MEASURING THE MOMENT OF FRICTION, COEFFICIENT OF FRICTION AND ANGLE OF FRICTION IN THE SLIDING BEARINGS FOR UNSTEADY MOTION

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Abstract: *The mechanism is analyzed for two different angle velocities of the operating part. The measurements were performed with lubrication and without lubrication. Forces in the mechanism were determined using the computer. These forces were derived without taking in account the variable load on the bearings, and the results were presented graphically. The bearing shell on which the measurements were performed has three different diameters (60, 70 and 80 mm). The material of the bearings is polyamide 6.6 with addition of molybdenum disulfide (MoS_2).*

Key words*: bearings, sliding bearings, lubrication of the bearings, the moment of friction, coefficient of friction, angle of friction.*

1. Introduction

In our experiments, we performed measurements of impact forces, moments of friction, coefficient of friction and angle of friction in the bearings, for this purpose a specially constructed mechanism (four bar mechanism, fig. 1.), with these dimensions: $O_2A = 76\ mm, AB = 192\ mm, BO_2 = 124{,}4\ mm$

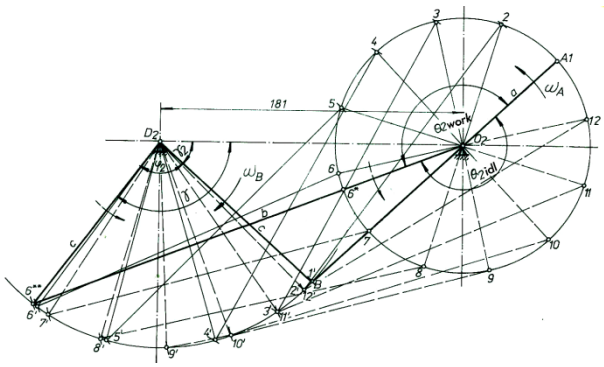


Fig. 1. Four bar mechanism

Plain bearings offer the advantage of noiseless operation and a high damping ability under cyclic and impact loads.

If designed and lubricated correctly, the plain (Sliding) bearings can carry heavy loads at a high rotational speed. These bearings are light in weight, have small radial dimensions and do not require special equipment for manufacture.

The reducing friction in bearings is often important for efficiency, to reduce wear and to facilitate extended use at high speeds and to avoid overheating and premature failure of the bearings. Essentially, a bearing can reduce friction by its shape, by its material, or by introducing and containing a fluid between surfaces or by separating the surfaces with an electromagnetic field.

2. Material for placenta of sliding bearings

For our experiments, the placenta of sliding bearings is of Polyamide 6.6 with the addition of molybdenum disulphide (MoS_2) is also known by various names (U.S. Plaskon, Zytel, Germany-Ultramid, Durethan; England-Maarnyl, etc.), and is one of the thermoplastic poly condensate [Pllana, 1984].

These placentas were done in three dimensions with inside diameters of 60 mm, 70 and 80 mm. The fig. 2 shows the test sample.

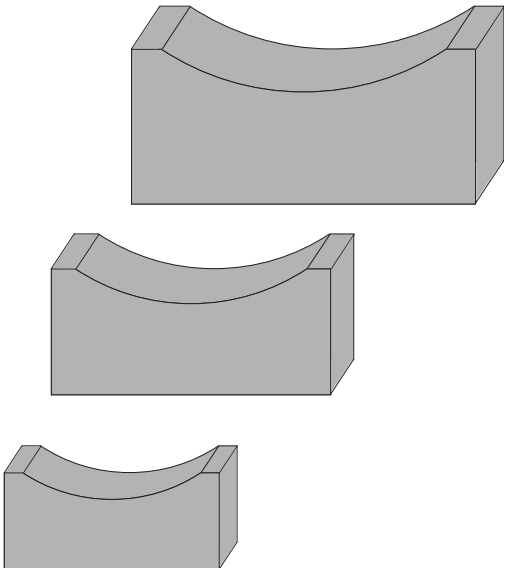


Fig. 2. The placenta of sliding bearings

Coefficient sliding friction and the amount of consumption in dry friction. tab.1.

Tab.1. Material for placenta of sliding bearings, POLIAMID 6.6+MoS2

Material	The coefficient of friction	Fraying [μm/Km]
POLIAMID 6.6+ MoS2	0,32 to 0,35	0,7

Mechanical properties of material of the placenta of sliding bearings, tab.2.

Tab.2. Mechanical properties of material for our experiments

Mechanical properties by:			Material
			POLIAMID 6.6+ MoS2
DIN 53 455 53 371	Yield on the train	N/mm^2	(80) 50
DIN 53 452	Yield bending	N/mm^2	(94) 27
DIN 53 371	modulus	N/mm^2	(3200) 1500
DIN 53 455 53 371	Elongation at break	%	(130) 250
	Volume weight	kg/m^3	1150

3. Measurement methods

Fig. 3 shows the diagram of the dependence of the angle of friction θ_1 of the operating member with the angles $\varphi_1(1,2,...)$ of the oscillatory member (working member), as in one way as well as in the other direction of motion.

