TEST STAND IN UNIVERSITY OF APPLIED SCIENCE GIESSEN FOR FRICTION FORCES MEASUREMENTS IN SLIDE BEARING USING THE ACOUSTIC EMISSION METHOD

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Abstract

The present paper shows particularly description of the construction of the test stand for experimental research performed in University of Applied Science Giessen and connected with the measurements of hydrodynamic friction forces in journal slide bearings by using the Acoustic Emission Method. The test stand is adapted for the friction force measurements for the low bearing load and for the high bearing load. For such test stand in the case of low and high loads the dependencies between friction forces and time can be exactly obtained. During the measurements the temperature changes are expected. The advantage of this method is the fact that oscillations of measured friction values can be executed directly from the source to the sensor, what enables us to do an "online-measurement". The Acoustic Emission Analysis is (in opposite to the aforementioned Friction Power measurement) a relative method, which means, that the absolute amount of a RMS-Value depends on the measuring chain.

Keywords: *AE- Acoustic Emission, RMS, test stand construction, journal bearing*

1. Test stand construction in Giessen

This section shows the particular description of the test stand construction.

Onto the base frame of a tribometer, which was used as chassis, the slide journal bearing test stand concluding two bearing under test with one common shaft was based. To indicate the friction conditions, the Acoustic Emission Analysis, a specialized mechanical system as well as temperature measurements were applied. One main aim of the construction was to reduce most of the influences on the acoustic emission signals, that are generated in the bearing under test and caused by mechanical oscillations of the drive of the bearing shaft, see Fig. 1. The speed controlled electric motor drives the intermediate shaft via a toothed belt which itself is connected via a curved-tooth gear coupling with the main shaft. The curved-tooth gear coupling is used to compensate the misalignments of the shafts and - most important - to disconnect the spurious mechanical couplings between the main and intermediate shaft. The main shaft is supported by hydrostatic slide bearings, to avoid mechanical disturbances caused by the rolling element bearings. The lubricants supply of the bearings is ensured by an external module.

