Advanced ball bearing friction measurement methodology

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The highly flexible measurement methodology presented allows to measure bearing friction under variation of speed and relevant parameters and with identical boundary conditions as found in a miniature electric motor. The effect of parameters such as axial preload, lubrication and run-in on bearing friction can be captured precisely and quantified. Fabrication tolerances, which significantly influence the measurements, are identified and considered for the evaluation.

Keywords (from 3 to 5 max): bearing friction, high speed ball bearing, measurement techniques

1. Introduction

Bearing friction is an important parameter in high-end miniature electric motors and significantly contributes to overall losses at high speed. Frictional losses in ball bearings depend on the bearing parameters (geometry, lubricant) and on operation conditions such as radial load, axial preload, state of run-in and temperature.

2. Measurement technique

To precisely measure bearing friction with identical mounting conditions as found in the application, the measurement principle [1] using a laboratory balance (Fig. 1, 2) was extended with an active air bearing which eliminates parasitic vibration and heating. The flexible setup allows to easily change parameters (load, axial preload, mounting conditions).

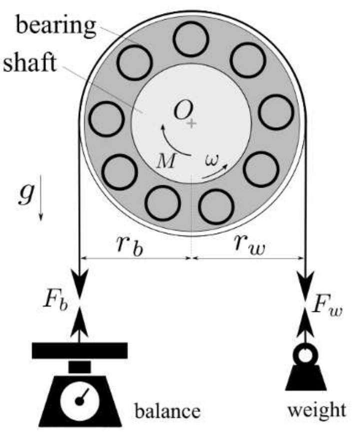

Figure 1: Measurement principle using a balance to register friction force and a known weight to define the radial load. The axial preload is defined by a preloaded spring. Note: $r_w \neq r_b$

Imperfections in all components lead to small deviations from ideal shape resulting in $\delta r = r_w - r_b \neq 0$, which has a significant impact on the measurement results.

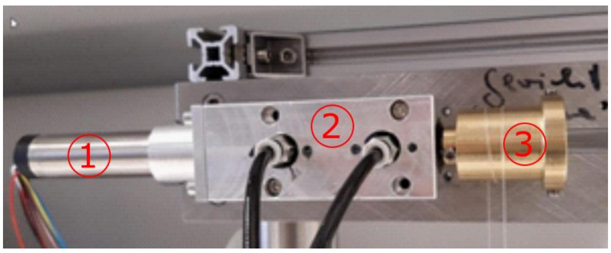

Figure 2: Bearing friction measurement components: Driving motor (1), air bearing (2), bearings under test (3).

δr is accurately identified by two measurements in opposite direction of rotation and allows to precisely capture bearing friction torque M considering measurement of the balance F_w and the known weight F_b with a resolution in the range of μNm:

$$M = r_w F_w - r_b F_b \tag{1}$$

3. Results

Friction measurements under variation of speed are given in Fig. 3 to illustrate the friction-curves for miniature ball bearings of different suppliers with two axial preloads. Measurement data can be compared to models [2] and used for parameter fitting.

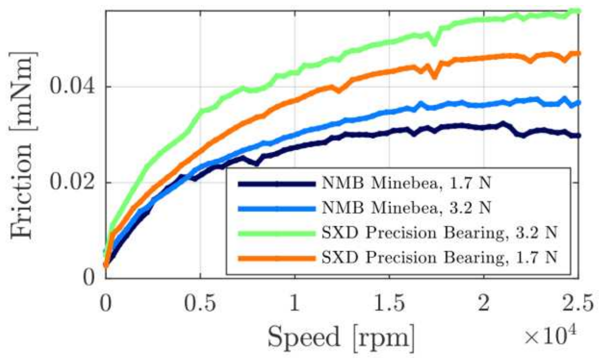

Figure 3: Friction measurements on two different ball bearings (DIN 625-1) at room temperature, dimensions: 6 mm x 2 mm, lubricant: Multemp SRL.

4. Discussion

Profound knowledge on low friction bearing technology is key in highspeed and high precision applications and typically related to effects of heating and lifetime.
Precise friction measurements allow to investigate effects of the main parameters involved as well as effects of run-in on bearing friction and fit suitable curves to describe friction.

5. References

[1] Trachsel, M et al., “Friction and 2D position measurements in small journal bearings” Tribology international, 102, 2016, 555-560.

[2] SKF, The SKF model for calculating the frictional moment, 1-15, https://www.skf.com