Creation of New Antifriction Materials from Industrial Wastes

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Abstract* – *This article describes the main processes of combined application of a protective coating on the machine parts. The characterization of the progressive coating process, which includes electric metallization followed by synthesis, was presented. Microstructure and performance of protective coatings for structural parts appointment powder obtained from industrial wastes were studied.

Key words – protective coatings, industrial wastes, metallization, oxide ceramic coating, wear resistance.

I. Introduction

Recently in obtaining of new powder materials manifested great interest in the technology of plasma coatings that are characterized by high productivity versatility, simplicity in automation of virtually unlimited size surfaces that are covered. Special attention consideration being given to apply composite ceramic, metal, bio metal and other synthetic tracks [1-3].

At present, an effective way to protect parts is application of hot-gas composition coating complex high physical and mechanical properties. In order to create special purpose coatings (wear-resistant, heat resistant and corrosion) methods of protection, which is composed of micro- and nanostructured films and phases are widely used.

II. Condition question

At present the questions related to the interactions process of surfaces in contact during their mutual movement. Creation and selection of tribotechnical materials on the decision of interrelated tasks on the basis of study of mechanics of friction and physical and chemical phenomena that pass on a surface are based.

Causing electro metal coverage with the further oxidizing will give possibility to protect details from wear and promote their longevity practically for ever and ever. Oxide ceramic coatings by very high micro-hardness are characterized. With the introduction of this technology to protect details of against wear in the most responsible nodes and mechanisms of machines can significantly extend the operating equipments time to repair or refusal.

This defence method is next to durability considerably will promote details corrosive firmness that works in the conditions of aggressive environment.

III. Material presentation

The protective coating put forward the following basic requirements: they must be solid, impermeable, have high adhesion strength of the base metal, high hardness, wear resistance and evenly distributed across the surface to be applied.

According to the trend of modern technology to develop high-quality composite materials and coatings with complex of high physical and mechanical characteristics of new topical powders, which from such compositions are formed.

The electric arc spraying is one way of applying metallic coatings on metallic and non-metallic surfaces. Electric arc spraying used to produce zinc and aluminum corrosion coatings and application of wear resistant coatings and restoration.

The protective coating spraying was got by continuous wire by means of electric metallize with the modified spray system (Fig.1), where an electric arc burns channel spray head that allows obtaining finely dispersed coverage. [4]

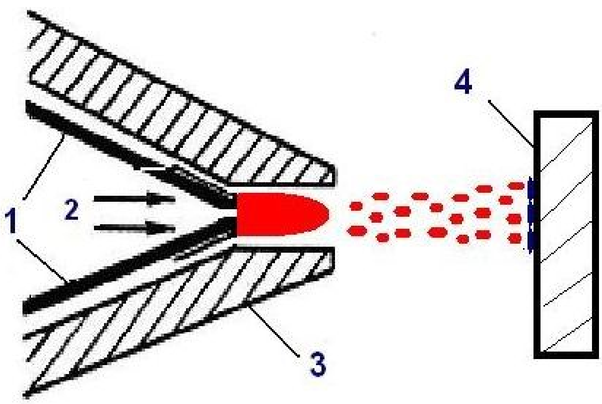

Fig. 1. The process electric arc spraying
1 - wires; 2 - an air stream; 3 - body spray head; 4 - lining

As source material used grinding steel sludge BBS15 formed after machining rings and roller bearings in terms of PJSC "SKF Ukraine". Grinding steel BBS15 sludge contains a significant amount of iron oxides and chromium products abrasion grinding wheels, and various oils, synthetic fluids, water, members of the coolant.

To obtain high-quality powder BBS15 applied a new patented technology, where the main difference from existing alteration's sludge industrial wastes is that after the chopping formed by the heat conducting additional growing-rolling-off to the ball mill to give powder particles smaller and regular spherical form [5, 6]. Obtained by metal powder technology - a high-quality powder particles with a regular shape and size, with high technological properties.

For applying corrosion protective coating on the details of construction designation commonly used method plasmas electrolytic oxidation (PEO), which is one of the most modern and advanced methods for metals surface and alloys protective layers have set important characteristics [7].

A general view installation of plasma electrolytic oxidation depicted in Fig.2.

Fig. 2. A general view installation of PEO

Research experiments conducted on four samples - bushing, which are made of industrial wastes (powder steel BBS15). For this prior and etched micro-sections were done. Digestion of samples by herbalist - 0.5...3% alcoholic solution of hydrofluoric acid HF was carried out.

For a start a general view of the sample will result №1 after applying for it combined coverage (Fig.3). Samples №2, №3 have a similar appearance, but inflicted on them coating different thicknesses and different modes of PEO, so leads only one photo.

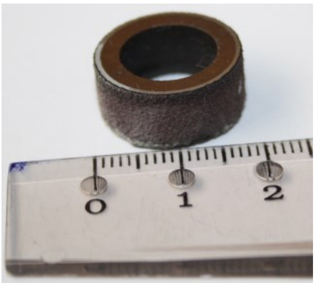

Fig. 3. General view of the bushings after applying the combined coverage

In Fig. 4 we see limit of the base metal in the upper (position 1), and lower dark gray shows the electro metal cover (position 2) and plasma electrolytic oxidized coating (position 3).

