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POBOL I. L. Ion nitriding of workhole surfaces in the long-length steel parts

The problems of surface hardening of workholes and recesses in parts using nitriding method are considered. The results of surface treatment in long-length products made of 38Kh2MYuA and 40Kh steels up to 2,500 mm long by ion nitriding are presented. It has been shown that nitrided layers with a thickness of up to 330 μm and a microhardness of up to HV 550-600 (for steel 40 Kh) and up to HV 750-800 (for steel 38Kh2MYuA) can be obtained on the hole surface, which should be accompanied by a significant increase in the wear resistance of hardened products.

UDC 621.793

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RESEARCH ON WEAR RESISTANCE AND FRICTION COEFFICIENT OF GAS-THERMAL COMPOSITE COATINGS WITH THE ADDITION OF NANO CARBON COMPONENTS WITHOUT LUBRICANTS

The Branch Research Laboratory "Plasma and laser technology" is developing a technology for introducing Nano carbon components into powder materials.

At the first stage of research into the coatings (table 1), Nano carbon was added in the materials (2% of the total volume of powder materials).

Table 1 – Powder materials without Nano carbohydrates.

	Name	Chemical composition
1	ПГ-СР4	Base: Ni; 13-17%Cr;0,6-1% C; 3-5% Si; 2,5-4%B; 4%Fe
2	ПР-БрОНСР	Base: Cu; 8% Sn; 5% Ni; 1%Si; 1%B
3	ПН-НД-42	Base: Ni – Cu; 42,5%Cu; 0,2%C; 0,9%Si; 1%B; до 3%Fe
4	ПР-Х4ГСР	Base: Fe; 3,8% Cr; 1,2% C; 2,5% Si; 2,2% B; 0,5% Cu
5	ПГ-19М-01	Base: Cu; 4% Fe; 8,5-10,5% Al
6	ПТ-ЮНХ16СР3	Base: Ni; 0,7% C; 16% Cr; 3,2% Si; 2,6% B; 1,2% Al

Due to the 2% error of the equipment, obtaining clear results of the influence of Nano carbon was impossible. It was decided to increase the amount of nanocarbon in 10% of the total volume of powders.

The mixing of Nano carbon components and powder materials was carried out mechanically. Disks made of steel 45, with a thickness of h = 4 mm and a diameter of d=70 mm with a hole d=30 mm, were used as the basis for spraying. Coating was performed by flame method and reflow sub layer. It should be noted that not all materials interacted with nanocarbon. And coating No. 2 during reflow began to boil and release bubbles, so the integrity of the coating was broken and this coating was removed in further studies. After spraying, the samples were ground to a roughness of Ra3,2.

Tests for wear resistance and friction coefficient were carried out as follows: the sample was degreased and weighed, then fixed in a self-centering cartridge of the equipment and determined the face runout of the sample within 3 μm. The friction body (indenter) is brought to the sample on a tripod, which was also weighed in advance. The modes of testing the coefficient of friction: test time t = 60 min, linear speed of rotation of the sample v = 5 m / s. The rotation frequency of the part n = 1837.33 rpm; the friction path was S = 18000 m; friction force F = 0.206 N, Indenter spherical with radius R = 1 m. Track diameter d = 30 mm, Specific pressure at the point is P_0 = 7.8 MPa.

A strain gauge sensor was connected to the indenter, which recorded the friction force. The value of the friction force was fixed continuously in the form of an oscillogram. The friction coefficient was determined by the ratio of the friction force to the normal load and was recorded every 5 minutes (12 times). At the end of the tests, the sample and indenter were degreased and weighed. The tests were carried out without lubricants.

During the study, the friction coefficient of composition No. 1 in the coating with the addition of 10% Nano carbon increased to 25 minutes, after which it began to decline. In a coating without Nano carbon, the friction coefficient increased to 10 minutes and after 5 minutes began to decrease. Subsequently, the friction track was analyzed for the samples. Brown oxides were formed in the sample with the addition of Nano carbon, which did not appear in the composition without Nano carbon. The track had scratches and holes. As a result, the friction coefficient of composition No. 1 with the addition of Nano carbon compared with the same composition without Nano carbon increased by 90%. The effect was negative.

In the study on the friction coefficient of composition No. 3, the friction coefficient of the coating with the addition of Nano carbon changed in a sinuous and had the greatest value in time from 35 to 45 minutes. The friction coefficient of the coating without Nano carbon also changed in a sinuous shape, but at the 35th minute the coating was run-in. On the friction track, both the composition with Nano carbon and the composition without Nano carbon was formed a weak appearance of brown oxides. The tracks had easy scratches and holes. The result of the research: the friction coefficient of composition No. 3 with the addition of Nano carbon increased by 11.6% compared with the same composition without Nano carbon. The effect was negative.

