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IMPACT OF THE SPEED OF SLIDING OF FRICTION LINING ON THE TRIBOLOGICAL PARAMETERS OF FRICTION CLUTCHES OF MOTOR VEHICLES

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Abstract: *Friction clutches are mechanisms placed between the engine and the gearbox and are used to transmit the torque from the engine of the vehicle to the transmission. The clutches should provide start and stopping of the vehicle without vibration and need to have a certain lifetime. The tribological parameters of the linings in these clutches depend on several factors: the quality of the linings, the conditions of the test (exploitation), the temperature between the friction surfaces, the specific pressure between the friction surfaces, the speed of sliding of the friction linings, the number of turns on the clutch, etc. In this paper, will be analyzed the impact of the speed of sliding of friction linings on the tribological parameters of the linings.*

Keywords: FRICTION CLUTCHE, FRICTION LINNING, SPEED OF SLIDING, TRIBOLOGICAL PARAMETERS

1. Introduction

The quality of friction lining in friction clutches is expressed by tribological parameters-coefficient of friction and specific wear. These parameters depend on the sliding that occurs during the engagement of the clutch.

The linings are made from different materials and there are various factors that determine whether a material is quality or not. These factors are: the speed, the temperature and the pressure between the friction surfaces, the number of engagements of the clutch, etc.

The temperature in the lining depends on the load and the number of engagements of the clutch in the unit time. Greater temperature in the liner is created at higher loads and at a larger number of engagement. The temperature is one of the most influential factors. It acts on the structure of the lining. The raised temperature leads to the softening of the lining, decreasing of the coefficient of friction and increasing of the specific wear of the coating. The lining in its composition should have substances that will enable removal of the heat from the lining, that is, the lining should be resistant to high temperature, provide a stable coefficient of friction and wearing within the permissible limits.

The pressure of the lining is achieved by the compressive force of diaphragm wound springs or diaphragm springs. This force creates a friction torque between the friction surfaces of the lining and the pressure plate of the clutch, which transfers the engine power to the transmission. By reducing the specific pressure between the friction surfaces, the friction torque between them decreases, the switch-on time increases, which leads to an increase in the friction and in the temperature. The increasng of the pressure leads to increas in the switch off force, so in this case, when the clutch reloads, the clutch's protective role on one side decreases, and on the other hand, the switch-on time is too short. This means that the pressure affects the temperature of the lining. The specific pressure has a greater impact on the wearing of the lining, and the smaller the friction coefficient. The wearing of the lining is the smallest at a pressure of 20 [N / mm^2]

By increasing the number of engagements of the clutch in the unit time, the temperature increases, thereby decreasing the coefficient of friction, and increasing the lining wearing. / 1/2/5 /

2. Research

The purpose of this research is to determine the impact of the sliding speed on the tribological parameters.

Determination of tribological parameters is performed according to the following expressions:

The specific workload when switching on the clutch is determined by expression [1]:

$$a = \frac{A_r}{F_{vk}} \quad \left[J/cm^2 \right] \tag{1}$$

A_r [J]- work of sliding during the engagement of the clutch

F_{vk} [cm^2] - total friction surface

$$F_{vk} = z \cdot F \ \ [\text{cm}^2] \tag{2}$$

$$F = \frac{\pi}{4} \cdot \left(D^2 - d^2 \right) \ \ [\text{cm}^2] \tag{3}$$

z- [-] number of friction surfaces

D - [cm] – outside diameter of the lining

d – [cm] – inner diameter of the lining

After determining of the specific workload, the specific heat load is determined by expression :

$$q = a \frac{x}{60} \ \ [\text{W/cm}^2] \tag{4}$$

X [1/min] – clutch engagement frequency

The work of sliding accomplished during the engagement of the clutch is :

$$A_r = \frac{1}{2} J \cdot \omega^2 \ \ [J] \tag{5}$$

$\omega [1/s]$ - angular speed on the bench test

$$\omega = \frac{\pi \cdot n}{30} \quad (6)$$

n - [1/min] – number of rotation

The specific depletion of the lining is determined by the expression :

$$\vartheta = \frac{\Delta b \cdot F}{A_{vk}} \text{ [cm}^3\text{/10MJ]} \quad (7)$$

A_{sr} [J] - average work per cycle

$$A_{vk} = \sum_{1}^{n} A_{sr} \quad (8)$$

n [-] – number of cycles

Clutch work of the sliding for a single cycle is calculated according to the expression :

$$A = \frac{M_{sr} \cdot \omega \cdot t}{2} \quad \text{[J]} \quad (9)$$

M_{sr} - the mean value of the torque read from the diagram of the machine for a given cycle

ω [1/s] - angular speed of the driven part

t [s] – time of sliding for given cycle

After determining A for each cycle, A_{sr} is determined as the mean value for one cycle, and then A_{vk} is determined as the total work from one test (product of the number of cycles and A_{sr}).

