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THE RESEARCH OF FRICTIONAL CHARACTERISTICS OF MODIFIED CARBON – CARBON COMPOSITES

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Summary. The results of experimental researches of the modified frictional C-C composites of a new generation.

Keywords: a frictional material, a disk brake, friction coefficient, C-C composites.

INTRODUCTION

Providing with the unconditional safety under the conditions of continuous growth of the traffic speed of vehicles is considerably defined by the effectiveness of the action of brakes. One of the main problems of brake mechanisms is the essential dependence of physical and mechanical and tribological characteristics of frictional materials of brakes on the multitude of accidental factors especially including the influence of the temperature factor is singled out as in the braking process the work of frictional forces is transformed into the heat energy. The temperature of the surface of frictional interaction of the tribological situation in the brakes can reach 400, 600 and even 1000^{o}C.

Thereupon some actual researches are the all-round researches of frictional materials of a new generation which differ from serial materials with more stable wide-ranging characteristics of the change of working temperatures in the braking process.

OBJECT AND PROBLEMS

For the last decades the science of our country, engaged with the research of frictional materials and the increase of vehicles operation safety, has received a significant development in the works of Chichinadze A., Alexandrov M., Kragelskiy I., Volchenko A., Gurin V., Hebda M., Gudz G.

One of the directions of braking efficiency increase is the application of the modified frictional C-C composites of a new generation, allowing to stabilize the friction coefficient [Bruneton 1997, Starchenko 2005, 2006, 2010, Fitzer 1987].

The experimental researches of the tribological characteristics of different frictional materials such as carbon-carbon composite materials (C-CCM) with the fabric-lined breaching structure of the reinforcement modified C-C composites and hybrid C-C composites were conducted on the serial friction machine (SFM-2) in the brake laboratory in Volodymyr Dal East-Ukrainian national university [Starchenko 2010]. All the trials are performed under the conditions of dry friction (Coulomb friction) and "wet" friction under the equal conditions of weighting (as a rider the brake discs made of hardened steel and C-C composites are used.

For the trial of carbonic materials with the fabric-lined breaching structure of the reinforcement the first examples of shoes were made of fine-grained industrial graphite (FIG-7). According to the results of conducted tests the apparent density of examples made of graphite (FIG-7) made up 1,77g/cm^3, open porosity-17,2% and densimetric density-1,7g/cm^3. The trials were conducted together with the rider made of steel 45 (HB=580…620) while having the equal speed of the rotation of the disc 1000 turns/per minute (2,62m/c) and different specific pressure - 2,0 and 3,35 MPa (fig.1).The results showed that while increasing the specific pressure from 2 up to 3,35 MPa the value of the friction coefficient of the graphite along the steel is decreased approximately in 2-3 times that is in accordance with the classical theory of tribology and the results of earlier conducted works with the graphites of different types.

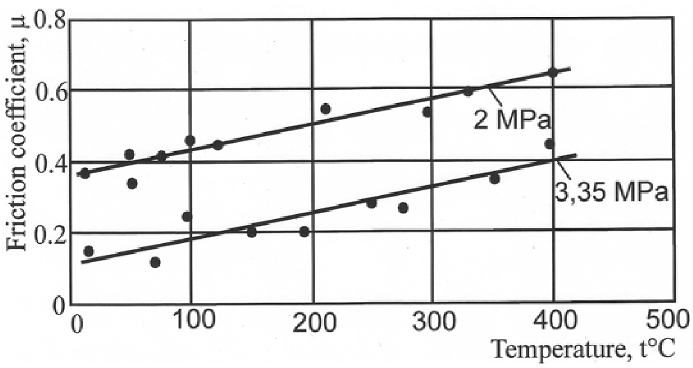

Fig. 1. The dependence of the constant of friction of graphite (FIG-7) on the temperature

For the further trials with the help of the fabric-lined method some development types were produced-shoes with the reinforcing framework on the basis of carbonic fabric URAL-TM4 with the pyrocarbonic matrix the billets were also sewn with the carbonic thread URAL NSH in two combinations with the pitch-15mm (fig. 2). Testing development types showed that apparent density of the material makes up 1,37g/cm^3, open porosity-14,92% and densimetric density-1,61g/cm^3. The trials showed that while the friction of the shoe made of C-CCM along the hardened steel the friction coefficient practically linearly is increased up to the temperature of 300°C and then becomes stabilized according to the value on the level-0,9 that might be conditioned by the change of the character of the friction process from the elastic one up to the viscoelastic one.

