Measurement of the Tribology Characteristics in Sliding Joint

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Abstract

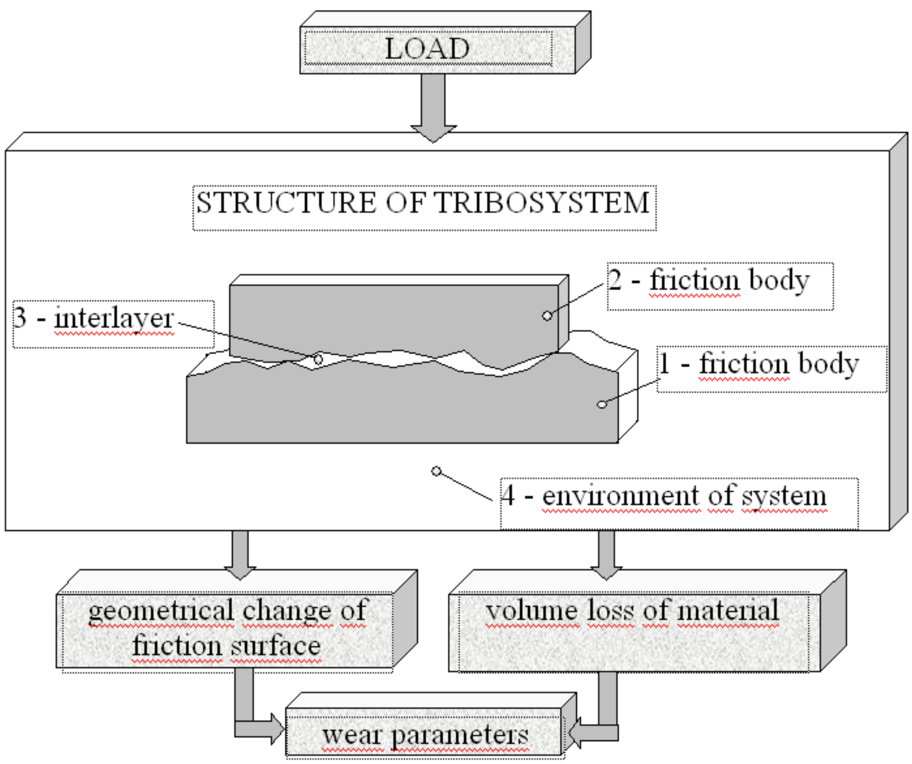
Submitted work is a contribution to assesment of the process of friction and wear. The contribution is focused on the description of the wear tests, which were realised on the test machine Tribotestor M' 89 for a pair ring-ring. Tribological characteristics as a coefficient of friction, temperature and roughness of the surface for the test rings made of brass are analysed in the paper. While testing following input variables were set: the sliding speed (0.8 m s^{-1}), the time duration of the test (2400 s) and load (50 - 500 N). During the run up (first 600 s of the test), the value of coefficient of friction sharply decreased from 0.55 to size 0.09 and then it stabilized at 0.09 till the end. While individual testing value of the temperature changed on average by 3.52 ° C.

Keywords: tribology, sliding pair, coeficient of friction, roughness of surface

1. Introduction

Tribological system is generally defined as a natural or artificial system, in which there is friction as a result of the interaction of the two surfaces and the environment. Tribological system represents one tribology joint (Ziegler,J. et al., 2004, Blaškovič,P. et al., 1990), consisting of four elements, Fig. 1.

