The Influence of Thermal Baking Modes on the Electrical Properties of the Carbide Coating and its Strength with the Base

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ABSTRACT

The article discusses the influence of thermal baking modes on the electrical properties of the carbide coating and its strength with the base. It is found that the electrical resistivity of the carbide coating applied by the baking method reflects the structural state of the material and allows optimizing the thermal regime of the process. By the value of the specific electrical resistance of the sintered coating, it is possible to predict the strength of its connection with the substrate.

KEYWORDS: *Friction, wear, surface, wear ability, pressure, heat, diffusion, secondary structures.*

INTRODUCTION

An effective way to increase the wear resistance of surfaces is the application of carbide coatings by baking, combining the process of cladding a pre-applied layer of powder and electric pulse action. By varying the modes of contact pressure and the power density of the electric pulse, it is possible to control the structure, physical and mechanical properties of the coating and the strength of its adhesion to the substrate [1, 2].

The electrical properties of metals and alloys are determined by the electronic structure, the state of the structure and reflect the physical and mechanical characteristics of the material. According to the electrical characteristics of the material, it is possible to predict phase-structural transformations, the degree of chemical purity, the density of defects in the crystal structure and other changes associated with the restructuring of the electronic structure. The method of measuring the electrical characteristics of a material is characterized by technological simplicity, therefore it is widely used in materials science research [3].

Figure 1 shows the effect of the homologous baking temperature of the carbide powder on the electrical resistivity of the formed coating. With an increase in the baking temperature, the electrical resistance of the coating varies according to an extreme dependence, reaching a minimum in the range (0.6 ...0.8) tpl, corresponding to the temperature of the most complete sintering of the carbide powder. The falling section of the dependence of the electrical resistance on the baking temperature of the powder material is explained by the formation of a more compacted structure and a lower density of various defects of the crystalline structure.

Heat generation under pulsed electrical action occurs through conduction channels, as a result, the structure of the formed coating acquires a heterogeneous character, in which there are areas of increased density located along channels of high electrical conductivity. The number of such channels depends on the chemical composition of the metal powder and the rolling pressure.

Heat generation is a secondary process initiated by the passage of a spark discharge, which is localized along the conduction channels and is characterized by high and ultrahigh heating and cooling rates, therefore, oxidative reactions to a certain homologous temperature practically do not manifest themselves, and the absence of oxide phases is confirmed by the nature of the drop in the electrical resistivity of the sintered coating with an increase in the baking temperature.

At homologous baking temperatures above 0.6...0.8, there is an increase in electrical resistivity associated with the formation of intermetallides, oxides and other chemical compounds. High temperatures also contribute to active gas release, which leads to an increase in porosity.

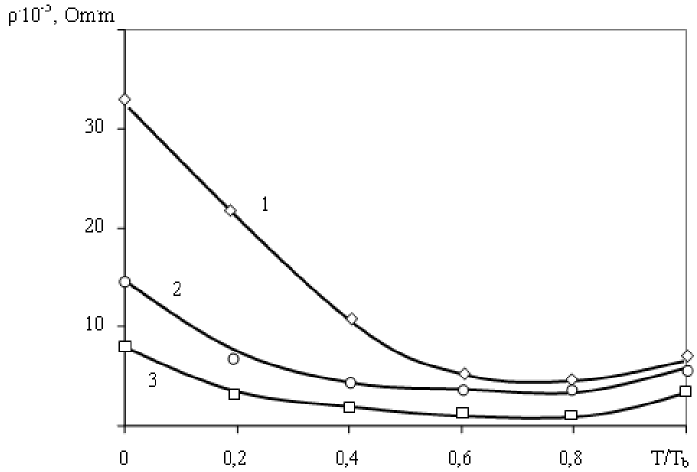

Fig. 1. Influence of the baking temperature of the carbide powder on the electrical resistivity: 1 – TN20; 2 – T14K8; 3 – VK8

The formation of the coating is carried out by deposition of several layers and repeated electrical pulse action, while the formation of an adhesive bond in the discharge passage zones is most likely. A strong adhesive bond is primarily associated with the formation of electronic bonds characterized by a lower electrical resistance, i.e. with a decrease in electrical resistance; the bond strength of the coating with the substrate should increase. The discharge passage zones determine the centers of formation of adhesive bonds and the "islet" of the formed coating.

Figure 2 shows the dependence of the adhesion strength of the coating with the substrate on its electrical resistivity. The dependence is extreme in nature, while the right branch reflects this assumption. The maximum adhesion strength falls on the range of values of specific electrical resistances (3.0...5.0).10-5 om·m, corresponding to the optimal sintering temperature of the carbide powder, at which the most compacted structure is formed.

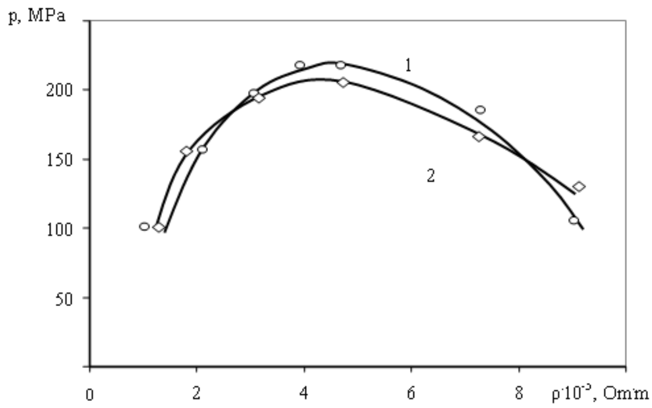

Fig. 2. The relationship between the adhesion strength of the baked coating and its electrical

resistivity: 1 – T15K8; 2 – TN20

In general, the increased adhesion of the baked coating is ensured by the development of chemical and adhesive bonds. An abnormally high activity of diffusion processes with pulsed transmission of electric current plays a certain role in the formation of the latter [4]. One of the main factors affecting the adhesion of the coating is the formation of oxide phases. The competing influence of these processes ultimately determines the bond strength of the coating with the substrate. There should be no strict physical dependence between the electrical resistivity and the bond strength of the coating with the substrate, since the electrical characteristics of the material are a complex manifestation of many factors.

The left increasing branch of the dependence $p = f(\rho)$ can be explained as follows. With a decrease in the electrical resistance of the contact of the powder layer with the substrate, a large number of conduction channels are formed and the electron flow is distributed over many channels. A thermal pulse is released in each conduction channel, the value of which may be insufficient to form a strong adhesive bond.

Nevertheless, the obtained experimental dependence, shown in Fig. 2, allows optimizing the baking modes and predicting the bond strength of the coating.

Based on the above, the following conclusion can be made:

- the specific electrical resistance of the carbide coating applied by the baking method reflects the structural state of the material and allows optimizing the thermal regime of the process;
- By the value of the specific electrical resistance of the sintered coating, it is possible to predict the strength of its connection with the base.

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