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SPECIAL PROBLEMS IN THE CASE OF HIGH SPEED BEARINGS

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Abstract: *The paper presents the researches viewing the settle of an exact computer programme in the calculation of the moment of friction in the case of the bearing working at high speeds.*
Key words: *bearings, moment of friction in bearings, high speed bearings.*

1. INTRODUCTION

The calculation relations for the moment of friction in bearings, indicated in different catalogues of bearings, are based on a series of coefficients which are different from catalogue to catalogue in quite large limits. Because these catalogues don't give definitions viewing the limits if the speeds on which the relations can be used, it was imposed the neccesity of performing some studies in this way. The relations for the calculation of the moment of friction given in catalogues don't consider a series of peculiarities of the internal geometry specific for the high speed bearings and also the unneglected effect of the centirfugal forces at high speeds.

2. THEORETHICAL MODEL FOR THE CALCULATION OF THE MOMENT OF FRICTION

Starting from this faults it has been elaborated a model of calculation for the moment of friction in the case of radial roller-bearings which work at high speeds. The model is based on the Houpert's relations (Houpert 1984), for the evaluation of different local moments of friction, completed by the setting of the centrifugal forces and the variation of the lubricant viscosity with the temperature.
So, for a radial roller-bearing, the total moment of friction can be written:

$$M_{tot} = \sum_{i=1}^{z} dT_R + \sum_{i=1}^{z} dT_C + \sum_{i=1}^{z} dT_{ER} \tag{1}$$

where dT_R is the resistant moment at rolling on a ball given by the relation:

$$dT_R = (T_{R_i} + T_{\mathrm{Re}})(1 + \frac{D_w}{d_{c_i} + D_w}) \cdot \frac{d_{c_i}}{2} \cdot 10^{-3} \tag{2}$$

dT_C is the moment caused by the glidings on the contact surfaces between the ball and the bearing races and it is calculated:

$$dT_C = M_{C_i}(1 + \frac{d_{c_i}}{D_w}) + M_{C_e} \cdot \frac{d_{c_i}}{D_w} \tag{3}$$

and dT_{ER} is the moment caused by the elastic hysteresis calculated with the relation:

$$dT_{ER} = M_{R_i}(1+\frac{d_{c_i}}{D_w}) + M_{R_e} \cdot \frac{d_{c_i}}{D_w} \tag{4}$$

In the relation (1) it is neglected the effect given by the ball cage. The relations (2) - (4) are deduced on the base of the ball stability stressed by the stresses and moments shown in figure 1.

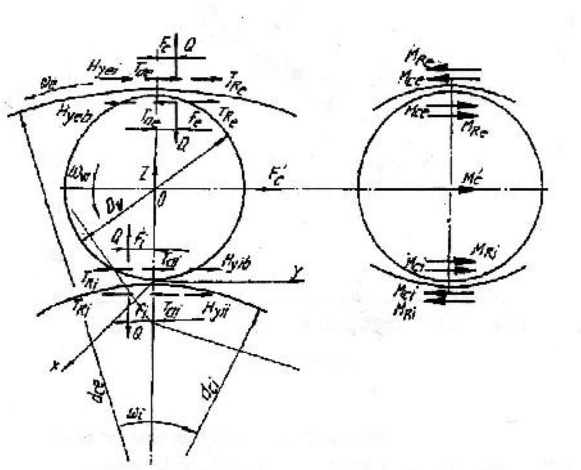

Figure 1: Schematic of the base of ball stability stressed by the stresses and moments.

$T_{Ri(e)}$ are the resistance forces at rolling caused by the lubricant presence and they are calculated with Hamrock's relation:

$$T_R = 2.86\, E\, R_y^2\, K^{0.348}\, G^{0.022}\, U^{0.66}\, W^{0.47} \tag{5}$$

where R_y is the equivalent radius of curvature for a ball/ball race contact in a running direction and it is calculated with the relation:

$$R_{y_{i(e)}} = \frac{D_w(1 \mp \gamma)}{2} \tag{6}$$

and K is the ellipticity factor.
M_C is the resistance moment caused by the curvature of the contact surface and it is calculated with the relation:

$$M_C = 6.58 \cdot 10^{-2}\, \bar{\mu}\, \frac{Q \cdot a^2}{\bar{R}} \tag{7}$$

where $\bar{\mu}$ is the medium friction coefficient on the contact surface, a is the major semi-axis of the contact ellipse, and $\bar{R}$ is the radius of the curvature of the deformed surface.

