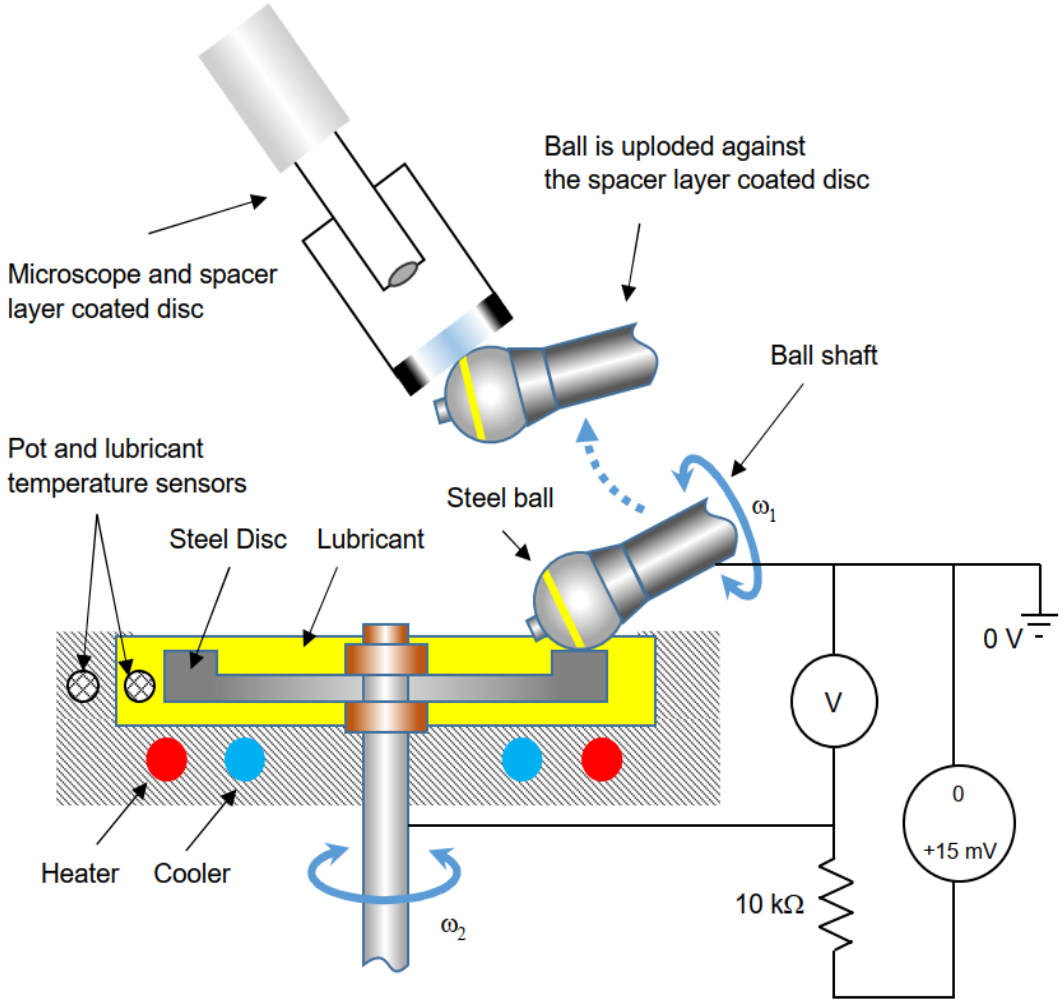


Tribofilm evolution during a scuffing test using barrel on disc machine

Spacer Layer Imaging Method (SLIM)