In the study, the coefficient of friction of the coating with the addition of Nano carbon of composition No. 4 did not change and had a stable value,

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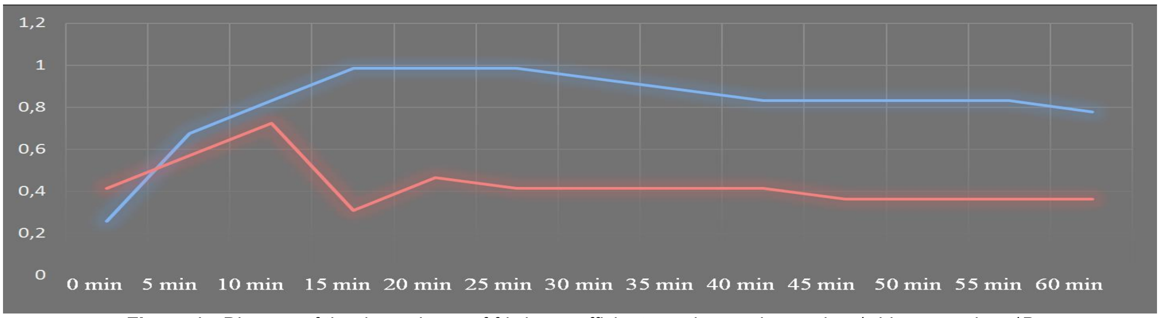

Figure 1 – Diagram of the dependence of friction coefficients on time: red: sample - 1; blue: sample – 1B

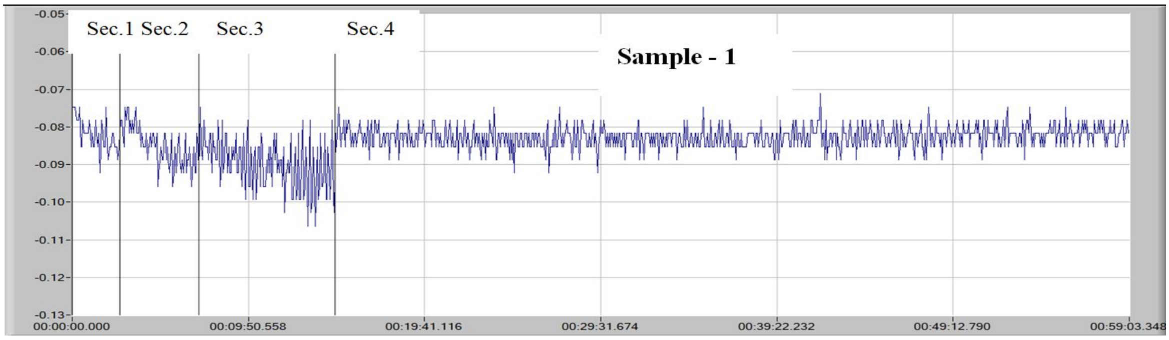

Figure 2 – Diagram of the dependence of friction coefficients on time: sample - 1

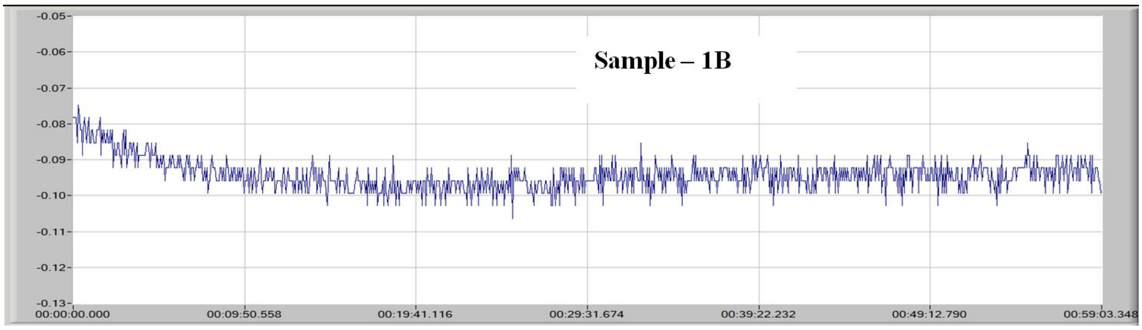

Figure 3 – Diagram of the dependence of friction coefficients on time: sample – 1B

