A STUDY OF GLOBAL FRICTION COEFFICIENT AND THE STARTING MOMENT VARIATION FOR RADIAL BEARINGS

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Abstract: *This paper proposes a precise method of global friction coefficient and the starting moment variation for three different radial bearings. For this purpose, a device was used made by a three-wheeled carriage, loaded with low gravitational loads and a high-precision tribometer on the principle of an inclined plane. The mathematical relations for computing the starting moment are further presented, as well as the experimental results obtained for 6202, 6302 and 6204 radial bearings, respectively. The proposed experimental method is very fast and accurate.*

Key words: *global friction coefficient, starting moment, radial bearing, experimental results.*

1. Introduction

The paper presents a study of global friction coefficient and the starting moment variation for some radial bearings. It is highly important to determine the starting moments with great accuracy, especially in the cases when bearings are engaged in frequent starts and stops, the loads reaching low or extremely low values.

Theoretical determination of the starting moment is also possible, but the results are normally influenced by both lubricant and the capsular elements of bearings.

Therefore, the experimental method suggested, which is very quick and accurate, is far better than other experimental or theoretical methods.

The method and equipment used are presented and further expanded on in References [1] and [3].

2. Measurement Methods

In order to determine the starting moment of radial bearings, a mechanical system was designed and produced, consisting of three radial bearings and a high-precision tribometer (Figure 1) [3].

The device (Figure 2) consists of a transversal bar 1 and a longitudinal bar 2, welded together. Both ends of the transversal bar are fitted with two identical bearings 7. Another bearing 7 is mounted at the loose end of the longitudinal bar, by means of a bolt 9 and a splint 8. On top of both transversal and longitudinal bar, a triangular plate 3 is clamped on the supports 4 by means of three screws 6. The alignment pin 5 is positioned at the mass point of the device, fixed on the triangular plate. The mass point was precisely determined, using the "hanging method". A gravitational load was applied at the

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mass point in order to distribute the load evenly upon the bearings. Bran loads are set on the triangular plate, centered by means of the pin. The device is placed upon the mobile table of a high-precision tribometer [2], [4].

Fig. 1. *Mechanical system consisting of a device of three radial bearings and a high-precision tribometer*

3. Computing Relations

The starting moment M_{fr} for the rolling friction of an external diameter for an unloaded bearing is determined with the relation:

$$M_{fr} = G_p \cdot \frac{D}{2} \cdot \frac{\operatorname{tg} \alpha_r}{\sqrt{1 + \operatorname{tg}^2 \alpha_r}}, \qquad (1)$$

where: G_p - bearing weight; D - external diameter of the bearing; α_r - the angle of tribometer's inclined plane when rolling appears on the external diameter.

Dimensional coefficient (with length dimension) k for the starting rolling friction is determined with the relation:

$$k = \frac{M_{fr}}{G_p}. \qquad (2)$$

The starting moment of rolling resistant M_0 is determined by means of relation:

$$M_0 = \frac{1}{6}(G_i + \Sigma G) D \frac{\operatorname{tg} \alpha_0}{\sqrt{1 + \operatorname{tg}^2 \alpha_0}} - M_{fr}, \qquad (3)$$

where: G_i - device weight; ΣG - total weight of bran weights; α_0 - the angle of tribometer's inclined plane when the device gets into motion.

The starting global friction coefficient μ_{global} for one bearing is determined by:

$$\mu_{global} = \frac{6 M_0}{(G_i + \Sigma G) \cdot d}, \qquad (4)$$

where d - internal diameter of the bearing.

4. Working Procedure

The global friction coefficient and the starting moment variation are determined by positioning the device loaded with low loads on a tribometer plate of the inclined- plane type. Calculations were only made for unlubricated bearings. With lubricated bearings, however, friction coefficient values may vary according to lubricant quality.

By establishing the angle when the device gets into motion, it is possible to determine the friction, as well as the bearings' starting moments and global (equivalent) friction.

The working procedure consists in measuring, for each value of the weights sum, the angle at which the device starts to move [1].