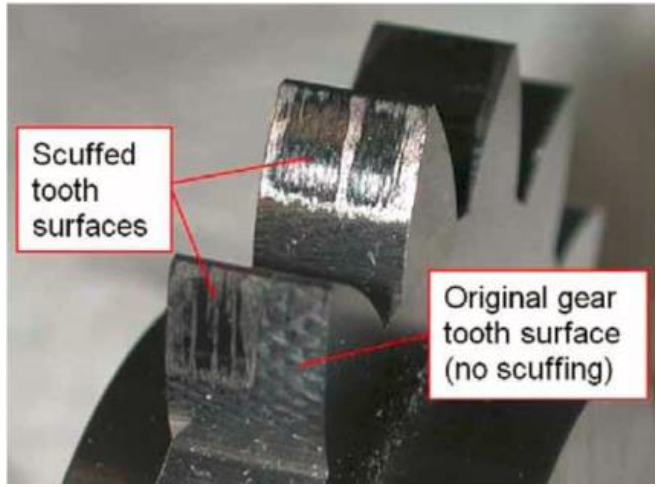
Tribofilm measurement using SLIM technique



Ball on disc machine

Scuffing study

Scuffing is a type of failure that is characterized by rapid wear and a roughened surface, a sudden rise in temperature and friction, as well as high noise and vibration.



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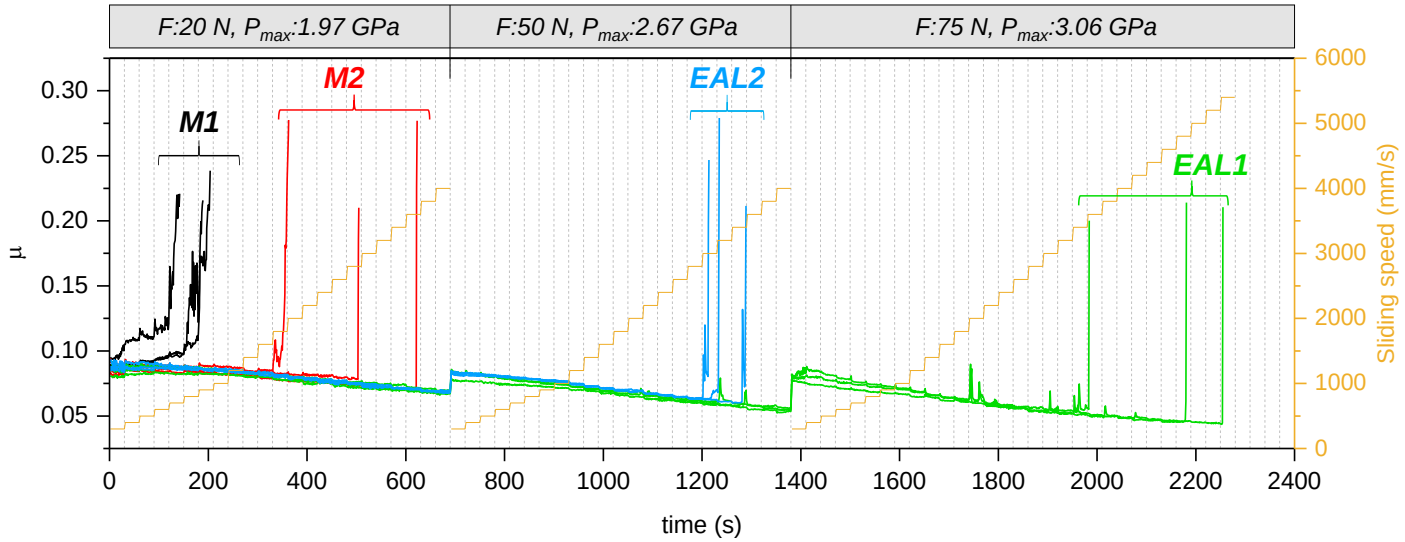
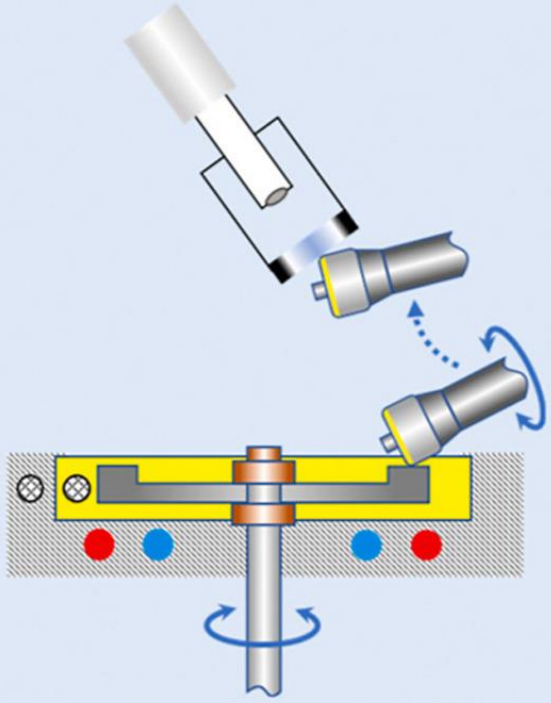


