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APPLICATION OF SINTERED POWDER MATERIAL FM-15 IN THE CLUTCH COUPLING OF "BELARUS-3522" TRACTORS

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The development and use of new sintered powder friction discs is an important scientific and practical task. Today, the mass-produced tractors of the "Belarus" family are equipped with dry clutch couplings; however, the world practice shows that such tractors are equipped with "wet" couplings. The carried out stand tests of the proposed development showed the possibility of application such devices provided that the required service life has been ensured.

Key words: friction disk, clutch, friction material, friction unit, counter-body, tractor.

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Introduction

The world growth of extraction and processing of natural resources, development of agriculture and construction stimulate the increased demand for auto-tractor vehicles. Any kind of auto-tractor vehicle has transmission and brake units, the main elements of which are friction discs. The most common friction discs are steel bases with friction linings applied. The application of disks of such design provides a high service life of the friction unit and stable operating parameters. World leader manufacturers of auto-tractor vehicles, such as John Deere, Claas, Case, Massey Ferguson, BelAZ, MTZ, Amkodor, Caterpillar (USA), Kamatsu (Japan), actively use friction discs in their vehicles.

The modern methodology for producing new products with high profitability is based on an approach where starting point is the required complex of operational parameters of the product, rather than a specified complex of physics and mechanical properties of its individual units. The operating conditions of the friction units are distinguished by a great variety of operational parameters: sliding speed, specific load and environmental properties and are characterized by their constant increase. Thus, the complex of operational requirements presented by the market to friction disks used in the friction units of autotractor vehicles has the following [1-3]:

- Torque – not less than 3 000 N·m;
- Specific heat load – up to 4 W/mm^2;
- Operational life – not less than 9 000 motor hours.

The development of the powder metallurgy technology made it possible to produce friction materials of a new type which are capable to satisfy the abovementioned requirements, differing in high heat resistance, tribotechnical properties in a wide variety of operating conditions. The heat conductivity of composite powder friction materials (20-30 W/m·K) is higher than the heat conductivity of polymer materials. This contributes to a much more homogeneous distribution of heat flows between the surface of the friction element and the material which is in contact with it during friction, where cast iron is in most cases. This, in turn, reduces the negative impact of thermal stresses on the surface of the disk, preventing its destruction during an operation [4-7].

Objectives: investigation of tribotechnical characteristics of the sintered powder friction material FM-15 for the clutch coupling of tractors MTZ-3522.

Materials and methods of experimental research

Friction discs with linings made of FM-15 material produced by the State Scientific Institution "Powder Metallurgy Institute" (Minsk) are designed for installation in the main clutch coupling of BELARUS-3522 tractors of 350 hp. The main application of the clutch coupling is torque transfer

from the engine to the tractor transmission. In addition, the clutch coupling should provide a full disconnection of the engine from the transmission (shifting gears should not cause any difficulties), as well as the smooth connection of the transmission to the engine in accordance with the specified control algorithm.

Tests have been carried out at the inertial-type stand C-149.00.000; balancing machine 1DS 1036 with a power of 250 kW has been used as a drive; inertial mass (10) with an inertia moment of 7.8 ... 8.2 kg·m^2 has been used as a loader. The clutch housing during tests was filled with oil M10G2 (GOST 8581-78). While testing, oil was supplied to the friction zone for lubricating and cooling the disks in a volume of 10-11 l/min. The data obtained were transferred to a computer; their processing was carried out by means of specially developed programs.

Discussion of the results

Clutch coupling with the tested discs worked out in the volume of 20000 on/off cycles. The diagram with on/off processes during the tests is shown in Figure 1.

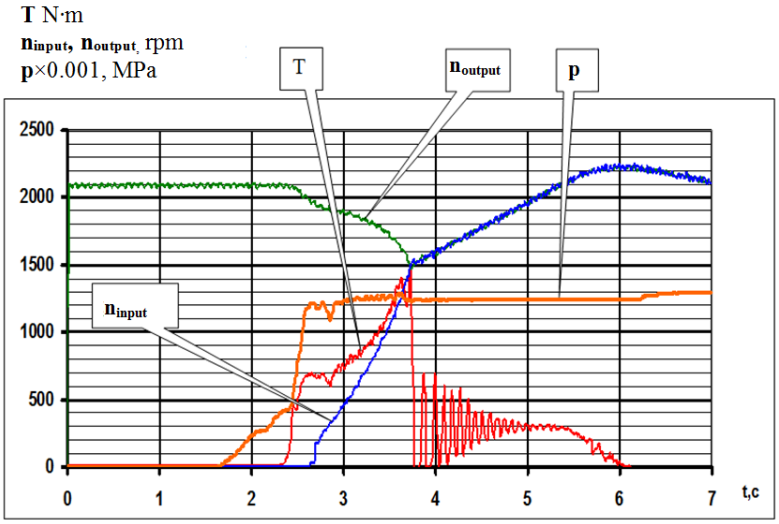

Fig. 1. The diagram of the change in the shaft rotation frequency of the balancing machine and the output shaft (n_{input}, n_{output}), pressure in the control channel (p), torque on the output shaft (T)

The obtained data show the input and output values of the clutch coupling parameters (synchronization of the input and output shaft speeds), as well as the dynamics of the frictional torque in time which was about 1 second.