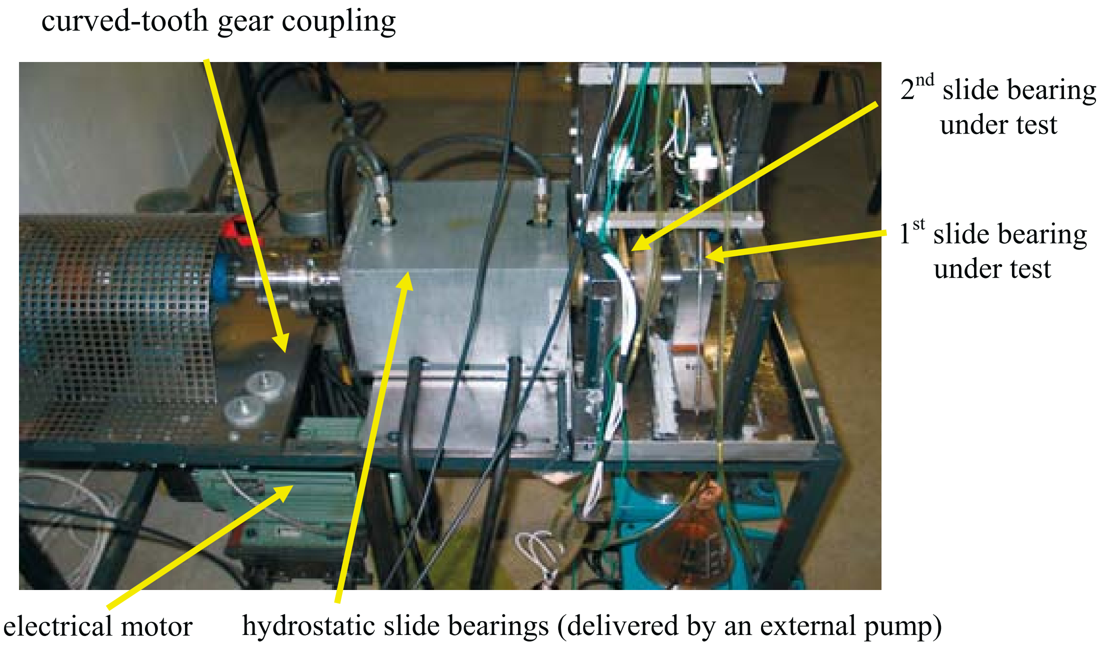

Fig. 1. Drive of the bearing shaft. The test stand is powered by an electric motor

The shaft under test, which is made of austenite steel, will be connected to the main shaft by a hydraulic clamping device [3], [4], [5]. Because the austenite steel itself has a huge damping attribute in case of acoustic emission waves, the remaining high frequency disturbances are reduced to their minimum. The test rings are fixed onto the test shaft by shrinking see Fig. 2. All of the test measurements are recorded simultaneously by a computer. For this computer a special software on DELPHI basis was invented. All test measurements are continuously saved on the hard disc of the computer. The evaluation and the graphic presentation of the outcome are made via the standard EXCEL program.

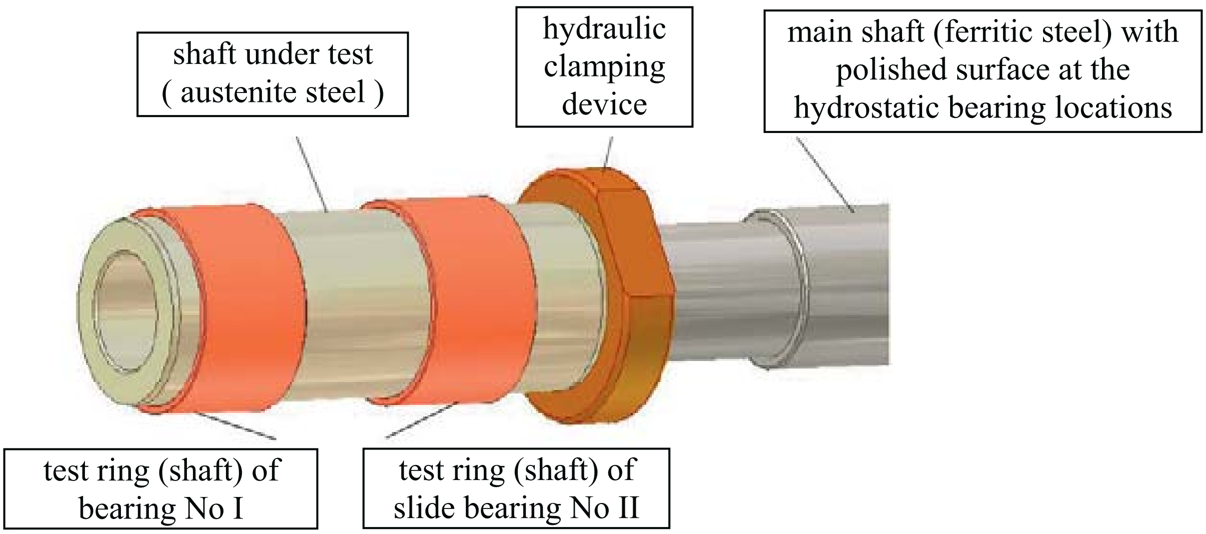

Fig. 2. Three-Dimensional plot of the bearing shaft. The shaft under test is fixed concentric at the main shaft through a hydraulic clamping device. The test rings of the bearings are shrieked onto the shaft under test

2. Lubricant delivery and friction forces geometry

The bearing sleeves are fixed into a horizontal split bearing carrier, Fig. 3. Throughout a bore hole in the upper bearing sleeve, the hydrodynamic slide bearing will be supplied with the lubricant.