$\varphi_1 = 0^\circ - 95^\circ$						
B_1	B_2	B_3	B_4	B_5	B_6	B_{6*}
0°	3°	12,3°	31,7°	62,8°	83°	85°
$\varphi_1 = 85^\circ - 0^\circ$						
B_7	B_8	B_9	B_{10}	B_{11}	B_{12}	B_1
5°	21°	40°	58°	72°	81°	85°

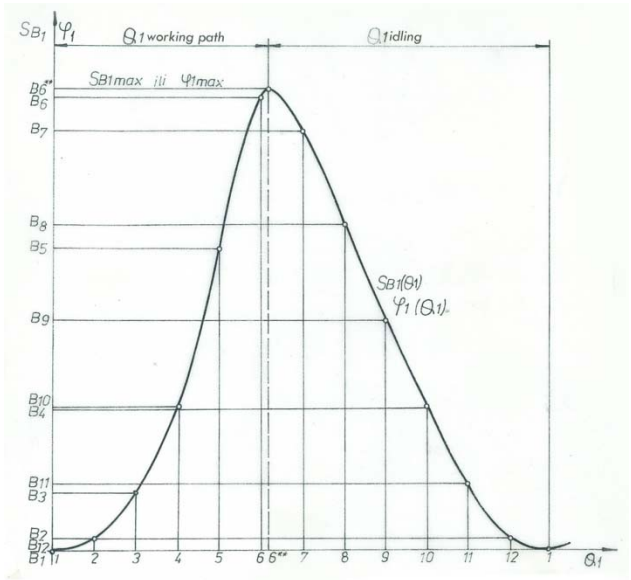


Fig. 3. Dependence angle of the angle θ_1 of the angle $\varphi_1(1,2,...)$

Radial forces which act on the placenta of sliding bearings (tab. 3)

Tab. 3

	G[N]	F_R[N]
1	20	189,3
2	40	378,4
3	60	567,6
4	80	756,6
5	90	851,4

Moments of friction in the bearings for small speeds are considered characteristic, and in this case it will be valid as:

$$M_T = F_N \cdot \mu \cdot r \qquad (1)$$

because:

$r = D/2$, from form (1) follows:

$$\mu = \frac{2 \cdot M_T}{D \cdot r} \qquad (2)$$

where:
$F_R = i \cdot G$ -radial forces
$i = 9,4$ –the leverage transmission ratio of the device
G- weights
μ - coefficient of friction,
D- diameter of placenta sliding bearings

From these results the appropriate coefficient of friction for the defined characteristic points of the oscillatory link mechanism has been calculated radial forces of different weights:

Fig. 4 shows the effect of the radial force of the placenta sliding bearings.

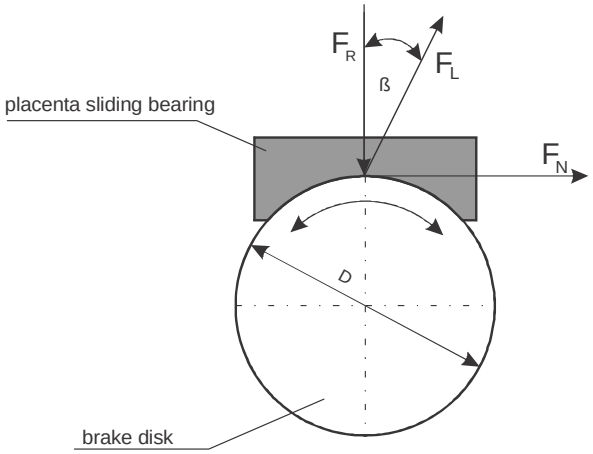


Fig. 5 The effect of the radial force on the placenta of sliding bearings.

Changing the angle of friction, this is the gradient of the resulting force F_R according to Figure 24 in the placenta of sliding bearings, given by the expression:

$$\sin\beta = \frac{F_N}{F_L}$$

because:

$$F_N = \mu \cdot F_R \ [N] \ and \ F_L = \sqrt{F_R^2 + F_N^2} \ [N]$$

follows:

$$\sin\beta = \frac{\mu}{\sqrt{1+\mu^2}}$$

In our measurements were used only the characteristic points B3, B4 and B5 for the working movement of the operating member of the measuring mechanism, and the points B8, B9, B10 and B11 for the reversible movement (idle movement) of the operating member of the mechanism.

4. RESULTS

Based on the diagrams for all combinations of loads, of speed of the samples of sliding bearings and of change of the angle oscillating link mechanism, and by using the calibrated chart, and the above mathematical procedure, were constructed tables of calculated moments of friction.

