The Influence of The Spindle Speed on the Damping Capacity of the Oil Film for a Radial Bearing with the Ratio L/D=1 as a Function of the Static Loading of the Bearing

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Abstract: *The main objective presented in this paper is to determine the acceleration taken during the shock by the bearing-lubricant film-spindle system and the damping of the lubricant film of the bearing with the ratio L/D=1, for the spindle speed n = 370 rpm, and n = 600 rpm, the dynamic load F_3=3332 N depending on the static load G_1 and G_2, and to determine the influence of the spindle speed on the damping capacity of the oil film for a radial bearing with the ratio L/D=1 as a function of the static loading of the bearing.*

Keywords: *acceleration of the bearing, damping capacity, radial sliding bearing, ratio L/D=1.*

1 INTRODUCTION

The main elements involved in the calculation of sliding bearings can be briefly listed as follows: *the geometry of the bearing* (the diameter and width of the surfaces in contact, the clearance between them, the absolute or relative eccentricity, the microgeometry of the surfaces, respectively their roughness), *the data external* (the load and the nature of the load, the velocities of solid surfaces, the kinematics of the assembly, vibrations, shocks, inertial effects), *the lubricant*, characterized by the physical properties; *the supply with lubricant*: the supply system of the lubricant, the dimensions of the supply slot, its position, the supply pressure; *the cooling of the bearing*, which establishes the lubrication regime and the working possibilities of the bearing.

The analysis of the listed factors leads to a series of important theoretical and experimental consequences for the good understanding of the behavior of radial sliding bearings in HD mode. The lubrication regime suitable to the calculated h_{min} is imposed by the roughness [1]; V. N. Constantinescu, recommends the relationship:

$$h_{\min adm} = k_m\left(R_{\max, fus} + R_{\max, cuz}\right), \qquad (1.1)$$

where k_m is the material factor (running-in);

$R_{\max}$ the maximum height of the irregularities.

For the spindles, the average height of the asperities can be considered $R_{1\,\max} \cong 5$ μm, and for the bronze bearings, finely machined, it can also be considered $R_{2\,\max} \cong 5$ μm. For couplings made of finely turned or ground steel spindle material, finely machined bronze bearing material is recommended k_m = 0,5 [3]. Thus, to ensure operation in fluid friction mode, the minimum lubricant thickness must be greater than an admissible value $h_{min,a} \geq 5$ μm. Considering the radial bushing bearing, the expression of the Sommerfeld number in dimensionless form is [1]

$$S_0 = 1/C_p\,, \qquad (1.2)$$

where

C_p is the standardized form of the lift coefficient, and has the value

$$C_p = \frac{\eta \cdot n}{p_m \psi^2} = \frac{1}{(L/D)^2}\frac{\left(1-\varepsilon^2\right)^2}{\pi\varepsilon\sqrt{\pi^2\left(1-\varepsilon^2\right)+16\varepsilon^2}} \qquad (1.3)$$

and η- viscosity of lubricant (Ns/m^2); n - spindle speed (rot/min); p_m-medium pressure (Pa); ε - the relative eccentricity; ψ - the relative clearance; L- length of bearing (m); D- bearing shaft diameter (m); h- fluid film thickness (m).

2. EXPERIMENTAL DEVICES AND ACQUISITION CHAINS

The experimentation methodology includes some practical experiments met during the working process of these bearings. Radial bearing during measurements is presented in figure 1.

It was focussed on the determination of the bearing′s acceleration in dynamic charging conditions and pressure distribution from the film to be lubricated in various places of the bearing′s body, P1- P5. The spindle and the bushing diamethers with L/D=1 are d_e =59,86 mm, D_e =60,08 mm; journal′s toughness 58-62 HRC, made of 18MoCr10 alloy steel; bushing is made of bronze with 88% Sn, 8%Sb, 4%Cu, figure 2.

The entrance revolution variations may be carried out through a gear box which assures revolutions of 600 and 370 rot/min. The dynamic loading is realized through the launching of a weight which hits the bearing at different heights. Attempts were made from heights H=40 cm, and we have the dynamic loading F_3=3332 N. Static working conditions are presented for the static loading G_1=2250 N and G_2=4500 N.

The acceleration of the bearing was determined using the ADXL 190 WQC acceleration sensor. The ADXL 190 WQC acceleration sensor is supplied with

DC power from a 9 V voltage source, the output signal being purchased by the ADuC 812 acquisition board, being processed by the PC through the MATLAB 6.5.0.18091 3a program [4]. The output signal of the sensor is the electrical voltage, at 250 mV corresponding to an acceleration of 9.8 m/s^2, by the calibration established by the manufacturer [5]. On the bearing, the acceleration sensor is fixed rigidly, in the diametrically opposite direction to the position considered, by means of a polyester adhesive solution. Data acquisition was performed position by position for each of the 5 positions P1-P5 on the periphery of the bearing. The amplitude of the shock is higher for the maximum position of the static pressure on the circumference of the spindle; thus, for the speeds n = 370 rpm and n = 600 rpm this maximum coincides with the P3 position on the spindle circumference. In these graphical representations, the maximum amplitude is found on the vertical axis, in the lower part of the graphs, since the dynamic load, as well as the static load is oriented vertically, from top to bottom.