The boundary between the base metal and electric arc coating is clearly expressed, but not uniform.

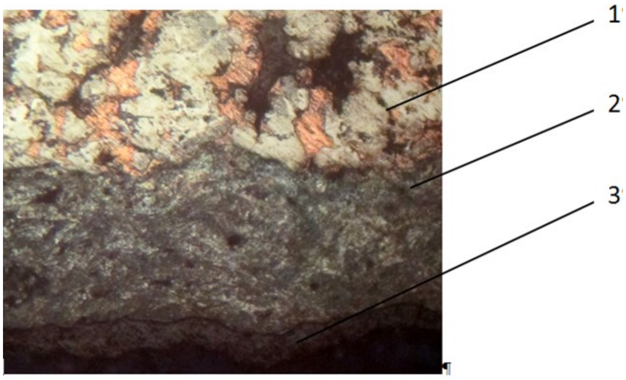

Fig. 4. The microstructure of samples-bushings (× 100)

In Fig.5 we see not etched region of the sample.

If we compare the micro structure is not etched and etched cover electric region, then seeing not only the difference in color (in Fig.5 electric arc coating has a bright colour, and in Fig. 4 is darker), also etched region we see the structure and grains coverage. The micro structure of etched regions with increasing ×250 ×400 in Fig.6. is presented.

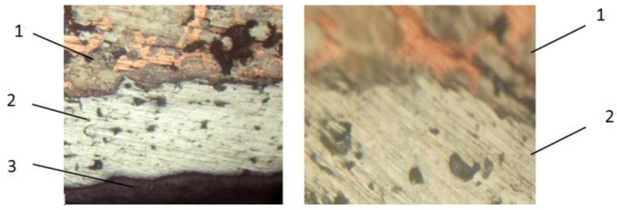

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Fig. 5. Microstructure not etched areas
by increasing the sample: a) × 100; b) × 250
1 - base metal; 2 - electro metallic coverage;
3 - plasma electrolytic oxidized coating

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Fig. 6. The microstructure of the etched area and sample:
a) × 250; b) × 400
1 - base metal; 2 - electro metallic coating;
3 - plasma electrolytic oxidized coating

In Fig.6 to show that the area between the base metal and the surface has a small, with which it can be conclude that electric arc coating has a very high adhesion to the base metal. Fig.4 and Fig.5 analyzed and found that the inclusion of graphite observed in the structure of the base metal and arranged randomly.

The micro structure of plasma electrolytic oxidized coatings characterized by a homogeneous structure and peculiar porosity. After digestion seeing a clear line distribution of electro metallic coating and coating, which plasma electrolytic oxidation is formed . This is typical for all samples.

In Fig.7, a - represents not etched region of the sample, and in Fig. 7, b - the etched region. Immediately you can notice that the PEO coating is characterized by many irregularities layer (depressions and protrusions).

After digestion can see a clear distinction and division electro metallic oxide ceramic coverage. The grains' oxide ceramic surface does not stand out.

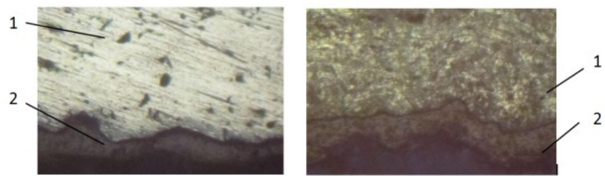

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Fig. 7. The microstructure the sample-bushing:
a) × 100 is not etched region; b) × 100 etched region
1 - electric arc coating; 2 - PEO coverage.

The combined sheeting forms an electro deposited metallic layer and plasma electrolyte by a ceramic oxide layer. The thickness of each coating by measurements in three places and the determination of the average value of thickness for each coating was determined. By adding average thickness of the electric and PEO coating found an average thickness of the combined protective coating.

Diagrams thickness of the coating method of applying for a four-bushings samples presented in Fig.8 and Fig.9.

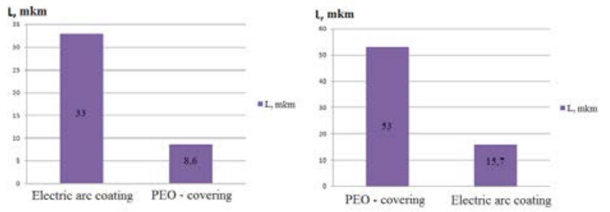

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Fig. 8. Diagram coating thickness on the method of application: a) sample №1; b) sample №2

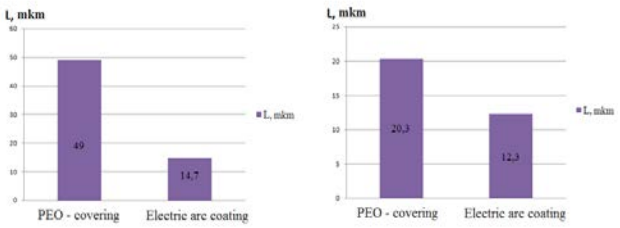

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Fig. 9. Diagram coating thickness on the method of application: a) sample №3; b) sample №4

To determine the micro hardness of micro hardness tester PMT-3 was used. We determined the micro hardness of base metal, electrical arc and plasma electrolytic oxidized surfaces by applying a three jabs in each area (two pricks made on the edges and in the middle of a coating or base metal). After pricks from an indenter there are imprints of diamond pyramid. Measured diagonal prints and framed in the formula. So find micro hardness each of samples.