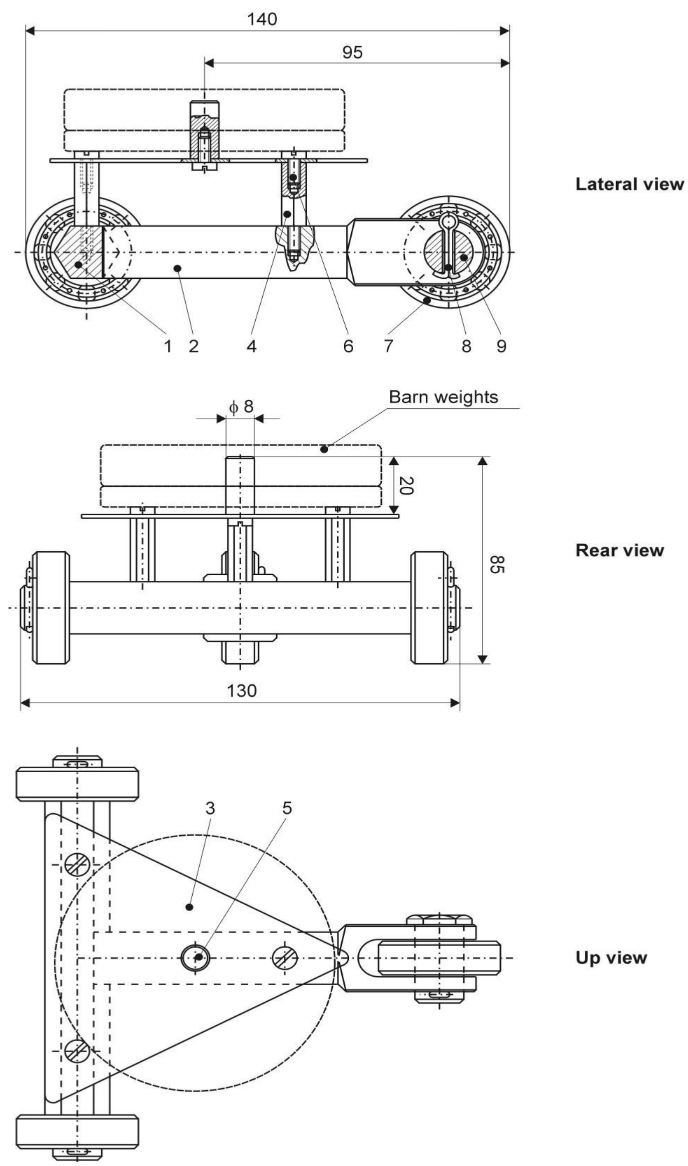

Fig. 2. *Three-radial-bearing device:*
1 - *transversal bar;* 2 - *longitudinal bar;* 3 - *triangular plate;* 4 - *support;*
5 - *adjusting pin;* 6 - *screw;* 7 - *bearing;* 8 - *splint;* 9 - *bolt*

5. Experimental Results

In Tables 1-3, the global friction coefficient (μ_{global}) and the starting moment (M_0) values term by (ΣG) loads for 6202, 6302 and 6204 bearings are presented, respectively.

In Figures 3, 4 and 5, the friction coefficient variation charts are presented for the three different types of bearings on the device, while in Figures 6, 7 and 8, the starting moment variation charts are presented for the same three types of bearings.

Table 1

The global friction coefficient and the starting moment values term by loads for 6202 bearing

Bearing	#	G_i [N]	ΣG [N]	D [mm]	μ	M_{fr} [Nmm]	M_0 [Nmm]	d [mm]	μ_{global}
6202	1	7.78	2.734	35	0.014	0.0187	0.841	15	0.032
	2	7.78	2.883	35	0.0136	0.0187	0.826	15	0.031
	3	7.78	3.563	35	0.0132	0.0187	0.855	15	0.0301
	4	7.78	4.159	35	0.0137	0.0187	0.932	15	0.0312
	5	7.78	5.039	35	0.0134	0.0187	0.986	15	0.0308
	6	7.78	6.119	35	0.0114	0.0187	0.908	15	0.0261
	7	7.78	10.443	35	0.0113	0.0187	1.179	15	0.0259
	8	7.78	11.673	35	0.011	0.0187	1.231	15	0.0253
	9	7.78	15.928	35	0.0091	0.0187	1.24	15	0.0209
	10	7.78	21.139	35	0.0092	0.0187	1.539	15	0.0213

Table 2

The global friction coefficient and the starting moment values term by loads for 6302 bearing

Bearing	#	G_i [N]	ΣG [N]	D [mm]	μ	M_{fr} [Nmm]	M_0 [Nmm]	d [mm]	μ_{global}
6302	1	8.89	2.862	42	0.037	0.0707	2.971	15	0.1011
	2	8.89	3.127	42	0.0324	0.0707	2.655	15	0.0884
	3	8.89	4.549	42	0.0256	0.0707	2.334	15	0.0695
	4	8.89	5.424	42	0.02	0.0707	1.931	15	0.054
	5	8.89	6.506	42	0.0204	0.0707	2.122	15	0.0551
	6	8.89	9.465	42	0.0131	0.0707	1.606	15	0.035
	7	8.89	12.065	42	0.0125	0.0707	1.763	15	0.0336
	8	8.89	16.339	42	0.0126	0.0707	2.157	15	0.0342
	9	8.89	19.075	42	0.0119	0.0707	2.265	15	0.0324
	10	8.89	21.532	42	0.012	0.0707	2.488	15	0.0327

Table 3

The global friction coefficient and the starting moment values term by loads for 6204 bearing

Bearing	#	G_i [N]	ΣG [N]	D [mm]	μ	M_{fr} [Nmm]	M_0 [Nmm]	d [mm]	μ_{global}
6204	1	16.51	8.363	47	0.0129	0.0791	2.431	20	0.0293
	2	16.51	9.723	47	0.0116	0.0791	2.298	20	0.0263
	3	16.51	10.32	47	0.0113	0.0791	2.292	20	0.0256
	4	16.51	11.19	47	0.011	0.0791	2.304	20	0.025
	5	16.51	12.273	47	0.0085	0.0791	1.845	20	0.0192
	6	16.51	15.236	47	0.0086	0.0791	2.059	20	0.0195
	7	16.51	16.603	47	0.0091	0.0791	2.273	20	0.0206
	8	16.51	17.83	47	0.0084	0.0791	2.189	20	0.0191
	9	16.51	20.356	47	0.0078	0.0791	2.169	20	0.0176
	10	16.51	22.106	47	0.0068	0.0791	1.963	20	0.0152