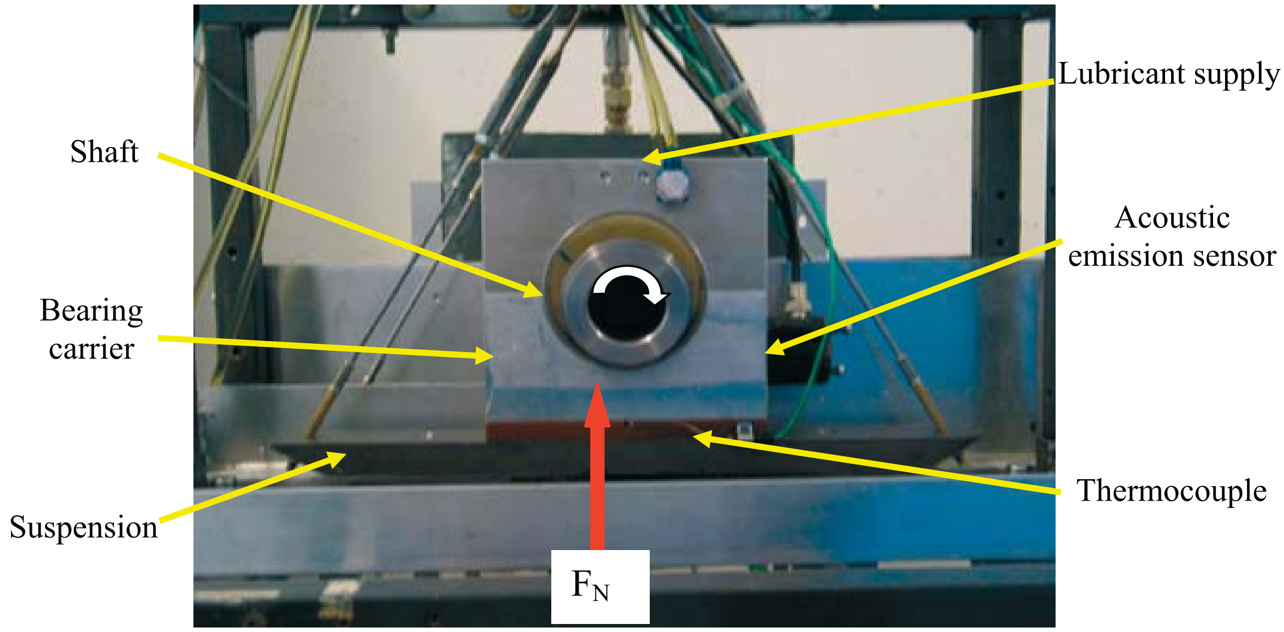

Fig. 3. Suspension of the 1st slide bearing under test with measuring devices (Acoustic Emission sensor, thermocouple) and the lubricant supply