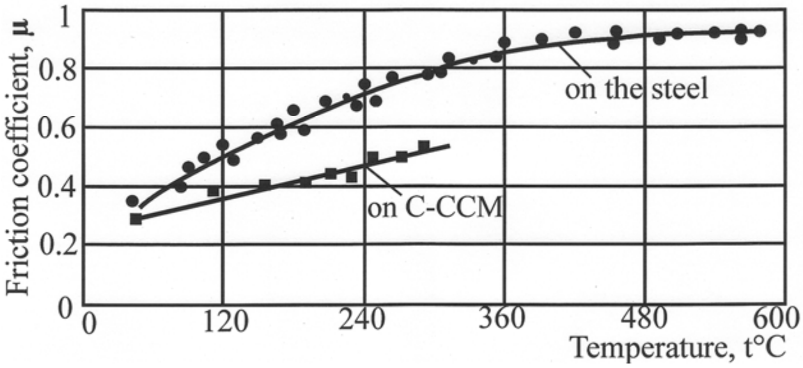

Fig. 2. The dependence of the constant of friction on the temperature; C-CCM, pressure-1,34 MPa

The confirmation of that is the evident decrease of the solidity of the steel disc while measuring after the trials with the temperature of the surface of more than 300C.

So if the initial steel solidity made up HB=580…20, then after the trials while the the temperature of more than 300°C the solidity decreases up to the values - HB=160…200. While using the disc and shoe from the same material - C-CCM under absolutely identical conditions the temperature of the surface didn't exceed 280°C that is evidently connected with a higher heat conductivity of carbonic composites in comparison with steel (in 20….40%) and lesser values of the value of the friction coefficient. For researching peculiarities of "wet" friction of the pair C-CCM - steel onto the surface of the friction some water was supplied with the continuous flow. The results of the trials are given in table 1.

It was established that while having equal conditions the constant of "wet" friction is less than while dry friction approximately in 2 times, while having the equal pressure - 1,34 MPa the friction constant accordingly makes up 0,15 and 0,34. While "wet" friction the same tendency of decreasing the friction constant with the growth of the pressure is observed.

Table 1. **The dependence of the constant of "wet" friction of carbon-carbonic composite material along the steel on the pressure**

Pressure, MPa	0,67	1,34	2,68	4,02	5,36	6,7	10,1	13,4	16,7
The maximum temperature,°C	17	17	19	20	23	25	26	30	32
The friction coefficient	0,20	0,15	0,11	0,11	0,10	0,10	0,09	0,09	0,08

The conclusion must be made that while dry friction of shoes made of “pure” C-C composites along the steel or along the disc made of the same material (a composite along a composite) under the conditions of small temperatures of the friction surface the value of the constant of friction isn’t high but with the growth of the temperature of the contact surface it has a steady tendency for the considerable increase.

The trials of modified C-C composites. For the increase of the friction coefficient at a small temperature of the friction surface and its stabilization of its wide-ranging change the technological scheme of production of new modified frictional C-C composites on the basis of pyrocarbonic matrix is offered. The distinctive peculiarity of which is the introduction of the friction modifiers into the structure: abrasive fine-dyspersated particles of alumina boron carbide and amorphous boron.

The development types are produced on the basis of the pyrocarbonic matrix [Gurin 2001, Starchenko 2008, 2004] with the reinforcing framework and carbonic tissue URAL-T22 and addition of amorphous boron or boron carbide. As a rider a rotating disc made of hardened steel was used. The trials were conducted under the conditions of dry and “wet” friction while the speed of the disc rotation 1000 turns, per minute and the pressure in the range 6,7…20.1 MPa (fig. 3). As it is evident from the received results the use of modified composites allows to solve the problem put by: to increase the constant of the friction at small temperatures(up to 200^{o}C) and increase its stability at high temperatures of the working range it being known that the stabilization is shifted into the sides of lower temperatures. The trials while “wet” friction showed that the value of the constant of friction is decreased and lies within the limits 0.24…0.27 at pressure 0,67 MPa and 0.12 ..0.20 at pressure 1,67 MPa in the temperature range up to 50^o C. In modified C-C composites the value of the friction coefficient is higher that is conditioned by the interaction of the abrasive particles of modifiers with the metallic disc surface even while continuous water supply.

