Influence of the specific sliding work on tribological parameters of friction linings for heavy vehicle clutches

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Abstract

Motor vehicle friction clutches still have dominant application in motor vehicles. Besides the fact that it`s basic concept is not changed, the quality and performance requirements are more rigorous. Fulfillment of these requirements seeks further development of friction lining material structure, and also development of manufacturing technol-ogy. The complex and profound nonlinear influence of the individual material components on clutch characteristics request continuous research of their interconnection.

This paper shows the way of organizing this research, in order to determine the correlation between the tribological parameters and specific sliding work in the process of actuating the clutch.

Key words: motor vehicles, friction linings, clutches, tribological parameters.

Introduction

Friction clutch is mechanism which is located between the vehicle engine and its gearbox. The clutch transmits the torque from the propulsion to the transmission. The main reason for the insufficient lifetime of the clutch is the sliding work which appears in the process of clutch engaging and disengaging [1]. That leads to outwear and also can lead to burning through of the friction lining [2].

Consequently the friction lining should be characterized with high quality expressed through its trigological parameters, which are:

-coefficient of friction between the friction surfaces μ (-)

–specific outwear of the lining θ(cm^3/10MJ)

The coefficient of the friction should be stableduring temperature change, the specific pressure and the sliding speed in the friction connection. In addition to the given terms, the specific outwear which presents the ratio of the volume of outwear lining and the total sliding work, should have small value.

Numerous researches available in literature point to the non-linear nature of the friction [3].
As result, efforts are made for continuously improvement of the friction lining structures which are constantly monitored by examining such effects on the individual clutch work characteristics[4], [5], [6], [7] and [8].

Analyzing the factors that most directly affect the value of the sliding work, it can be accepted that the dominant effect has the value of the specific sliding work in the process of connecting q (J/cm^2). It is the ratio between the total sliding work L (J) in the process of engaging the clutch and the verall contact surface of the friction connection Af (cm^2). Starting from the fact that with increasing of specific connection work increases the specific lining outwear θ and thereby ncreases the temperature in the friction contact what directly affects the change in the value of the friction coefficient μ, there is a need for termining the interdependence of changes in value q = q(μ, θ).

1. Research purpose and task

Based on what was given above as a purpose and task of these research is to determine the character of the dependence of specific outwear θ and friction coefficient of friction connection μ of the pecific sliding work q.

2. Research methodology

Research methodology includes the study of the available knowledge and experience of clutch and lining manufacturers as well as the literature data; own experimental research of the influence of the change of specific sliding work when engaging the clutch q to the change of the friction coefficient and μ and specific clutch outwear θ; analysis of the results and conclusions.

3. Research

3.1 State

Friction lining quality is checked by the manufacturers on the basis of tests and through determining their heat and tribological haracteristics.

The main tests are determining the abrasive adhesion changes between the surfaces that are in friction. As a criteria for the quality of lining is taken that friction coefficient μ should have greater value than 0.22, whilst there is no abrasive-adhesion phenomena in the contact between the surfaces in friction. Tribological tests are determining the change of the friction coefficient μ depending on temperature in the contact, from the specific sliding work q in the process of engaging, etc.

According to available information some manufactures perform the following tests given in table 1, 2 and 3.

Tests are performed on a test bench that works in regime of braking so that sliding time (braking) of clutch is adjusted and the number of clutch actuating (engaging) is one engaging per 2 minutes.

determine on the temperature on the friction surfaces.

3.2 Own research

In order to evaluate the influence of specific sliding work q on tribological parameters (μ, θ) of friction lining and starting from the technical capabilities of the available test equipment the fol lowing program is adopted.

1. Tests were performed on test benches for clutches (figure 1) that operates on the principles running rotating masses which generate torque equivalent to the moment of inertia of the vehicle whose clutch is tested.

2. Based on capability analysis of the test bench which is a product of the company Fichtel Sacks – type K-D-14 – Germany, and on the products of main lining manufactures it is adopted the test to be performed with dimensions f350/f195/3.5, often used in vehicles. Tests are performed for 2 regimes:

–Regime A - Testing of thermal loading

–Regime B - Testing to determine the tribological parametars

In the tables 4 and 5 are given test indicators under regimes A and B.

