Considerations on Certain Tribological Aspects of the System Brake Shoe–Drum

Miőriţa Ungureanu¹, Vasile Nasui²

Abstract: The paper presents some considerations about the tribological system brake shoe-drum in the braking process to mining hoisting machines. Below are presented the components of the tribosystem, its parameters and the analysis of the functional parameters for braking process.

Key words: tribological system, parameters, braking process.

1 INTRODUCTION

The brake shoe-drum tribosystem

An assembly of elements interconnected by structure and function define a system. Czihoş [6], presents in a general manner the tribomechanical system. According him is an entity whose technical functions are related to the interactions of the surfaces in relative movement" establishing its frame content and main characteristics.

The specific problem of each tribological system, especially complex, can be approached systematically in an unitary form. [12]

The mechanical tribosystems are grouped into five categories:
- Tribosystems of guiding of movement;
- Tribosystems of information transfer;
- Tribosystems of transmission of load;
- Tribosystems of material transport;
- Tribosystems of fabrication.

The study and previous research on friction processes, aging processes and lubrication and also on their implications have been conducted on each trybosystem.

A trybosystem has the following characteristics (Fig.1):

![Fig. 1. The general structure of a tribosystem](image-url)
• Element 1, 2, 3, ..., n;
• Relevant properties of Element 1, 2, 3, ..., n;
• Specific relations between the elements of the system.

2. THE SHOE-DRUM BRAKING TRIBOSYSTEM STRUCTURE

To determine the structure of the brake shoe-drum friction tribosystem we start from the general relations of tribosystems and from the functional scheme of the braking system (Fig. 3),

\[ S_{TP} = \{ E_{TP} \cdot P_{TP} \cdot R_{TP} \} \]

where:
- \( E_{TP} \) – structure elements
- \( E_{TP} = \{ E_1, E_2, E_i, E_n \} \)
- \( i=1 \ldots n \), current number of material elements of the system
- \( P_{TP} \) – relevant properties of the element
- \( P_{TP} = \bigcup P_{i_1}(E_1) \bigcup P_{i_2}(E_2) \cdots \bigcup P_{i_j}(E_n) \)
- \( j=1 \ldots n \), current number of the property
- \( R_{TP} \) – specific relations between elements

![Fig. 2. The shoe-drum braking tribosystem structure](image1)

Entrances \([X]\), exits \([Y]\)
1) Entrances \(X\) are considered the dates of the braking process, that is the process parameters.
2) Exits \(Y\) are represented by the wear parameters of the shoe and drum, the quality parameters of the braking process (e.g., the braking duration), energetical parameters of the process (the transformation of braking work in heat).

The Function of Tribosystem \( T \)

In order to reach the aim – the stop of the drum—the function of the system is the transformation of the entrances into exits with the help of a transfer function \( T \). The transfer function is the one that shapes the process by an equation of the type:

\[ X \xrightarrow{T} Y \]

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The shaping is located on material level as well as on energetical and informational also[7]. In conclusion, the movements of the tribosystem elements are taken into consideration, movements appeared as a sequence of the application of a force, the transformations of the elements during the process, the influence of disturbing factors on the process as well as the analysis of the losses.

On the basis of the above said we can build the general scheme of the friction tribosystem, scheme that thus becomes the start reference point for ulterior using. These will consider the type of hoisting machines, the state of the system at the moment of the braking process (the position of the cage, the speed of the system).

3. THE ANALYSIS OF THE FUNCTIONAL PARAMETERS THAT INFLUENCE THE TRIBOLOGICAL SYSTEM FOR A 2Ț3,5X1,7A MACHINE

As resulted from the tribosystem scheme (Fig. 3), for the study of the coupling under tribological aspect, the following process parameters are of interest:
- The contact pressure between the shoe and the drum (for studying the wear and the deformations);
- The braking work (for studying the heating of coupling elements).

3.1 The Contact Pressure between the shoe and the drum

The distribution of specific pressures on friction surfaces between the shoe and the drum determines the type of the wear and influences its durability [2]. As research [3],[13] prove, for the brakes where the force developed by the actioning mechanism is a basic parameter, after the running, the wearing of the shoes on the length levels and establishes as uniform, in these conditions the distribution of the pressures can be considered constant and uniform on all the contact length.

