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Investigation and Selection of a Surface Electrode with Improved Properties for Restoration of Worn Parts of Machines from Steel 110G13L

N.Z. Khudaykulov, M.M.Abralov, B.D. Yusupov

Associate Professor, Department of Technological machines and equipment, Tashkent State Technical University named after Islam Karimov, Tashkent, Uzbekistan

Associate Professor, Doctor of Philosophy in Technical Sciences (PhD), Department of Technological machines and equipment, Tashkent State Technical University named after Islam Karimov, Tashkent, Uzbekistan

Researcher, Department of Technological machines and equipment, Almalyk branch of Tashkent State Technical University named after Islam Karimov, Almalyk, Uzbekistan

ABSTRACT: The article presents an analysis of welding electrodes for the restoration of worn machine parts made of steel grade 110G13L, which are distinguished by the release of toxic dust in the aerosol. To improve sanitary and hygienic indicators, it is rational to replace manganese with nickel.

KEY WORDS: high-manganese steel, restoration, wear-resistant surfacing, OZN-7M electrode, wear resistance, aerosol vapors, dust emissions.

I.INTRODUCTION

Parts made of high-manganese steel 110G13L with hardening welding are widely used for the manufacture of working bodies of construction machines (bulldozers, excavators, motor graders, etc.) operating under conditions of abrasive wear and shock loads.

When parts made of manganese steels are hardened by wear-resistant surfacing, their low impact-resistant core is preserved, and the cutting edge is protected from rapid wear, which increases their service life by 2-4 times. In addition, high-manganese steel undergoes phase hardening during operation, as a result of which its strength increases significantly and the wear resistance of non-deposited sections of machine parts increases [1].

II . LITERATURE SURVEY

OZN-7 electrodes are successfully used to restore parts made of steel 110G13L. However, these electrodes contain a significant amount of ferroalloys (chromium and manganese) in the electrode coating, which leads to the content of a significant amount of their oxides in the aerosol, and the sanitary and hygienic characteristics are higher than the maximum permissible concentrations (MPC)[4].

Environmental issues in welding and surfacing of manganese steels are especially important, since when these steels are melted, a certain amount of manganese oxides passes into the environment from the base metal.

In order to create electrodes of the OZN-7 type with sanitary and hygienic properties at the MPC level in the aerosol, the coating components were changed and, due to their ratio, the content of chromium and manganese oxides in it was reduced. The presence of manganese in the coating due to its low evaporation temperature leads to a high content of its oxides in the aerosol[2,3].

The choice of a combination of materials in the coating and their proportions and quantities found provide the least loss of chromium for oxidation and lead to a minimum of its content in aerosol vapors, which makes it possible to abandon the use of toxic manganese as a deoxidizer and improve the sanitary and hygienic characteristics of the electrode coating.

To improve sanitary and hygienic indicators, it is rational to replace manganese with nickel. Alloying of the deposited metal with nickel contributes to an increase in residual austenite in the deposited alloy, which significantly increases the plastic properties of the alloy and the resistance to impacts of a high degree of dynamics, and therefore, durability in operation [6].

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III . METHODOLOGY

A comparative evaluation of widely used electrodes OZN-7 in surfacing parts made of steel 110G13L and experimental OZN-7M electrodes with a reduced content of manganese components in the coating, ITR-69 electrodes, standard UONI-13/55 electrodes was made. For comparison, UONI-13/55 electrodes were chosen, since they provide an unalloyed deposited layer and, consequently, minimal outgassing.
The emission of dust during welding was evaluated depending on the number of deposited layers (Table 1) and the thickness of the coating (Table 2)[8].
Surfacing was carried out with direct current of reverse polarity. Surfacing current 140 A.

Table 1
Dust emission depending on the number of deposited layers

Electrode	Layer number	Dust release, g		Deposited metal content, %							
		g/kg	g / min	C	Si	Mn	Cr	B	V	Ni	Ti
OZN-7	1 2 3	30.48 48.80 46.00	0.451 0.672 0.664	0.55	2.75	3.0	2.9	0.49	0.53	-	-
OZN-7M	1 2 3	20.70 23.34 27.65	0.291 0.320 0.373	0.57	1.40	0.42	2.97	0.48	0.40	1.15	0.07
ITR-69	1 2 3	20.70 23.34 34.10	0.302 0.337 0.478	0.68	0.25	0.42	3.60	-	1.18	0.22	-
UONI-13 /55	1 2 3	17.36 19.74 17.96	0.404 0.315 0.292	0.11	0.30	0.82	-	-	-	-	-

The average content of the deposited metal is given for the third layer of welding, the electrode diameter is 4 mm, except for the ITR-69 electrode (3 mm).

Table 2
Dust emission depending on the coating thickness

Electrode	Bushing diameter, mm	Dust emission	
		dependence on the thickness of the electrode coating, g / kg	time dependence, g/min
OZN-7	5.7 5.9 6.1	46.78 46.45 45.91	0.689 0.683 0.661
OZN-7M	5.7 5.9 6.1	28.98 27.76 27.65	0.384 0.355 0.320
UONI-13 /55	5.0 6.0	19.83 16.27	0.233 0.200

The emission of dust was measured on the third layer of hardfacing. The intensity of dust emission was determined in two ways: the amount of emitted dust in grams, related to the number (in kilograms) of the electrodes used in this case, the amount of dust (in grams), related to the unit of time (in minutes). As you can see, dust emission, determined in relation to the mass of the used electrodes, and in relation to time, on the first layer is noticeably lower than on subsequent ones.
When surfacing alloyed metal (electrodes OZN-7, OZN-7M, ITR-65), the intensity of dust emission increases with an increase in the number of layers. When using electrodes UONI-13 /55 (low-alloyed metal), it practically does not change. This is obviously caused by an increase in alloying in the second and third layers of the deposited metal. The distribution

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coefficient of alloying elements between the gas phase and the solid metal practically does not change, and the content of slag-forming elements increases.

