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# FEATURES OF CAST IRON WELDING WITH ELECTRODES WITH OXIDIZING COATING[21]

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***Annotation***. *Application issues of manual arc cold-welding of cast iron by electrodes on Cv-08A wire with oxidizing coating containing oxidizing agents, slag-forming and stabilizing elements of marble, hematite, quartz sand, chromium oxide, aluminum powder, mica and soda are considered.*
***Key words:*** *cast iron, welding, oxidizing agents, hematite, coating.*

# ОСОБЛИВОСТІ ЗВАРЮВАННЯ ЧАВУНУ ЕЛЕКТРОДАМИ З ОКИСЛЮВАЛЬНИМ ПОКРИТТЯМ

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***Анотація.*** *Розглянуті питання застосування ручного дугового холодного зварювання чавуну електродами на дроті Св-08А з окислювальним покриттям, що містить окислювачі, шлакообразующие і стабілізуючі елементи - мармур, гематит, кварцовий пісок, оксид хрому, алюмінієвий порошок, слюду і соду.*
***Ключові слова:*** *чавун, зварювання, окислювачі, гематит, покриття.*

## Introduction

In iron castings different defects are detected at different processing stages. In addition, the reduced strength and high brittleness of grey irons in some cases lead to breakdowns during operation of the parts made of them, which in turn leads to failure or downtime [1].

Welding processes are widely used to eliminate defects in cast iron castings and to repair damaged parts.

## State of the question

Noteworthy is the work carried out by P.S. Elistratov on the development of EMF type electrodes on Sv-08 wire coated with oxidative form. Under conditions of high-temperature phase of the welding arc carbon is the most active oxidizing agent. Oxidized carbon as CO gas is removed from the welding bath. The large thickness of the coating and high values of welding current used at welding by the electrodes of MES did not allow to establish optimal limits of electrode manufacturability [1].

## Purpose and mission statement

The purpose of this work was to create electrodes for cold welding of cast iron on the rods from Cv-08A wire and coating containing oxygen-containing component - hematite, which differ

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from the electrodes of the brand MES with improved welding and technological properties and high quality of the molten metal by changing the slag and alloying coating system.

## Research Materials and Methodology

Metal electrodes for manual arc welding, manufactured by pressing method, were used for research. Rods of electrodes were made of steel welding wire of Sv-08A grade according to GOST 2246 with diameter of 3 and 4 mm.

The electrodes were coated with sour look. Aluminium powder of PAP-1 grade according to GOST 4135 was used as a weld metal deoxidizer. Hematite (Fe2O3) in accordance with GOST 4418 was used as an oxidizing component.

Coating weight factor of electrodes was 0.45...0.47 at coating thickness on the side of 0.8 mm of electrodes with diameter of 3 mm, and 1 mm - electrodes with diameter of 4 mm. 5 versions of electrodes were produced. For comparison, the EMF electrodes were manufactured.

Welding and surfacing of samples for testing hardness and chemical composition of weld metal and molten metal, as well as welding and technological properties of electrodes, in accordance with the requirements of GOST 9466, were produced both on alternating and direct current of forward and reverse polarity. Welding transformer TD-502.U3 and rectifier VDU-504 were used as power sources. Current strength for 3 mm diameter electrodes was 100 ... 120 A, and for 4 mm diameter electrodes - 160 ... 180 A.

For manufacture of welded samples plates from cast iron of mark СЧ 21 according to GOST 1412 with thickness of 30 mm were used. Preparation of edges for welding of butt joints corresponded to GOST 9466. Hardness of metal of a seam and the clad metal was measured on device TK-2 (on a scale C), microhardness was measured on device ПМТ-3, at loading 100 g. Samples for chemical analysis of molten metal were taken from three upper layers of eight-layer cladding in accordance with GOST 7122.

## Results of the study and their discussion

The general character of the microstructure of the welded seams was estimated with the help of the optical microscope MIM-8M on transverse microsections of 15x25x30 mm, etched in 5% nitric acid alcohol solution.

The main task in the development of ZTM-Ch electrodes was the maximum removal of carbon from the weld metal due to its oxidation with oxygen of the gas and slag phases of the arc.

To study the degree of carbon burnout from the weld metal the multilayer cladding with the height of 20 mm by the studied electrodes on the mechanically processed plate surface from grey cast iron of mark СЧ 21 was made and the chemical analysis of the weld metal by depth with the step of 1 mm from the top of the clad metal to the base metal was made.

The obtained results show that in the weld metal molten by the developed electrodes with increasing distance from the base metal the carbon content in the weld metal decreases sharply and reaches the minimum required values at the height of 6-7 mm. This corresponds to the second pass at welding with 4 mm diameter electrodes. The content of Si, Mn alloying elements as well as P and S harmful impurities is also reduced.

At welding by electrodes of mark SES the decrease in the content of carbon in weld metal is less intensive and the level of carbon below 0,12 % is reached at height more than 10 mm that corresponds to the third pass. The reduction is similar to that of other elements.

The results obtained confirm the assumption of a more complete decarburization of the weld metal by the composition of ZTM-Ch electrodes coating, which makes it possible to conduct further studies.

Graphically, the results of these studies are shown in fig. 1.