Based on the results of processing the diagrams with on-process, dependence of change in time of the cyclic operation and frictional power was plotted (Figure 2).

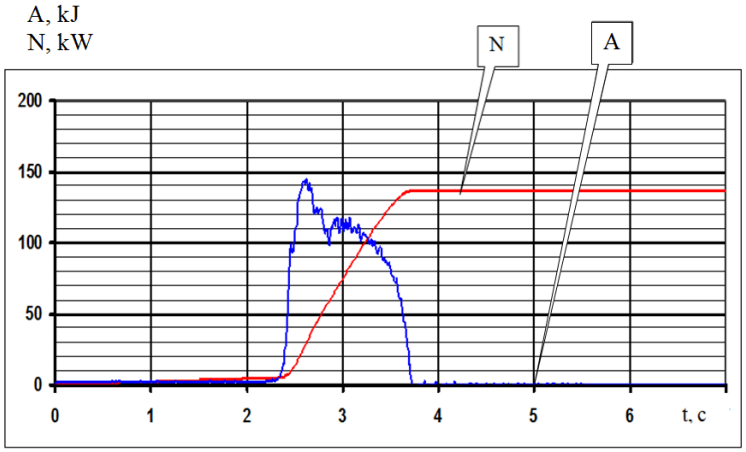

Fig. 2. The diagram of the change in the work (A) and the frictional power (N) versus the braking time (t)

The values of the dynamic friction torques of the clutch coupling during the tests are summarized in Table 1.

Table 1 The dynamic friction torques of the clutch coupling

Runtime, cycles	Oil temperature,°C	Oil pressure in the control channel, MPa	The range of variation of the dynamic friction torque of the clutch coupling, N·m
180	76	1,0	1300-1600
182	20	1,0	1000-1500
11980	80	1,25	800-1500
19720	78	1,2	700-1450
19722	25	1,15	700-1400

The values of the static breakaway torques of the clutch coupling discs during the tests are given in Table 2.

Table 2 Values of the static breakaway torques

Runtime	Oil temperature	Oil pressure in the control channel	The range of variation of the static torques of the clutch disc disruption
cycles	°C	MPa	N·m;
180	70…75	1,0±0,02	1850-1870
		1,1±0,02	1990-2010
		1,2±0,02	2180-2200
		1,3±0,02	2340-2380
		1,4±0,02	2500-2540
		1,5±0,02	2700-2740
	20…25	1,0±0,02	1950-1970
		1,1±0,02	2050-2080
		1,2±0,02	2200-2240
		1,3±0,02	2380-2400
		1,4±0,02	2500-2540
		1,5±0,02	2600-2650
19 940	20…25	1,0±0,02	1850-1870
		1,1±0,02	2000-2030
		1,2±0,02	2130-2160
		1,3±0,02	2300-2340
		1,4±0,02	2480-2520
		1,5±0,02	2600-2670

Investigation by means of an optical microscope of the friction surface of the sintered powder friction material based on copper FM-15 after the run-in has enabled to detect particles of tin bronze, graphite, steel powder PH-30 and pores. In the structure of the material it is possible to notice a clearly developed structure of the pores, which in the process of work is filled with lubricant and it is its source. The developed sintered powder friction material FM-15 represents tin bronze with introduced additives of antifriction and friction functions (graphite, steel powder PH-30). The microstructure of the sintered powder friction material FM-15 is a homogeneous α-solid solution of tin in copper, with uniformly located graphite particles and powder PH-30 over the section field.

Conclusions

The carried out stand tests of friction discs for clutch coupling have showed:
- wear of friction discs was: the first (contacted with the piston) – in the range of 0.04-0.06 mm, the second – 0.18-0.20 mm, the third – 0.30-0.35 mm, the fourth – 0.16-0.17 mm;
- the material galling into the grooves was observed on the friction surfaces of all friction discs;
- the runtime of the material was 20 000 on/off cycles that corresponds to the necessary requirements.

From the scientific point of view, the data obtained in the work are very important for the development and evaluation of the performance of sintered powder friction materials based on copper under lubricating for the specified operating modes of the tractor "Belarus". They were as a supplement to the already existing developments of compositions of sintered powder friction materials based on copper at the Powder Metallurgy Institute. A theoretical and practical assessment of the material application, the possibility of introducing a steel powder and its effect on tribotechnical properties have been carried out. It is planned to carry out further studies in this direction with the purpose of evaluating the effect of powder additives on the heat conductivity of the friction material. The developed sintered powder friction material is tested at the enterprises: Amkodor and BelAZ.

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