Oils can provide different scuffing capacities in gears

Scuffing study-methodology

The scuffing tests were performed using the barrel-on-disc technique provided by a mini-traction machine

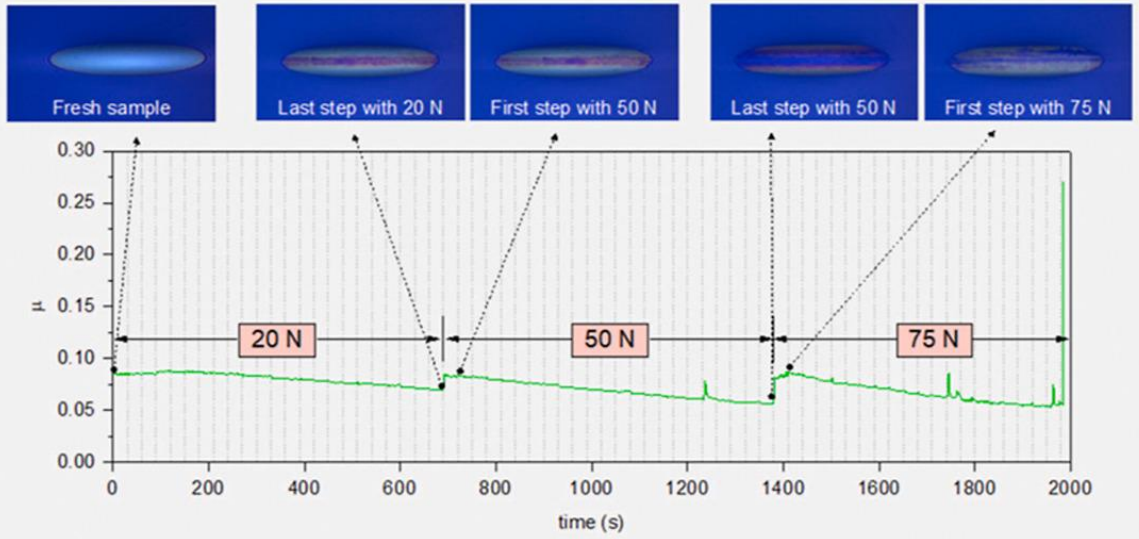
Barrel-on-disc scuffing test:
- Evaluating the scuffing capacity of industrial oils with high accuracy
- Imaging the tribofilm evolution in scuffing test stages



