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Electrical contact surfacing using powder materials enclosed in a metal shell

M.M. Payazov, E. Z. Dosmatovich

Assistant of the department of "Technological machines and equipment" of Tashkent State Technical University named Islam Karimov, Tashkent, Uzbekistan.
Head of the Department of Technological Machines and equipment, of Tashkent State Technical University. Islam Karimova, Doctor of Technical Sciences, Professor

ABSTRACT: This article provides a study of the Improving the method of electro contact surfacing using powder materials to save expensive alloys

KEY WORDS: electrical contact surfacing, using powder materials, in a metal shell, carbon steels, deposited layer modes, physical and mechanical properties, experiments, research.

I. INTRODUCTION

Improving the method of electro contact surfacing using powder materials will make it possible to achieve significant savings in expensive alloys. However, the widespread implementation of this process is hampered by several reasons: firstly, rapid wear of the electrodes of electrical contact installations; secondly, the limited wear resistance of the deposited layer, which is explained by the inability to use dielectric materials, such as aluminum oxide, silicon carbide, etc., as a wear-resistant phase.

II. LITERATURE SURVEY

As shown in [1], the critical concentration of these substances in the powder material charge is 1....2%. Exceeding this value as a result of the separation of conductive particles by dielectric particles leads either to a complete cessation of the electrical contact process, or to local overheating with melting and release of metal particles in the form of droplets.

As is known, ensuring high wear resistance while simultaneously reducing the consumption of alloying elements in surfacing materials is possible, in particular, with the widespread use of composite materials, the refractory component of which is usually a dielectric [2]. Currently, the only effective way to increase the amount of wear-resistant dielectric filler during electrical contact surfacing is to change the ratio between the particle sizes of the matrix and filler [3, 4], however, in this case, the content of components with low electrical conductivity is limited to 8....10 %.

III. METODOLOGY

We have investigated the possibility of electrical contact surfacing of powder materials enclosed in a metal shell in order to increase the wear resistance of the deposited layer by increasing the number of non-electrically conductive components; The possibility of simultaneously increasing the service life (durability) of electrodes of electrical contact installations was also studied. The essence of the proposed method is that when the powder is placed in a shell, its contact with the electrode is excluded, therefore, the resistance of the electrode should increase. It becomes possible to pre-manufacture powder material for electrical contact surfacing: it can be plated (by drawing, rolling) or sintered, and the shell protects the powder from oxidation. The presence of a metal shell will increase the number of components with high electrical resistance, since in this case the current flows through the shell and heats it to the temperature of transition to the plastic state; with a certain force applied to the electrode, the shell is connected to the base metal, and the powder material is heated by the heat coming from the shell.

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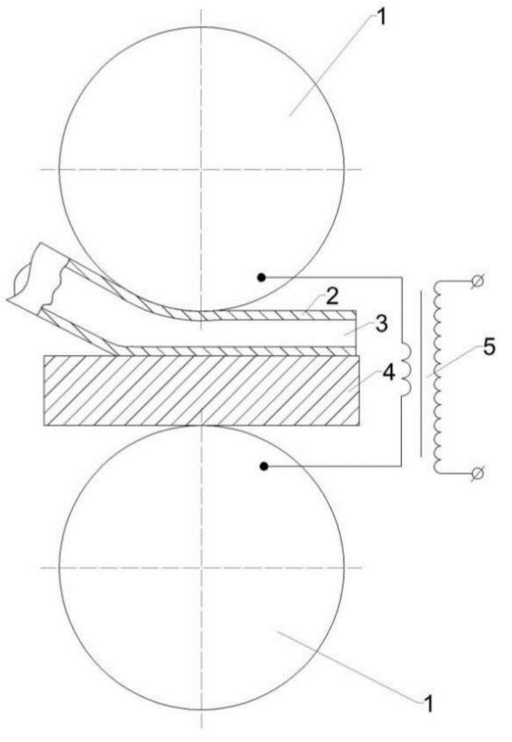

Picture. 1. Scheme of the process of electrical contact surfacing of powder material enclosed in a metal shell: 1 ─ electrodes of the electrical contact installation; 2 ─ metal shell; 3-powder material; 4 ─ workpiece to be deposited; 5 ─ power supply.

In picture 1 shows the proposed diagram of the electro contact surfacing process. To confirm the proposed provisions, the following experiments were performed.