Table number 1 - Regime of testing performed by the company Borg-Beck from England

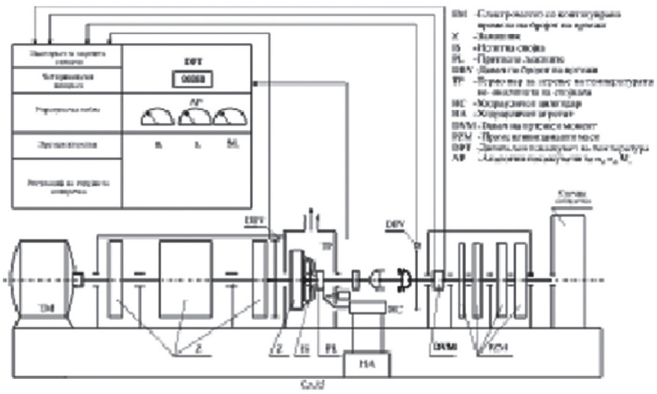
	dimension	Test 1	Test 2	Test 3	Test 4
specific work	J/cm^2	60	230	880	330
time of stopping	s	1	4	15	4
number of cycles	-	40	50	1	1
number of actuating	1/min	0,5	0,5	0,5	0,5
Temperature between friction surfaces <500° C					

Table number 2 - Regime of testing performed by the company Raybestos from Germany

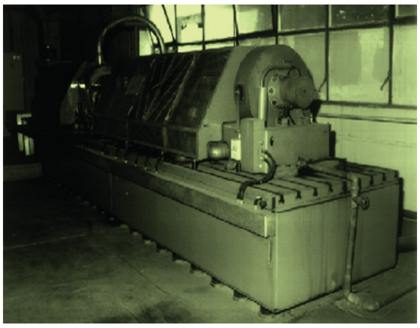
	dimension	Test 1	Test 2	Test 3
specific work	J/cm^2	160	230	340
number of actuating	1/min	1	1	1
number of cycles	-	45	45	45
Friction coefficient **μ_{min}>0,22**				

Table number 3 - Regime of testing performed by the company Borg-Beck from Italy

	dimension	Test 1	Test 2	Test 3
specific work	J/cm^2	80	170	250
number of cycles	-	1110	550	360
Temperature between friction surfaces (170-210) ° C				



a



b

Figure 1. Schematic preview and photography of test bench for friction clutches

Tests for determining the tribological parameters are quantified by specific work load, including:

test-1: Normal load when specific work is (40-60)J/cm^2 and temperature between friction surfaces is T~(150-170) °C ,

test-2: Heavy load when specific work is (80-100)J/cm^2 and temperature between friction surfaces is T~(200-220) °C,

test-3: Heavier load when specific work is (~150)J/cm^2 and temperature between friction surfaces is T~(220-250) °C

test-4: Very heavy load when specific work is (»200)J/cm2 and temperature between friction surfaces is T~(250-280) °C,

During the exploitation vehicles are loaded on average 80% of nominal load and 20% with heavy load. Very heavy load appears only in some extreme cases, but for security in this cases control of load is performed.

3. In order to obtain reliable indicators tests are performed on 6 linings from each manufacturer. The test is conducted with prior alignment of friction surfaces with 500 cycles of load according totest 1B after which were performed prior measurements to flatness of the surface and to the thickness of the lining. After this preparation is done, the test of tribological parameters is conducted according to the indicators of table 5.

3.3 Test results

Based on conducted tests, results about tribologigal parameters i.e. about their dependents on the specific sliding work in the process of connecting are obtained. The results mean value of testing the samples are shown diagrammatic as follows:

- On the figure 2 diagram are presented the results for lining of manufacturer T1,
- On the figure 3 diagram are presented the results for lining of manufacturer T2, and
- On the figure 4 diagram are presented the results for lining of manufacturer T3.