a b c

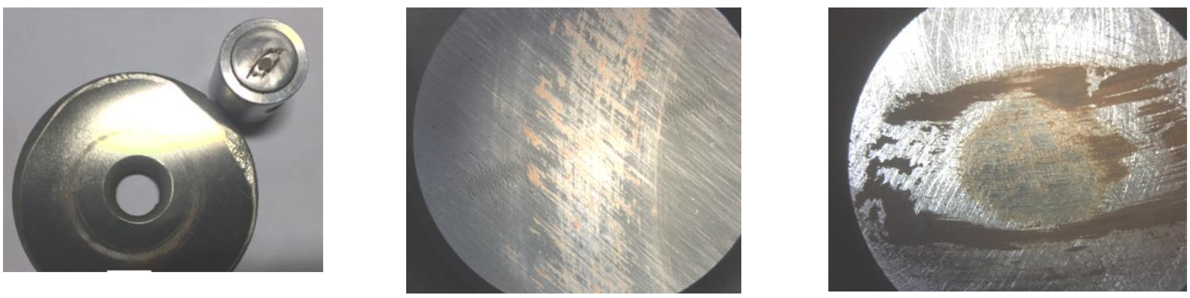

Figure 4 – Coating of composition No. 1 without the Nano carbon (b) and coating with Nano carbon (c)

this indicates that the coating was run-in. The coefficient of friction of the coating without Nano carbon increased to 10 minutes, then for 15 minutes it was at the same level and in 25 minutes it started to decline. Oxides did not appear on the friction track in both the composition with Nano carbon and the composition without Nano carbon. The tracks had easy scratches and holes. The result of the research: the friction coefficient of composition No. 4 with the addition of Nano carbon compared with the same composition without Nano carbon decreased by 508%. The effect is positive.

In the study, the friction coefficient of coating composition No. 5 with the addition of Nano carbon was constantly decreasing. On the other side, the coefficient of friction of the coating without Nano carbon increased to 20 minutes, and then began to decline, in the end it changed a little in sinuous shape. On the friction track, both the composition with Nano carbon and the composition without Nano carbon were formed the brown oxides. The tracks had bright scratches and holes. The result of the research: the friction coefficient of composition No. 5 with the addition of Nano carbon compared with the same composition without Nano carbon decreased by 476.9%. The effect is positive.

In the study, the friction coefficient of the coating with the addition of Nano carbon of composition No. 6 was constantly decreasing. The coefficient of friction of the Coating without Nano carbon increased to 10 minutes, and then the coating was run in and had a constant value. On the friction track, both the

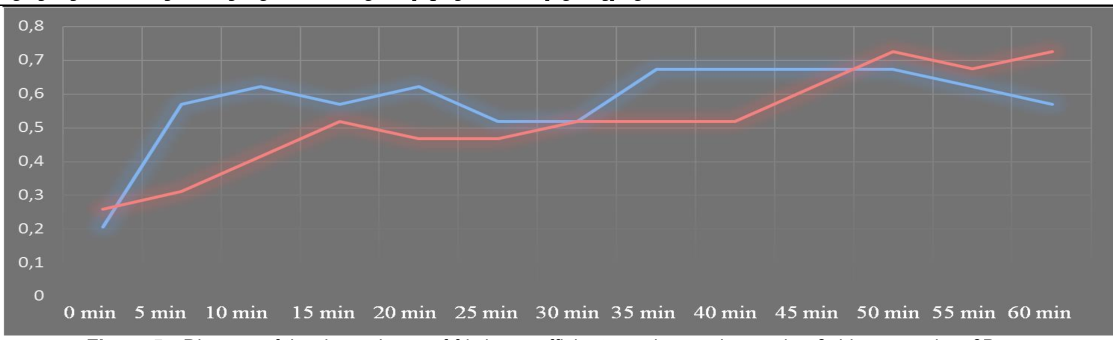

Figure 5 – Diagram of the dependence of friction coefficients on time: red: sample - 3; blue: sample – 3B

