RESEARCH OF BASE AND ALLOYED OIL MC-20 INFLUENCE ON THE TRIBOTECHNICAL CHARACTERISTICS OF ROLLER BEARINGS

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Abstract: This article is devoted to research of the influence of an oil additive "serpentinite" on to roller bearings friction behavior. In this article the influence of the additive «serpentinite» on the roller bearings (208 series) friction behaviour is considered. It has been established that the serpentinite addition to the oil MC-20 allowed to reduce friction losses at the start-up of the mechanism 15-20% in comparison with the base oil.

1. INTRODUCTION

The questions, related to the definition of friction losses in roller bearings determined by the content and properties of the lubrication oils, are interesting to many branches of modern machine-building industry. It is known (Garkunov, 1985), that in roller bearings we can see the following types of losses as losses due to elastic hysteresis in contact zones of rolling elements with the running path of the rings, rubbing friction losses between rolling elements and separator, bearing races and separator (for several types of the bearings). Friction losses also appear between roller's end-faces and thrust surface of the inner ring (for roller radial-axial bearings), on the contact areas that appear due to the difference in instantaneous speed of the rings and rolling elements (Rozenberg, 1970) (so called „differential friction"), and also spinning of the balls. Special case is the case with friction losses in the lubricating material. This lubricating material fills the separator sockets, contact areas and working elements of the bearings. In this situation there is an overcoming of hydraulic friction.

Lubricants, used for roller bearings lubrication, have different antifriction properties and reduce friction losses to different extents. Friction losses differ in the case of various concentrations of additives in alloyed oils. Due to the appearance of new oils and lubricant compositions on the market there is a necessity to study their influence on the tribotechnical properties of the roller bearings.

2. RESEARCH METHODOLOGY

Investigations of the lubricant materials' influence on the tribotechnical properties of the roller bearings were carried out in the Department of "Machine Science and Machine Parts" on the experimental unit DM-28M (Fig. 1).

The unit makes it possible to determine the static friction characteristics and carry out tests within the following range of shaft speed: $0 < n \leq 800$rpm and the following total bearings load: $0N < F \leq 800$N. The tests of 208 series radial ball bearings with dynamic load rating of C=32000N and static load rating of C_o=17800N in the ranges of shaft speed and total bearings load mentioned below are still being carried out. The lubrication is performed at the normal oil level (center of the lower rolling element)

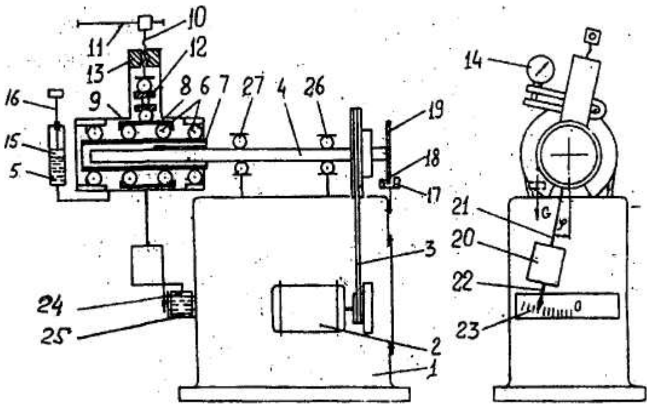

Fig. 1. Scheme of DM-28M unit: 1 – molded case, 2 – elektromotor, 3 – drive belting, 4 – shaft, 5 – oil reservoir, 6 – tested bearings, 7 –common liner. 8 – sleeve, 9 – housing, 10 – loading screw, 11 – tap wrench, 12 – dynamometer, 13 – nut, 14 – indicator, 15 – piston, 16 – screw, 17 – photoresistor, 18 – electric lamp, 19 – disk, 20 – load, 21 – rod, 22 – hand (arrow), 23 – moment scale, 24 – blade, 25 – oil sump

During the experimental part of the research, according to scale 23 the friction torque values are defined $T_{q,i,j}$, q=1,2,3,…,p (p – tests repeat number while the shaft speed and load values are fixed) at various values of total load F_j, j=1,2,3,…,m (m – quantity of the loads, equal to the quantity of trial runs) and shaft speed n_i, i=1,2,3,…, k (k – quantity of speed shaft values during the one trial run). One test run is carried out at fixed values of F_j and k different values of the shaft speed. At each value of shaft speed p values of friction torque $T_{q,i,j}$, are defined. Before the beginning of the trial run with number j, temperature measurement of the lubricating composition is carried out – $\tau j(^0C)$, and after finishing the trial run the realization time is fixed – t_j(min).

