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INFLUENCE OF THE NUMBER OF THE CLUTCH ENGAGEMENTS ON THE WEARING OF FRICTION LININGS OF MOTOR VEHICLE CLUTCHES

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Subject review

Friction clutches are still dominantly used in road motor vehicles. Beside the fact that the basic concept remains the same, requirements for quality and performance are becoming stronger and stronger. Further development of the friction linings structure and production technology is crucial for fulfilling the requirements. This paper shows how the research was organized in order to determine the influence of the number of cycles on lining wearing at different temperatures of friction surfaces.

Keywords: *friction clutches, linings, motor vehicles, parameters*

Utjecaj broja uključivanja spojke na trošenje tarnih obloga spojki motornih vozila

Pregledni članak

Tarne spojke se još uvijek dominantno koriste u cestovnim motornim vozilima. Uz činjenicu da osnovni koncept ostaje isti, zahtjevi za kvalitetom i radnim svojstvima su jači i jači. Daljnji razvoj konstrukcije tarnih obloga i tehnologije proizvodnje od presudne je važnosti za ispunjenje zahtjeva. U radu se pokazuje kako je organizirano istraživanje radi utvrđivanja utjecaja broja ciklusa na trošenje obloga pri različitim temperaturama tarnih površina.

Ključne riječi: *motorna vozila, obloge, parametri, tarne spojke*

1 Introduction

A clutch is a friction mechanism, which is placed between the engine and the gear box. It transfers the torque from driving to working part. For efficient transformation of the torque, the quality of the friction pair flywheel-lining-pressure plate has big influence. [8]

Basic reason for the insufficient life of the clutch is the occurrence of sliding in the process of engagement, disengagement and overload of the clutch. In order to increase the life of the clutch a big effort has been done to improve the quality of friction linings, which is needed to fulfill some technical requirements [3, 5].

The wearing of lining depends on the composition of the friction material and its technology of production, clutch friction elements, clutch construction, the number of the clutch engagements and disengagements and so on.

Testing of linings quality is accomplished by different treatments. The linings are tested standalone or in an assembly with the clutch. The testing of the standalone sample does not give realistic results for the lining quality. These are used by manufacturer's linings for the sole purpose of maintaining the quality of linings; they use their experience in the production of linings. The testing of the assembly of clutch and linings can be exploitation and laboratory. Exploitation testing is expensive and time consuming. The laboratory testing is cheap and short.

2 Aim of the research

The aim of the research is to determine the dependence of the number of cycles on the lining wearing at different temperatures of friction surfaces.

3 Research

To determine the dependence of lining wearing of the number of cycles (engagement - disengagement), testing is performed on friction linings.

There are 2 models of the test benches. One of them works in conditions of braking, and the other test bench works with moving of certain rotary mass.

- In the first case the clutch works in conditions of braking, providing that the kinetic energy of rotary mass has been spent in the clutch which is a brake (Fig. 1).

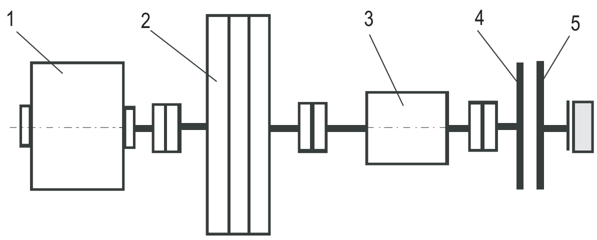

Figure 1 Test table works in condition of braking (1 - drive engine, 2 - rotary mass, 3 - transmitter, 4 - moving parts of the clutch and 5 - fixed parts of the clutch)

In the second case the clutch is loaded in the following way: from the state of rest, certain rotary mass is moved, whose inertia moment is equivalent to the inertia moment of the vehicle, whose clutch is tested (Fig. 2).

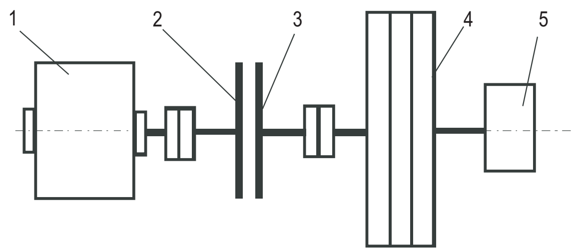

Figure 2 The test bench works with certain mass moved (1 - drive engine, 2 - driving parts of the clutch, 3 - working parts of the clutch, 4 - rotary mass and 5 - brake)

- Except these 2 types of test benches, there is a test bench that very often (Fig.1) inserts another clutch instead of the brake. In one of the tests, one works in terms of moving of rotary mass, and the other one in terms of braking.

