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INVESTIGATION OF JOURNAL SLIDE BEARINGS UNDER THE ANGLE OF THEIR FUNCTIONING

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Abstract

Paper presents the structure and principle of operation of a stand for measurements of influence of the lubrication method and process on functioning of journal slide bearings in their various technical states. Measurements performed on the stand make it possible to take advantage of the new method of evaluating the influence of physical and chemical properties of lubricating oil on the coefficient of friction in the mixed friction conditions.

On the basis of the presented investigation results pertaining to journal slide bearings loaded with a constant-direction force during fast increasing and decreasing of loads within an assumed time interval, the Author has come to a conclusion that relation between physical and chemical properties of lubricating substance and properties of bearing metal can be determined by means of the operation indicator.

***Key words**: functioning, operation indicator*

1. Introduction

Functioning of journal slide bearings [3,4,5] as machine elements is determined by their capability of carrying out functions in given conditions and within an assumed time interval. Main characteristics of journal slide bearing operation are their reliability and durability, which depend on:

- lubrication process;
- lubrication method;
- material and structure properties of the bearing sleeve and journal.

The process taking place during fast increasing and decreasing of machine loads has a negative effect on operation of a journal bearing. The contacting surfaces are then not fully separated by a layer of lubricating substance (mixed friction) and in the friction nodes a complex process occurs of friction of solid bodies in the presence of lubricant.

The paper analyses this complexity and an attempt is made to determine the operation reliability indicator of a journal slide bearing during increasing and decreasing the loads on a test stand within an assumed time interval.

2. Investigation methodology

The test stand (Fig. 1) consists of a TSA16 bench lathe with a connected journal slide bearing.