Fig. 1 Tribological system (Ziegler,J. et al., 2004)



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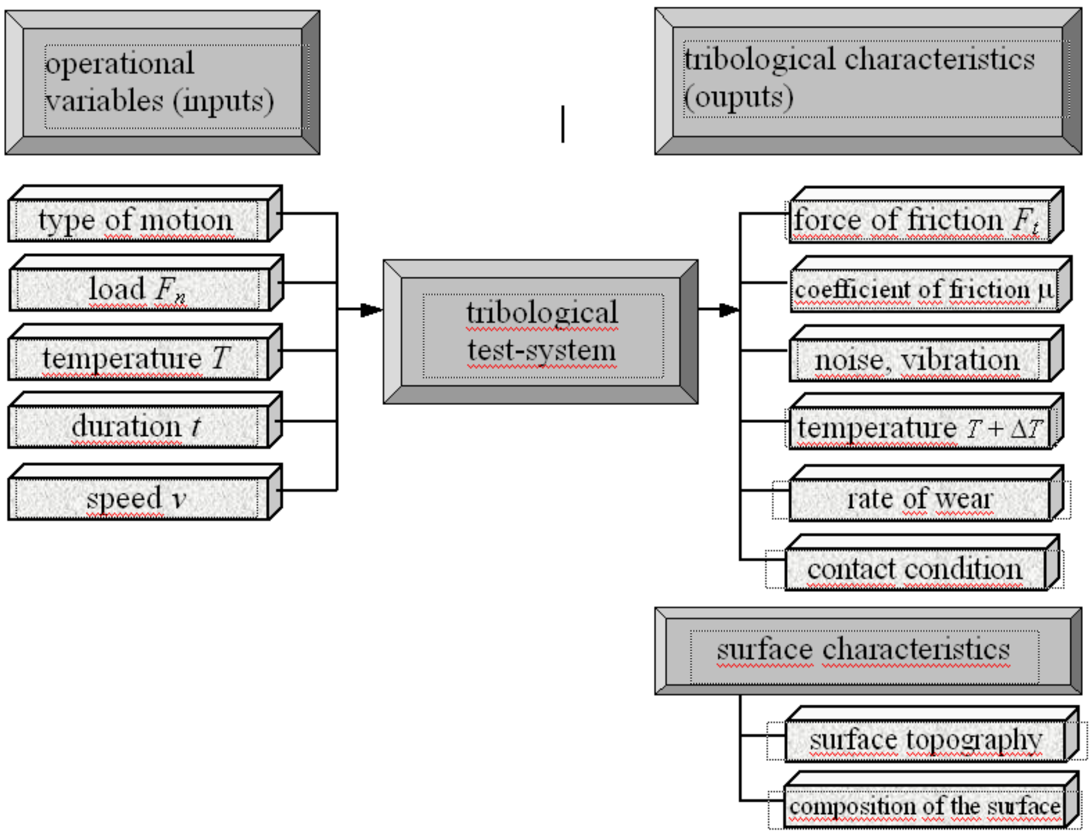
Different methods and techniques are used to investigate tribological processes. Tribological tests can be divided into three main groups: model tests by laboratory testing machine, tests by simulation testing machine and operational tests. The first group includes simple testing samples of the test model. In these cases, the input parameters are transparent and easy to maintain on constant level. Recorded output quantities represent tribological characteristics. Inputs and outputs of tribological system are shown in Fig. 2.

Fig. 2 Chracteristics and parameters of the tribological test (Blaškovič,P. et al., 2008)

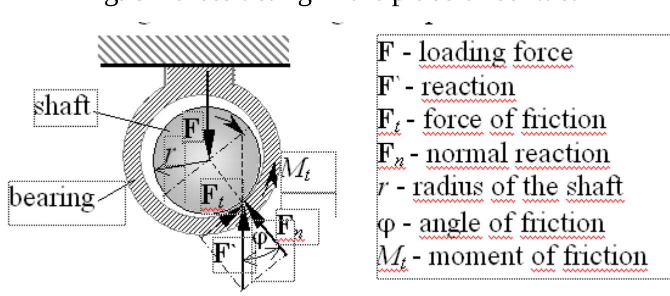


2. Sliding friction in rotational joint

Sliding friction is the result of relative motion of two contact surfaces, which in the area of contact vary in size and direction. If the sliding contact surfaces are ensured some kind of freedom of movement, we are talking about the friction bearing. Sliding pair consists of two machine or other components, in contact at guiding surfaces (Barysz, I. et al., 1995).

