XVII IMEKO World Congress
Metrology in the 3rd Millennium
June 22–27, 2003, Dubrovnik, Croatia

AIR BEARING DEVELOPED FOR TORQUE CALIBRATION TO PROTECT DISTURBING EFFECTS TO REFERENCE TRANSDUCERS

Paul Hohmann

CEH Calibration Engineering Hohmann, 64291 Darmstadt, Germany

Abstract – World-wide we handle high precision transducers in the quantity torque as well as force for comparisons in measurement. These transducers are used as a reference in calibration machines, also. Here the disturbing effects caused by specimen the directly coupled, are responsible for a loss in accuracy. At primary torque standard machines air bearings guarantee the precision of the torque value produced by beam mass combination.

Air bearings are responsible to keep the precision of torque calibration machines

1. AIR BEARINGS USED IN TORQUE CALIBRATION MACHINES TO MINIMISE DISTURBING INFLUENCES TO THE REFERENCE

First should be listed which disturbing effects are given. A main difference in torque calibration is the position of measuring axis: Horizontal or vertical. This air bearings are designed to rotate. In case of torque calibration they are responsible to keep the moments vector in circle.

!:! Calibration machines

working with a lever mass system do have a horizontal axis. Table 1 lists the effects which mostly appear at calibration machines with this design.

Table 1	effect	Causation
1	Bending moment	Weight of specimen and couplings angel displacement of axis.
2	Axial force	Length deflection of specimen. Strong couplings
3	Moment offset	Axis offset
4	Different cross force on the bearing	Different number of masses , different lever designes. Transfer wrenches as a specimen
5	Hysteresis	Bearing friction
6	Lateral force	Weight of specimen and couplings

Table 2	Effect	causation
1	Bending moment	angel displacement of axis. Offset in axis.
2	Axial force	Length deflection of specimen Weight of specimen and couplings
3	Moment offset	Tighten screws on while clamping couplings
4	Hysteresis	Bearing friction
5	Lateral force	Transfer wrenches as a specimen

1.2 A vertical measurement axis

Vertical axis is possible for calibration machines working with reference transducers only. Table 2 However as there is a horizontal axis, too, the above table is mainly relevant..

2. DESIGNS OF ROTATING AIR BEARINGS

2.1 H-Type

Figure 1 shows a rotating type . Its rotor is responsible for radial support. Both planar discs are responsible for the axial support. Bending moments are supported as a combination of all named parts.

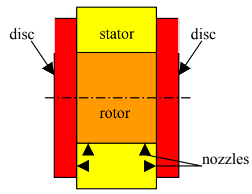


Fig. 1. Example of a H-Type air bearing

The H-Type caused all disturbing influences in table 1 and 2 Its clear geometric design is easy to calculate and to produce. The used material is aluminium with hard lapped surface. The hardness is similar to ceramic, so a touch down is not a critical regarding abrasion. The happened dust parts are smaller than the width of 4µm gap between rotor and stator. So the bearing cleaned itself if it´s powered by air.

2.2 I-Type

Figure 2 is a rotating type as well. Its rotor is responsible for support radial forces. The both planar discs are responsible for axial support only in overload case. Bending moments are supported only by rotor. Axial position is not clear

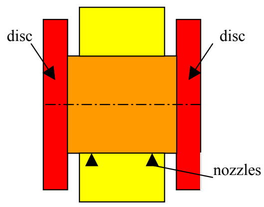


Fig. 2. Example of an I-Type air bearing

2.3 Calotte-Type.

Figure 3 is as well a rotating type. It´s rotor is responsible for radial support. The spherical calotte is responsible for axial support only in vertical down. Bending moments are supported only by rotor. Axial position is clear saved by disc2. The used materials are hardless steel and 2 components plastic to get a clear inner shape of the rotor.