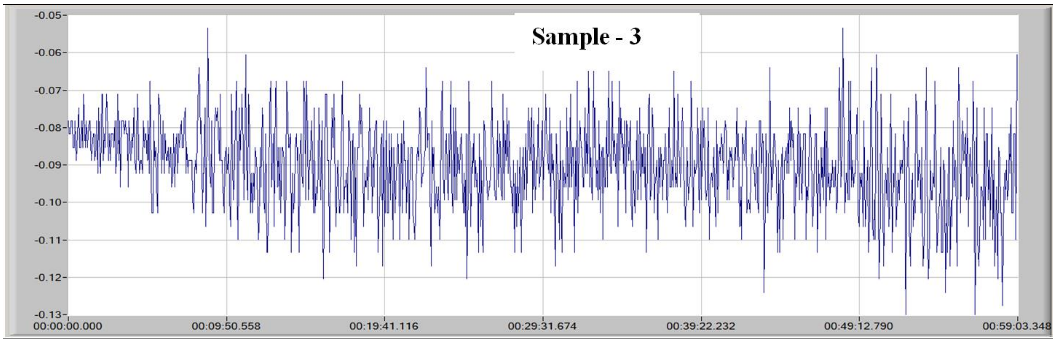

Figure 6 – Diagram of the dependence of friction coefficients on time: sample - 3

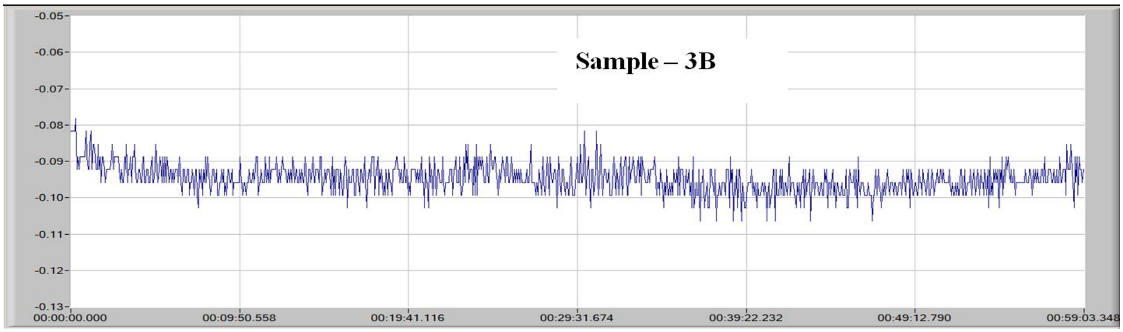

Figure 7 – Diagram of the dependence of friction coefficients on time: sample – 3B

a b c

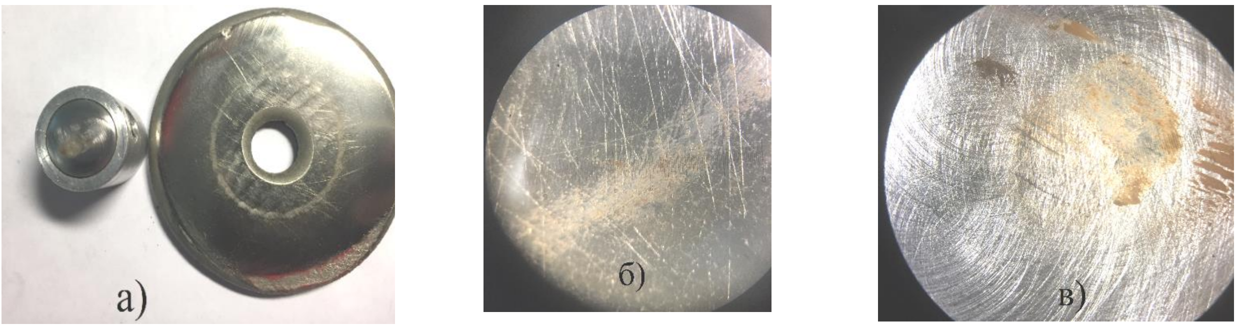

Figure 8 – Coating of composition No. 3 without the Nano carbon (b) and coating with Nano carbon (c)

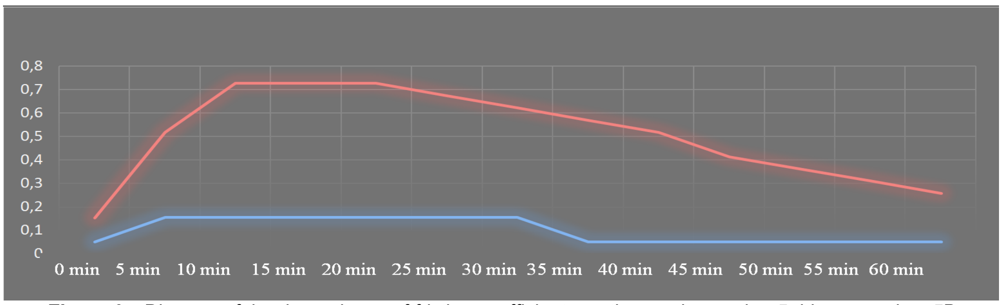

Figure 9 – Diagram of the dependence of friction coefficients on time: red: sample - 5; blue: sample – 5B

