DETERMINING THE MIXED LUBRICATION REGIME OF A PLAIN BEARING BASED ON ACOUSTIC EMISSIONS (AE)

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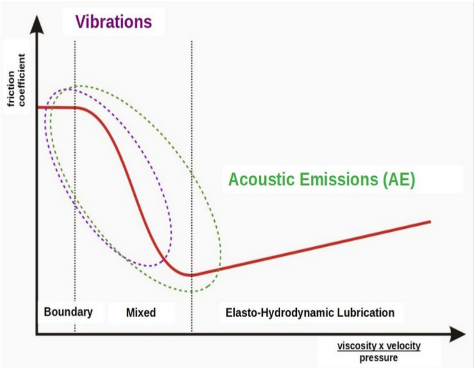
OPERATION OF PLAIN BEARINGS IN MIXED FRICTION

Plain bearings are operated in the transition from fluid friction (EHL) to mixed friction. Friction losses in the lubrication gap are minimised there (see Stribeck curve below).

In large scale industrial bearings, maintaining the optimum friction regime therefore involves controlling the oil pressure in the lubrication gap of the plain bearing. For minimising operating cost reasons, it is very important to be able to maintain the optimum operating point by controlling the oil pressure.

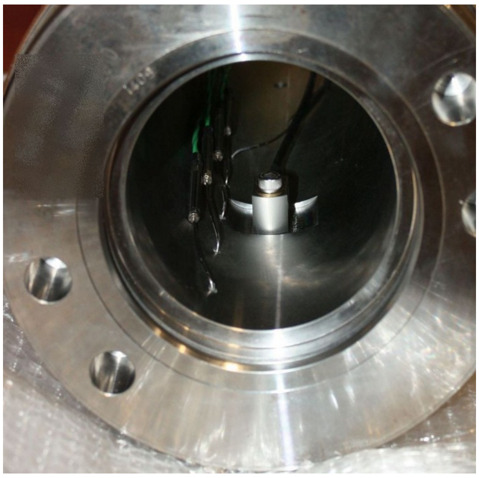


RELATIONSHIP BETWEEN FRICTION COEFFICIENT AND FILM THICKNESS

The lubricated sliding friction contact between two solid bodies is a complex process. Depending on the surface pressure and the relative speed there are various friction scenarios that are described by the Stribeck curve.

In the liquid friction regime the solids are separated by a lubricating film. In the area of mixed friction, the lubricating film breaks down briefly. This results in sporadic contact between the solids generating AE temporarily.

When solid contact accumulates frictional heat is generated.This can be detected in a plain bearing bush with the aid of temperature sensors and thus provide an indication of operation in the mixed friction area.