As a result, moment matrix, temperature and time values and all initial data are given in Tab. 1.

Tab. 1. The results of trial run # j

$n(rpm)$	n_1	n_2	…	…	n_{i-1}	n_i	…	n_k
$\tau_j\left({}^0C\right)$	$F_j =$ N, $j = 1, 2, 3, \ldots, m$						t_j(min)	
$T(N\cdot mm)$	$T_{1,1,j}$	$T_{1,2,j}$	…	…	$T_{1,i-1,j}$	$T_{1,i,j}$	…	$T_{1,k,j}$
	…	…	…	…	…	…	…	…
	$T_{p,1,j}$	$T_{p,2,j}$	…	…	$T_{p,i-1,j}$	$T_{p,i,j}$	…	$T_{p,k,j}$
$F_{mp}(N)$	$F_{1,1,j}$	$F_{1,2,j}$	…	…	$F_{1,i-1,j}$	$F_{1,i,j}$	…	$F_{1,k,j}$
	…	…	…	…	…	…	…	…
	$F_{p,1,j}$	$F_{p,2,j}$	…	…	$F_{p,i-1,j}$	$F_{p,i,j}$	…	$F_{p,k,j}$
f	$f_{1,1,j}$	$f_{1,2,j}$	…	…	$f_{1,i-1,j}$	$f_{1,i,j}$	…	$f_{1,k,j}$
	…	…	…	…	…	…	…	…
	$f_{p,1,j}$	$f_{p,2,j}$	…	…	$f_{p,i-1,j}$	$f_{p,i,j}$	…	$f_{p,k,j}$

3. PROCESSING OF RESEARCH RESULTS

After completing the experimental part of the work the reduced factors and friction forces in the tested bearings are defined in accordance to $T_{q,i,j}$, F_j and n_i. In the roller bearings friction forces are reduced to inner diameter of the bearing. Superficial (reduced) friction factor:

$$f = \frac{F_{mp}}{F_n} \tag{1}$$

where: F_{mp} – friction force (N), reduced to inner diameter of the bearing, F_n – the force (N), acting on the bearing. Taking into consideration the fact that $T_n=F_{mp}\cdot d/2$, (1) can be written down in the following way:

$$f = \frac{2\cdot T_n}{d\cdot F_n} \tag{2}$$

where: T_n – bearing friction torque (Nmm), d – inner diameter of the bearing (mm).

In unit DM-28M all the bearings are symmetrically located with respect to the force application plane. In this connection, disregarding the item's dead weight, it can be considered that each of them is loaded with force

$$F_n = 0,5\cdot F \tag{3}$$

where F – axial force on the screw. The friction torque of the bearing T_n is connected with the friction torque T, which was measured by scale 23 using the relation:

$$T_n = 0,25\cdot T \tag{4}$$

Using equations (3) and (4), formula (2) can be written as follows:

$$f = \frac{T}{d\cdot F} \tag{5}$$

As $F_{mp}=f{\cdot}F$, then taking into consideration (5), the reduced friction force can be shown in the following way:

$$F_{mp} = \frac{T}{d} \tag{6}$$

Using the moment matrix that corresponds to the trial run # j, taking into consideration (6) the reduced friction forces matrix can be found. The matrix will correspond to the same trial run:

$$\begin{pmatrix} T_{1,1,j} & T_{1,2,j} & \ldots & T_{1,k,j} \\ \ldots & \ldots & \ldots & \ldots \\ T_{p,1,j} & T_{p,2,j} & \ldots & T_{p,k,j} \end{pmatrix} \cdot d^{-1} = \begin{pmatrix} F_{1,1,j} & F_{1,2,j} & \ldots & F_{1,k,j} \\ \ldots & \ldots & \ldots & \ldots \\ F_{p,1,j} & F_{p,2,j} & \ldots & F_{p,k,j} \end{pmatrix} \tag{7}$$