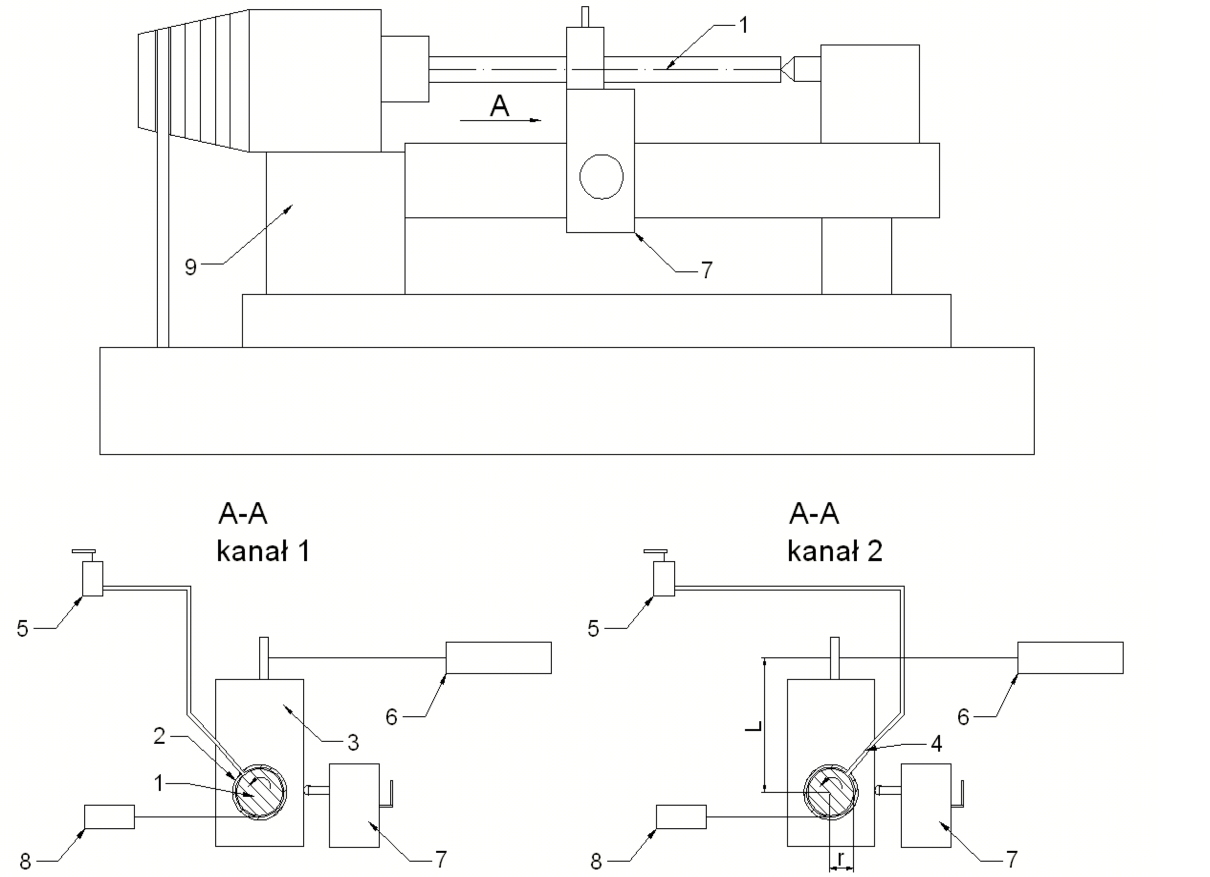

Fig.1. Diagram of the test stand where: 1 – steel shaft; 2 – TUP1 slide sleeve; 3 – bearing aluminium casing; 4 – lubricating oil inlet channel; 5 – 300 ml oiler; 6 – electronic weigher; 7 – carriage; 8 – UT 50 digital meter; 9 – 0.4 kW electric motor

The journal slide bearing has the form of a pendulum suspended on a steel shaft fixed in the lathe fast headstock and loose headstock. A 6 mm diameter channel was drilled in the aluminium casing to supply gravitationally the lubricating substance to space between the slide sleeve (bearing metal with PTFE sliding surface) (Fig.2) and the steel shaft. The radial clearance is 0.041 mm. The bearing casing is pressed down by the lathe carriage.

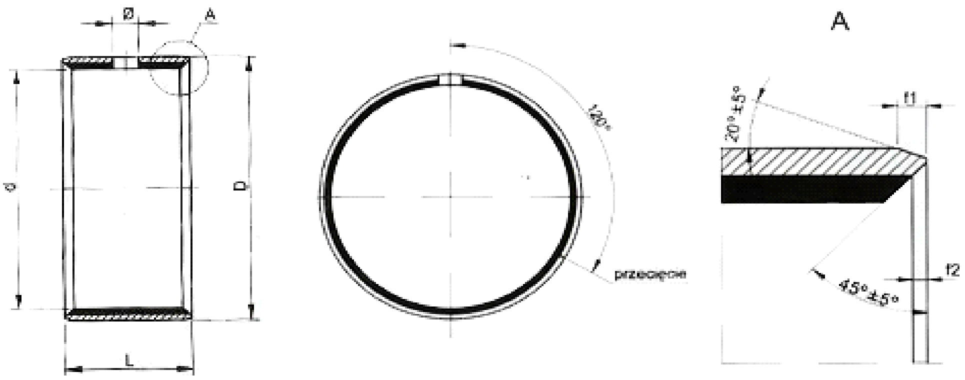

Fig.2. Slide sleeve, where: d = 25 mm; D = 28 mm; = 6 mm; L = 30 mm

As the force system is closed within the pendulum and the pendulum is freely suspended on the shaft, it can deflect from the balance point under the influence of friction in bearing. By balancing the friction torque in bearing with a weight force transducer the frictional resistance is measured and then the coefficient of friction calculated.

The test is carried out in two stages lasting about 1 minute:

- The start-up stage: the stand is activated, with not loaded bearing, then it is slowly loaded up to a requested value the bearing is to operate at. Measurements are carried out each time the load is changed.
- The hold-up stage: When the requested bearing operation load has been reached, the load is slowly decreased until the bearing no-load state is reached.

Additionally, by changing the bearing casing position in relation to carriage, the lubrication process can be changed, which may be treated as equivalent to deteriorated lubrication conditions. Therefore, the test stand makes it possible to investigate coefficients of friction with taking into account changes in the lubrication method and process.