Surfacing was carried out using powder material without a shell and in a shell. Surfacing of powder without a rim was carried out in a known manner. For surfacing according to the proposed method, a charge consisting of powders of the PG─S1 alloy and carbon ferrochrome FH 800 was poured into a shell (in the form of a tube with a diameter of 5 mm) made of 08kp steel. The resulting workpiece was drawn to a diameter of 4 mm, purged with argon, sealed, and drawn again to a diameter of 3 mm. Then, electric contact surfacing of powder material enclosed in a metal shell was carried out on a plate of St3 steel 10 mm thick. We studied the dependence of the adhesion strength on the mode parameters (current Iв, time of flow of the current pulse tи, duration of the pause between pulses tп, force on the electrode P). The adhesion strength of the coating to the base metal was determined by tearing off the pin with an applied force according to the method [5].

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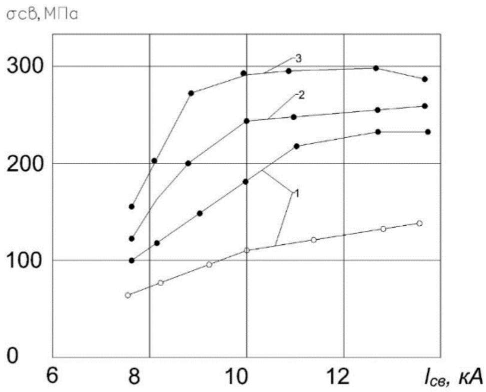

Picture. 2. Dependence of the adhesion strength of the coating to the base metal on the current and force on the electrode: 1 ─ P ═ 3.2 кН; 2 ─ 2.3; кН; 3 ─ 1.7 кН; • ─ powder PG-S1 + FH800 in a shell; ○ - the same, without shell

In picture 2 shows the dependence of the adhesion strength of the coating to the base metal on the current and force on the electrode. Under optimal surfacing conditions, the adhesion strength of powder material enclosed in a metal shell is 2-2.5 times higher than that of powder without a shell. As the force on the electrode increases within the studied limits, the adhesion strength of the coating to the part decreases. This is explained by a decrease

in the heating temperature in the joint zone associated with the deformation of the metal shell before the electric current pulse is turned on: at the same time, the contact area between the shell and the part increases, the electrical resistance of the contact and the current density decrease.

Comparative tests carried out to determine the physical and mechanical properties of coatings obtained using powder materials, enclosed in a shell and without it (Table 1), showed that in the first case, due to a significant reduction in the porosity of the layer, its hardness and wear resistance increase. The reduction in porosity is facilitated by the presence of a shell, which allows the powder to be pre-compacted during the drawing process and, in addition, creates a favorable stress state during surfacing, close to the state of all-round compression. The service life (durability) of the electrodes of the electrical contact installation increases significantly. When surfacing PG─S1+FH800 powder in a shell, the durability of a bronze electrode of type BpX is 200...250 m before regrinding versus 30...40 m when surfacing powder of the same composition without a shell. Consequently, the use of a metal shell during electrical contact surfacing using known materials provides the following advantages: the physical and mechanical properties of the deposited layer increase as a result of reduced porosity; the adhesion strength of the coating to the base increases; oxidation of the powder material is prevented; a favorable state of stress is created, close to all-round compression; the service life of the electrodes increases; the thickness of the deposited layer is stabilized due to the precise dosage of powder material; it becomes possible to reduce stress in the deposited layer, since the shell is a kind of soft layer between the base metal and the coating.

In order to determine the possibility of increasing the a mount of non-conductive components in the charge, the temperature field was studied during electrical contact surfacing of PG─S1+FH800 powder (with different amounts of boron carbide) enclosed in a metal shell.

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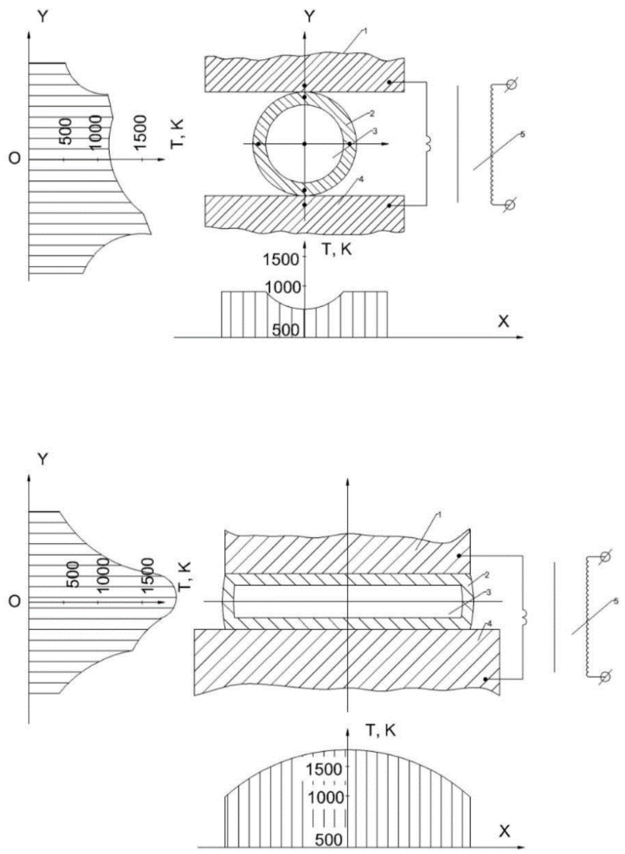