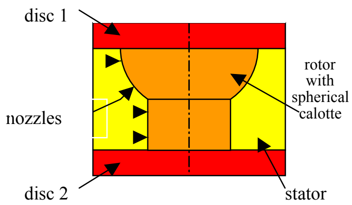


Fig. 3. Example of a calotte-Type air bearing

3. HOW TOMEASURE FRICTION ON ROTATION AIR BEARINGS

Generally all air bearings need dry and micro filtered air by about 4 up to 8 bar. Table 3 is an overview which phenomenon's are responsible for friction.

Table3	phenomenon's	causation's
	humidity	Water in the gap
	Temperature differences	Rotor would be clamped in case of different materials
	friction	Dust parts bigger than air gap

3.1 Method 1 in horizontal axis position

The rotor should be centred as good as possible by add on small masses (picture 1). The result should be a uniform motion in rotation.

An additional mass part by a clear force should be fixed on a clear radius on the rotor . So the rotor swings like a pendulum. The measured lost of amplitude in millimeter is the parameter to calculate the friction of the bearing.

M_r = Friction moment

a = loss in amplitude

r_a = radius of reading

m_z = additional mass for pendulum effect

g = local gravitation

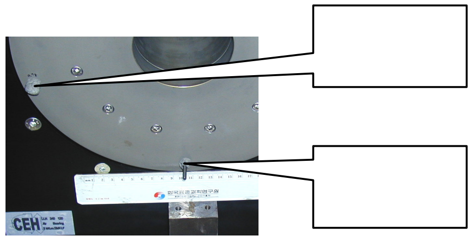
r_m = radius of additional mass for pendulum effect

$$M_r = \frac{1}{4} \cdot \frac{a}{r_a} \cdot m_z \cdot g \cdot r_m \quad (1)$$

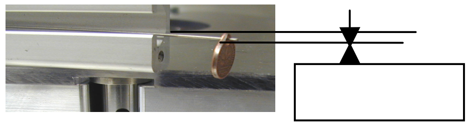
3.2 Method 2 in vertical axis position

In vertical position a pendulum effect is not possible. So a method which is traceable to a basic quantity without a need of expensive high precision equipment would be introduced in the followings. Generally friction in a non rotating bearing is not measurable. Similar effects as in use by calibration are the needed driving moment for the kick off between still standing to a slight rotation.

Picture 1 shows a the swinging rotor like a pendulum



The Spring is calibrated in displacement by hang on a mass part of for example 0,01 N (picture 2). This force should make the rotor slow growing rotating (picture 3). The radius of load income point multiplied with the spring force is the moment we looking for. This effect should be happened in both rotating directions. The measures are comparable to the first method. Only the number of supporting nozzles are quiet different in acc. to the designs, position and dimensions of bearings.



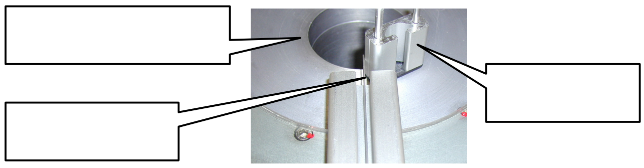
Picture 2 shows a hang on a mass part of for example 0,01 N

4. RESULT OF FRICTION MEASURING

4.1 H-Type results

Friction is measured in 3 different sizes listed in table 4

Table4	Rotor ∅	Rotor length	Max. torque	Max. bending moment	Max. cross force	Measured friction
Type	mm	mm	N·m	N·m	N	mN·m
LLH 40-40	40	40	100	8	200	**0,0001**
LLH 80-180	80	180	2500	120	2000	**43**
LLH 120-180	120	180	5000	180	2400	**45**



Picture 3 friction test by vertical air bearing axis

5. CONCLUSIONS

Air bearings are on the way to become a good partner in the field of torque calibration as a nearly frictionless component. In case of hard coated aluminium surface it is more robust in daily use.

Author: Dipl.-Ing. Paul Hohmann, CEH Calibration Engineering Hohmann, Römergasse 7a, D-64291 Darmstadt, e-mail: paul.hohmann@t-online.de