Three load steps

Sliding speed increase in load step

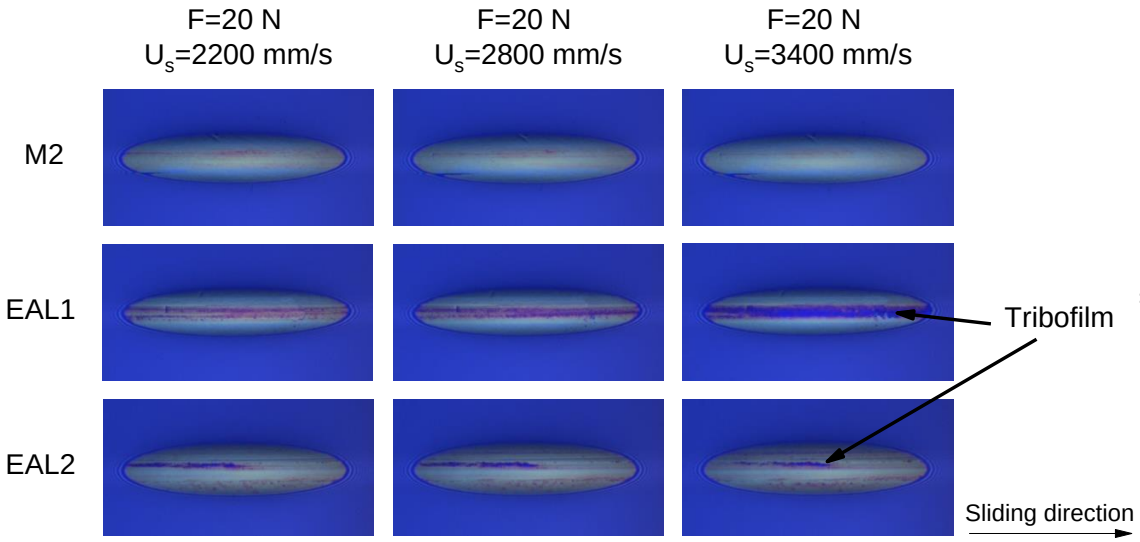
Tribofilm imaging

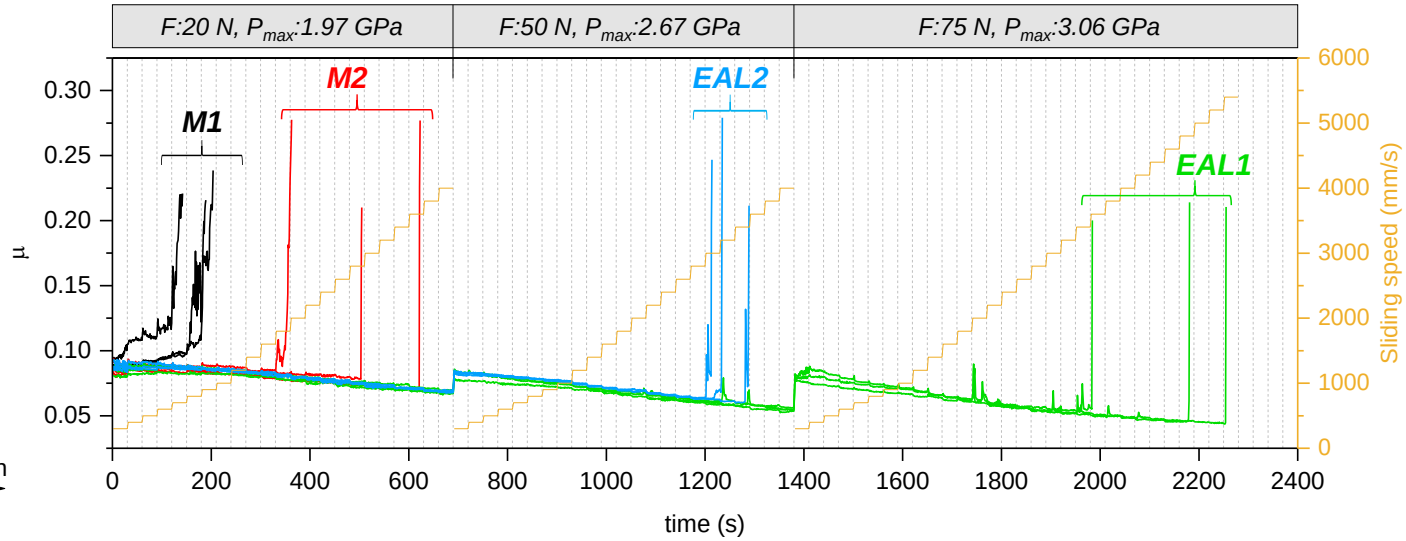


Scuffing study-Results

The advantages of the developed test are:

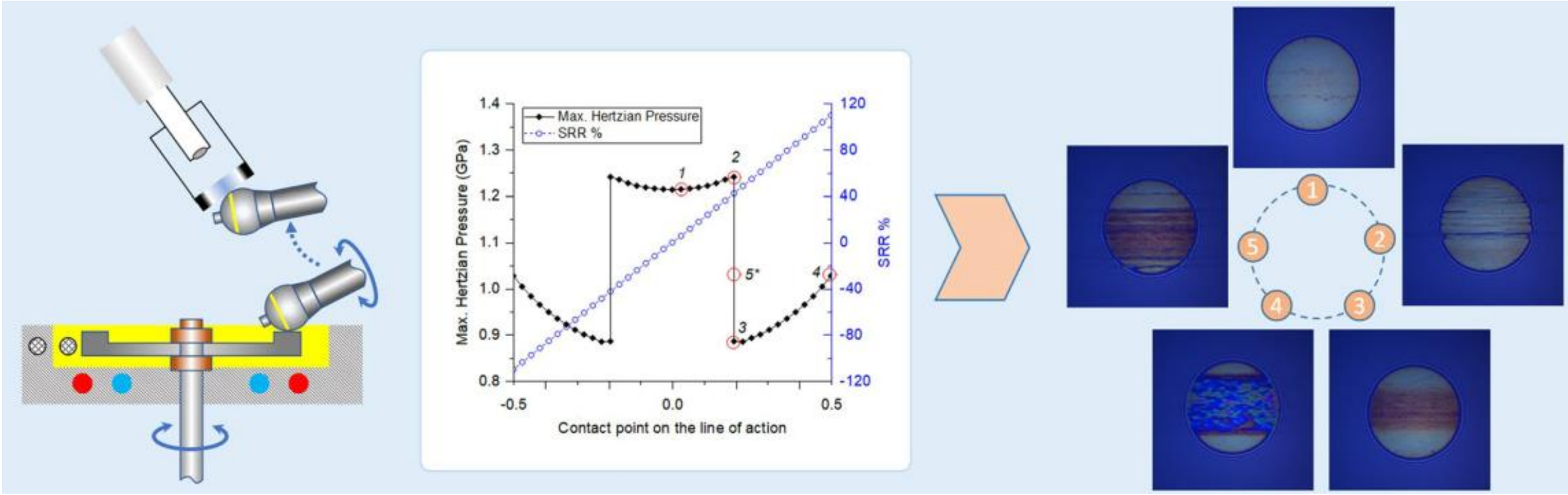
- Differentiating between the scuffing capacity of the oils which had similar FZG scuffing capacity in their datasheet.
- Providing high sliding speeds while maintaining a low entrainment speed so that high-performance oils can be tested successfully.
- Minimizing the wear before scuffing by using rolling–sliding conditions.





Tribofilm thickness along the line of action-Method

Four distinct locations along the line of action were chosen to investigate the evolution of the tribofilm using the SLIM technique.