Picture. 3. Temperature field at the initial (ɑ) and final (b) moments of surfacing of the powder enclosed in a metal shell: 1 — electrode of electrical contact installation; 2 — shell; 3 — powder material; 4 — base metal; 5 — power supply; • — thermocouple placement locations

Temperature was measured using chrome-alum and platinum-platinum-rhodium thermocouples. The location of thermocouples was determined by the boiling point of water (373 K) and the melting point of lead (602 K). The signal was recorded using a K12-22 loop oscilloscope.

As can be seen from picture. 3, at the initial moment of electric contact surfacing, the temperature in the middle region of the powder material is significantly lower than the temperature of the shell. This is explained by the low electrical conductivity of the powder: Almost at the moment all the current flows through the metal shell. However, heating the powder with heat received from the shell and compacting it with force applied to the electrode leads to a decrease in the electrical resistance of the powder layer, its further heating and compaction due to plastic deformation of the particles; the temperature is equalized across the cross section of the powder core.

Further heating leads to overheating of the latter, which, if the mode is incorrectly selected (high current or increased pulse duration), can cause disruption of the stability of the electrical contact process, melting of the powder material, burn-through and splashing of molten metal.

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Table 1. Comparative characteristics of the physical and mechanical properties of coatings

Presence of shell	Coating material	ε	HRC	Porosity, %	б сц, МПа
No	ПГ-С1	1,0	50	5 7	120 140
	ПГ-С1+50 % ФХ800	2,5	60	8 10	120 140
Existent	ПГ-С1	1,5	54	1 2	280 320
	ПГ-С1+30 % ФХ800	2,9	59	1 2	300 320
	ПГ-С1+50 % ФХ800	3,5	61	2 3	300 320

Note. Here ε is the relative wear resistance.

In table 2 shows the physical and mechanical properties of the deposited layer. An increase in the amount of boron carbide to 20% leads to a sharp increase in porosity, a decrease in the plastic properties of the coating, as well as wear resistance due to a deterioration in the adhesion strength between particles of the powder material (as evidenced by chipping of the solid component of the composite layer during wear resistance tests). Obviously, when more than 15% boron carbide is introduced, the resulting powder material is characterized by high electrical resistance and low thermal conductivity and does not have time to warm up during surfacing, therefore it is poorly compacted and sintered. However, the presence of the shell made it possible to slightly increase the critical number of dielectric components (up to 15%), while the electrical contact process remains stable throughout the surfacing.

Table 2. Physic-mechanical properties of the deposited layer at different carbide contents

Coating material	ε	Porosity,%	$a_н$, МДж / м^2	Surface characteristics
ПС1(ПГ-С1+50 %ФХ800)	1,0	2 3	0,59	Clean
ПС1+5 % B_4C	1,3	3 5	0,54	»
ПС1+10 % B_4C	1,6	3.... 5	0,50	»
ПС1+20 % B_4C	1,4	5...10	0,42	visible pores
ПС1+30 % B_4C	0,5	10....12	0,26	There are cracks

CONCLUSION

The use of a metal shell for electro contact surfacing of powder materials makes it possible to expand the technological capabilities of the process. The service life of electrodes of electrical contact installations is sharply increased, and consequently, the consumption of expensive bronze is reduced. It becomes possible to increase the number of components in the powder material that have low electrical conductivity.

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AUTHOR'S BIOGRAPHY

	**Payazov Mirgiyaz Miraxmatovich,** Assistant. Date of birth: December 14, 1986 in Tashkent, Republic of Uzbekistan. Has more than 20 published scientific works in the form of articles, journals, theses and tutorials. Currently works at the department of "Technological machines and equipment" in Tashkent State Technical University
	**Ermatov Ziyadulla Dosmatovich ,** Head of Department, Doctor of Science, Professor was born May 16, 1978 year in Tashkent city, Republic of Uzbekistan. Has more than 100 published scientific works in the form of articles, journals, theses and tutorials. Currently works at the department of "Technological machines and equipment" in Tashkent State Technical University.