3. Investigation results

Experimental tests were carried out on a journal slide bearing. When the lubricating substance was supplied through channel 1, a correct lubrication method was applied, when it was supplied through channel 2, deteriorated lubrication conditions were brought about (Fig.1 detail A-A). Two kinds of lubricating substance were supplied:

- Pure SAE 30 CastelGarden lubricating oil (correct lubrication process) with 255 mPas viscosity at 20C;
- Pure SAE 30 CastelGarden lubricating oil with 10% addition of the Lotos diesel oil (deteriorated lubrication conditions) with 153 mPas viscosity at 20C.

All the tests were carried out at constant 20C temperature of lubricating substance controlled by a UT 50 digital meter.

Table 1. Results of tests carried out when the journal slide bearing was lubricated with pure lubricating oil supplied gravitationally through channel "1"

Journal speed n [rpm]	Increase of the bearing load F [N]													
	0	2,5	5	7,5	10	12,5	15	15	12,5	10	7,5	5	2,5	0
	Weigher indications during increasing the load G [N]							Weigher indications during decreasing the load G [N]						
92	0	0,09	0,26	0,5	0,72	0,9	1,09	1,09	0,84	0,64	0,32	0,17	0,06	0
148	0	0,12	0,23	0,39	0,65	0,88	1	1	0,81	0,54	0,29	0,15	0,06	0
224	0	0,13	0,28	0,47	0,66	0,87	1,06	1,06	0,85	0,64	0,42	0,23	0,09	0

Table 2. Results of tests carried out when the journal slide bearing was lubricated with pure lubricating oil supplied gravitationally through channel "2"

Journal speed n [rpm]	Increase of the bearing load F [N]													
	0	2,5	5	7,5	10	12,5	15	15	12,5	10	7,5	5	2,5	0
	Weigher indications during increasing the load G [N]							Weigher indications during decreasing the load G [N]						
92	0	0,12	0,3	0,56	0,8	1,04	1,3	1,3	1	0,75	0,48	0,23	0,1	0
148	0	0,15	0,31	0,54	0,78	1,03	1,27	1,27	0,99	0,75	0,48	0,25	0,1	0
224	0	0,17	0,38	0,59	0,82	1,07	1,3	1,3	1,04	0,78	0,51	0,32	0,1	0

Table 3 . Results of tests carried out when the journal slide bearing was lubricated with pure lubricating oil with 10% addition of Lotos diesel oil supplied gravitationally through channel "1"

Journal speed n [rpm]	Increase of the bearing load F [N]													
	0	2,5	5	7,5	10	12,5	15	15	12,5	10	7,5	5	2,5	0
	Weigher indications during increasing the load G [N]							Weigher indications during decreasing the load G [N]						
92	0	0,2	0,52	0,79	1,05	1,36	1,66	1,66	1,3	0,99	0,67	0,43	0,16	0
148	0	0,21	0,42	0,69	0,96	1,28	1,56	1,56	1,2	0,84	0,58	0,32	0,16	0
224	0	0,23	0,52	0,81	1,11	1,38	1,64	1,64	1,23	1,02	0,74	0,42	0,17	0

Table 4 . Results of tests carried out when the journal slide bearing was lubricated with pure lubricating oil with 10% addition of Lotos diesel oil supplied gravitationally through channel "2"

Journal speed n [rpm]	Increase of the bearing load F [N]													
	0	2,5	5	7,5	10	12,5	15	15	12,5	10	7,5	5	2,5	0
	Weigher indications during increasing the load G [N]							Weigher indications during decreasing the load G [N]						
92	0	0,2	0,47	0,75	0,98	1,22	1,45	1,45	1,09	0,78	0,57	0,37	0,17	0
148	0	0,22	0,53	0,77	1,02	1,26	1,52	1,52	1,17	0,92	0,68	0,42	0,18	0
224	0	0,26	0,54	0,81	1,05	1,29	1,56	1,56	1,22	0,95	0,66	0,5	0,2	0

Then, using the test results (Fig.1), the coefficient of friction (1) and the Hersey number (2) are calculated:

$$\mu = \frac{G \cdot L}{F \cdot r} \quad (1)$$

$$\lambda = \frac{\eta \cdot n''}{F} \quad (2)$$

where:

L – pendulum height [m],
r – journal radius [m],
G – weigher indications [N],
F – bearing loading force [N],
η - dynamic viscosity [Pas],
n" – journal rotational speed [rpm],

which are used as a basis to determine the change processes.