Table4

Test regime A	dimension	Test 1	Test 2	Test 3
number of revolutions	1/min	1900	1900	1900
specific work	J/cm^2	66	209	323
frequency of engaging	1/min	0,6	0,6	1,2
number of cycles	-	40	50	25

Table 5

Test regime B	dimension	Test 1	Test 2	Test 3	Test 4
number of revolutions	1/min	1600	1600	1600	1600
specific work	J/cm^2	46	107	149	210
frequency of engaging	1/min	1,5	1,5	1,5	1,5
number of cycles		1000	1000	250	90

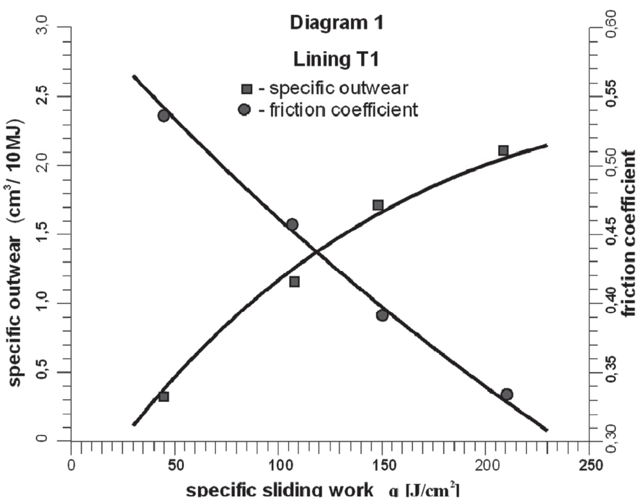


Figure 2. Diagram of the trobological parameter change a = a(μ, ϑ) for friction lining, product of the manufacturer T1 – Ruen Kocani

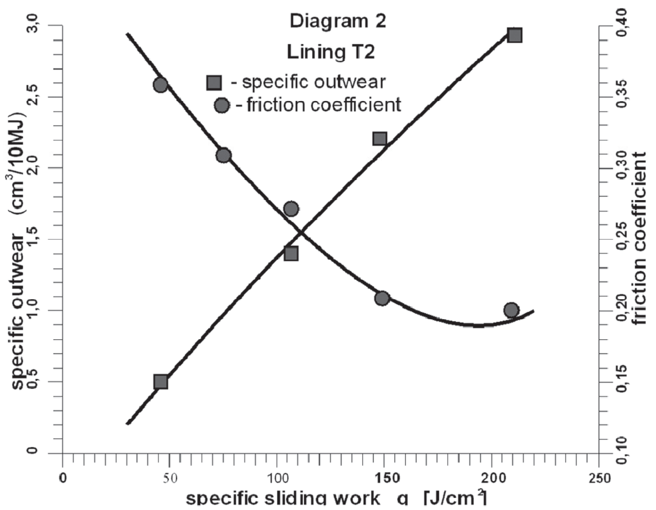


Figure 3. Diagram of the trobological parameter change a = a(μ, ϑ) for friction lining, product of the manufacturer T2 – Fiaz Mladenovac

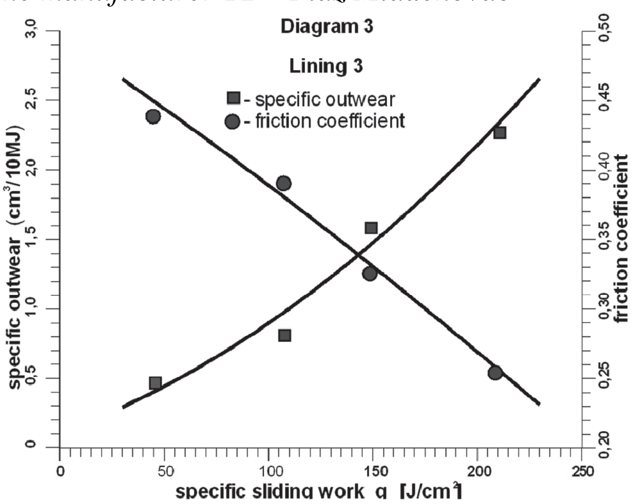


Figure 4. Diagram of the trobological parameter change a = a(μ, ϑ) for friction lining, product of the manufacturer T3 – Raybestos Germany

3.4 Analysis and conclusions

According to the performed tests, the following conclusion can be drawn:

- For the three types of the lining there are different values for the friction coefficient and the specific outwear depending on specific working load. This difference occurs due to their different quality.
- All three types of linings have in common that by increasing the specific working load the friction coefficient decreases and the specific lining outwear increases.
- Conducted tests provide an opportunity for further research in the field of determining of lining quality in terms of their structure and manufacture technology in order to achieve better tribological parameters.

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