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Abrasion resistance analysis of coatings at electro-arc spraying using a pulsating spraying airflow

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Abstract. In the global practice of application, more than 50% are metal coatings applied by the method of electric arc metallization, which has the following advantages: high productivity, simplicity of equipment, low power consumption, the ability to 6obtaining coatings with high-performance properties through the use of scarce and inexpensive wires of industrial production.

But the main drawback is the process of oxidation of alloying elements during transportation of molten electrode particles by spraying airflow.

A series of scientists' works are aimed at improving the design of spray heads of electric arc metallizers, which involves improving the design of the air nozzle through the use of inserts and devices providing a change in the spraying airflow, and leads to a significant increase in the price of the process.

To reduce the oxidizing effect of the spraying airflow on the liquid metal of the electrodes the method of pulsating air injection into the electrode melting zone has been developed.

This paper presents the influence of the pulsating spraying flow on the indicators of abrasive wear and reduction of oxidation of metal particles, at the arc metallization to obtain coatings with the specified properties and application of resource-saving.

Keywords: abrasive, alloying elements; oxygen; arc metallization; pulsating airflow; electrodes.

Introduction

To reduce the impact of oxygen during coating, the department of "Automation and mechanization of welding production" of Priazov State Technical University has developed a method of electroarc spraying with a pulsating spraying airflow. Earlier in [1,2,3,4] the principle of the method, the characteristics of equipment to ensure the pulsation of the spray flow, shape and duration of pulses, the impact of the flow on the atomized material are presented.

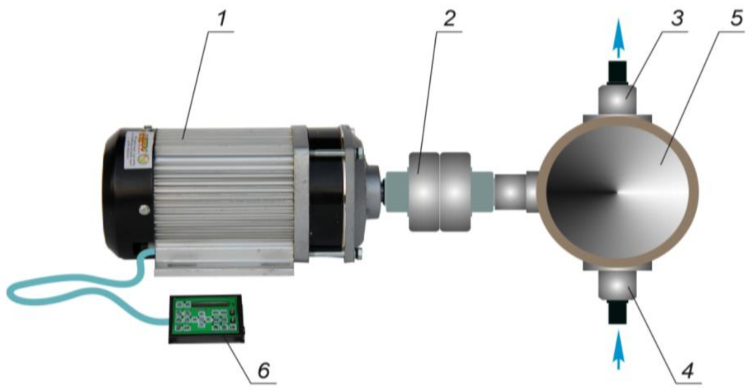


Figure 1. - Core design scheme of the pulsator for industrial application: 1 - AC motor; 2 - elastic coupling; 3 - pulsator valve; 4 - inlet connection; 4' - outlet connection; 5 - pulsator base; 6 - control panel (start-stop buttons).

The research data on the influence of the pulsating flow on the decrease of the influence of air oxygen on the liquid metal of electrodes at the arc spraying with the pulsating spraying flow, on the metal mass transfer are given in [5,6,7,8].

At the same time, there are no data on the influence of the pulsating spraying airflow on the technological parameters of the spraying, such as abrasive wear and reduction of oxidation of metal particles.

This paper presents the results of the study of the influence of atomizing flow pulsation frequency on the above-mentioned parameters.

The complex of studies of durability at abrasive wear of coverings, by a method of arc metallization with the use of the pulsator developed for industrial application, was carried out.

Chemical composition of wires of solid cross-section, which were used in the research process for the application of coatings is given in the table.

Table.1- Chemical composition of solid cross-section wires used in abrasion resistance studies.

Wire type	Elements content						
	C	Si	Mn	Cr	Ni	S	P
X10CrNiT	0,06	0,4-0,1	1,0-2,0	18,0-20,0	8,0-10,0	0,15	0,03
Q345 (GB/T) L03453	0,10	0,7-0,95	1,8-2,1	0,2	0,25	0,03	0,023

In the research process, the stationary metallizer EM-17 and current source VDU-504 were used. The basic parameters of the spraying mode are given in the table.

Table. 2 - Basic parameters of the electric arc spraying mode of the samples for abrasion resistance tests

Wire type	Spraying mode parameters				
	I_a, A	U_a, V	P_{air}, MPa	V, cm/sec	f, Hz
X10CrNiT	180-200	28-30	0,5±0,05	7,2	20-120
Q345 (GB/T) L03453					

Spraying was carried out on 100×50×20 mm St.3 steel samples. The thickness of the coating applied during abrasive wear tests was 2.5 - 3.0 mm. Preparation of samples surface for spraying was carried out by blasting, where as a working material we used a bead of BCK-2 grade.

