Eddy Current Sensors as Essential Components for Tribology Test Rigs

The engineering requirement for increasing performance density leads to higher loads on components with smaller dimensions. Therefore, today's components must be by far more resistant than in earlier times. Under these circumstances, materials are also continuously improved and designs modified. In this regard, it is the inconspicuous components such as plain bearings – indispensable components for the suspension of shafts – that are subject to extremely high stresses. These parts must be checked in advance for their load capacity and tested with regard to their physical limits. The engineers of the Institute of Tribology and Energy Conversion Machinery (ITR) of Clausthal Technical University have designed their own test rigs for the thorough testing of plain bearings. Special sensors are used to verify changes in distances and positions. Sensors made by Micro-Epsilon, the sensor specialist based in Ortenburg.

Sensors made by Micro-Epsilon have already been used for a lot of different tribology test rigs. One recent example is a test rig for testing plain bearings under water lubrication.

Certain types of machine applications offer the possibility to add a medium used in industrial processes such as water to the bearing positions as well, in order to use it as a lubricant there. In this context, special requirements are made on the material of the bearing. The material must have running-in and emergency running properties and must be adaptable in case of deformation. In addition, other characteristics such as corrosion resistance, abrasion resistance, (fatigue) strength and environmental compatibility play an important part as well. Other requirements are easy mounting possibilities of the bearing as well as an economical production. The task is to optimise the friction, wear and lubrication characteristics, taking into account the technical, economic and ecological product requirements. If a sufficient supply of water to the bearing locations is ensured, the tribological behaviour is mainly dependent on the parameters of bearing load, bearing geometry, lubricant viscosity and surface velocity. These parameters are decisive factors for the tribological condition of the hydrodynamic bearing. As a natural resource, water is used in various applications such as energy generation, in the food industry, in process engineering or also in the chemical industry as a process medium. Its use is beneficial due to its availability at relatively low cost as well as its thermo-physical and chemical characteristics. Moreover, it normally does not add to the pollution of the environment and to the contamination the manufactured products.

The examinations concentrate on hydrodynamic plain bearings with bore diameters in the range of 70 to 150 mm. In this context, volume flow rate measurements to determine static through-

put characteristics are an important aid in verifying predictions resulting from plain bearing calculation programmes. In addition, the gap width is determined by eddy current distance measurements between test bearing housing and shaft, and the pressure build-up in the lubricating film as well as the shaft and bearing temperatures near to the surface are measured.

Eddy Current Technology for Harsh Environments

Since the installation space for gap width measurements is very limited, the smallest possible sensors were looked for. They were found at Micro-Epsilon – their product range includes a miniature series with a minimum diameter of 2.4 mm. Eddy current sensors are ideal for such installation environments because the measurements are not influenced by water, oil or other non-conductive materials in the measurement gap. The especially high metrological requirements in such a test rig can only be met by eddy current sensors. In addition, the sensors from Micro-Epsilon are characterised by a very high limit frequency and resolution in the sub-micrometer range, thus enabling very precise measurement results to be achieved on the test rig. Sensors of the EU1 series with 1 mm measuring range in an unshielded design were used for this test rig. Micro-Epsilon is renowned for solving such challenging tasks. They offer eddy current sensors in many hundred different designs. If required, the sensors can also be customised to individual needs. A special feature of the eddy current sensors from Micro-Epsilon is the adaptation board which is adjusted individually for each measurement task and thus complements the controller. This technology makes it possible to achieve results of the highest quality.

Hydropulse Test Rig for Plain Bearings

Another test rig at the ITR is used to test the loads and effects on machine shafts running on plain bearings, i.e. plain bearings in combustion engines. In this regard, the task is to measure important bearing parameters, e.g. maximum temperature, maximum pressure, minimum lubrication gap height, power loss and oil throughput. The continuous increase of the required performance of machines subject to high dynamic loads such as combustion engines leads to continuously increasing demands on the plain bearings used. The requirements made on this tribological system are extremely complex. In addition to the material, factors such as component elasticity, lubrication, gap parameters, load and movement are also of primary importance.

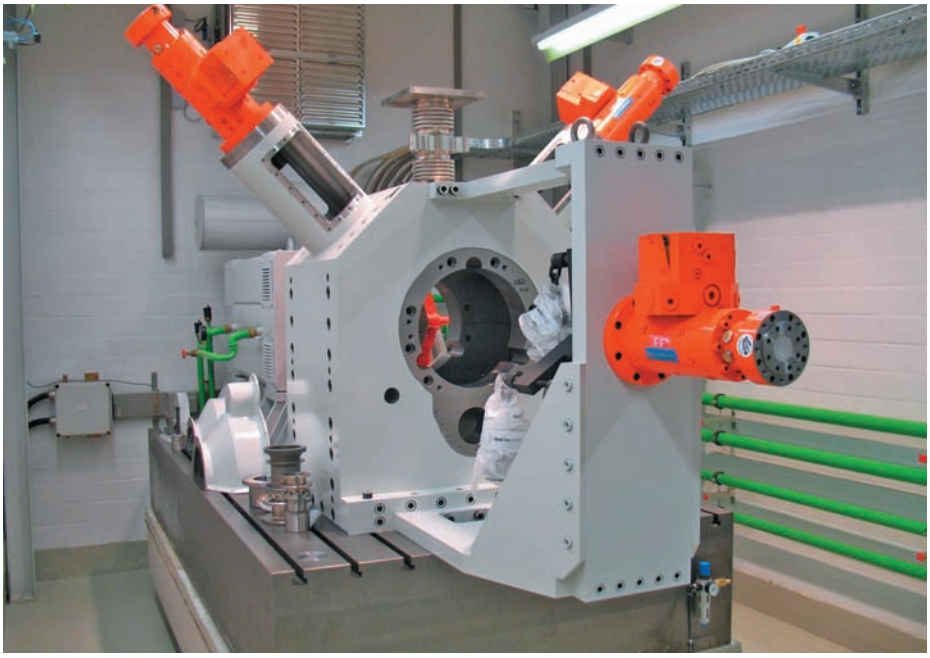
In particular, the static and dynamic load values of the bearings are rising further. On the one hand, this requires continuous improvement of the calculation and simulation methods, but on the other hand new technologies and materials must be consistently applied as well. The lifetime of highly loaded radial plain bearings with the bearing materials usually used today would be very limited if the performance density were increased further without additional engineering work. During operation in the area of increasing mixed friction, the plain bearing would be bound to fail due to the local temperature and pressure peaks as well as the pressure loads changing over time.

