7th World Tribology Congress, WTC 2022
July 10-15, 2022, Lyon, France

Macroscale superlubricity of diamond-like carbon coatings and ceramics using different lubricants - From model test to application

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There is enormous potential in the optimization of tribological systems to increase the energy efficiency of technical systems. To this end, different lubricants with DLC coatings and ceramics are being tribologically tested in this project. In model friction tests, promising tribosystems were identified with which superlubricity was demonstrated in different lubrication regimes. The comparison with literature values and the application parameters shows that the tribosystems could be suitable for plain bearings.

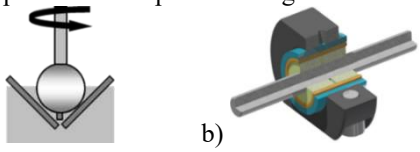
Keywords: tribology, superlubricity, DLC-coating, ceramics

1. Introduction

In total, approx. 23 % (119 EJ) of the world's total energy consumption comes from tribological contacts [1]. In the most cited publication on superlubricity, it was demonstrated that the origin of graphite's ultralow friction lies in the incommensurability between rotated graphite layers [2]. In our previous work, liquid superlubricity (friction coefficients < 0.01) was obtained with mesogenic fluids [3]. Consequently, there is a strong interest to transfer these results to technical applications. The challenge is to stabilize superlubricity at application-specific parameters for lifetime lubrication.

2. Methods

Different lubricants, materials (IKTS: ceramics) and coatings (IWM: a-C:H, IWS: ta-C) were tribologically investigated using a model friction test (Fig. 1a). After a running-in, velocity ramps (Stribeck curves, 0-1.4 m/s) were performed to analyze the friction under different lubrication regimes. After this screening, the most promising variants were investigated close to the application on a plain bearing tribometer (Fig. 1b).



a) b)

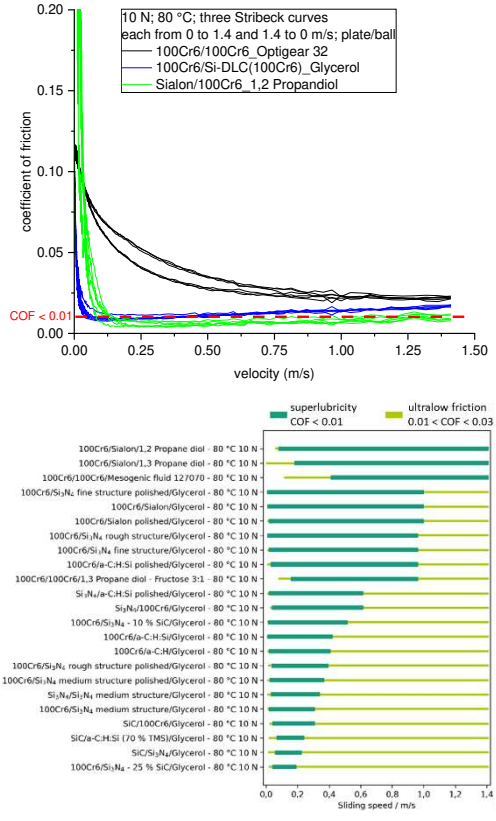
Figure 1: a) Model friction test with rotating ball-on-3-plate geometry; b) Testing of plain bearings.

3. Results

Compared to a reference oil, superlubricity can be achieved by selecting the appropriate combination of friction partners and intermediate medium (Fig. 2a). Superlubricity is achieved either at boundary and mixed friction or in the hydrodynamic range, but not in the entire speed range (Fig. 2b).

4. Discussion

Promising tribosystems for achieving superlubricity have been identified. The best results were achieved with a steel balls against ceramics or DLC coatings lubricated with glycerol. The model lubricants and coating systems used in this study still need to be optimized for the application parameters and lubrication conditions.



a)

b)

Figure 2: a) Result of friction tests; b) Overview of best variants for achieving superlubricity in the model test.

5. References

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Acknowledgement

This work was funded by Fraunhofer (PREPARE project “SupraSlide”)