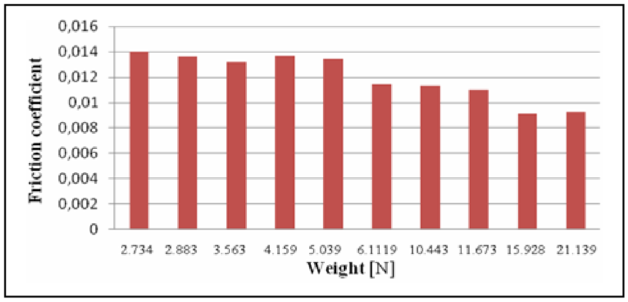

Fig. 3. *The friction coefficient variation chart for the 6202 bearing*

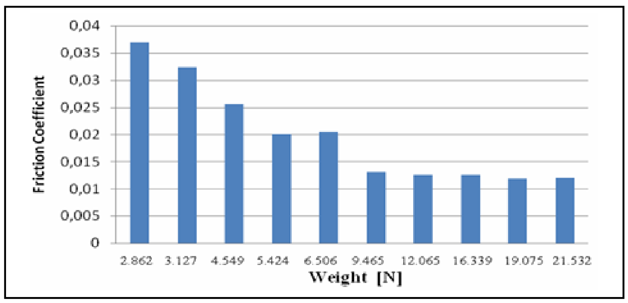

Fig. 4. *The friction coefficient variation chart for the 6302 bearing*

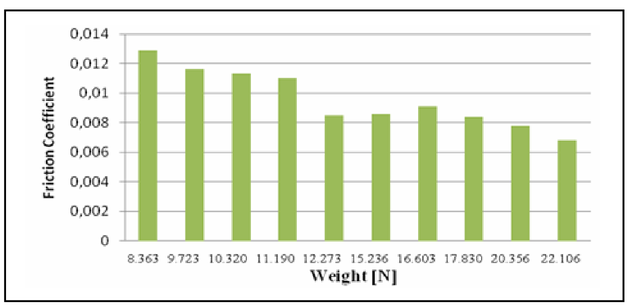

Fig. 5. *The friction coefficient variation chart for the 6204 bearing*

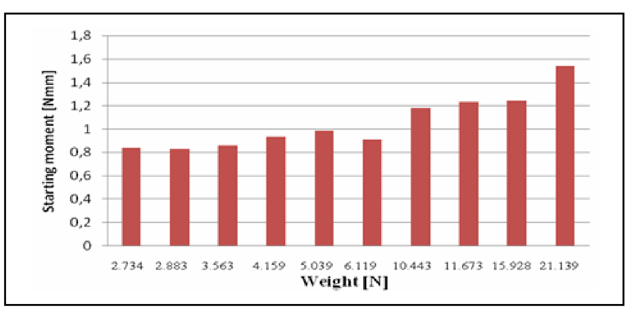

Fig. 6. *The starting moment variation chart for the 6202 bearing*

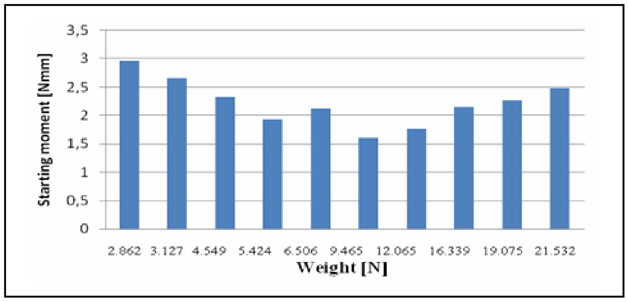

Fig. 7. *The starting moment variation chart for the 6302 bearing*

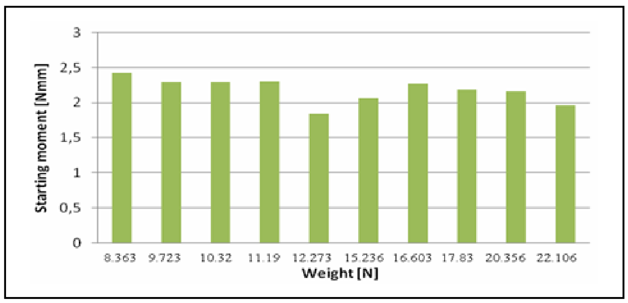

Fig. 8. *The starting moment variation chart for the 6204 bearing*

6. Conclusions

The paper can be of great interest for all those who use bearings engaged in frequent starts and stops, the loads reaching low or extremely low values. It is easy to notice that with 6202 bearing, the starting moment increases simultaneously with the load. Conversely, with 6302 and 6204 bearings, the starting moment decreases to a minimum value for a medium load of 9 N and 12 N respectively, and then increases again.

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