Since questions regarding lifetime, maximum load and improvement potential must be clarified in advance, another test rig was built at the ITR of Clausthal Technical University.

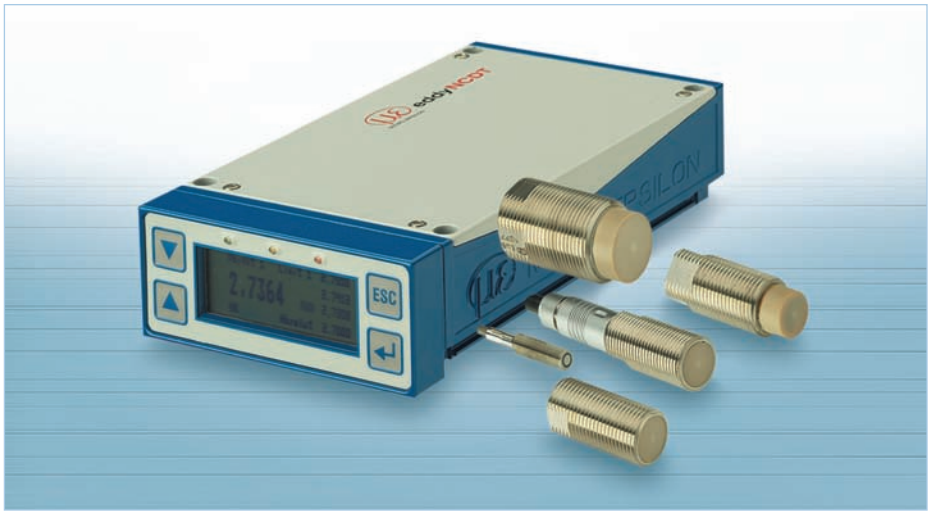
In order to estimate the bearing lifetime by means of calculation, data gained by experiments are required as input for the modelling of bearings. With the aim of verifying the assumptions made with regard to the real conditions in the lubrication gap, essential gap parameters such as gap width and pressure build-up in the lubricating film are determined and the shaft and bearing temperatures near to the surface are measured. The measurements are carried out on a special high-performance hydropulse test rig.

Plain bearings up to a diameter of 70 mm are examined on the test rig. The bearing load amounts to more than 50 MPa.

Again, eddy current sensors made by Micro-Epsilon are used to measure the



▲ **Der neue Hochleistungs-Prüfstand im Aufbau. Erst einmal fertig, werden damit höchste Belastungen auf Gleitlager bei bis zu 200 m/s Umfangsgeschwindigkeit getestet.**
New high-performance test rig under construction. When completed, it will enable testing of plain bearings for maximum loads at peripheral speeds of up to 200 m/s.



▲ **Die Wirbelstromsensoren der Serie eddyNCDT von Micro-Epsilon messen in allen Tribologie-Prüfständen des ITR Wege unter höchsten Belastungen**
Eddy current sensors of the eddyNCDT series from Micro-Epsilon are used to measure displacements under maximum loads on all tribology test rigs of the ITR

lubrication gap. Two sensors of the eddyNCDT series are located on either side, i.e. in front of and behind the test bearing in the housing. From this position, the sensors measure directly on the plain bearing and thus check whether continuous lubrication is possible. Deformations of the bearing in the micrometer range are also recorded by the eddy current sensors.

High-Performance Test Rig under Construction

A new high-performance test rig at the ITR also uses eddy current sensors from Micro-Epsilon. This new test rig, which is currently being built, will be used to examine the tribological, fluidic and rotordynamic processes present in highly loaded plain bearings under maximum peripheral speeds of the shaft. Due to the positive experience with eddy current sensors made by Micro-Epsilon on the existing test rigs for the examination of hydrodynamic radial plain bearings or plain bearings with especially high loads, ITR decided to use sensors of the eddyNCDT series on this new test rig as well. The shaft reaches peripheral speeds of up to 200 m/s, whereas normal test rigs usually reach a maximum of 120 m/s.
The position of the test bearing housing as well as the relative movement between the rotor and the test bearing are recorded by means of eddy current displacement sensors. The bearing gap of the plain bearing between bearing surface and rotor is also measured with eddy current sensors. For that purpose, 22 channels are integrated into the test setup. The eddyNCDT miniature sensors with a measuring range of 0.5 mm are directly integrated into the test rig, which makes it possible to measure the bearing gap with the highest possible accuracy.

▶ INFO

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