Vibration	Vibration Behavior Associated with Deposited Material Attached to Oil-lubricated Bearing	Rotating Machinery
Forced Vibration		

Object Machine

Rotating machinery using tilting-pad journal bearings having high surface pressure (surface pressure 20kgf/cm^2 or more, PV value about 2,000kgf/cm^2・m/s)

Observed Phenomena

Shaft vibration immediately after start-up was about 10μm, but for the subsequent 20 days, it gradually became large, displaying a behavior like thermal bending or abrupt increase and decrease in vibrations, and eventually returned to the original vibration level (Fig.1).

Cause Estimation

Disassembling inspection proved that, a) the bearing load pad had a deposited material of about 15μm (Fig.2), and b) the stationary part had no trace of contact to cause thermal bending. Thus, the following assumption was made as to the outbreak mechanism of this phenomenon: (1) gradual accumulation of the deposited material on the load pad resulted in changes of oil film characteristics (reduction in damping), leading to gradual increase in vibrations, (2) growth of deposited material exceeding the oil film thickness resulted in contact with the shaft, to generate thermal bending vibrations, and (3) contact of the shaft with the deposited material caused a partial exfoliation of the deposited material, resulting in the recovery of oil film characteristics and sudden decrease of vibrations.

Analysis and Data Processing

Chemical analysis of the deposited material proved that deteriorated oil was exposed to high temperature to combine with cupper, to form metal soap. Cupper assumedly melted in oil from the heat exchanger, but it was only a small amount, so that high temperature of the bearing face was assumed to be the root cause, and thus bearing temperature was analyzed (Fig.3). On an assumption that the rotor under question bent in the center due to the bearing load, and the shaft was in an inclined condition within the bearing (about 0.5‰ as calculated from the load), the following was verified: a) the maximum bearing temperature was about 130 to 140ºC, and b) the high temperature area was inclined to the thinner side of the oil film, which agrees well with the area of deposition. From the above, it was determined that the shaft inclination (rotor bending) was the cause of high temperature of the bearing face.

Countermeasures and Results

The pad back side was made spherical, so as to allow the pad to be inclined associated with shaft bending (Fig.4), and at the same time, the side seal gap was enlarged to enhance bearing cooling as well as increase in oil quantity. These improvements have resulted in bearing temperature reduction, and the instable vibration behaviors such as gradual increase in vibrations, thermal bending vibrations, and sudden changes in vibrations do not occur anymore.

Lesson

(1) Heavy load acting on the rotor causes it to bend, thus heat generation of the bearing increases due to shaft inclination.
(2) As high bearing temperature contributes to accumulation of deposits to change the oil film characteristics, a plan to restrict heat generation and cooling is important.

References

Nothing in particular

Keywords

Tilting pad bearing, deposits on bearing, gradual increase in vibration, thermal bending vibration, sudden change in vibration, Morton effect, double tilting pad (DTP) bearing

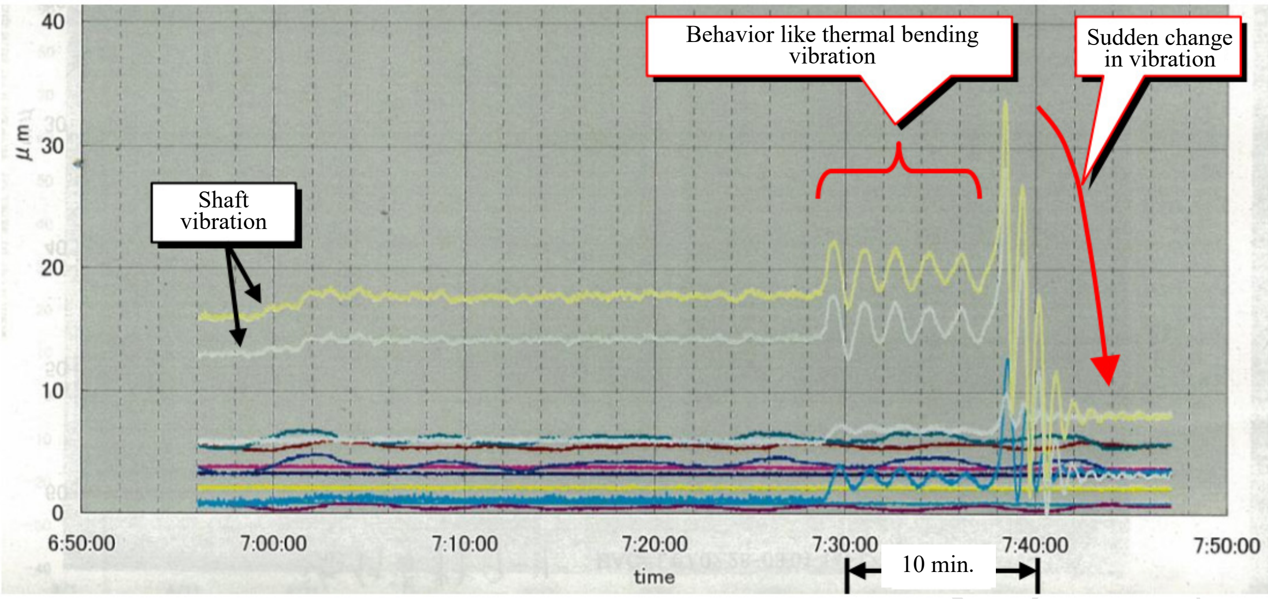

Fig.1 Vibration behavior observed after continuous gradual increase in shaft vibration