Tests for abrasive wear were carried out according to the Brinel-Havort method [12] with some changes, that is, the well-known scheme was taken as a basis, when the rotating rubber disk under load is pressed with its flat side to the sample, but the abrasive is fed and pulled on the surface of the sample by self-capturing the recesses of the circle while rotating of the last inside the chamber filled with abrasive, Fig. 2.

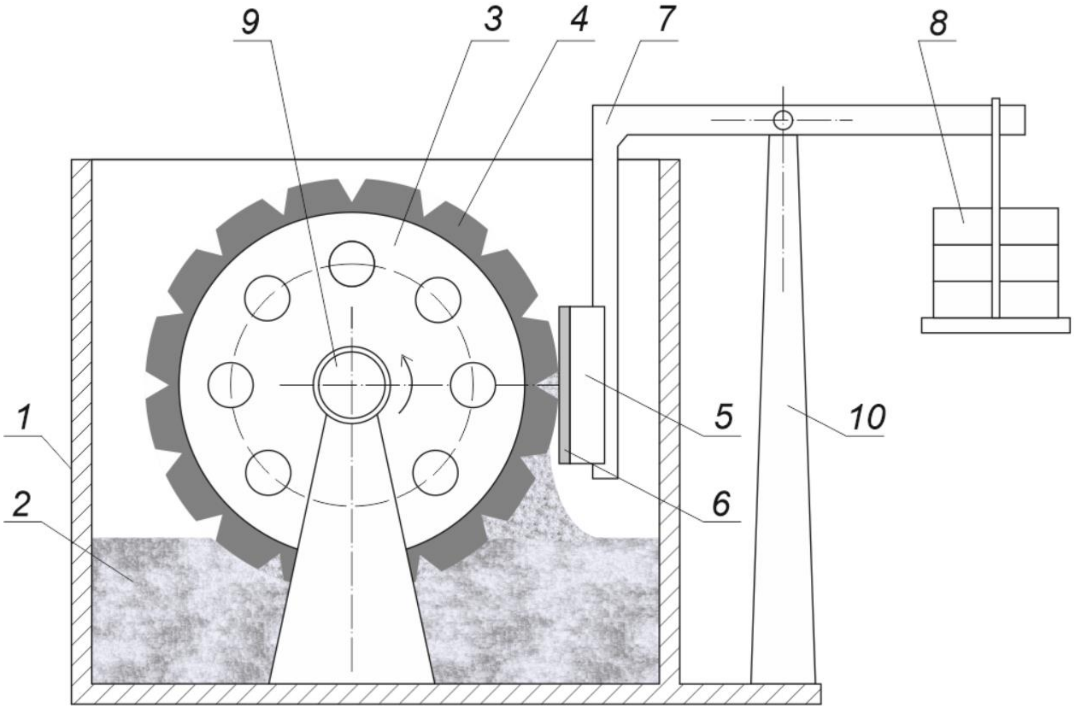


Figure 2. Installation layout for abrasive wear testing

1 - installation case, 2 - abrasive material, 3 - assembly disk, 4 - rubber disk, 5 - arbor, 6 - test sample, 7 - lever, 8 - load, 9 - drive mechanism, 10 - rack.

The study used a rubber disc with a diameter of 220 mm, on a circular pattern there are 25 wedge-shaped cutouts with an opening angle of 300, depth of 25 mm, the speed of rotation of the disc 5.5 rpm. The clamping force of the test piece is 25 kg. Silicon carbide of grades 64C, 63C, grit size 63-16 (0.8-0.2 mm) was used as an abrasive. Wear was determined by weight loss of the sample over a certain period of time.

To determine the wear resistance of each type of coating, a series of five samples was tested, i.e., each value obtained from the weight loss of the sample is an average of five measurements. The total testing time for each sample was 80 minutes.

The samples were sprayed using a basic spraying mode and using 20-120 Hz pulsating spraying flow frequencies.

Based on the test results, a comparative analysis of the wear resistance of applied coatings under abrasive wear conditions was made.

The relative wear resistance - ε - was used as an indicator of wear resistance, which was determined according to the recommendations of work [12] from the expression

$$\varepsilon = \frac{\Delta P_b}{\Delta P_{smp}}. \quad (1)$$

where ΔP_b - change in weight of the benchmark during the test, g.

ΔP_{smp} - change in weight of the sample during the test, g.

As a reference, the coating X10CrNiT applied without spray flow pulsation was chosen. According to the results of the tests, the graphs were drawn.

