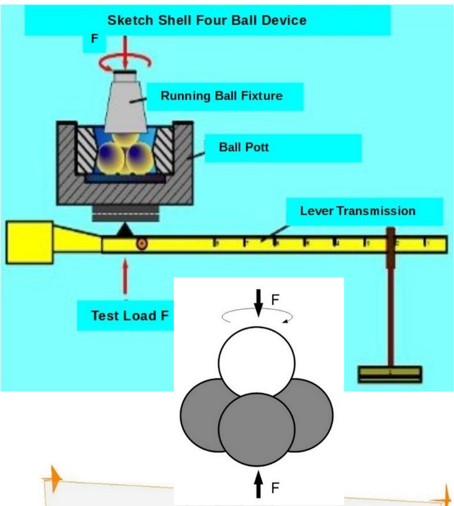
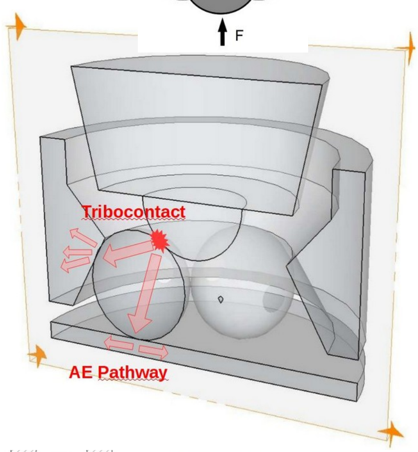
DETECTION OF ACOUSTIC EMISSIONS ON THE FOUR-BALL TESTER

GMBU

Gesellschaft zur Förderung von Medizin-, Bio- und Umwelttechnologien e.V.
Erich-Neuss Weg 5, 06120 Halle (Saale)

CONTACT. Dr. Stefan Gai Tel. 0345 777 96 40 stefangai@gmbu.de





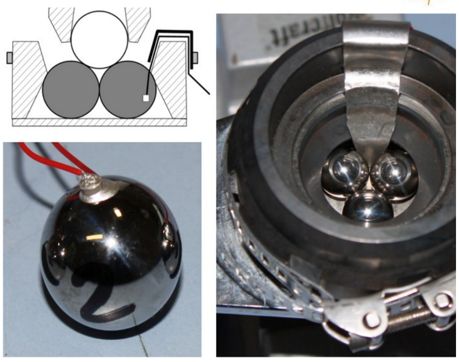


Figure above. Fixing the piezosensor at one of the stationary balls

LUBRICANT CHARACTERISATION WITH THE FOUR-BALL APPARATUS

The SHELL four-ball apparatus (VKA) is a tribometer used in the development and testing of lubricants and additives (DIN 51350).

The lubricant is tested with four balls in a tetrahedron arrangement. One ball (running ball) rotates and slides on three identical balls (stationary balls). At a fixed speed, the test load F (lever) is increased in discrete steps until the balls are welded together.

The determination of the welding point as a function of the speed and the contact pressure is used as the test parameter. The ball calotte diameter (etc.) is determined as a wear parameter.

WEAR OF THE LUBRICATED TRIBOCONTACT IN FAST MOTION

In the VKA, a reproducible tribocontact is realised by the 3 contact points of the running ball. This standardisation of the test procedure means that the test procedure essentially "only" depends on the lubricant properties.

In the test process the dynamics of a lubricated tribocontact are run through in fast motion, from the build-up of the lubricant film to the running-in of the solid contacts and welding as a result of scuffing processes. The process reproduces key features of the lubricating film dynamics in the tribological process, as described by the Stribek curve.