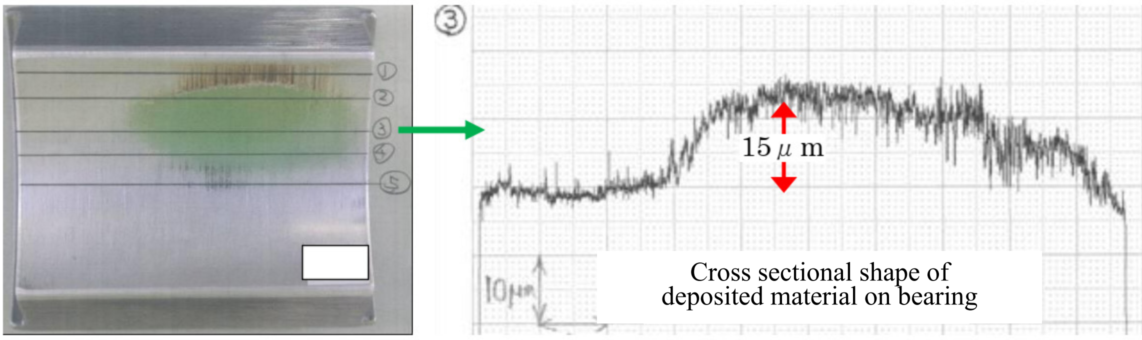

Fig. 2 Deposited material on bearing (cupper content exhibits green)

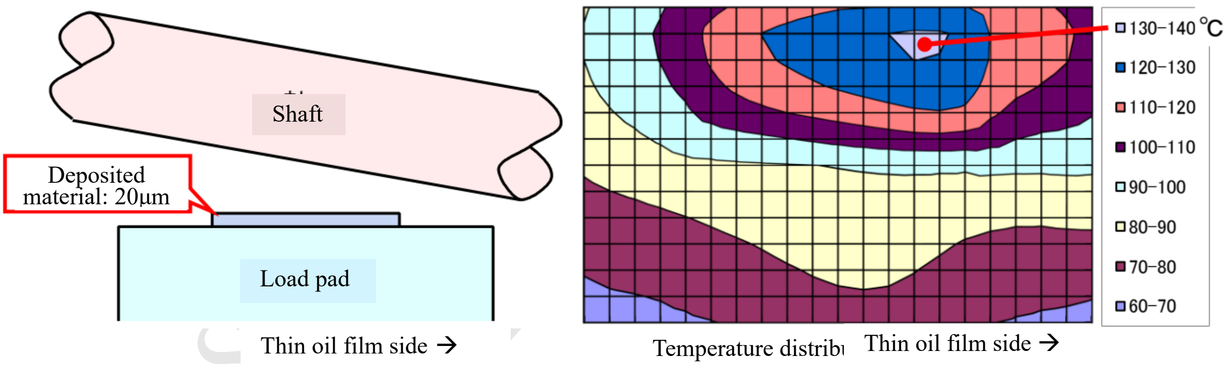

Fig.3 Analysis of bearing temperature (in case of deposited material: 20μm)

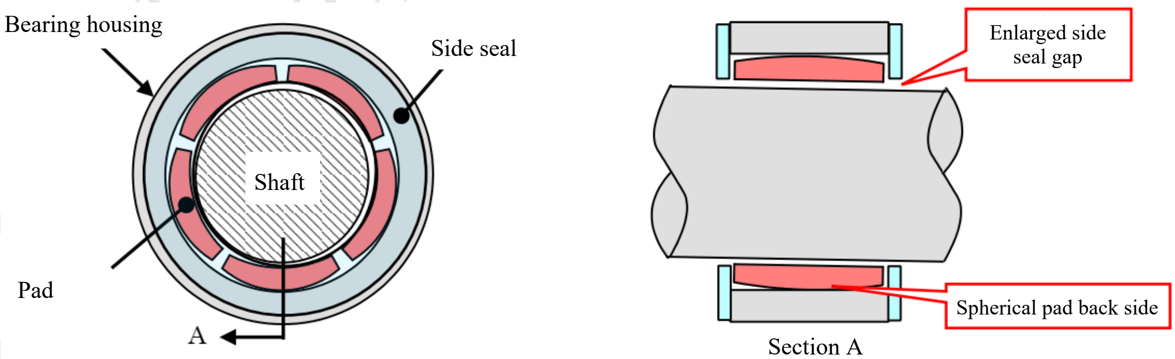

Fig.4 Improved bearing