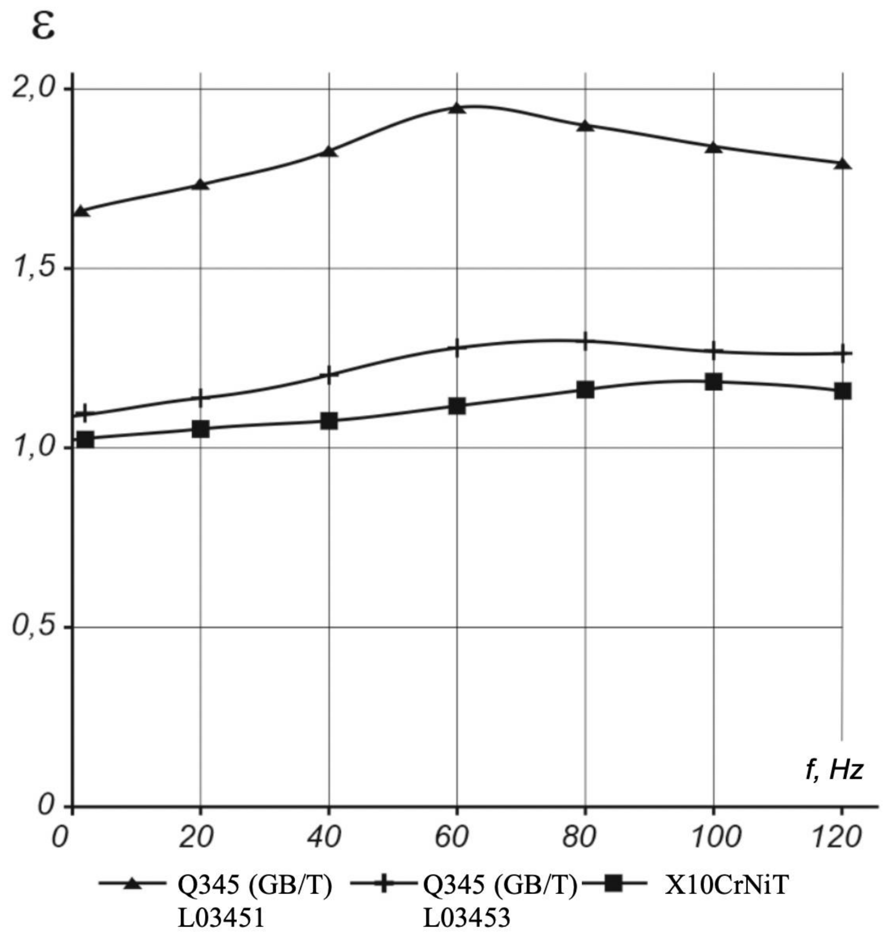


Figure 3. The nature of change in the abrasive resistance of the coatings at a different frequency of spraying airflow.

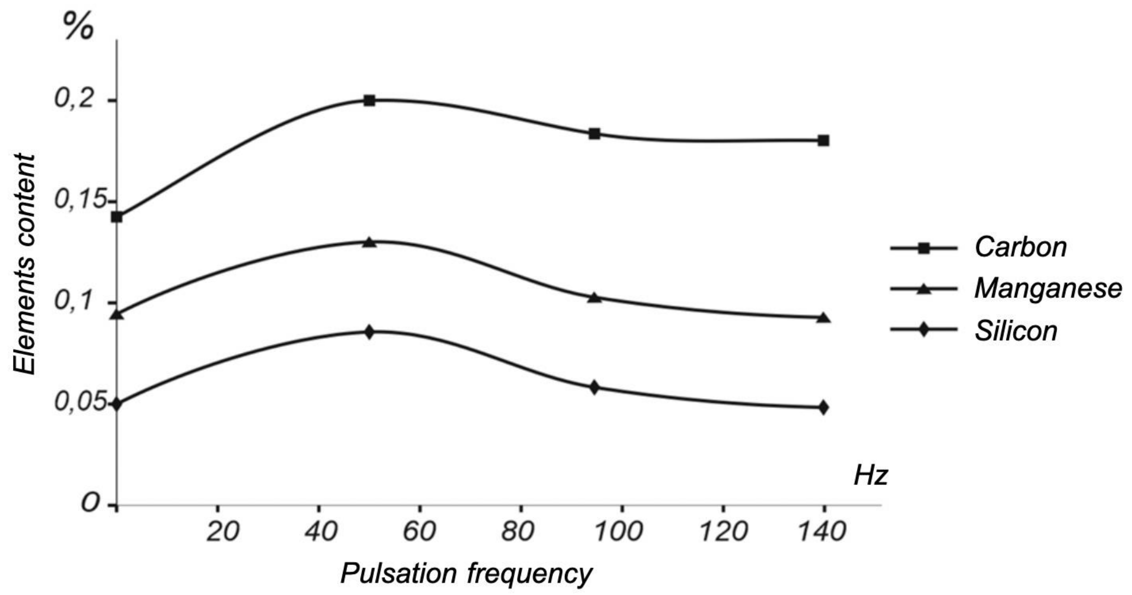
The general analysis shows that the wear resistance of the Q345 (GB/T) L03451 wire coating exceeds the wear resistance of the coating taken as a benchmark. The increase of chromium and nickel content in high-alloy wires provides a slight increase of wear resistance at abrasion wear, however, this increase is insignificant.