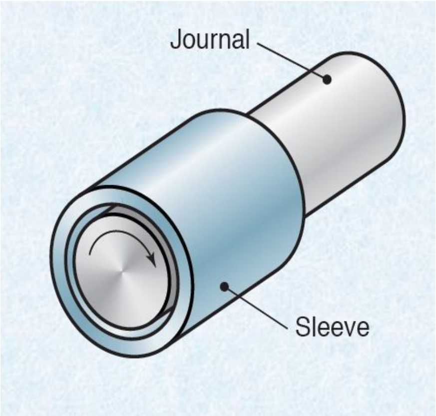


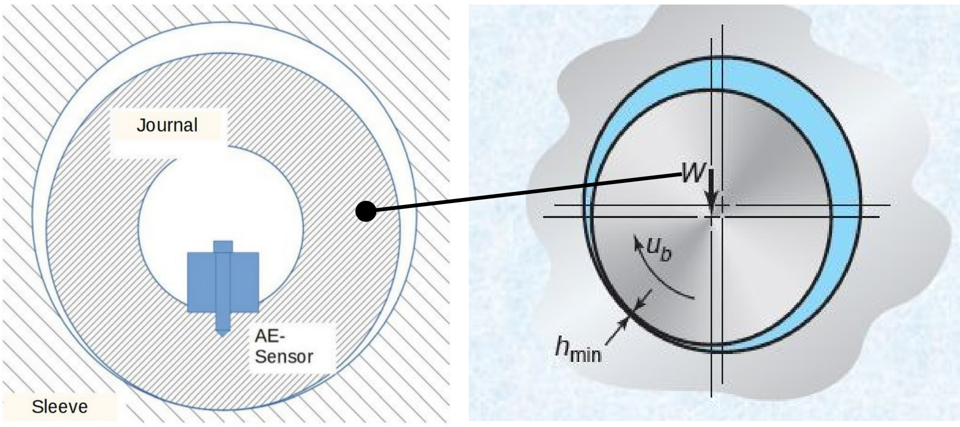
A SENSOR CONCEPT FOR DETECTING AE IN THE PLAIN BEARING

The aim of the work was to clarify the question, whether it is possible to use an AE sensor to detect the breakdown of the lubricant film in a plain bearing operating in the transition between EHL-contact and mixed friction zone.

Transferring the GMBU tribosensor concept (DE 10 2014 103 231), an AE sensor was placed in the immediate vicinity of the tribocontact in the plain bearing pin designed as a hollow shaft (see Fig.s left and below).

The plain bearing is used to support the planet wheels of a planetary gearbox, which was tested on a test bench. By varying the speed and torque, the surface pressure w and the circumferential speed u_B can be varied in the plain bearing and thus indirectly change the height of the lubrication gap h_{min}.





TESTING ON THE DRIVE TESTING STAND

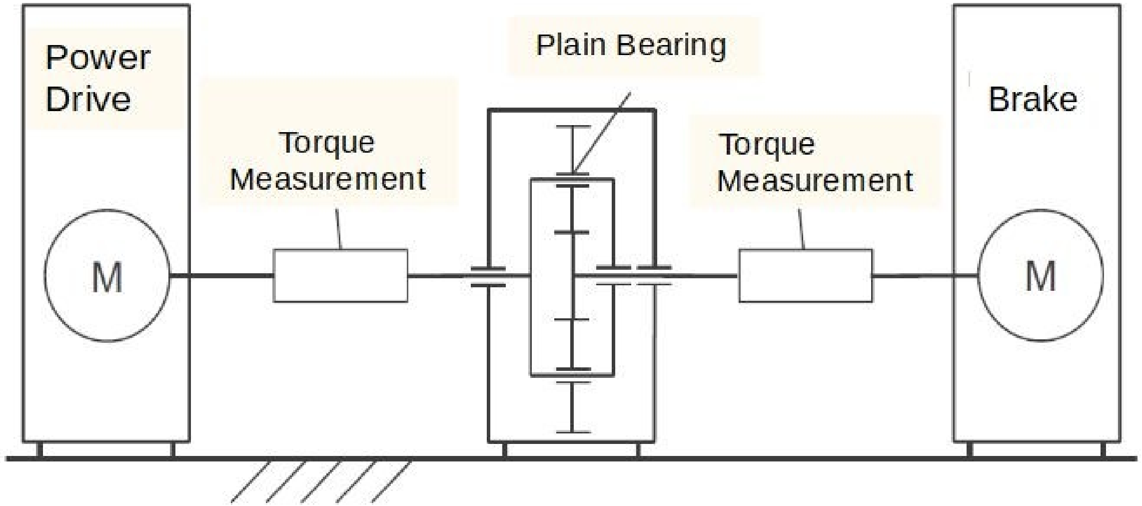
The gearbox was operated at various stationary load points by varying the torque, the speed of the sun and planetary gear and the oil pressure as part of test bench tests (see fig. right).