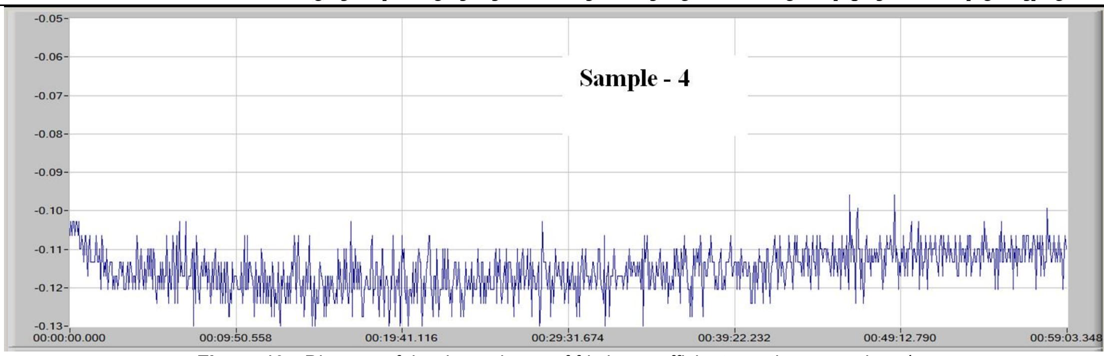

Figure 10 – Diagram of the dependence of friction coefficients on time: sample – 4

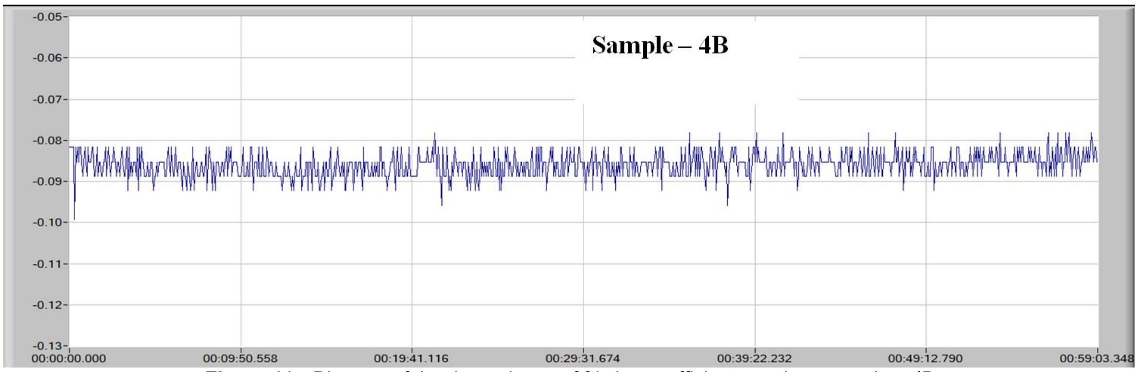

Figure 11 – Diagram of the dependence of friction coefficients on time: sample – 4B

a b c

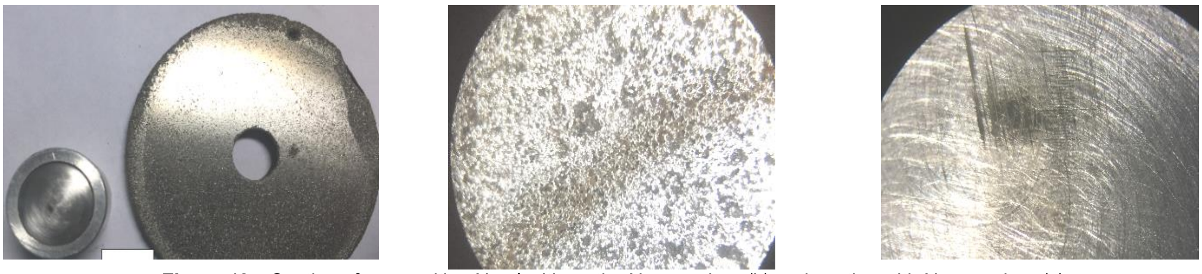

Figure 12 – Coating of composition No. 4 without the Nano carbon (b) and coating with Nano carbon (c)

