THE RELATION BETWEEN TRIBOMODEL AND TRIBOSYSTEM FOR SLIDING BEARINGS

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ABSTRACT

Specialists recommend using tribomodels for material characterisation, especially when friction and wear may be important. Specialised literature contains some models of passing from tribomodel to actual tribosystem. This notice presents the importance of tribomodelling and how to pass to the actual tribosystem, using adequate testing equipment.

KEYWORDS: boundary friction, tribosystem, tribomodel, physical modelling.

In the actual development stage the manufacturing of machines and aggregates is related to costs. This requires the efficiency improvement of all stages in the production of machines and aggregates: designing, execution and exploitation.

Today’s industrial units extensively use facilities operating at very high loading and speed, resulting in the necessity to study the actual tribosystem properties from the tribological point of view. Nonetheless, this is an expensive and lasting process, for which reason the physical modelling of the respective processes on less expensive laboratory tribomodels is required.

METHODS OF PHYSICAL MODELLING

Physical modelling implies the study of friction processes on tribomodels using special laboratory facilities (stands). The modelling characteristic is that the tribomodel keeps the basic properties of the actual tribosystem, for example: the pair of involved materials, loading diagram, lubricating conditions and medium, friction nature etc. Based on the results obtained on the tribomodel, some conclusions can be drawn regarding the evolution of the processes on the tribosystem, if the transition relation from the tribomodel to the actual tribosystem is found.

In the case of the boundary friction of the sliding bearings, the paper [1] shows the transition from the tribomodel to the tribosystem by finding the relation among the friction coefficient, wear rate and temperature, as a function of the information given by the tribomodel. Operational relations are suggested as follows:

\[ \phi (N, v, K_F, \alpha, A_f, Q, t, I) = 0 \]

\[ f (N, v, K_F, \alpha, A_f, Q, t, F_f) = 0, \] (1)

where:
- \( N \) – bearing load, [N];
- \( v \) – sliding speed between contact surfaces, [m/s];
- \( K_F \) – coefficient for shape and size, [m\(^{-1}\)];
- \( \alpha \) – coefficient considering the value of the material internal friction, [dB/m];
- \( A_f \) – specific friction mechanical work, [j/m\(^3\)];
- \( Q \) – mass consumption of lubricant, [kg/s];
- \( T \) – duration of transitory conditions until reaching the boundary lubrication conditions, [s];
- \( I \) – wear rate, [m\(^3\)/s];
- \( F_f \) – friction force between triboelements, [N].

The coefficient for shape and size considers both the ratio of the contact surfaces of triboelements, as well as the ratio of their volumes. It is determined by means of the relation below:

\[ K_F = \frac{S_0}{\sqrt{V_0} / K_a} \] (2)

where:
- \( S_0 \) (S) – contact surface of the fixed (mobile) triboelement;
- \( V_0 \) (V) – volume of the fixed (mobile) triboelement;
- \( K_a \) – mutual coverage coefficient; \( K_a = S_0 / S \).

Based on experimental determinations, the authors of the paper [1] defined the dependence relations for the wear rate, friction force and duration before reaching the boundary conditions:

\[ \pi_1 = \frac{1}{1 \cdot A_f^3 \cdot Q^3 \cdot K_F^3 \cdot \alpha^3} \] (3)
rate and friction force, on the one hand, and the will be useful to determine relations between the wear processes occurring in the sliding bearings under boundary lubrication conditions. For this purpose, it can be calculated by the relationship:

$$\pi_F = \frac{1}{F \cdot K_F} \cdot \frac{1}{\alpha^3} \cdot \frac{1}{N^3 \cdot \eta^3 \cdot Q^3 \cdot A^3}$$  \hspace{1cm} (4)$$

$$\pi_t = \frac{1}{Q^3 \cdot A^3 \cdot K_F} \cdot \frac{t \cdot N^3 \cdot \eta^3 \cdot \alpha^3}{2}$$  \hspace{1cm} (5)$$

Based on these relations, the transition from the tribomodel to the tribosystem was made as a function of the previously shown parameters and the measured values.