Tribofilm thickness along the line of action-Results

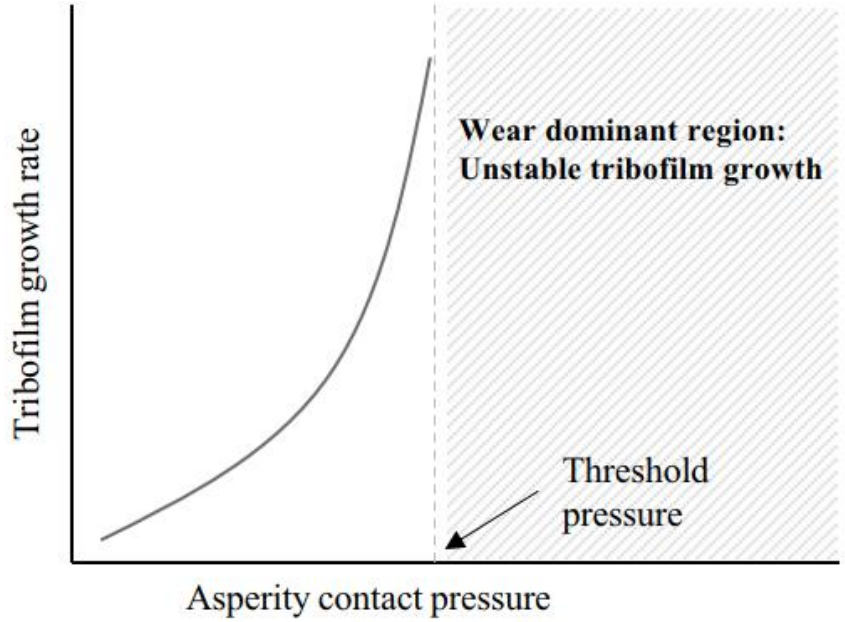
- The tribofilm formation does not depend on the slide to roll ratios in the range of this simulated gear which has low entrainment speed and low temperature rise at different locations along the line of action

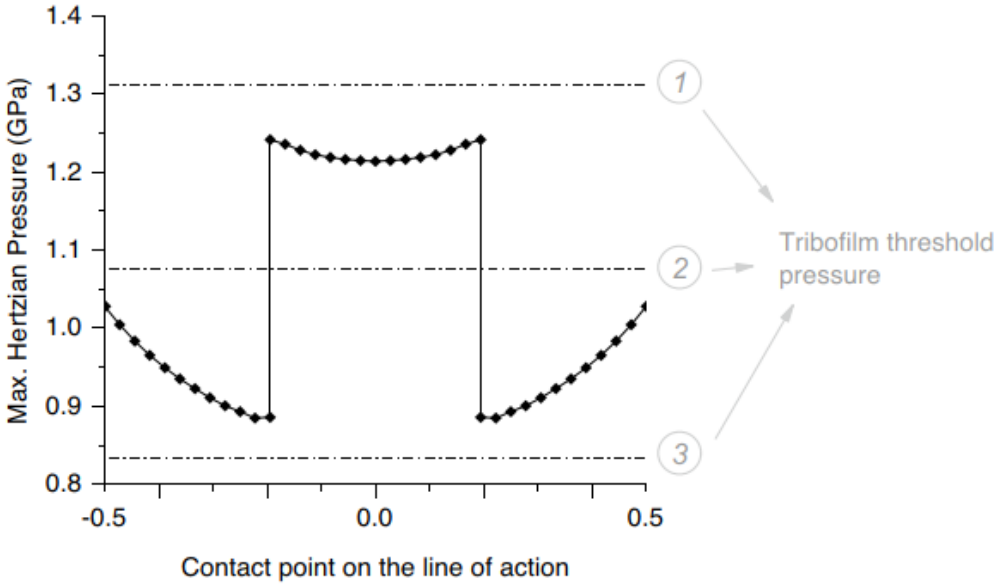
- There is a tribofilm threshold pressure around which the tribofilm growth rate is maximum.

- The tribofilm threshold pressure is very sensitive to the surface roughness; thus, it is attributed to the pressure in asperity level. Despite having a similar Hertzian pressure and shear stress, the pressure in asperity level can significantly alter the tribofilm formation mechanism.

- Above this threshold pressure, the tribofilm formation nis not stable, and the wear is dominant. Below this threshold pressure, the tribofilm growth rate rises by increasing the pressure.

- Considering a specific point on the line of action, the tribofilm growth rate mainly depends on its relative pressure compared to the tribofilm threshold pressure. The points which are closer to the threshold pressure have the highest growth rate. The points with higher pressure are prone to damage.





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Questions?