This lubricant flows by gravity to the bottom bearing sleeve and therefore to the bearing gap. The continuous flow will be ensured by a reciprocating piston pump which pumps the lubricant out of a lubricant reservoir (Erlenmeyer flask) to the bearing. The lift of the pump can be adjusted by a control unit. There is also a stirrer, which avoids the separation of lubricants - with different formulations - that shall be tested in the future. The intensity of the mixing can be adjusted via several speeds of the stirrer. A thermocouple, that is fixed throughout a bore hole in the bottom bearing sleeve, measures the changes in temperature during the test. Additionally we used a heat conductive paste to achieve an optimized thermal conduction. The Acoustic Emission sensor is placed at the bearing carrier. The sensor transforms the oscillations, that are generated in the bearing, coupled with the high viscosity grease, into electrical signals. These electrical signals are referred to a pre-amplifier by passing a coaxial cable. The pre-amplifier adjusts the impedance and amplifies the signal at 30dB. Behind the pre-amplifier there is a band-pass filter, that filters the signal in the range of 30kHz – 130kHz and as well amplifies it at another 40dB. The filtered and amplified Acoustic Emission signal will be converted into an energy equivalent direct current voltage by the Root-Mean-Square module [1]. The bearing carrier is connected to the suspension via an interlayer of vibrating-damping Pertinax®. This suspension, that realizes the induction of the bearing load as well as the measuring of the Friction Force, is constructed out of a base plate which is connected to the load cells by two steel ropes. The load cells do have a measuring range of 1000N each and are connected with a carrier frequency measuring amplifier, which transfers the incoming load signals into force equivalent output voltage (+/- 10V). The center lines of the load cells form a angular of 60 degrees, both are fixed by an adapter. The needed bearing load is conducted into the adapter via a steel rope. The whole construction of the suspension forms an equilateral triangle. At the centric of the triangle there is the central point of the bearing bore. This construction of the suspension enables us to measure the friction forces in the bearing under test while testing. The conducted bearing load is allocated symmetrical to both load cells – if the shafts do not rotate [2]. While rotating, the friction force (out of mixed or hydrodynamic friction) produce a torque in the suspension. This torque reliefs the load cell I and stresses the load cell II additionally at the exactly same amount. Because of the geomatrical connection Fig. 4 and Fig. 5, the formula (1) for the Friction Force F_R can be determined as follows [1]:

$$F_R = \frac{F_2 - F_1}{2.69}, \tag{1}$$

where:

F_1 - force on the section of the left rod,
F_2 - force on the section of the right rod.