Fig. 3 shows the process of the clutch engagement, when the power plant is used as an internal combustion engine (Fig. 3a) and an electric engine (Fig. 3b).

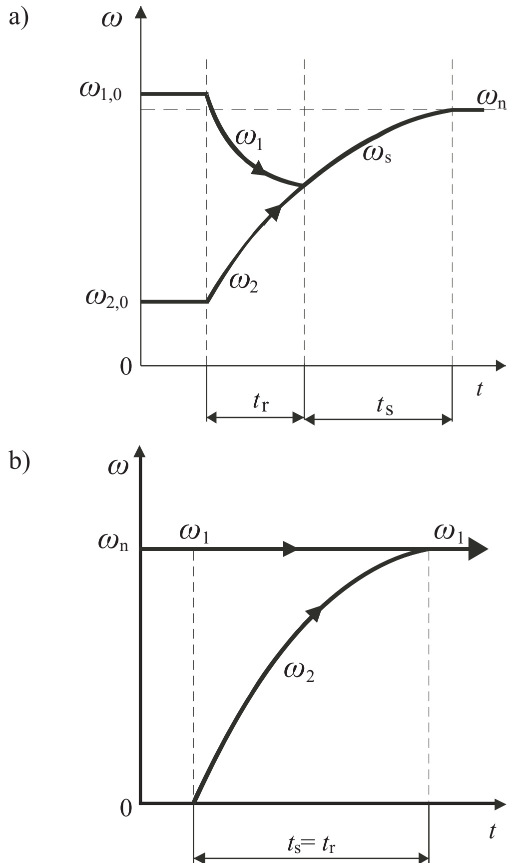

Figure 3 a) Process of the clutch engagement, with an internal combustion engine; b) Process of the clutch engagement, with an electric engine

$\omega_{1,0}$ – angular velocity of the driving part (crankshaft of the internal combustion engine), rad/s
$\omega_{2,0}$ – angular velocity of the driven part. (Drive shaft of the gearbox), rad/s
ω_1 – angular velocity of the driving part (electric engine), rad/s
ω_2 – angular velocity of the driven part (when electric power is), rad/s
ω_n – angular velocity after turning of the clutch, rad/s
t_r – time of sliding, s
t – time of acceleration of the angular velocity of the driven part, s

The period of the clutch engagement is considered, in the time t_r (the time of sliding) the angular velocity of the driven part ω_2 increases, the angular velocity of the driving part ω_1 decreases. After the time of sliding t_r passed, the two parts (driving and driven part) are accelerated with angular velocity ω_s and during t_s they gain angular velocity ω_n.

At electric engine driving can be approximately considered that the decrease in angular velocity is negligible ($\omega_s = \omega_n$ =const) and that the initial angular velocity of the driven (working) part is very small ($\omega_2 = 0$). The increasing of the angular velocity depends on the angular velocity of the driven part, the sliding time (t_r), the size of the rotary mass, the amount of torque of working part) [1, 2].

From diagrams (Fig. 3) it can be seen that, when using electric motor as a power plant, there is a slight derogation of the angular velocity ($\omega_1 = \omega_n$) and the time of sliding is equal to the time of the acceleration of the working part ($t_r = t_s$), that in relation to the internal combustion engine vary ($\omega_{1,0} > \omega_n$). The time of engagement of the clutch is the sum of the sliding time and the time of the acceleration of the working part.

The work of driving part (engine) is spent on accelerating of the driven part and the work of slipping, during the process of engagement of the clutch.

The settings are done at the test bench for clutches, which works by moving to rotating mass. According to the possibilities at the test bench and regime of the world producers of the linings and clutches can be determined the mode of testing of the friction linings, the lining dimensions ∅350×∅195×3, 5.

Test mode [3]:
$e_{wl} = 107$ J/cm^2 – specific working load
$n = 1600$ 1/min – number of the revolutions per minute
$J = 10,22$ kg·m^2 – inertia moment of the rotating mass.
$\vartheta \approx 150$ °C, 200 °C, 250 °C – temperature of friction surface (pressure plate)
N – number of cycles,

The 9 pairs of linings are examined, at temperatures of $\vartheta \approx 150$ °C, $\vartheta \approx 200$ °C and $\vartheta \approx 250$ °C.