The reading moments of the calibration diagram based on moves from experimental diagram					
Angle φ_z and characteristic points		F_{R1}[N]		F_{R2}[N]	
		a	b	a	b
$\varphi_z(0° - B3')$	B_3	570	240	1000	350
	B_4	600	210	1100	360
	B_5	400	130	750	200
$\varphi_z(B3' - 0')$	B_8	450	135	800	175
	B_9	550	150	1060	235
	B_{10}	650	125	1150	235
	B_{11}	430	120	750	200

The reading moments of the calibration diagram based on moves from experimental diagram							
Angle φ_z and characteristic points		F_{R3}[N]		F_{R4}[N]		F_{R5}[N]	
		a	b	a	b	a	b
$\varphi_z(0° - B3')$	B_3	860	550	1700	680	1760	730
	B_4	1430	505	1880	650	1920	720
	B_5	1100	280	1350	340	1400	370
$\varphi_z(B3' - 0')$	B_8	1170	260	1400	370	1360	375
	B_9	1500	350	1850	460	1850	475
	B_{10}	1600	400	1950	520	2030	550
	B_{11}	1000	350	1250	410	1300	425

Coefficient of friction: μ					
Angle φ_z and characteristic points		F_{R1}[N]		F_{R2}[N]	
		a	b	a	b
$\varphi_z(0° - B3')$	B_3	0,1004	0,0422	0,0882	0,0308
	B_4	0,1057	0,0369	0,0968	0,0317
	B_5	0,0704	0,0229	0,0662	0,0176
$\varphi_z(B3' - 0')$	B_8	0,0792	0,0237	0,0704	0,0154
	B_9	0,0968	0,0264	0,0934	0,0207
	B_{10}	0,1145	0,0211	0,1013	0,0207
	B_{11}	0,0757	0,0211	0,0660	0,0174

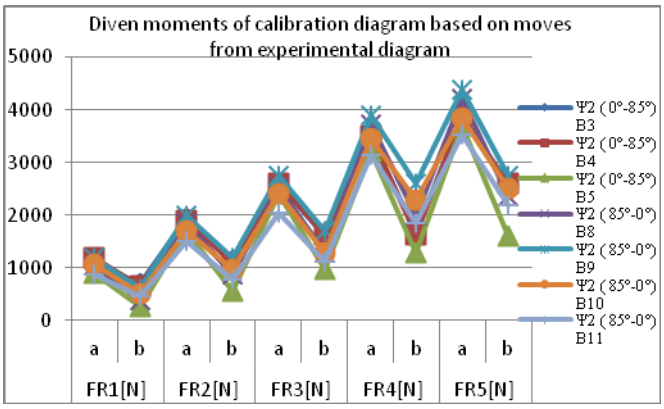
Coefficient of friction: μ							
Angle φ_z and characteristic points		F_{R3}[N]		F_{R4}[N]		F_{R5}[N]	
		a	b	a	b	a	b
$\varphi_z(0° - B3')$	B_3	0,0505	0,0322	0,0748	0,0299	0,0689	0,0285
	B_4	0,0839	0,0296	0,0828	0,0286	0,0751	0,0281
	B_5	0,0645	0,0164	0,0594	0,0149	0,0548	0,1444
$\varphi_z(B3' - 0')$	B_8	0,0687	0,0152	0,0616	0,0162	0,0523	0,0146
	B_9	0,0882	0,0205	0,0806	0,0202	0,0724	0,0186
	B_{10}	0,0939	0,0234	0,0858	0,0229	0,0794	0,0215
	B_{11}	0,0587	0,0205	0,0550	0,0180	0,0508	0,0166

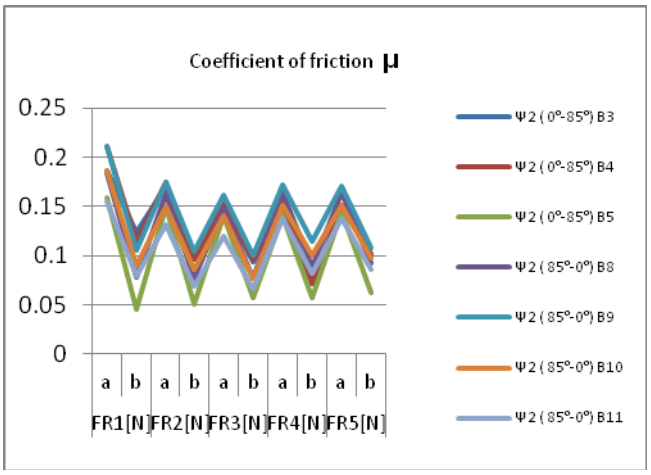
a-Measurement without lubrication
b-Measurement of lubrication.

For each radial force were obtained curves for the case with lubrication (LIS grease and without lubrication), diagram 1 and 2.

a) the case when the experiments were carried out without lubrication,

b) the case when the experiments were performed with lubrication (grease LIS).





6. CONCLUSION

On the basis of experimental tests in the adopted four-member mechanism of the device for testing the placenta of sliding bearings, this can be concluded:

- In most experiments it has been confirmed that the friction coefficient in the sliding bearings decreases by increasing the radial forces in the placenta of the sliding bearings,
- In terms of lubrication, the coefficient of friction is reduced by approximately half the value without lubrication,
- Considering the low values of the coefficient friction for the material polyamide 6.6 with the addition of molybdenum disulphide (MoS2), is very good for application,
- With the measurements it is proved that by increasing the dimensions of sliding bearings it comes to the decreasing of the friction coefficient, and thus also to the decreasing of the moment of friction.

7. REFERENCES

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