Using the relations (7) and (5) the superficial friction factors matrix in the trial run # j can be found from the equation:

$$\begin{pmatrix} F_{1,1,j} & F_{1,2,j} & \ldots & F_{1,k,j} \\ \ldots & \ldots & \ldots & \ldots \\ \mathrm{F}_{p,1,j} & \mathrm{F}_{p,2,j} & \ldots & \mathrm{F}_{p,k,j} \end{pmatrix} \times F_j^{-1} = \begin{pmatrix} f_{1,1,j} & f_{1,2,j} & \ldots & f_{1,k,j} \\ \ldots & \ldots & \ldots & \ldots \\ \mathrm{f}_{p,1,j} & \mathrm{f}_{p,2,j} & \ldots & \mathrm{f}_{p,k,j} \end{pmatrix} \tag{8}$$

The elements of resulting matrixes are brought under the related cells of the above table.

As a matter of table records, it is possible to settle the dependence (function) of friction force and friction factor from the shaft speed and total bearing load: $f=g(F)$, $f=s(n)$, $F_{mp}=p(F)$, $F_{mp}=q(n)$. These dependences are showed up and compared for different lubricating materials.

4. THE PURSUANCE OF THE RESEARCH

On the basis of the methodology, investigations researches of the lubricant materials' influence on the tribotechnical properties of the roller bearings (208 series) were carried out.

There were trial runs of base oil MC – 20 and oil MC – 20 with addition of 1% geomodifier of the serpentinite fine particles with the average size $d\approx 0,6$μm in submicron content. The quantity of the normal loads and the quantity of test runs were selected as $m=16$.

Normal bearing loads were selected as the type of monotonically increasing sequence:

$$\left\{F_j \mid j = 1, 2, \ldots, 16\right\} =$$

$$\left\{125\text{N}, 250\text{N}, 500\text{N}, \ldots 6000\text{N}, 7000\text{N}, 8000\text{N}\right\}$$

Load change from 500N to 6000N was carried out with the step of 500N.

The quantity of speed shaft values during one test run was taken as $k=8$. Selected shaft speeds were placed as the type of monotonically increasing sequence:

$$\left\{n_i \mid i = 1, 2, \ldots, 8\right\} =$$

$$\left\{0\text{rpm}, 100\text{rpm}, 150\text{rpm}, \ldots, 400\text{rpm}\right\}$$

Shaft speed change from 100(rpm) to 400(rpm) was carried out with the step of 50(rpm). The quantity of test repeats at fixed shaft speed and fixed normal bearing load was taken as $p=10$.

On the basis of the data o resulting from 32 preliminary test runs of the base oil MC-20 and oil MC-20 with geomodifier, dependences of the reduced friction force and superficial friction factor from normal bearing load at fixed values of shaft speed were established.

In particular, at static friction, alloyed oil MC-20 on the interval has better antifriction impact on the elements of the system DM-28M than base oil (Figure 2).

At fixed values of shaft speed $n_i=50\cdot(i+1)$ (rpm), $(i=1,2,3,\ldots,7)$, dependences of reduced friction force and superficial (reduced) friction factor from normal bearing load (Figure 3, Figure 4) were found. After than comparison it can be said that in the case of friction, base oil MC-20 has the best antifriction properties.

After an increase of the shaft speed there is a corresponding increase of reduced friction force and superficial (reduced) friction factor in the whole selected load range. The given consistent pattern is the characteristic of the system with base oil as well as with alloyed oil.

In the Cartesian coordinate system (Figure 3), on each straight line $F=F_j$ there are 70 experimentally obtained points $\{(F_j;\ F_{g,i,j})|\ q=1,2,\ldots,10;\ i=1,2,\ldots,7;\ j=\text{const}\}$. The number of all points, which are indicated in the Cartesian coordinate system, is 1120. There is overlapping of the points in each „vertical row" (Figure 3, Figure 4). It means that the same events appear in identical conditions as well as in various conditions.