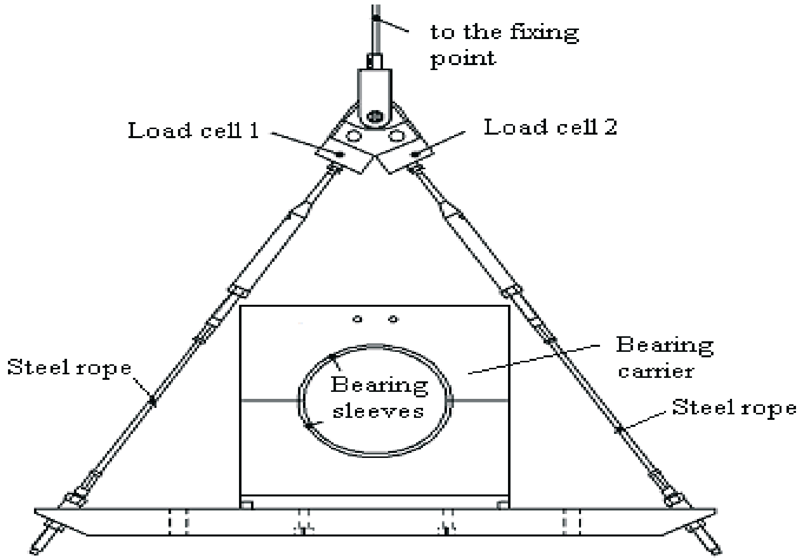

Fig. 4. Drawing of the suspension of one test module

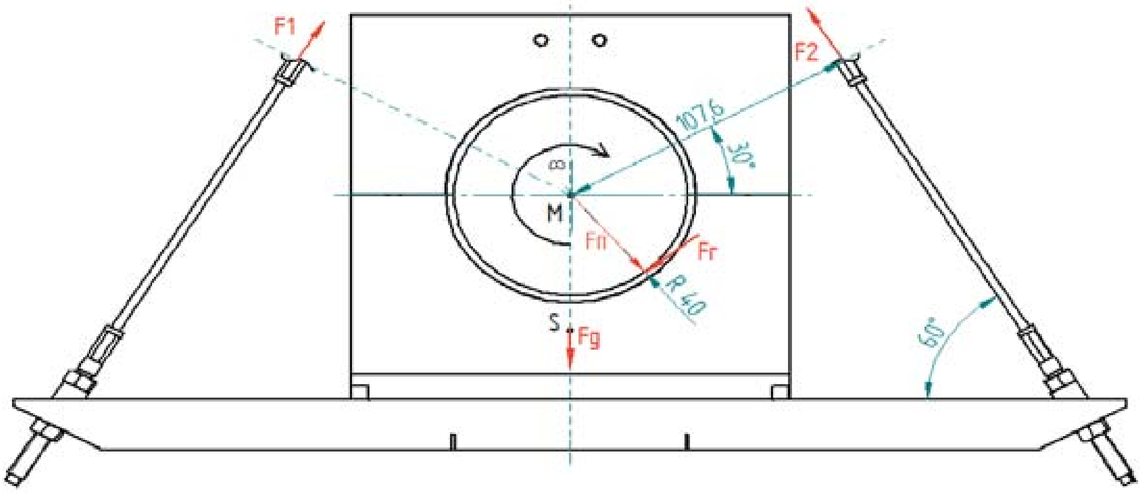

Fig. 5 Suspension of one test module, direction of the forces, geometrical parameters

Lubricant delivery in slide bearing is presented in Fig. 6. One can see the speed control for the lubricant pumps, the two lubricant reservoirs (Erlenmeyer flasks) and the stirrers for the mixing of the lubricant.

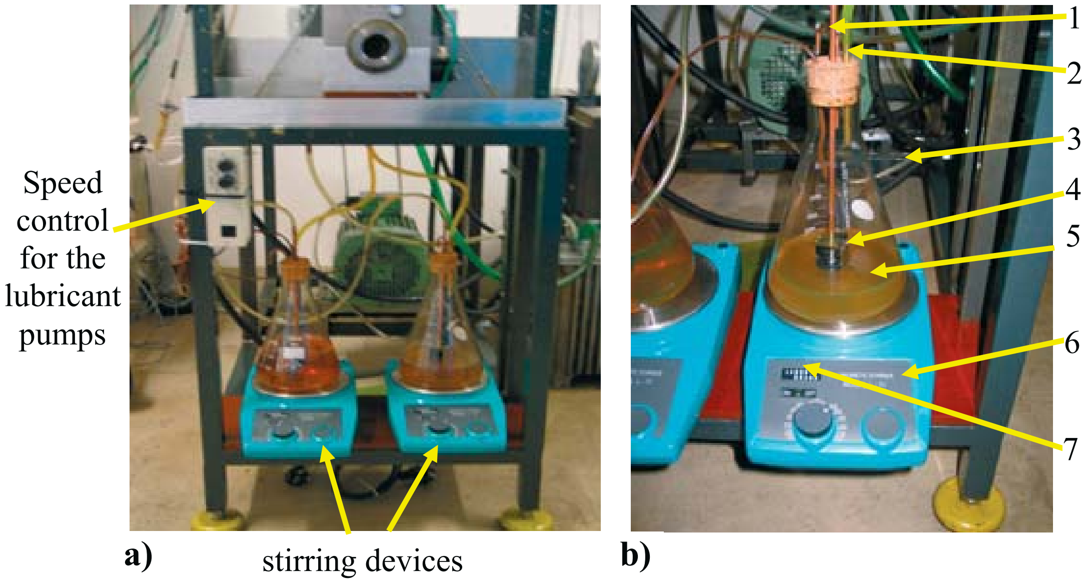

Fig. 6 a) Oil delivery in the slide bearings under test, b) some details: 1 - delivery line, 2 - oil return flow hose, 3 - Erlenmeyer flask, 4 - reciprocating piston pump, 5 - lubricant, 6 - stirring device, 7 - speed control of stirrer device

3. Conclusions

Presented in this paper construction of the test stand enables the friction forces measurements in slide bearing using the acoustic emission effects.

Moreover the friction forces measurements in slide bearing for the same conditions but on two different test stand constructions enables the very useful comparisons between obtained results.

Acknowledgement

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