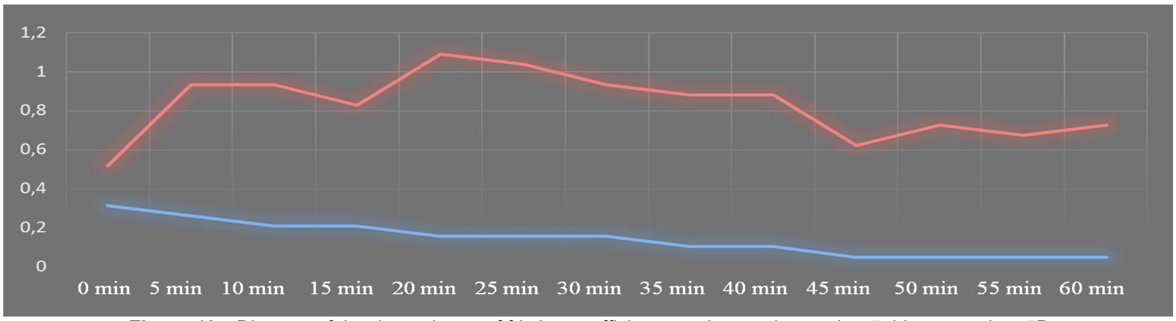

Figure 13 – Diagram of the dependence of friction coefficients on time: red: sample - 5; blue: sample – 5B

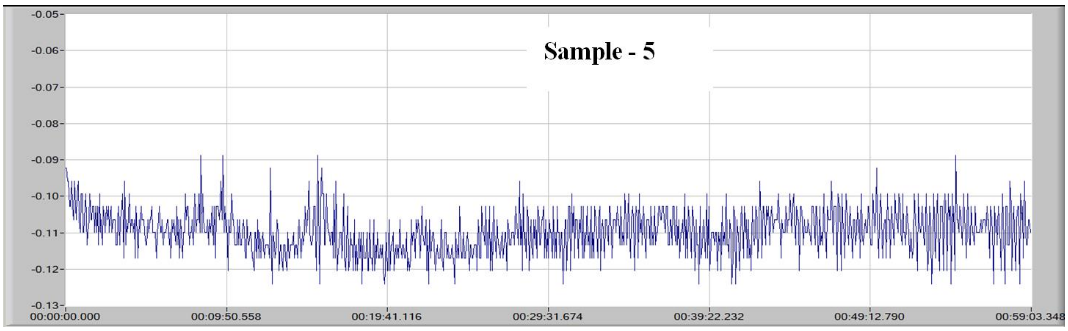

Figure 14 – Diagram of the dependence of friction coefficients on time: sample – 5

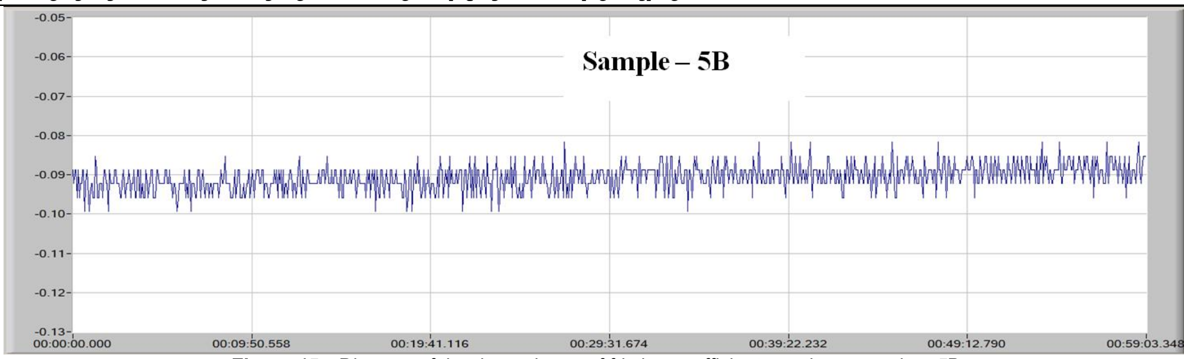

Figure 15 – Diagram of the dependence of friction coefficients on time: sample – 5B

