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THE BEHAVIOR OF THE BEARINGS AT HIGH SPEED

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Abstract: *The paper presents some specific problems concerning the 6306 radial ball bearings damages, working at high speeds and the correlation of the damages with the electric resistance of the lubricant film, from λ point of view.*
Keywords: *radial bearings, high speeds bearings, thickness of lubricant film.*

1. INTRODUCTION

The high speed expresses, in fact, the high peripheral speed in the bearing and it is estimated through the d·n product (the product of the bearing's diameter bore and the working speed), with values between $(0,7 \div 3)\cdot 10^6$ mm·rot/min limits.
In the case of bearings working at high speeds the approach from the theoretical point of views of the performances faces big difficulties because of the complex kinematics, dynamics and thermal phenomenon which amplify together with the speed rise. In the same time the lubrication processes at high speeds are complex, showing a series of phenomenon that have the reduction tendency of the film thickness in the elements of the bearing.

2. THEORETICAL AND EXPERIMENTAL ASPECTS

In the working of the high speed bearings, a major importance represents the maintaining of the lubricant film. To characterize the behavior of the bearings it has been established a correlation between the total film thickness at the level of balls-ball races contacts and the electric resistance of the lubricant film of the tested bearings depending on speed (the measurement of resistance is specially indicated for small film thicknesses corresponding to mixt runnings.

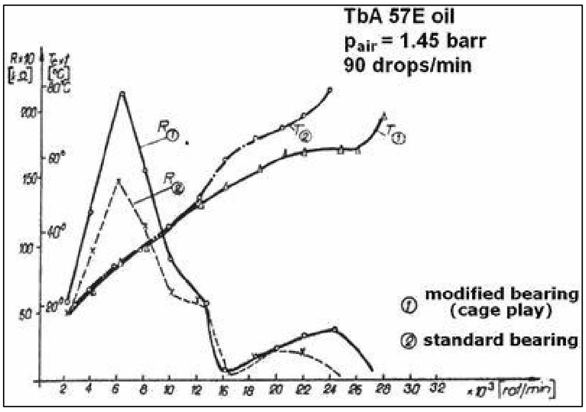

Figure 1: The evolutions of the electric resistance and of the temperatures

In figure 1 it is presented the evolutions of the electric resistance of the lubricant film as well as of the temperatures, for the 6306 MAUP bearing in two versions of the cage play (standard and the cage outer diameter smaller Ø 58.9).

The experimental determinations have allowed the establishment of some lubricant film thicknesses, in the high speeds conditions, between (0.1 ÷ 0.3)μm values.
Concomitantly with the experimental tests was elaborated a programme for calculus of the lubricant film thickness based on Hamrock and Dowson relations [1], in which there were introduced corrections concerning the lubricant state parameters variation (η and αβ) depending on temperature.
Based on the lubrication theory EHD, the minimum thickness of the lubricant film at the level of contacts between the rolling and the bearing races is given by relation (1), in isometric conditions and for a punctual contact:

$$h_{\min,iso} = 3{,}63 * R_y * U^{0,68} * G^{0,49} * W^{-0,073} * \left[\left(1 - e^{-0,68k}\right)\right] \quad (1)$$

where R is the radius of curvature equivalent on the moving direction; U, G and W are the speed, the corporeal and the stress parameters and K is the factor of ellipticity (the ratio of the semi-axis of contact ellipses ratio).
The film thickness, considering the thermic effects is given by the relation:

$$h_{\min,Th} = h_{\min,iso} * \phi Th \quad (2)$$

It presents practical importance λ, the parameter of the film defined by the relation:

$$\lambda = \frac{h_{\min}}{\sqrt{\sigma_1 + \sigma_2}} \quad (3)$$

in which σ_1 and σ_2 are the mean square deviations of the heights of the roughness from the both surfaces in contact.
The results which were obtained for different greasing mediums are shown in Table 1.

Table 1

	Oil Type							
	Oil L 4/1				Oil LA 32 modified			
	30°C	50°C	70°C	90°C	30°C	50°C	70°C	90°C
λ_{int}	3,58	3,58	2,98	2,44	1,18	1,52	1,40	1,20
λ_{ext}	4,42	4,45	3,69	3,02	1,45	1,87	1,73	1,49

In the working at high speeds, it is experimental ascertained the decisive role which the cage has in the faulting weight (in the case of the bearings having aerose cages).The repeated collisions between the cage and the rolling elements, as regards the aspect of some energy generation and dissipation phenomenons, lead in many cases to the acceleration of the cage vibrations on the rotation running direction and implicit to the loss of the cage running stability. It has to be verified the cages' rate of wear in seats, controlling the outside surface of the cage which mustn't be in contact with the collar of the bearing ring. It also mustn't appear settlements from the cage material on the contact surfaces of the rolling units and rings.