The coefficient of friction is determined by the expression :

$$\mu = \frac{M}{z \cdot r_{sr} \cdot P} \quad (10)$$

M [N m] – torque of the clutch

z – [-] number of friction surfaces

r_{sr}- [m] - average radius of friction lining

P [N] – pressing force of the clutch

$$r_{sr} = \frac{1}{2} \cdot d_{sr} \quad \text{[m]} \quad (11)$$

$$d_{sr} = \frac{2}{3} \cdot \left(\frac{D^3 - d^3}{D^2 - d^2} \right) \quad \text{[m]} \quad (12)$$

3. Experiment

The examination was carried out on a test bench with the following characteristics :

Electric motor with direct current. and having the following characteristics:

• rated power .... 204 [KW]

• nominal torque .... 955 [Nm]

• number of rotations

(with continuous change) .... (0-2,000) [1 / min]

- Main swing table with inertial torque .... 40 [kg m2]
- Shutdown time with setting .... (0-24) [mm]
- Force of disconnection .... 15 [KN]
- Torque that can be tested:

  • maximum torque .... 5.000 [Nm]

  • dynamic limit torque .... 3,500 [Nm]

- Additional inertia:

  • own inertial torque .... $J_s = 2.43$ [kg m^2]

  • inertial torque of the variable swing weights:

  1. $J_s = 1.98$ [kg m^2]
  2. $J_s = 3.79$ [kg m^2]
  3. $J_s = 5.8$ [kg m^2]
  4. $J_s = 8.07$ [kg m^2].

The following measurements were performed on the existing installation of the test bench:

- Measurement of the torque the clutch is transmitted at the moment of its engagement,
- Measuring the number of rotations of the drive unit,
- Measuring the number of rotations of the driven part,
- Measurement of the ambient temperature of the clutch

These data during the experiment are visually monitored on the given indicators of the measurement sizes.

To control the duration of a cycle, 4 potentiometers are used for individual parts of the cycle:

- t_1 - sliding time when switching on the clutch,
- t_2 - shutdown time,
- t_3 - time of slowing down the driven part,
- t_4 - time of control of the state of relative rest (this time is at time t_3).

Test mode:

- the inertial torque - 10.22 [kg · m^2]
- switching frequency 0.6 [1 / min]
- speed [m / s] (number of rotations [1 / min]):

7.13 (500), 11.4 (800), 171 (1200), 22.7 (1600)

- specific work [J / cm^2]: 10.5, 27, 60, 107

The test was performed in three samples for 4 speeds and the mean values of the tribological parameters was used:

Table 1: The mean values of the used tribological parameters

a[J/cm^2]	10.5	27	60	107
V[m/s] (n[1/min])	7,13 (500)	11,4 (800)	171 (1200)	22,7 (1600)
μ	0,45	0,44	0,42	0,40
ϑ[cm3/10Mj]	0,21	0,41	0,68	0,82

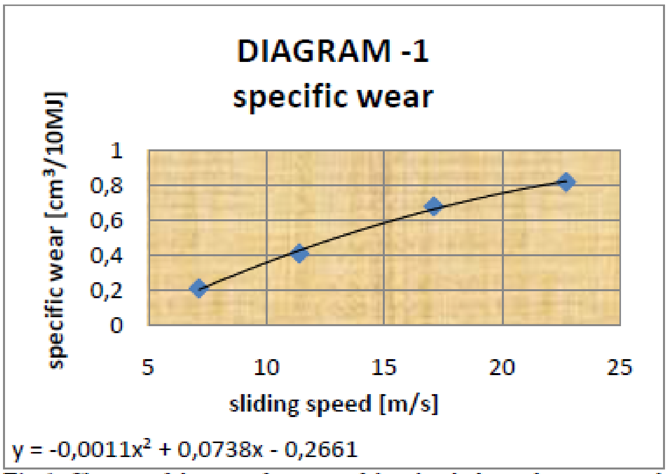

Fig.1. Change of the specific wear of the clutch depending on speed of sliding

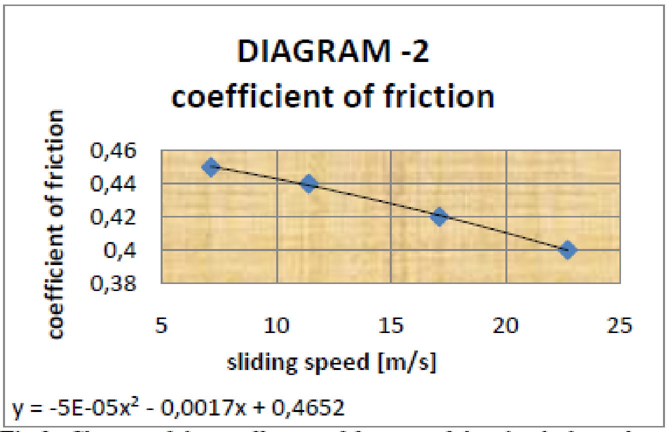

Fig.2. *Change of the coefficient of friction of the clutch depending on speed of sliding*

4. Analysis and conclusion

The speed of sliding on the friction surfaces depends on the number of rotations of the clutch and from the frictional radius of the clutch. The radius for a given clutch is constant, and the speed of sliding depends on the number of rotations of the clutch. Higher speed of sliding creates more heat on the lining, while the wearing torque, and therefore the coefficient of friction decreases. The wear of the lining is increasing. At lower speed, there is a greater friction coefficient, and less wearing.

The dependence of the frictional parameters on the speed of the tested lining is given with the expressions:

For the coefficient of friction: $y = -0{,}001x^2 + 0{,}0078x - 0{,}2661$

For specific wear: $y = -5E^{-05}x^2 - 0.0017x + 0.4652$

These diagrams refer to a certain quality of linings. With another quality, similar curves will be obtained.

The performed tests, from a methodological approach, provide the possibility for further research in the domain of determining the influential components of the structure of the material of friction clutches, on the performance of the clutch, By expanding the tests, the dependence of the coefficient of friction and the specific wear of the friction lining at different temperatures of the friction surfaces, the specific pressure between the friction surfaces, etc. can be determined.

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