Fig. 1. Radial bearing during measurements

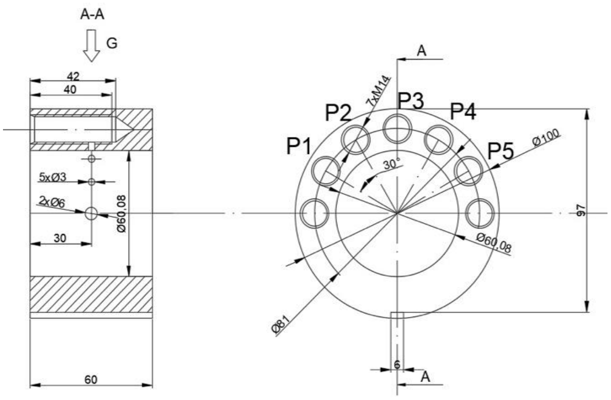

Fig. 2. Experimental radial bearing bushing

3. EXPERIMENTAL RESULTS

Figure 3 and Figure 4 show the damping of the lubricant film of the bearing acceleration of the bushing bearing from the moment of shock for position P1-P5, at the speed n = 370 rpm, in the case of the one dynamic load F_3, respectively the two static loads G_1 = 2250 N, G_2 = 4500 N, respectively at the speed n = 600 rpm, in the case of the one dynamic load F3 and of the two static loads G_1 = 2250 N, respectively G_2 = 4500 N. The signal taken by the data acquisition system ADuC 812 has been analyzed by PC with the help of MATLAB 6.5.0.18091 3a program [2], [5].

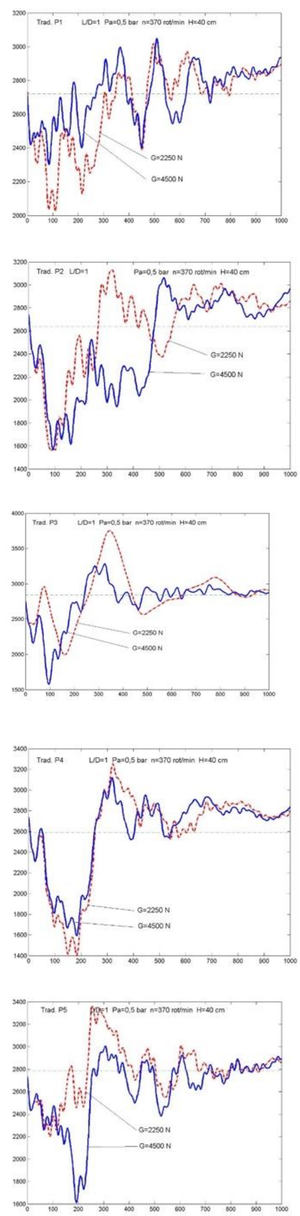

Fig. 4 Damping of the lubricant film of the bearing with the ratio L/D=1, for the spindle speed n = 370 rpm, the dynamic load F3=3332 N depending on the static load G1, G2

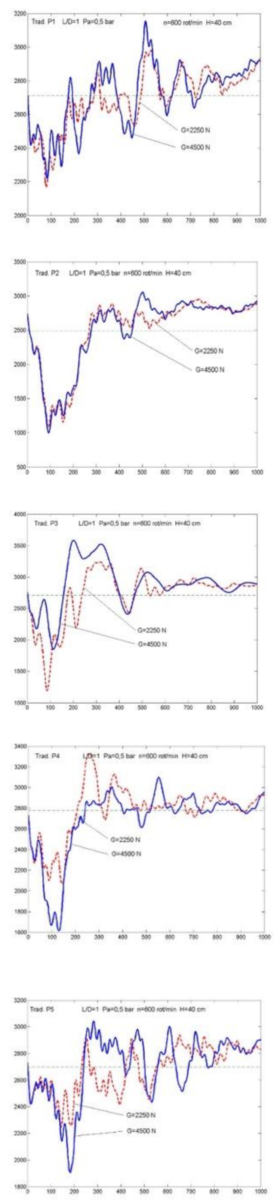

Fig. 5 Damping of the lubricant film of the bearing with the ratio L/D=1, for the spindle speed n = 600 rpm, the dynamic load F3=3332 N depending on the static load G1, G2

4. CONCLUSIONS

Following the analysis of the performed measurements, the following can be found:

1. the amplitude of the shock in the lubricant film is significantly higher the lower the spindle speed, the increase in spindle speed leads to a

significant improvement in the absorption of shocks and vibrations in the lubricant film. This conclusion is valid in both static loading situations studied;

2. in the bearing entrance area, corresponding to positions P1, P2, the shock absorption in the lubricant film is the same regardless of the static load G1, G2, the graphs being similar;
3. the greater the static load, the greater the acceleration taken by the lubricant film, the load being maximum in the area of positions P3, P4 on the periphery of the bearing;
4. in the exit area from the bearing, position P5, the acceleration taken over by the system is the greater the greater the static load;
5. damping of the lubricant film of the bearing to the maximum amplitude of the shock, in all the investigated situations was recorded in the period 0.5-1 ms; at the dynamic load, F3 = 3332.5 N, the maximum value of the bearing acceleration is between 31.6-58 m/s^2 for the axle speed n = 370 rpm, and between 19.6-47 m/s^2 for n = 600 rpm.

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