Integration of sensorized thin-film systems permits the direct determination of operating states in the main loading zones of plain bearings and sealing systems. As part of the INTELLA (intelligent, lightweight bearings and seals for automotive and mechanical engineering) WING project subsidized by the Federal Ministry of Education and Research, the Fraunhofer IST is researching into the implementation side.

Bearing and sealing components must be able to handle a wide range of loads, speeds and temperatures when operating. Due to the breadth of the operating range the components are in most cases working under suboptimal operating conditions, and thus at low efficiency and poor effectiveness. One reason for this is the fact that components are designed for maximum loading and are thus overdimensioned. To improve the efficiency and thus the effectiveness of components of this kind, active systems are required which in a control loop adjust bearing and seal-gap geometries. These active systems consist of actuators and sensorized thin-film systems which will be described in more detail below.

Sensorized thin-film systems

The strategy referred to as “downsizing” whereby greater performance is achieved with lighter components can in the case of dynamically stressed machine elements only be implemented by adapting to the load situation. To do so, actuators are already being used which represent an additional system component. To detect operating temperatures in face seals manufactured by Eagle Burgmann and in bearing rings manufactured by KSB AG, sensorized three-layer systems are used. These have a total coating thickness of less than 10 µm, are deposited directly on
the component and were developed at the Fraunhofer IST. An insulating layer is deposited homogeneously in the main loading zones as a base coating with a thickness of 3–4 µm. Chromium meander structures 200 nm thick are laid down on this and these covered by an insulating and wear-protective layer (d = 3 µm). Insulating layers take the form of hydrocarbon films modified with silicon and oxygen or even alumina oxide films. The challenge in these developments is to be found not only in the coating system itself but also in the three-dimensional structuring since the sensor structure contacts lie outside the high-load areas.

Sensor properties of the thin-film system

In its test rigs the EagleBurgmann company is testing gas seals with integrated temperature sensor systems. Fig. 1 shows a test set-up which demonstrated the precise measurement of temperature profiles in the area of the sliding parts of gas seals. The graph shows measurement results from the corresponding test series.

It shows a dynamic test run in which different operating parameters such as speed and operating pressure are varied. Changes in the temperature at the slip rings are plotted as a red curve. Steeper gradients are primarily due to increases in turbulence levels with larger speed jumps.

Outlook

As part of the “INTELLA” project not only temperature sensor systems but also piezoresistive coating systems for load detection in bearings are being developed. These sensorized thin-film systems should in combination with actuator systems contribute to the active control of components and thus to components having improved functional capabilities and weighing less.

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Results of dynamic test runs with temperature sensor system.

- TGLR meander 6 [°C]
- Sealing pressure [bar]
- Speed [rpm]

* Turbulence level with n rising

2 Meander structures for temperature detection at the axial bearing ring surface of KSB AG.