We find sliding friction in the rotation motion of the body too. Sliding friction of rotating bodies are generated in the shaft bearings directed against the sense of their rotation. Direction of the force of friction is the direction of the tangent to the interface of the journal of the shaft. The size of resistive forces of rotating bodies is expressed by friction moment, see Fig. 3.

Fig. 3 Forces acting in the place of contact



Consideration of the friction angle (φ) of small size together with equilibrium in the vertical direction might leads to conditions (1):

$$\sin\varphi = \mathrm{tg}\varphi, \; F' = F \qquad (1)$$

On the basis of the distribution of the forces in the rotating body (Fig. 3), it is possible to express the friction moment M_t as follows:

$$M_t = F_t\, r = F' \sin\varphi\, r \quad [\mathrm{Nm}] \qquad (2)$$

By substitution of conditions (1) to the equation (2) we get:

$$M_t = F\, \mathrm{tg}\varphi\, r = F\, \mu\, r \quad [\mathrm{Nm}] \qquad (3)$$

If we can determine the size of the load force and the friction moment we obtain tribological characteristics in the form of the coefficient of friction:

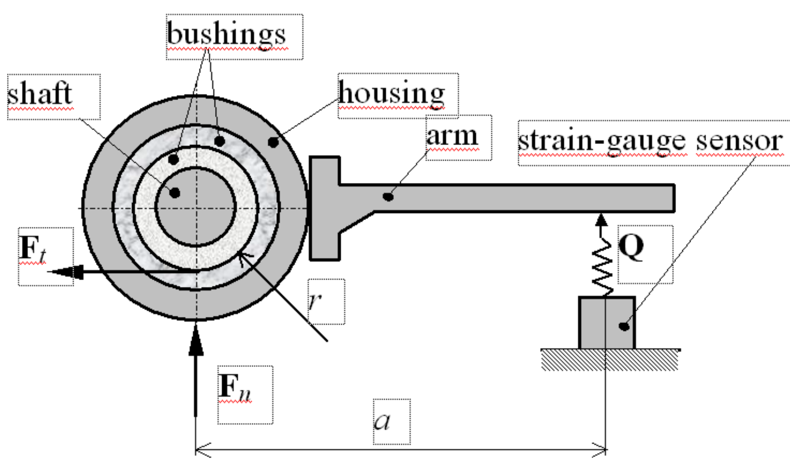
$$\mu = \frac{M}{F\, r} \quad [-] \qquad (4)$$

When evaluating the friction processes the quantification of parameters which characterise them are important. Coefficient of friction is the primary factor that characterizes the process of friction. It is a that parameter, which specifies the ratio between the size of the normal load and the friction force, respectively friction moment. Equipments for experimental tests of friction use principally different solutions. Measurement of the individual variables depends on the type of technical equipment.

3. Measurement of the coefficient of friction by test-machine Tribotestor`89

Test equipment Tribotestor`89 is appointed for quite fast ascertainment of characteristics of rotational sliding joint. Equipment enables providing 4 elemental tests: limited loading test, test speed load, strength test for assignment of p-v diagram and of life test. It is possible to simulate operational conditions of work of sliding joint. Working variables are: loading force (*F*) - its variation and size, sliding speed (*v*) - its variation and size, duration (*t*). Test machine consists of mechanical part, electronical equipment and control desk. Software serves for control of equipment and also for entering parameters of the test, collection and archivation of measured data. Sliding pair under test consists of internal bushing on the shaft and external fixed bushing in the housing. Scheme of sliding pair is in the Fig. 4. Shaft is supported to the machine part under test to transfer motor speed to internal bushing.