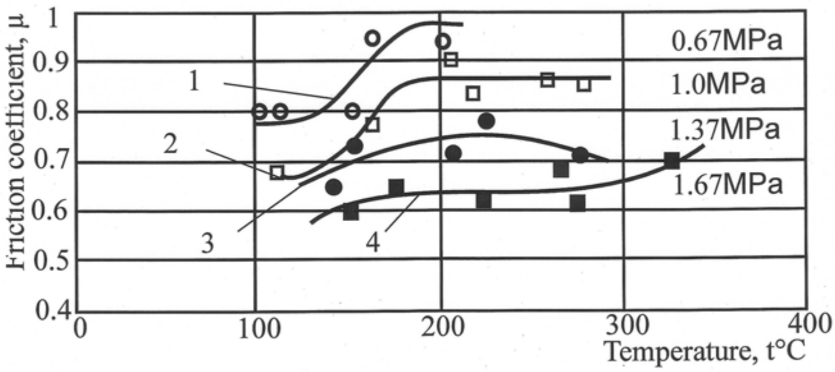

Fig. 3. The dependence of the friction coefficient
on the temperature of the friction surface

While the trials of hybrid C-C composites for the increase of their thermalphysic properties the method of using of different according to the structure fibres (hybridization) in the reinforcing framework and providing their spatial location in the stuff was chosen. Thereupon for the decrease of the temperature tensity of the contact friction surface tension the shoe material is needed which would possess high thermal capacity and heat conductivity that would contribute to the heat abstraction which is formed as a result of the work of frictional forces on the contact friction surface. The development types are produced on the basis of the reinforcing framework which is made of carbonic fibres in the form of a carbonic tissue URAL-T22 and copper wire (d=0.15mm) moreover the layers of the carbonic tissue were alternated with the layers of the net from copper wire. The compression of the matrix with the pyrocarbon was conducted with the thermogradient gas-core method with the use of radially moving zone of the pyrolysis. While dry friction of the shoe from the hybrid composite along the hardened steel the constant of friction practically doesn't depend on the value of the pressure on the surface of the friction.

The temperature on the contact didn't exceed 109^{o}C and the temperature of the disc made up 150…200^{o}C that testifies to quite high thermophysical characteristics of a new hybrid composite and must be referred to the positive properties of the reinforcement at the expense of the use of the copper wire.

Table 2. **The dependence of the constant of "dry" friction on the pressure**

Pressure, MPa	0,48	0,71	0,98	1,19
The friction coefficient	0,42	0,40	0,46	0,46
Temperature, ^{o}C	47	68	97	109

As it had to be expected the constant of "wet" friction is less than while dry friction and is smoothly decreased as the pressure increases (table 3).

Table 3. **The dependence of the constant of "wet" friction on the pressure**

Pressure, MPa	0,48	0,98	1,43	1,91	2,39	4,79	7,18
The friction coefficient	0,24	0,18	0,16	0,14	0,14	0,12	0,12
Temperature, ^{o}C	27	22	24	40	40	40	45

The important fact is the fact that the use of the net made of copper wire in the structure of the reinforcing framework of hybrid C-C composites considerably allows to decrease the thermal tension of the contact surface of the friction and increase the stability of the constant of the friction in the wide temperature range (table 2). Received results allow to prognose that brake shoes from hybrid composites with the copper wire will work effectively and safely and even under the conditions of the increased humidity.

CONCLUSIONS

As a result of some experimental researches it is defined that the frictional materials for the brakes of vehicles in the form of modified C-C composites have better tribological indices and substantially increase the effectiveness of the brake process that provides the minimization of the brake way and the time of braking thereby contributing to the increase of the traffic safety of vehicles.

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ИССЛЕДОВАНИЕ ФРИКЦИОННЫХ ХАРАКТЕРИСТИК УГЛЕРОД-УГЛЕРОДНЫХ КОМПОЗИТОВ

Валерий Старченко, Мария Павленко, Вячеслав Овчаренко, Андрей Манько

Аннотация. Приведены результаты экспериментальных исследований модифицированных фрикционных С-С композитов нового поколения.

Ключевые слова: материал фрикционный, тормоз дисковый, коэффициент трения, С-С композиты.