$$\bar{R} = \frac{2fD_w}{(2f+1)} \tag{8}$$

M_R is the moment given by the elestic resistance to the pure rolling (hysteresis) and it is calculated with the relation:

$$M_R = 7.48 \cdot 10^{-7} (\frac{D_w}{2})^{0.33} Q^{1.33} \cdot [1 - 3.519 \cdot 10^{-3} (K-1)^{0.806}] \tag{9}$$

H_y is the hydrodinamics force developed because of the lubricant's presence and can be expressed in function of T_R (Houpert 1984);
T_a is the traction force in the lubricant film and it is expressed in function of T_R, M_C and M_R based on the stability of the ball (Houpert 1984);
F'_C and M'_C is the force and moment caused by the ball – cage interaction which can be considered with negligible weights.
Because of the high speed the normal loads Q at the ball-ball race contact have another distribution than in the case of low/depressed speeds.
The centrifugal forces weight becomes essential at high speeds and low radial loads. Plus it is obtained a load distributed on the whole circumference of the exterior bearing race.
The estimation of all the parameters which interfere with relation (1) was made with the helps of a calculation programme. In this programme the viscosity which interfere with the speed parameter v is corelated with the normal speed through the intermediate parameter temperature.
For Tb A 57E oil, to which the experimental tests have been made with this corelation is presented in figure 2 (Bolfa T. 1991).

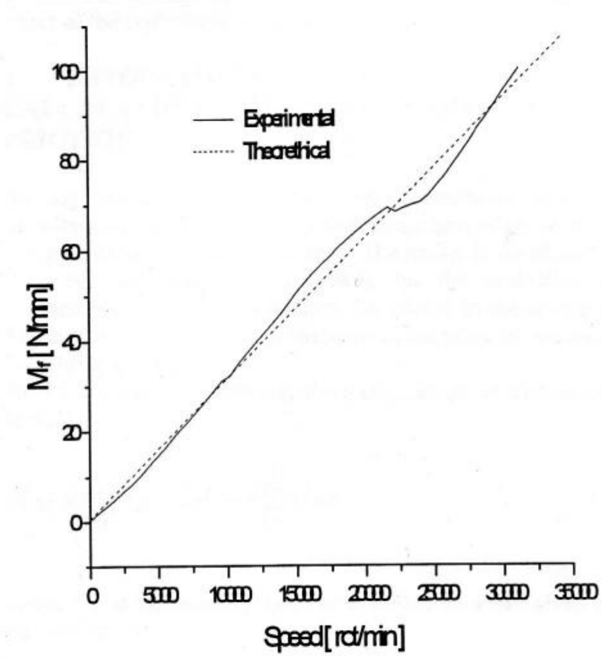

Figure 2: Correlation of the viscosity with the normal speed of rotation.

Also, the exponent of viscosity variation with the pressure α_p was correlated with the temperature (Bolfa T.& Neamtu T. 1985).

3. CONCLUSION

The model was applied to the 6306 MAUP bearing radial loaded with a 26 N force, on the range of revolutions/speed from 0 to 31.500 [rot/min].
The results obtained by simulation on the computer are shown in figure 3.
It is observed an explicit increwasing of the moment of friction, explained by the occurrence of the speed parameter v in the general calculation relation of the moment of friction, with some disturbances in the zone of 18.000÷23.000 [rot/min] speeds, in facts explained by the loss of the cage stability.
It is observed a very good concordance between the two curves, the experimental one and the theoretical one.

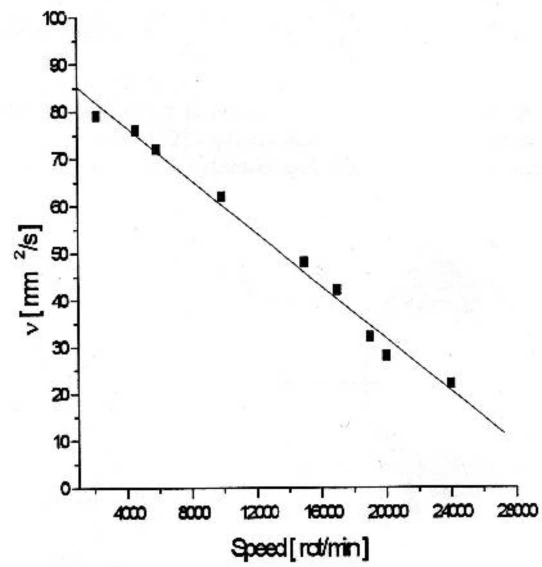

Figure 3: Moment of friction obtained by computer simulation (full line) and experimentally versus speed of rotation.

Knowing the moment of friction in the bearing it is possible to calculate the lost power through friction using the relation:

$$P = M_f \ \mu \tag{10}$$

The criterion which uses the demanded power in bearing can be considered as certain criterion viewing the comparison of different constructive solutions adopted for high speed bearings.

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