The formula for determining the micro hardness is follows:

$$H_{\mu} = \frac{1{,}854 \cdot P(\mathrm{kg})}{(N_{л} \cdot 0{,}0003)^2} = \left[\frac{\mathrm{kg}}{mm^2}\right] \qquad (1)$$

P – the weight of the load, kg; $N_{л}$ – he number of divisions limb.

It is give result generalized graphics micro hardness changes from the base metal, coating cover. Numerical data micro hardness mean values for base metal, electro metallic and PEO-coating are shown in Table 1.

TABLE 1

THE AVERAGE VALUE MICRO HARDNESS SAMPLES OF INDUSTRIAL WASTES ARE MADE

Sample	Coating		
	Base metal	Electric arc cover	Base metal
№ 1	592,8	327	3876,5
№ 2	653,3	295,6	8305
№ 3	736,3	613,6	4616
№ 4	991,6	1526,6	7157

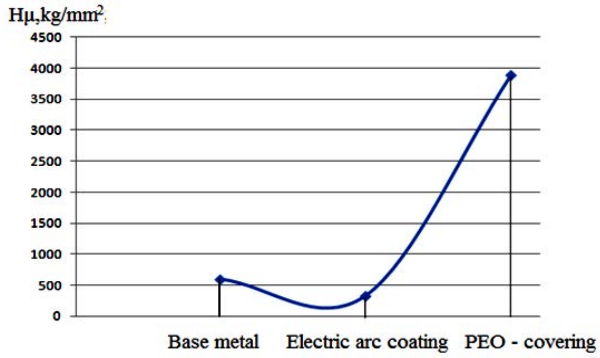

Fig. 10. The generalized dependence of change microhardness of the coating method for bushings, which are made of industrial wastes

From Fig.10 is seen micro hardness change depending on the coating method. Micro hardness first arc comes to the surface, then begins to grow very rapidly, moving to PEO coverage.

Among the most progressive and most productive applied programs for processing and analyzing metallographic images with the ability to visualize three-dimensional objects on a two-dimensional photographs are ***Avizo***®. So to test our samples to the reliability of the results we apply the software methods.

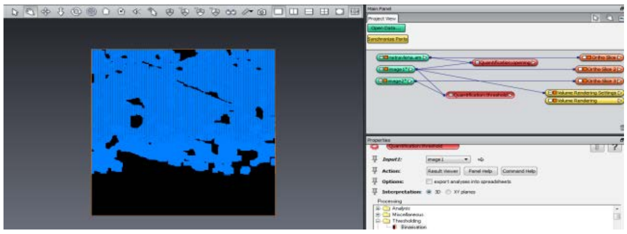

Fig. 11. Not etched sample - cut bushings with coverage

These same actions do with etched sample.

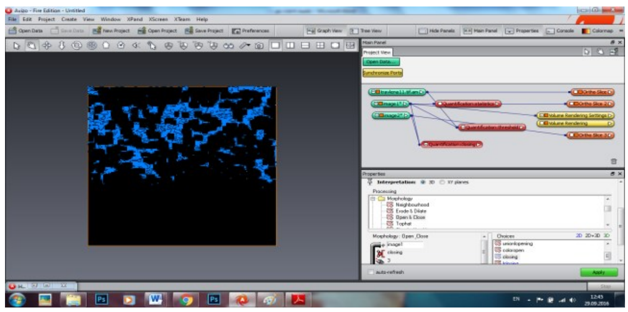

Fig. 12. Etched sample - cut bushings with coverage

Fig.13. Generalization histogram changes microhardness of the coating method for bushings №1 - №4 (etched region), which are made of industrial wastes

Conclusion

Based on the analyzis of scientific literature and previous studies it is shown that the methods of powder metallurgy enable the creation of anti-friction composite materials from industrial wastes with different constituents of various structural components included in the material (especially steel powder BBS15).

It is proved that promising direction is the development of composite materials based on structural steel powders obtained from industrial wastes.

It is applied the combined protective coating on the machine parts of construction purposes are bushings, operating under conditions of reverse-translational friction. On the sleeve applied protective coating using electric arc metallization and plasma electrolytic oxidation.

In the process of experimental studies conducting the following main characteristics of coatings were found: the largest combined thickness of the protective coating bushings is equal to 63.7 microns; the largest micro arc coating hardness bushings H_{μ}=1526,6 kg/mm^2, and the greatest micro hardness plasma electrolytic oxidized coating bushings made H_{μ}=1526,6 kg/mm^2

Checking the accuracy experimental research has been tested using modern software ***Avizo®***. The margin of error was 5%.

Proved that generalization micro hardness samples - bushings begins to increase after plasma electrolytic oxidation.

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