a b c

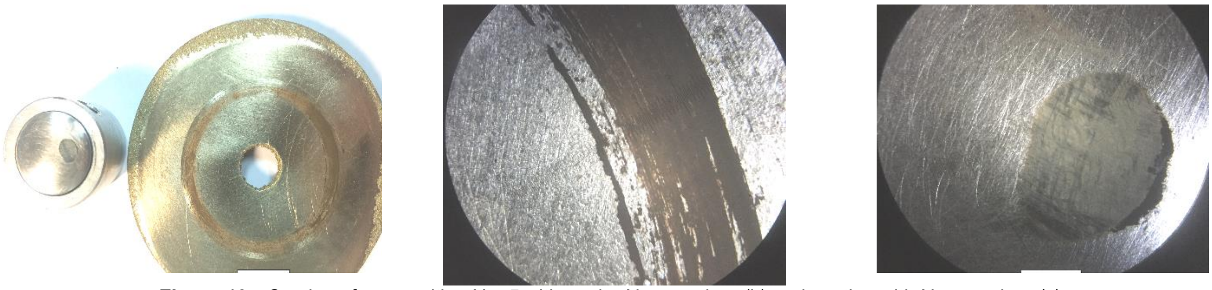

Figure 16 – Coating of composition No. 5 without the Nano carbon (b) and coating with Nano carbon (c)

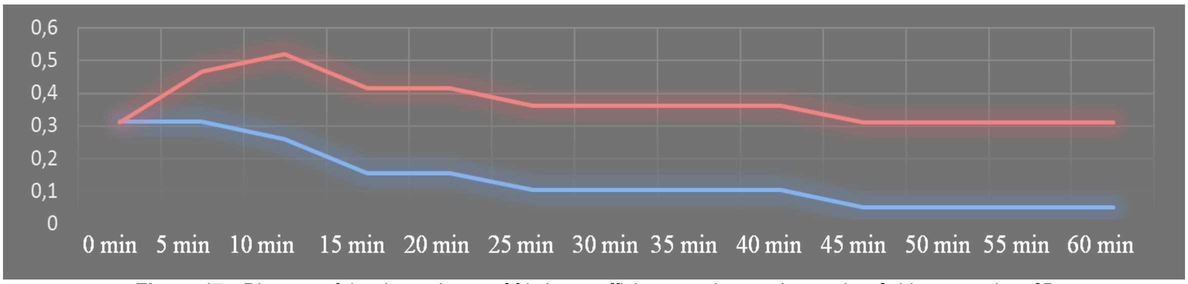

Figure 17 – Diagram of the dependence of friction coefficients on time: red: sample - 6; blue: sample – 6B

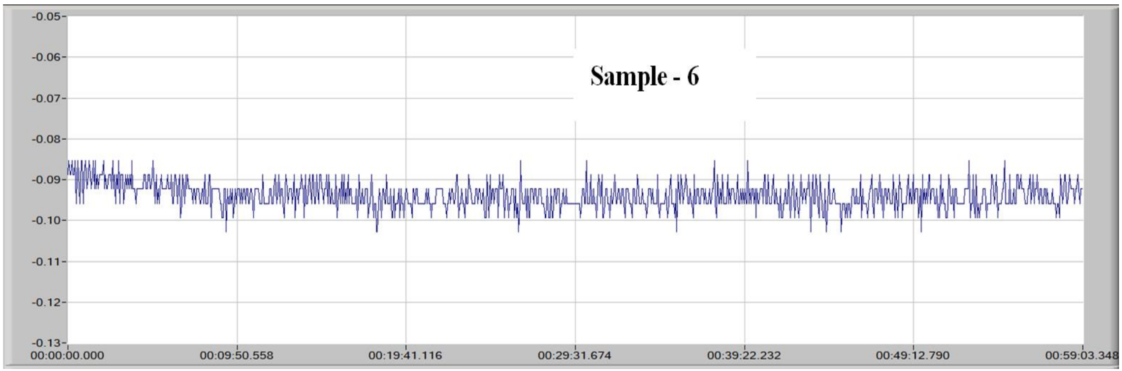

Figure 18 – Diagram of the dependence of friction coefficients on time: sample – 6

