Wear and fretting in corrosive atmospheres at ultra-high temperature using an SRV tribometer test rig

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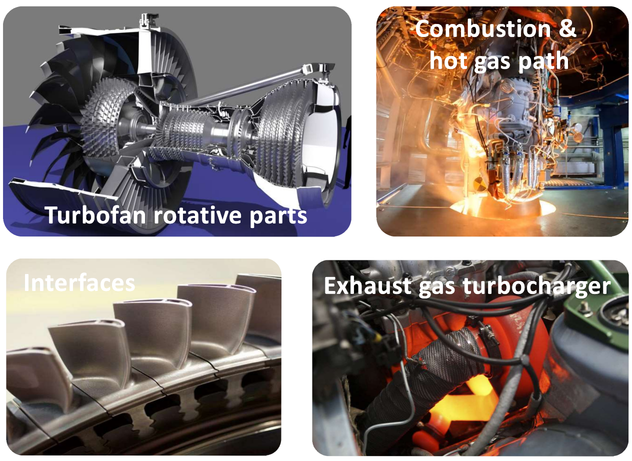


High-temperature Tribology in the Aerospace and Transportation Sector

Efficient Pre-Screening : From real-world applications to laboratory scale

As a result of ever increasing aeroengine performance, leading to higher temperatures in the hot gas path, and in view of the use of alternative fuels (SAFs, H_2), a thorough understanding of the mechanisms behind wear and fretting in engine components at ultra-high temperature in diverse corrosive atmospheres is of utmost importance. The DLR Institute for Test and Simulation of Gas Turbines addresses this topic by making use of the latest developments in SRV tribometer and test rig prototypes.

Tribology at DLR-SG

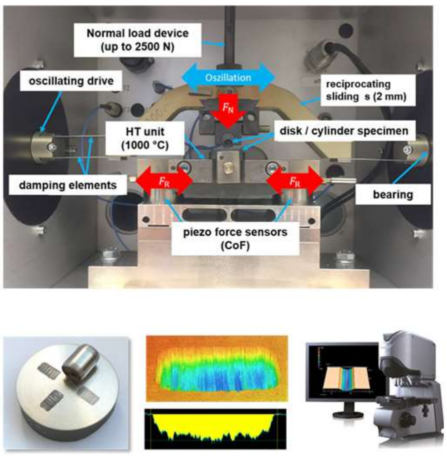
From real-world applications to lab scale

Contact configurations on system level are abstracted to laboratory scale using ball/disk or cylinder/disk contact pairs on a linear oscillating SRV testbench. The following test and analysis equipment is being used:

- Normal load F_N: 25 – 2500 N
- High-res measure of friction force F_R
- Test frequency f: 1,0 – 500 Hz
- Stroke s: 0,1 – 5,0 mm
- Temperature up to 1000 °C
- Confocal microscopy / WLI
- SEM / EDX, Raman

Chemical composition of investigated materials [wt%]

Materials	Co	Cr	Mo	C	Si	others
Tribaloy T-800	bal.	17,5	28,5	< 0,1	3,5	Ni, Fe
Tribaloy T-400	bal.	8,5	28,5	< 0,1	2,6	Ni, Fe



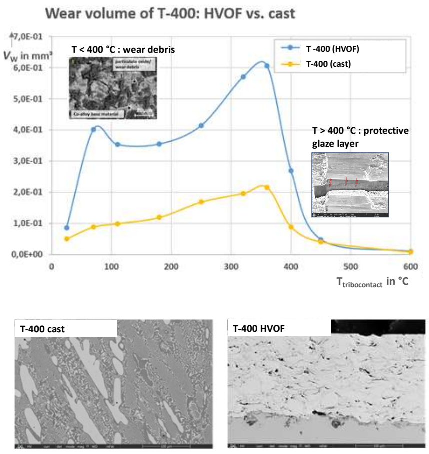
SRV tribometer with high-temperature unit, disk/cylinder geometry, and measurement of wear volume

Co-alloys for high-temperature applications

Cobalt-based alloys have the ability to exhibit improved tribological behavior at high temperature due to the formation of compacted oxides, leading to wear-protective glaze layers. Controlling the underlying physical mechanisms through technological measures would enable the tailored use of Co-alloys for a wide range of industrial applications.

Key findings of this present study on the influence of manufacturing process on wear and friction characteristics are:

- Transition temperature between mild and severe wear is clearly identifiable
- Formation of glaze layer for T > 400 °C, depending on microstructure and chemical composition (Cr-content)
- reduced wear characteristics for cast alloys, as compared to alloys applied by high-velocity oxygen fuel (HVOF)



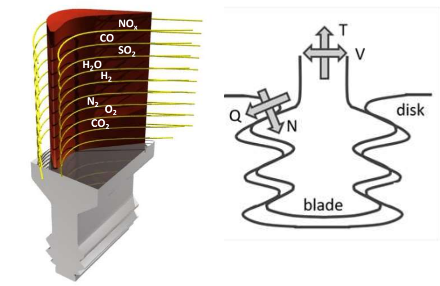
Temperature dependency of wear behavior for T-400 (top); morphology and microstructure (bottom)

The influence of corrosive atmospheres is of particular interest for aeroengines and gas turbines in general. A focus will be placed on atmospheres containing high amounts of SO_2 and H_2O vapor. For this purpose, a test chamber with the following specifications is being designed and manufactured by Optimol Instruments Prüftechnik GmbH:

- Test chamber for corrosive gases N_2, O_2, CO_2, SO_2, CO, NO, H_2O vapor ...
- Ambient pressure up to 20 bar

Outlook

The underlying physical mechanisms behind the tribological behavior of Cobalt-based alloys at high temperature are understood. Future work will focus on reproducing and closely resemble the friction and wear performance of aerospace components under harsh real-world application, meaning at high temperature and in combination with corrosive atmospheres.



At system level: Influence of combustion gases on fretting damage in a turbine blade-disk contact