Thus, if the wear rate on the model (I_{TM}) is measured, the wear rate on the friction system (I_{TS}) can be determined:

$$t_{TS} = t_{TM} \cdot \left( \frac{N_{TM}}{N_{TS}} \right)^{\frac{2}{3}} \cdot \left( \frac{\eta_{TM}}{\eta_{TS}} \right)^{\frac{2}{3}} \cdot \left( \frac{K_{TM}}{K_{TS}} \right)^{\frac{2}{3}} \cdot \left( \frac{\alpha_{TM}}{\alpha_{TS}} \right)^{\frac{2}{3}} \cdot \left( \frac{Q_{TM}}{Q_{TS}} \right)^{\frac{1}{3}} \cdot \left( \frac{A_{TM}}{A_{TS}} \right)^{\frac{1}{3}} \cdot \left( \frac{\pi_{TM}}{\pi_{TS}} \right)^{\frac{1}{3}}$$  \hspace{1cm} (6)$$

If the friction force on the model is measured, then the friction force on the friction system can also be calculated by the relationship:

$$f_{TS} = f_{TM} \cdot \left( \frac{N_{TM}}{N_{TS}} \right)^{\frac{2}{3}} \cdot \left( \frac{\eta_{TM}}{\eta_{TS}} \right)^{\frac{2}{3}} \cdot \left( \frac{K_{TM}}{K_{TS}} \right)^{\frac{2}{3}} \cdot \left( \frac{\alpha_{TM}}{\alpha_{TS}} \right)^{\frac{2}{3}} \cdot \left( \frac{Q_{TM}}{Q_{TS}} \right)^{\frac{1}{3}} \cdot \left( \frac{A_{TM}}{A_{TS}} \right)^{\frac{1}{3}} \cdot \left( \frac{\pi_{TM}}{\pi_{TS}} \right)^{\frac{1}{3}}$$  \hspace{1cm} (7)$$

For calculating the transitory conditions duration on the tribosystem for the same wear rates as on the tribomodel, by means of measuring the duration on the tribomodel, the following relation is applied:

$$t_{TS} = t_{TM} \cdot \left( \frac{N_{TM}}{N_{TS}} \right)^{\frac{2}{3}} \cdot \left( \frac{\eta_{TM}}{\eta_{TS}} \right)^{\frac{2}{3}} \cdot \left( \frac{K_{TM}}{K_{TS}} \right)^{\frac{2}{3}} \cdot \left( \frac{\alpha_{TM}}{\alpha_{TS}} \right)^{\frac{2}{3}} \cdot \left( \frac{Q_{TM}}{Q_{TS}} \right)^{\frac{1}{3}} \cdot \left( \frac{A_{TM}}{A_{TS}} \right)^{\frac{1}{3}} \cdot \left( \frac{\pi_{TM}}{\pi_{TS}} \right)^{\frac{1}{3}}$$  \hspace{1cm} (8)$$

**CONCLUSIONS**

Considering the suggested modelling, the author proposes that taking into account other parameters as well (for example: surface layer parameters, bearing dimensions, hardness of contact surfaces etc.) it can result a more accurate estimation of the friction and wear processes occurring in the sliding bearings under boundary lubrication conditions. For this purpose, it will be useful to determine relations between the wear rate and friction force, on the one hand, and the following parameters, on the other hand: contact pressure, contact surface roughness, their hardness and lubricant. After determining such relations, the next step would be the transition from the tribomodel to the actual tribosystem according to the previously shown methodology where the condition is imposed that the wear process on the friction model should have the same progress as on the friction system.

The approach of passing from tribomodel to tribosystem has to be done in a systematic way, taking into account the model (fig.1) proposed in [2] for sliding bearings. So, the parameters influencing the friction processes are grouped in two:

A. superficial layer parameters:
- microgeometry (X1)
- mechanical characteristics as hardness (X2),
- composition (X3),
- stress state (X3),
- characterisations (X5) and structure characterisations (X5),
B. commanding parameters:
- design: sizes (U1), shapes (U2),
- exploitation: kinematics (U3), energetic (loading) (U4), medium (U5).

**REFERENCES**


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