The external forces that act on the drum and determine the contact pressures are (Fig. 4):

\[ T = \mu \cdot N \] (6)

- \( \mu \) - the friction coefficient between the she and the rim
- The contact pressure between the shoe and the drum is determined:

\[ P = \frac{N}{S} \] (7)

S - the drum contact surface of a shoe

\[ S = b \cdot l \] (8)

where:
- b - the width of the shoe,
- l - the length of the shoe.

The contact pressure is conditioned by the forces developed by the actioning device. The normal force in this case is determined by the relation [8]:

\[ N = \frac{G_0 \cdot d \cdot z \cdot f \cdot k_1 \cdot n}{8 \cdot c^2 \cdot k_1 \cdot n} \] (9)

where:
- \( G_0 \) - the transverse elasticity module of the arch material
- d - the diameter of arch material ,
- z - number of the arches in the package (floor)
- f – deformation of arches in braking position
- c – the ratio between the medium diameter of the arches \( D_m \) and the diameter of the round steel:

\[ c = \frac{D_m}{d} \] (10)
• n – the number of working coils of the arches;
• \( k_i \) - coefficient, to end the relation:

\[
k_i = 1 + \frac{1}{2c} - \frac{1}{2c^2}
\]  

(11)

For this system the friction force is:

\[
T = \mu \cdot \frac{G_0 \cdot d \cdot z \cdot f_i}{8 \cdot c^3 \cdot k_i \cdot n} \cdot i
\]

(12)

\[
p = \frac{N}{b \cdot l}
\]

(13)

\[
p = \frac{G_0 \cdot d \cdot z \cdot f_i}{8 \cdot c^3 \cdot k_i \cdot n}
\]  

(14)

Starting form the equation (14) we analyse the variation of the specific contact pressure of the shoe with the rim according to the deformation of the arches (Fig. 5).

\[P_i = 2.651 \times 10^5\]

\[\varphi_0, \theta_0, t_f, 47.5\]

Fig. 5. The contact pressure \( P_f \) \( (N/m^2) \) function of deformation of arches \( f_i \) (mm)

3.2 The determination of the braking work

In mining there are used different types of hoisting machines, with different tachograms of speed and acceleration. As a conclusion the determination of an analytical method of calculation of the braking work generally applicable is difficult to realise [4][14].

Expressing the work realised by a shoe over the braking process by the formula:

\[
L_{f1} = \int_0^{t_f} M_{f1} \cdot \omega_f \cdot dt
\]

(15)

\[
M_{f1} = \mu \cdot N \cdot R
\]

(16)

The braking moment developed by the two shoe-brakes applied to the drums is established as being the sum of the moments created on each shoe, if all four shoes develop the same moment of braking and work simultaneously then:

\[
M_{f(i)} = 4M_{f1(i)}
\]

(17)

where:
• \( M_{f(i)} \) - is the moment of braking developed by a shoe
• \( M_{f1(i)} = \mu \cdot R \cdot N_{(i)} \)
• \( R \) - radius drum (friction)
• \( N_{(i)} \) - the result of normal pressing forces of the shoe on the drum
• \( \mu \) - the friction coefficient between the shoe and the drum

\[
L_{f1} = \int_0^{t_f} \mu \cdot N \cdot R \cdot \omega_f \cdot d_i = \mu \cdot R \int_0^{t_f} N \cdot \omega_f \cdot d_i
\]

(19)

As it can be observed by formula (19) the basic components on which the braking work depends are:
• The angular braking speed \( \omega \);
• The result of normal pushing forces on the rim \( N \).

But \( N \) - has a variable character and \( \omega \) - has a variable character.

As a conclusion, the braking work is a time function and depends on the angular speed of the rim and the normal force resulted by pressing the shoe on the drum.

4. CONCLUSIONS

The paper represents a part of the research on braking systems on mining hoisting machines.

On the basis of describing the technical function of the friction tribosystem shoe-drum we can realise the analysis process for different real situations (for different hoisting machines, for different types of braking, for different environmental conditions). In this paper it has been exemplified the manner of determining the main functional parameters that influence the tribological system for the hoisting machine 2Т3,5x1,7A.

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