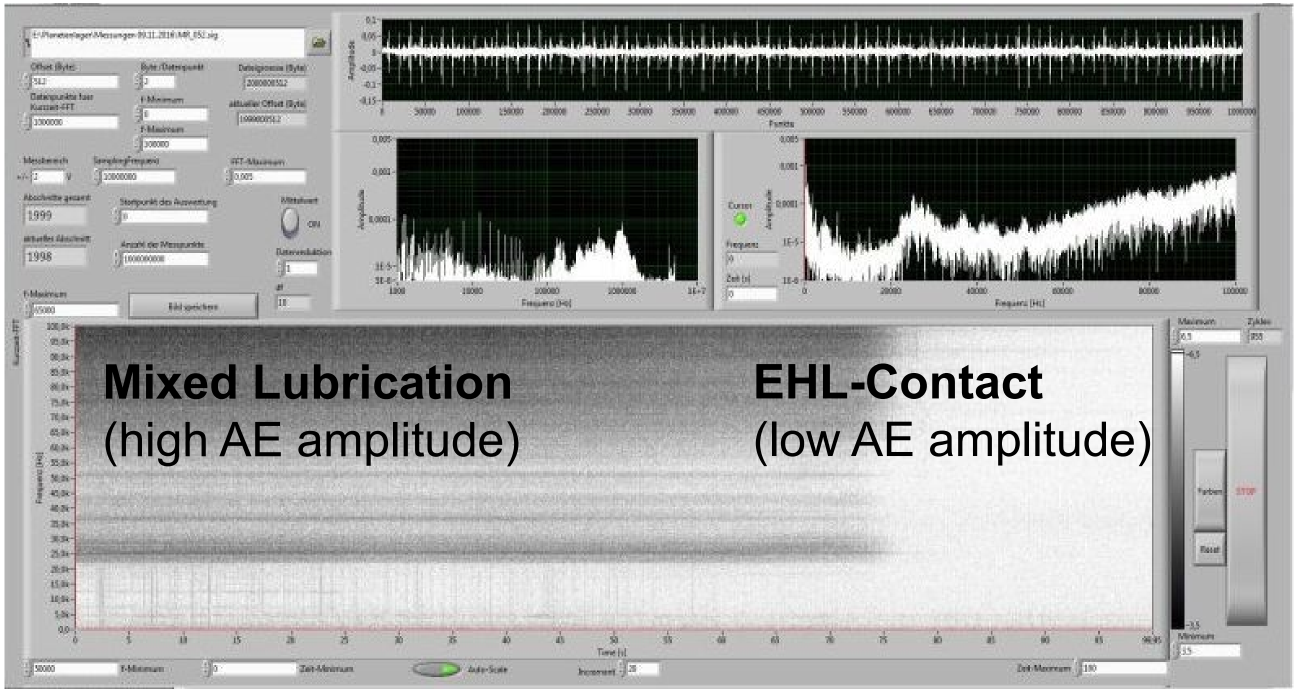
Transient load tests were carried out to verify the transition from mixed to fluid friction using the AE measurement method. For this purpose, the speed of the sun wheel was reduced and run to zero. The rack speed was kept constant. The planetary speed increased as the sun wheel speed fell. The Sommerfeld number, which is directly proportional to the speed, increases accordingly.

The lubricating film thickness should therefore increase in the course of the test, i.e. there should be a transition from mixed to liquid friction in the lubrication gap.

The AE spectrogram on the bottom right shows the signal intensities over time (in the frequency band from Hz to approx. 1 MHz) in the transient test. The brighter the pixel area, the lower the signal level.

The transition from high to lower signal intensities in the high frequencies is clearly recognisable. This is a strong indication that a sporadic breakdown of the lubricating film takes place in this area and that these events in the mixed friction area determine the signal intensities. In the area of liquid friction (EHL), this lubricant film breakdown does not occur.





CONCLUSIONS

The tribosensor concept shown here enables almost undamped detection of AE signals induced by the contact between the bearing pin and plain bearing bush. The clear geometry of the tribologically stressed elements bushing and bearing pin allows (unlike in tooth flank engagement) a high-resolution temporal insight into the sliding-friction process.

The tribosensor concept proves to be fundamentally sensitive for monitoring plain bearings in the transition area.