At low frequencies (20 Hz) there is no significant increase in the abrasion resistance of the coating. As the pulsation frequency of the spraying flow increases, the abrasion resistance increases.

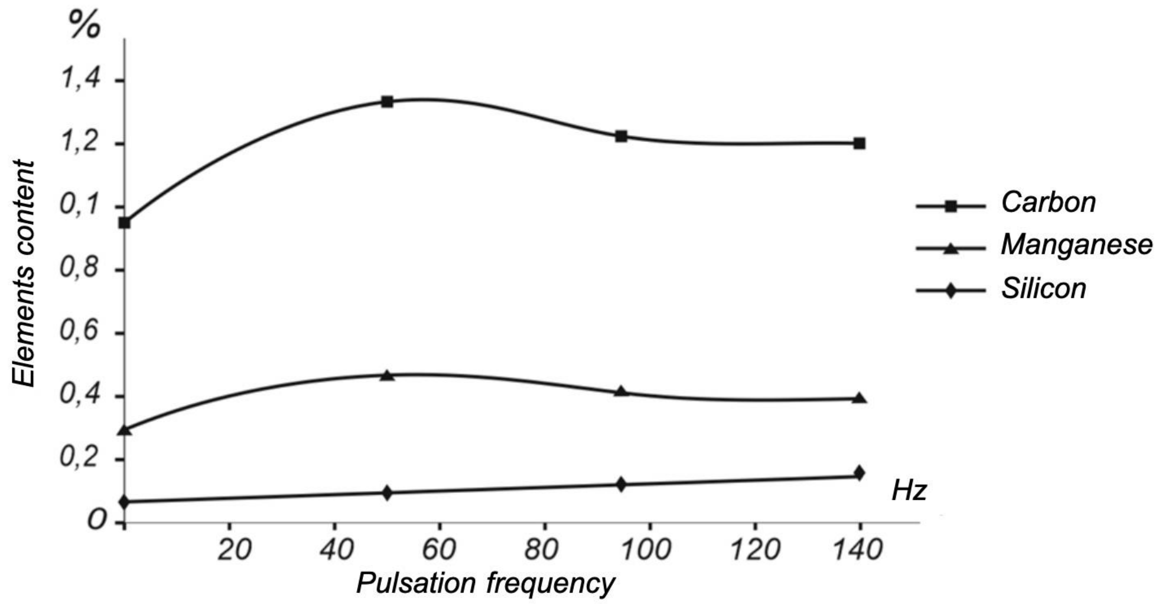
The maximum value is achieved at the pulsation frequency in the range of 60±5 Hz. For Q345 (GB/T) L03451 wire, the increase in abrasion resistance is 26% at 60 Hz frequency. There is also a maximum increase in abrasion resistance for wires X10CrNiT and Q345 (GB/T) L03453 at 60 Hz pulsation frequency of the spraying flow. With an increase in the frequency of spraying flow pulsation of more than 80 Hz, the level of abrasion resistance decreases for the tested wires.

Increase of abrasive resistance corresponds to the character of change of chemical composition of coatings when the maximum reduction of losses of alloying elements of tested wires is reached.

The effect of spraying airflow pulsation frequency on the chemical composition of coatings is presented in graphs [7-11].



a



b

Figure 4. The effect of the pulsation frequency of the spraying airflow on the chemical composition of coatings for different wires: a - Q345 (GB/T) L03451 wire; b - X10CrNiT wire.

The presented graphs (Fig. 4) show that when using a pulsating air-spraying flow there is an increase in the content of alloying elements in the coating. So, at a frequency of pulsation 43 Hz the content of carbon increases on 38 %, manganese on 46 %, silicon on 42 % for wire Q345 (GB/T) L03451 (Fig. 4, a) in comparison with a covering without pulsation. A similar increase in the content of elements is observed in the sprayed coatings when using X10CrNiT wire (Fig. 4, b). The optimum frequency of pulsations is a range of ≈60 Hz, where the minimum oxidation of elements is observed. At increase in frequency over 80 Hz, some growth in losses is observed, as a time of interaction of the liquid metal with the oxygen of an air-spraying jet increases.

Summary

Thus, the increase in abrasion resistance is the greatest when the maximum reduction of losses of alloying elements of the tested wires is achieved.

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