THE TRIBOSENSOR CONCEPT (DE 10 2014 103 231)

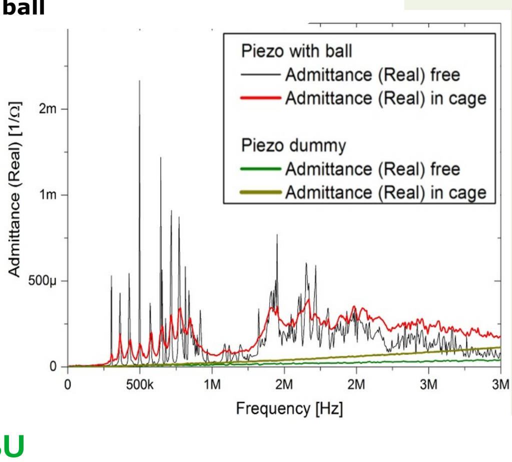
The concept is based on the question of the extent to which the dynamics of the tribocontact and in particular the elastohydrodynamic effects can be recorded over a wide frequency range with high temporal resolution by recording the AE.

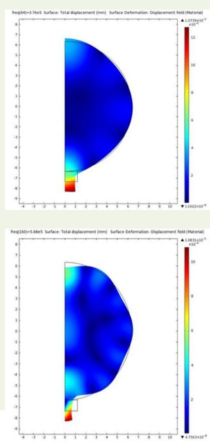
For this purpose, a piezo element was fixed to one of the stationary spheres, with which minimal deflections of the sphere can be recorded. The digital recording of the signals was carried out with a 16-bit resolution and a data rate of 25 MSa/s. Data evaluation of time series and spectrograms.

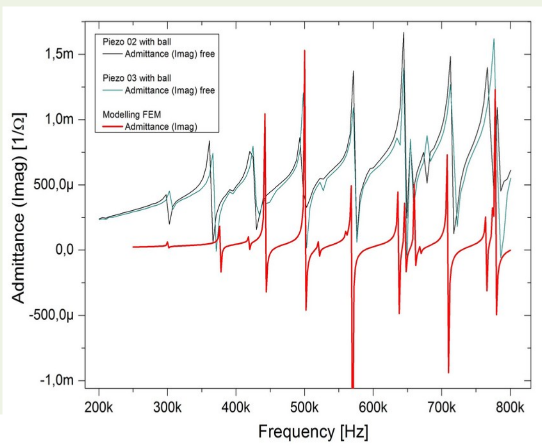
CHARACTERISATION OF THE SENSOR

The signal transmission behaviour was investigated by measuring admittance spectra and an FEM modal analysis. The low-frequency admittance peaks were confirmed as natural resonances of the spheres. The sphere diameter and the way in which the sphere ensemble is installed in the cage have a decisive influence.

Figure below. Admittance measuring and modal analysis of the ball







FRICTION WEAR IN FAST MOTION

The figure right shows the spectrogram (0 - 4 MHz) and the time series of the amplitude from start-up, run-in to the start of seizure. The higher the intensities in the spectrogram, the brighter the pixel dots. The increased AE amplitudes at start-up result from the unlubricated trefoil contact. The contact points are only supplied with lubricant when the running ball rotates. In the run-in area, the AEs subside, the maxima of the solid surface are levelled and the lubricating film has built up. At time 2.71s to 2.77s, the amplitudes remain small, but the spectrogram shows the excitation of the eigenmodes in horizontal lines as a result of increased friction, which can be interpreted as an early indicator of the onset of the scuffing process.

In the 2.81s time range, a sharp increase in the intensity of the amplitudes sets in. The clearly visible increase in amplitude over time can be written down. However, the spectrogram also shows a strong increase in signal intensity for the high-frequency components, which indicates increased friction and scuffing for the time range 2.81s to 2.86 s.

The zoomed-in sections reveal a high resolution of the dynamics of the friction event. Typical signal structures that could indicate stick-slip excitation of the vibrations can be seen at the highest resolution in the area of the start of the seizure.

A strict separation of mechanical and electrical signal components was not possible in this setup. This must be taken into account.

CONCLUSIONS

The tribosensor concept shown here enables an almost undistorted recording of AE induced in the lubricated friction contact. The clear geometry of the tribological elements (balls) enables a high-resolution time insight into the friction process. To the best of óur knowledge this is the first time of showing such a high resolution dynamic in tribocontacts of VKA.

The concept proves to be fundamentally viable for the upgrading of tribometer investigations as well as a sensor solution for tribocontacts on machine elements (bearing rings, gear wheels etc.).