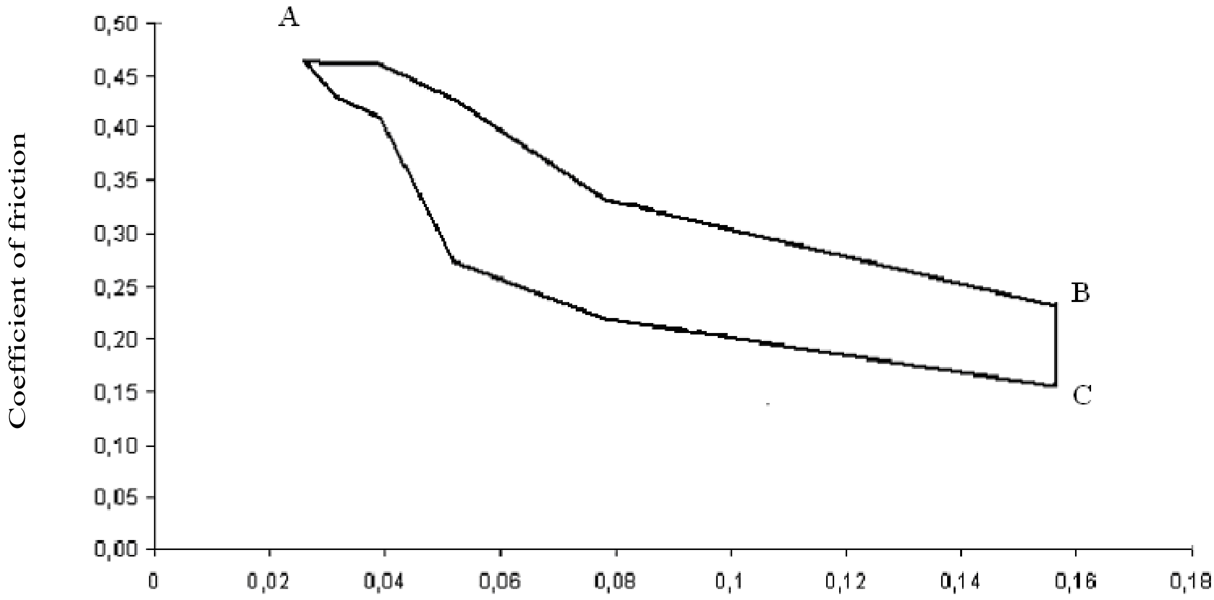

Fig.3. Diagram of coefficient of friction change as a function of bearing static loads, where: BA – load increase, AC – load decrease

The field enclosed by the lines of coefficient of friction changes is a measure of slide bearing operation in the presented measurement conditions. The operation indicator WD equals to the ratio of the field area to the range of Hersey number.

Table 5. Results of the journal slide bearing operation indicator calculations

Journal speed [rpm]	WD			
	Correct lubrication method and process	Correct lubrication method, deteriorated lubrication process	Deteriorated lubrication method, correct lubrication process	Deteriorated lubrication method and process
92	0,25	0,51	0,32	0,55
148	0,26	0,51	0,34	0,57
224	0,29	0,55	0,35	0,59

4. Final remarks and conclusions

The presented test stand may be used for determining the durability of journal slide bearings in various technical states, loaded with a constant-direction force during fast increasing and decreasing the loads within an assumed time interval by means of the calculated operation indicator WD. Its calculation makes it possible to evaluate:

- durability of the lubricating substance boundary layer, i.e. the smaller the operation indicator value the greater the boundary layer durability.
- bearing lubrication method, i.e. the smaller the operation indicator value the better the lubrication method.

The performed investigations have shown that rational evaluation of the journal slide bearing lubricating ability is possible by evaluating the operation indicator determined from changes of the coefficient of friction as a function of static loads, without taking into account the lubricant viscosity changes due to changing temperature.

In order to make the rightness of the above conclusion reliable [1,2] and to formulate a diagnosis, more tests must be carried out on different systems (e.g. with other kinds of bearing metals). Also different diagnostic systems should be used (e.g. electric motor power loss gauge, vibration pick-up etc.).

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