Thus, it was found that dust emission, in addition to the composition of the coating, also depends on the number of layers during surfacing. At the same time, the total level of dust on all layers of surfacing electrodes is significantly higher than that of welding electrodes of the UONI-13 /55 type, and only the new OZN-7M electrodes are comparable in terms of dust emission to the UONI-13 /55 electrodes.

We studied the effect of changing the coating thickness of experimental, OZN-7 and UONI-13 /55 electrodes on the amount of dust released during welding and surfacing (see Table 2). For the manufacture of experimental electrodes, bushings of a standard diameter (6.1 mm) and a smaller one (5.9 and 5.7 mm) were used.

Changing the thickness of the electrode coating also significantly affects the amount of dust released during surfacing and welding. The thicker the coating, the less dust is released into the atmosphere. This is due to the fact that with an increase in the diameter of the sleeve, in order to maintain the level of alloying in the deposited metal, remixing is carried out in the direction of increasing the number of components of the slag protection. The number of charge components responsible for alloying the alloy does not change.

The analysis of the conducted studies showed that in order to obtain surfacing electrodes at the level of the maximum permissible concentration (MPC) in an aerosol, it is rational to reduce the manganese content. Components in the coating, replacing them with a small amount of nickel powder to austenize the weld metal. The environmental properties should not be changed by reducing the diameter of the sleeve and, accordingly, the diameter of the electrodes, so as not to worsen the gas and slag protection. Their comparative wear resistance during abrasive-impact wear on the “Rotor” machine.

The tests were carried out with different energy of a single impact (table 3). As can be seen from the data obtained, the wear resistance of surfacing with new OZN-7M electrodes is slightly higher than with OZN-7 electrodes. Obviously, this is due to the greater resistance of nickel austenite compared to martensite. If we compare these two brands of electrodes in terms of wear resistance with the well-known T-590 electrodes, then their resistance is 2.5-3.5 times higher when working under conditions of abrasive-impact wear. Thus, electrodes of high wear resistance OZN-7M have been developed and mass-produced, in terms of ecology at the level of MPC in aerosol.

Table 3

Test results of deposited layers

electrodes	Energy of a single impact E, J / m ^{2}	Hardness HRC	Relative wear resistance	Note
OZN-7	0 1.0 2.5	51 59 63	- 4.00 3.85	No breaks were observed
OZN-7M	0 1.0 2.5	50 58 65	- 4.30 4.00	No breaks were observed
110G13L (standard)	0 1.0 2.5	26 39 42	- 1.00 100	No breaks were observed
T-590	0 1.0 2.5	60 59 58	- 1.80 1.10	Spalls on the surface of the sample at E = 2.5 10 ^{5} J / m ^{2}

OZN-7 and OZN-7M electrodes are successfully used for hardening and restoration of ripper tips of imported excavators, drilling augers and bits, excavator buckets, dredge scoops, parts made of 110G13L steel. Hardness in the second layer is 50÷55 HRC , wear resistance in the development of frozen soils of categories 4 and 5 is 2.5÷4 times higher compared to steel 110G13L and 2.5 times higher than known T-590 electrodes in abrasive-impact wear .

So, the best option is the new OZN-7M electrodes with a diameter of 5 mm. In terms of price, they are at the level of industrial electrodes OZN-7 and are not inferior to them in terms of technological properties. The deposited metal microstructure, consisting of boride -carbide eutectic and austenitic matrix, provides high strength characteristics and complies with sanitary and hygienic requirements in terms of MPC in aerosol. Electrodes OZN-7M are promising for wide application in many areas of industry.

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IV . CONCLUSION

For surfacing of parts made of steel 110G13L and various structural steels, OZN-7M electrodes have been developed and industrially tested, which have environmental properties at the level of world standards.
Cr and Mn oxides in the aerosol due to the optimal quantitative and qualitative ratio of components in the coating composition.
The coating composition of the proposed electrodes is selected taking into account the thickness of the coating of the electrodes.
The metal deposited by the proposed electrodes has a high resistance under conditions of intense abrasive wear. They are successfully used to strengthen the working bodies of construction machines.

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AUTHOR'S BIOGRAPHY

	**Khudaykulov Nurulla Zikirillayevich.** Associate Professor, was born June 3, 1972 year in Tashkent city, Republic of Uzbekistan. Has more than 35 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.
	**Abralov Muzaffar Makhmudovich**, Associate Professor, Doctor of Philosophy in Technical Sciences (PhD), was born March 4, 1978 year in Tashkent city, Republic of Uzbekistan. Has more than 50 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.
	**Yusupov Bekzod Dilmurod.** Researcher, was born February 14, 1994 year in Andijan city, 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 Almalyk branch Tashkent State Technical University.