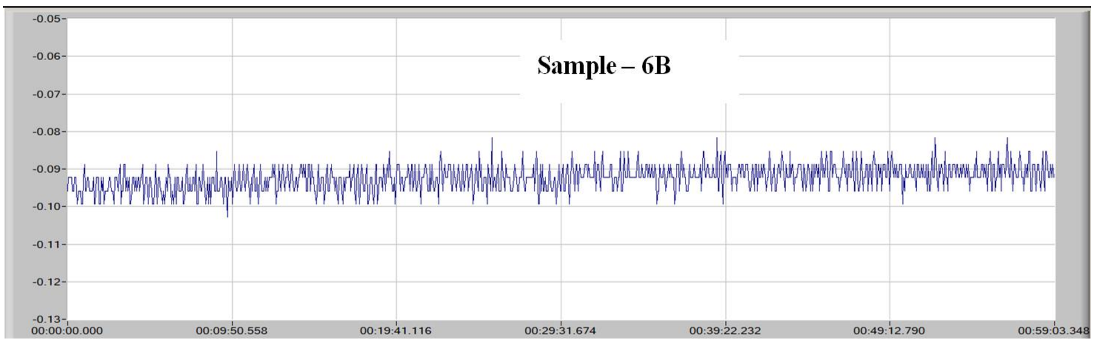

Figure 19 – Diagram of the dependence of friction coefficients on time: sample – 6B

a b c

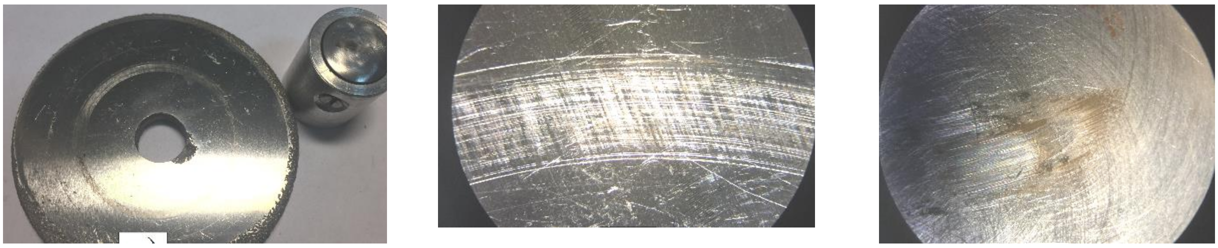

Figure 20 – Coating of composition No. 6 without the Nano carbon (b) and coating with Nano carbon (c)

composition with Nano carbon and the composition without Nano carbon were formed the brown oxides. The tracks had bright scratches and holes. The result of the research: the friction coefficient of composition No. 6 with the addition of Nano carbon compared with the same composition without Nano carbon decreased by 476.9%. The effect is positive.

Conclusion. The result of the analysis of hardening and restoration methods and used powder materials showed the prospects of applying powder materials based self-fluxing Nano carbon by adding these components to produce plasma and flame spray coating.

The studies did not reveal any fundamental differences in the phase composition and structure of the studied coatings; a certain decrease in the porosity of the coating with the addition of nanostructured carbon was determined.

The use of self-fluxing powders with their subsequent melting reduced the porosity of the coating by 2-3 times.

On the friction track of some samples with the addition of Nano carbon crated brown oxides, which was not observed in the composition without Nano carbon.

It was determined that the friction coefficient of a composition with the addition of Nano carbon compared to the same composition without Nano carbon decreased to 508%.

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SOKOROV I. O., VANUK E. A., GHAZBAN ZADEH E., KUIS D. V., LEVANTSEVICH M. A., LOBKO D. N. Research on wear resistance and friction coefficient of gas-thermal composite coatings with the addition of nano carbon components without lubricants

In this work, we have defined the wear resistance and coefficient of friction of gas-thermal coatings that made of improved Nano carbon components and develop a recommendation for the practical use of them.

A significant value of coatings with a Nano scale structure is due to increased plasticity and the ability to reduce residual stresses, which allows increasing the coating thickness to the millimeter.

The result of the analysis of hardening and restoration methods and used powder materials showed the prospects of applying powder materials based self-fluxing Nano carbon by adding these components to produce plasma and flame spray coating.

Nanostructured coatings are characterized by ultra-high strength. Compared to not melted, the melting of coatings slightly reduced their fragility and the adhesion of the coating with the basement increased by about 3 to 4 times. The raised adhesive property is the reason for the small boundary between the coating and the basement. This fact enhances the wear resistance, too.

It was determined that the friction coefficient of a composition with the addition of Nano carbon compared to the same composition without Nano carbon decreased to 508%.

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Введение. Получение требуемых параметров точности обрабатываемых деталей зависит в первую очередь от качественных характеристик станка, которые формируются несущей системой, а именно ее – компоновкой, качеством изготовления и сборки, используемыми материалами, конструкцией базовых деталей. Это все определяет пространственное положение оси шпинделя. Его смещение от начального положения приводит к ухудшению характеристик геометрической точности обрабатываемых деталей, таких как точность линейных размеров, отклонений формы и расположения поверхностей, позиционных отклонений. Также шпиндельный узел воспринимает эксплуата-

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