Fig. 4 Scheme of sliding pair

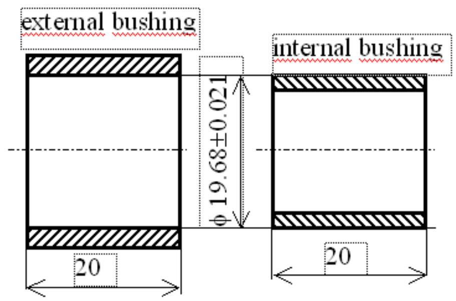


As a consequence of a friction which is a result from rotation of test shaft and from housing there is heeling moment of friction on an arm. Heeling moment of friction is transferred by arm to strain-gauge sensor of force of friction. On the basis of detached force of friction and known loading force the coefficent of friction is calculated by programme similarly as in relation (4):

$$\mu = \frac{Q\, a}{F_n\, r} \quad [-] \qquad (5)$$

Arm (*a*) was set to 150 mm. The loading force is defined by spring across stepping electomotor and screw gearing. Stepping electomotor is controlled by computer. Structural parameters of both bushings are illustrated in Fig. 5. Steel STN 12060 is material of internal bushing. This internal bushing was used during all tests. External bushings were made of brass STN 423213. External bushings were changed while testing.

Fig. 5 Important parameters of bushings



During all tests sliding joint was lubricated by the same lubricant - mineral gear oil (CASTROL Manual – EP 80W). While testing following input variables were fixed:

- sliding speed (*v*) 0.8 $m \cdot s^{-1}$
- duration 2400 s
- loading (F_n) 50 N – 500 N

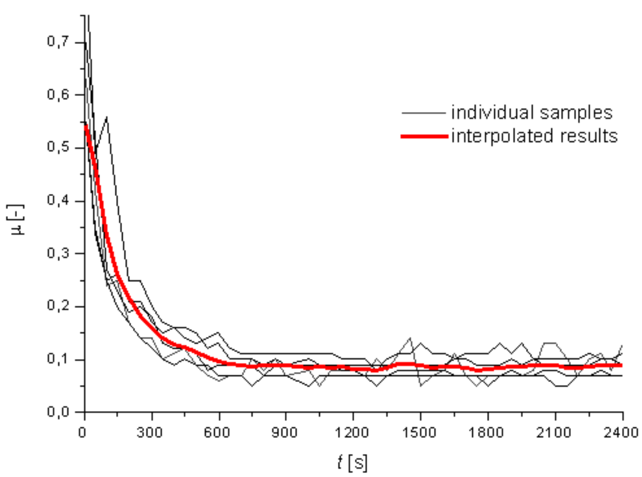
Process of load was increased from level 50 N to 500 N during run up 600 s, then run up the level 500 N was held. Given parameters of load were chosen on the basis of recommended value of sliding speed and loading force in technical literature (Barysz, I. et al., 1995, Rusnák,J., 2005).

4. Results

Coefficient of friction and temperature depending on the time have been analysed from the results of the measurements by test-machine Tribotestor`89. Results are represented in the graphs, which show changes in the output tribology parameters.

The figure 6 shows course of the coeficient of friction for individual tests bushing from which resulting course was obtained. During the run up (first 600 s of the test), the value of the coefficient of friction sharply decreased from 0.55 to size 0.09 and then it stabilized at 0.09 till the end.

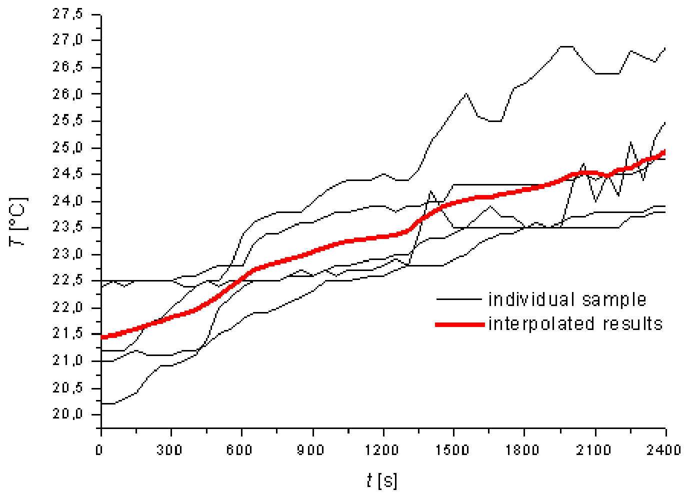
Fig. 6 Variation of the coeficient of friction



Variation of temperature was detected at contact sliding surface by thermoeletric sensor. While individual testing value of the temperature changed on average by 3.52 °C, Fig. 7.