5. CONCLUSIONS

1. The developed methodology allows us to carry out investigations of the lubricant materials influence of on the tribotechnical characteristics of ball and roller bea-rings from normal loading on the radial bearings (208 series) at its lubrication with the base and alloyed oil MC-20 that reduce friction losses per 15–20% in com-parison with base oil, but at dynamic friction – the base oil MC-20 has the best antifriction properties.
2. On the average, while the loading is fixed, with an increase of the shaft speed - the reduced friction force increases faster with the use of alloyed oil MC-20.
3. With the increase of shaft speed, rate of increase of the reduced friction force is decreased on the whole load range for the same oil.
4. The dependences of superficial (reduced) friction factors on the load significantly differ on the interval $F \in [250\text{N}, 2500\text{N}]$ at base oil as well as at alloyed oil MC-20.
5. The values of superficial (reduced) friction factors at identical values of the normal bearing load and shaft speed differ by the small quantity for the base and alloyed oil MC-20.
6. The obtained graphs have local maximums and minimums, flexible points that need to be additionally explained.
7. It is necessary to continue investigations at the used set of conditions for preparing the statistics.

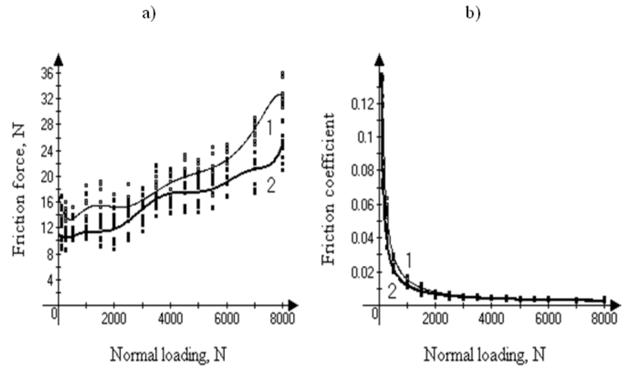

Fig. 2. Dependences of friction force (a) and superficial friction factor (b) from normal bearing load for base (1) and alloyed (2) oil MC-20 at static friction

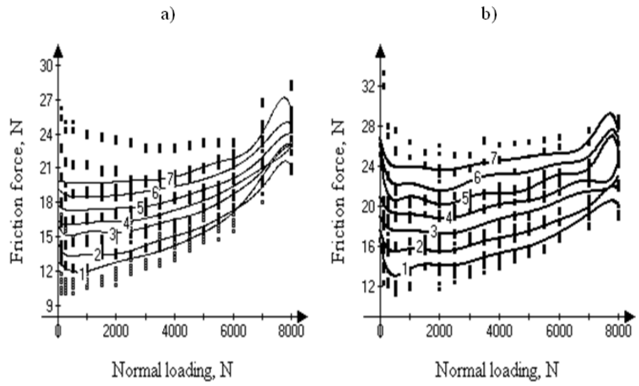

Fig. 3. Dependences of friction force from normal bearing loading at fixed values of shaft speed (1 – 100 rpm, 2 – 150 rpm, 3 – 200 rpm, 4 – 250 rpm, 5 – 300 rpm, 6 – 350 rpm, 7 – 400 rpm): a) based oil MC-20; b) alloyed oil MC-20

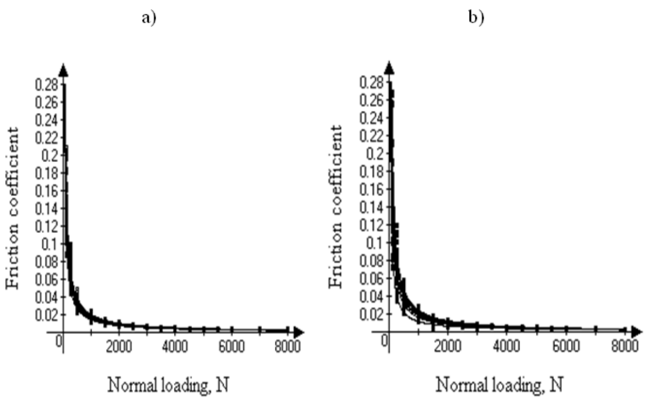

Fig. 4. Dependences of superficial (reduced) friction factor from normal bearing loading at fixed values of shaft speed: a) base oil MC-20; b) alloyed oil MC-20.

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