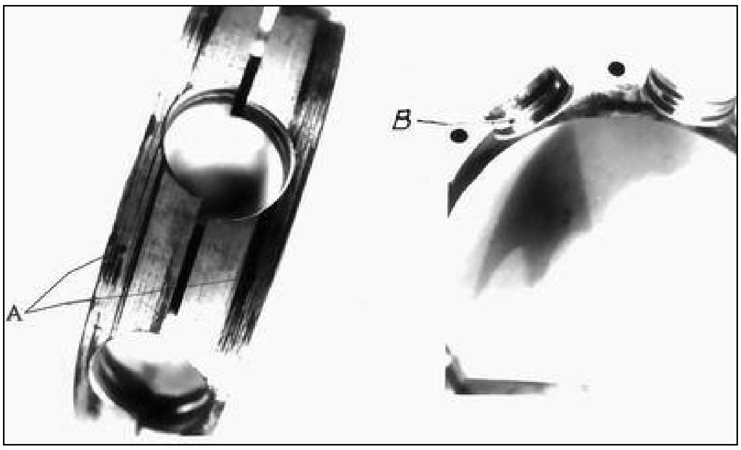

Figure 2: The typical wear forms which develop on the cage

In figure 2 are presented the typical of wear forms which develop on the cage in the case of very high speeds. There are pronounced wear prints observed on the cage guiding shoulders (the A surfaces), as well as in the balls seats (the B surfaces).

Because of the presented failures it has been ascertained a change of the roughness on the ball races. So, for a bearing which presented very high rubbings on the outside surface of the cage, the roughness has increased on the inner ball races from 0.02μm to 0.04μm, and on the outer ball race, placed in the area where the cage-ring wear prevails, the roughness has changed from 0.02μm to 0.1μm.
This roughness increase has leaded to the accentuated decrease of the λ parameter of the film, the calculated values for the modified roughnesses being presented in Table 2.

Table 2

	Oil L 4/1				Oil LA 32 modified			
	30°C	50°C	70°C	90°C	30°C	50°C	70°C	90°C
$h_{min\ i}$ [μm]	0,53	0,54	0,45	0,35	0,177	0,228	0,211	0,181
$h_{min\ i}$ [μm] corrected	0,38	0,39	0,32	0,25	0,127	0,163	0,151	0,130
$h_{min\ e}$ [μm]	0,66	0,67	0,55	0,43	0,218	0,282	0,261	0,224
$h_{min\ e}$ [μm] corrected	0,47	0,48	0,397	0,31	0,157	0,202	0,187	0,160
λ_{int}	13,64	13,74	11,38	9,01	4,49	5,79	5,36	4,60
λ_{ext}	16,85	16,97	14,05	11,13	5,55	7,15	6,62	5,68
	Oil Air 3514				Oil Tb A 57 E			
	30°C	50°C	70°C	90°C	30°C	50°C	70°C	90°C
$h_{min\ i}$ [μm]	0,24	0,14	0,14	0,12	0,55	0,32	0,36	0,17
$h_{min\ i}$ [μm] corrected	0,17	0,10	0,10	0,08	0,39	0,23	0,26	0,12
$h_{min\ e}$ [μm]	0,30	0,17	0,18	0,15	0,68	0,39	0,45	0,21
$h_{min\ e}$ [μm] corrected	0,22	0,12	0,13	0,11	0,48	0,28	0,32	0,15
λ_{int}	2,47	1,41	1,47	1,22	5,47	3,19	3,68	1,77
λ_{ext}	3,06	1,75	1,82	1,51	6,78	3,94	4,54	2,17

Analysing the experimental and theoretical results, it is noticed a good correlation between the thickness of the lubricant film values. In the same time diverse factors which influence film thickness have different weights, being noticed the decisive influence which roughness has on the λ film parameter.

3. CONCLUSIONS

The made up studies have, pointed the prevalence of same stressed wear phenomenons at the level of the contacts between the cage and the guide ring, as well as in the cage seats for balls. The wear phenomenons presence, having as a natural consequence the pollution of the lubricant, also affect the contacts between the balls and the bearing races, with the change of the roughnesses and the reduction of the λ film parameter.
From these findings it is assessed the execution of constructive modifications especially at the cage level(a smaller outer diameter of the cage, owlets through cage, cage guided on balls, oblong seats of the balls).

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