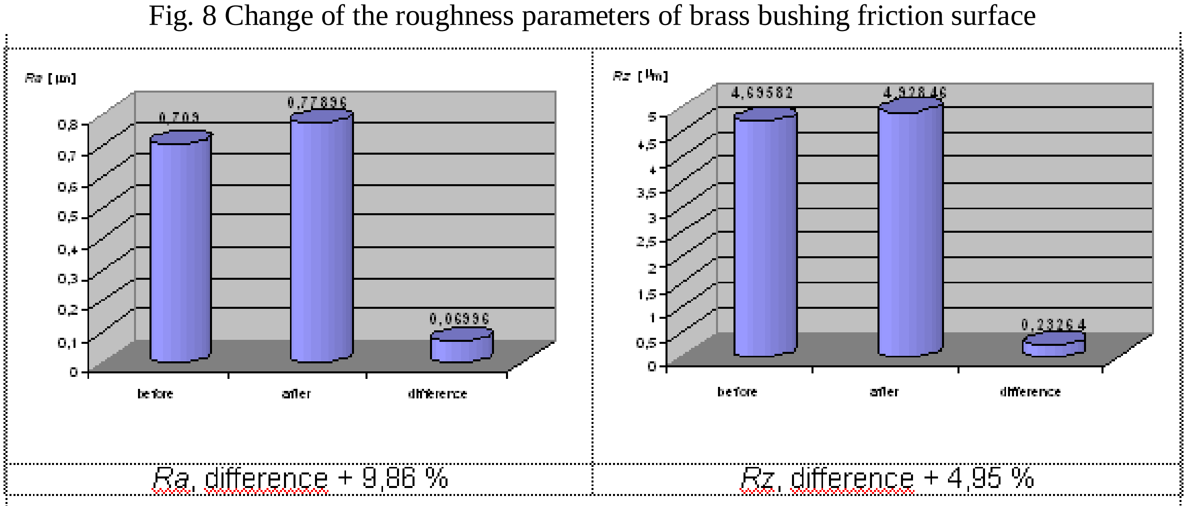
Fluctuating values of temperature might be included by non-even lubrication of contact surface. Temperature was rising not only during the running while size if loading force was rising up too, but during all time of test. It means that temperature was growing although size of the loading force was constant.

Fig. 7 Variation of the temperature in the contact surface



Changes of friction surfaces were recorded by measuring by surface rougness tester TR-200. Measurements of external bushing were made on supposed areas of contact with another surface. Measurements of internal bushing were made on whole circumference. 10 measurements were always realised and then arithmetic average was calculated. Monitored parameters were *Ra* and *Rz*. The value of Ra represents the mean arithmetic tolerance profile. Value *Rz* represents the mean value of profile`s high divided into several pieces. Parameter *Rz* informs less about general state of the surface but it considers accidental extreme disparities of the surface. That`s why paramenter *Rz* fits *Ra*. As presented in the Fig. 8 there, has been growth of both the values *Ra* and *Rz* while testing.

Fig. 8 Change of the roughness parameters of brass bushing friction surface



5. Conlusion

The procedure of the realised experimental tests of the detection of tribology characteristics in sliding joint is described in the contribution. During the tests the characteristics of the coefficient of friction (μ), the temperature in the place of contact surfaces (*T*) and roughness of the surface (*Ra* and *Rz*) were monitored. The sliding pair was formed from the fixed bushing made of brass in the housing and rotating busihg made of steel drives on to shaft.

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