Test method:

- Friction linings are riveted on the disk and together with the clutch are mounted on the test bench.
- Friction linings are submitted to 500 cycles with 75 % contact surface of the total surface of linings.
- Dismantling of the friction disc and the clutch and the test bench.
- Dismantling of linings and disc.
- Measuring the thickness of each lining of 16 places (8 places evenly to the outer diameter, 8 places evenly to the inner diameter)
- Determination of the average thickness of the lining.
- Re-assembling of the linings with hard drive installation disk, clutch and the test bench.
- Fulfillment of the test with 1000 cycles and the temperature of $\vartheta = 150$ °C, dismantling and measurement of linings (after linings wear).
- Fulfillment of the test with 2000 cycles and repetition of the procedure.
- Fulfillment of the test with 3000 cycles and repetition of the procedure.
- Fulfillment of the test at the temperature of 200 °C.
- Fulfillment of the test at the temperature of 250 °C.

The process of the test clutch engagement is shown in figure (Fig. 4). Fig. 4a shows the change of the angular velocity of electric engine, where the time of engagement of clutch can be seen and angular velocity decreases. Fig. 4b shows the change of the angular velocity of the working part, angular velocity increases are shown. Fig.4c shows the change of frictional torque.

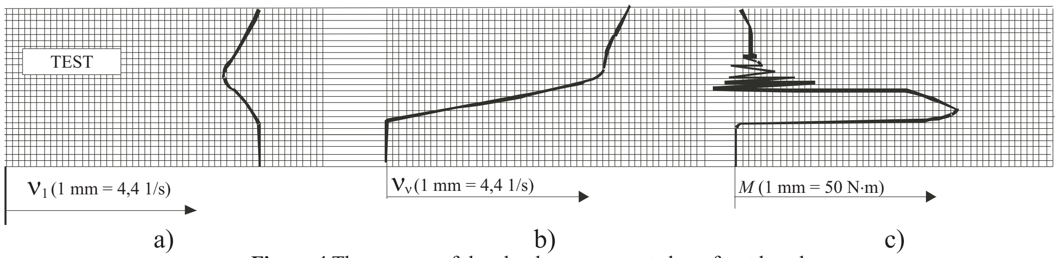

Figure 4 The process of the clutch engagement shot of test bench

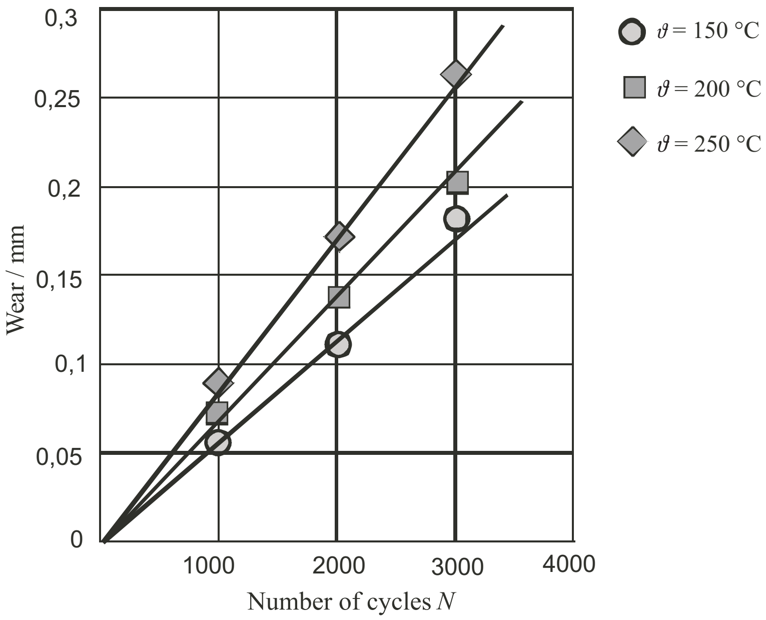

Figure 5 The results of the examination linings wear

The results of the examination are shown in Tab. 1 and Diagram (Fig. 5).

Table 1 Lining wear

Number of cycles *N*	1000	2000	3000	Temperature ϑ /°C
Wear /mm	0,056	0,115	0,179	150
Wear /mm	0,069	0,138	0,202	200
Wear /mm	0,088	0,171	0,260	250

4 Analysis and conclusions

From these tests we can draw the following conclusions:

- By increasing the number of cycles, there is an increase of the lining wear.
- Increasing the temperature the lining wear increases too.
- Dependence of the lining wear on the number of cycles is linear (at different temperatures).
- This research confirms the hypothesis – linear wearing of the linings depends on the cycle of engagement, and this allows predicting the lifetime of the linings.

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