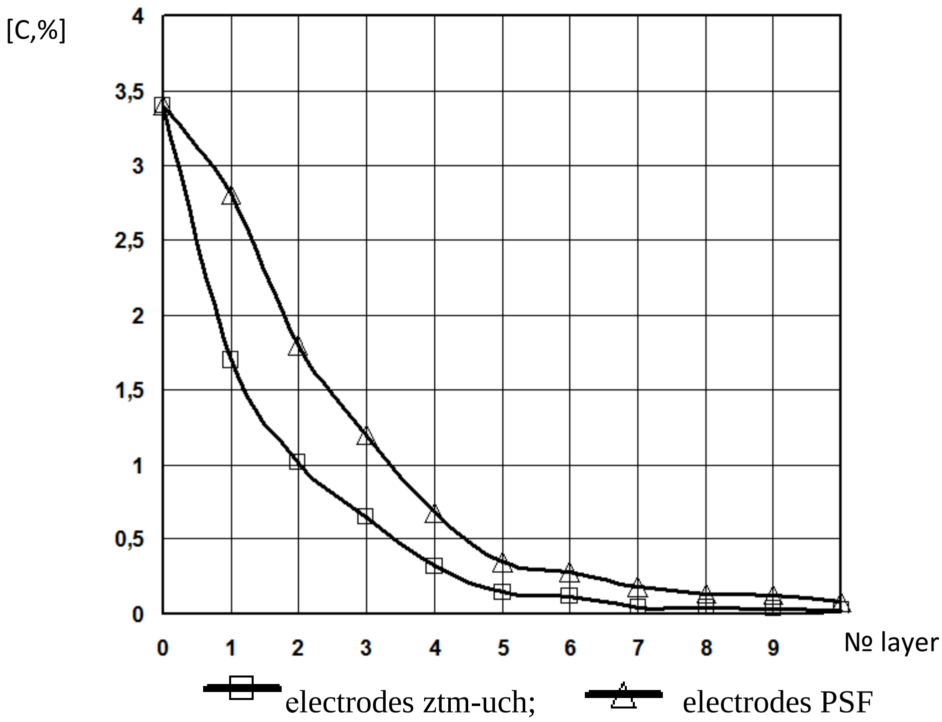


Figure 1 - Dependence of carbon content in metal on seam height

In order to study the effect of carbon content in the molten metal on the hardness, the dependence of the hardness of the molten metal on the seam height was studied. Measurements were made on three-layer cladding grinding in seven points with a pitch of 1 mm (fig. 2).

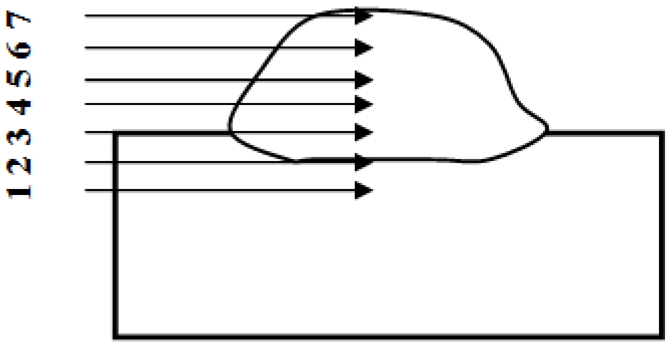


Figure 2 - Diagram of hardness measurement of molten metal

The results of hardness measurements are given in table 1.

As can be seen from Table 1, the hardness of the molten metal decreases in the height of the seam. Maximum weld metal hardness in the fusion zone (point #2).

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At electrodes ZTM-UCH hardness of metal in the fusion zone is much lower than at electrodes of PSF that allows to mechanically process welded seams.

The study of macrostructure of welded samples at cladding from 1 to 5 layers (fig. 3) showed that the alloy line of cast iron-steel is smooth without obvious defects and discontinuities. The molten metal in all samples is dense, without cracks and slips.

A smooth transition from the base metal (grey cast iron СЧ 21) to the cladding is seen on the undressed slate (fig. 4). The amount of structurally free graphite gradually decreases as it is removed from the base metal in full accordance with the degree of cast iron decarburization with oxygen of coating.

Table 1 - Hardness of the molten metal, HRC

| Electrode option | Numbers of points (from below up through 1 mm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| electrodes PSF | 18 | 55 | 48 | 46 | 42 | 35 | 20 |
| electrodes ztm-uch | 18 | 43 | 38 | 30 | 20 | 17 | 16 |

The width of the thermal influence zone revealed after metallographic etching (fig. 5) is 0.3-0.35 mm.

The structure of the basic metal is plate graphite, matrix is sorbite-like and thin-plate pearlite with insignificant amount of ferrite.

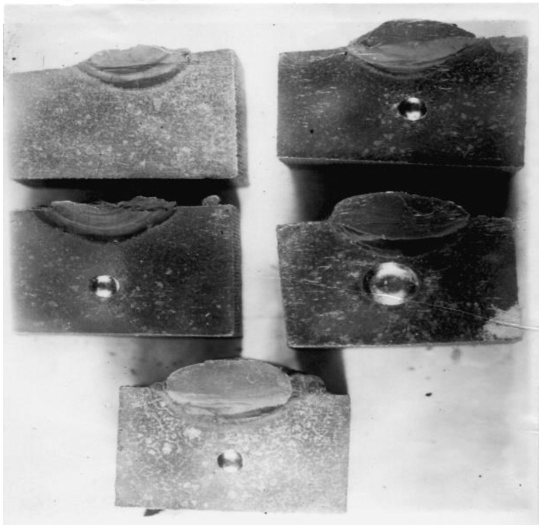
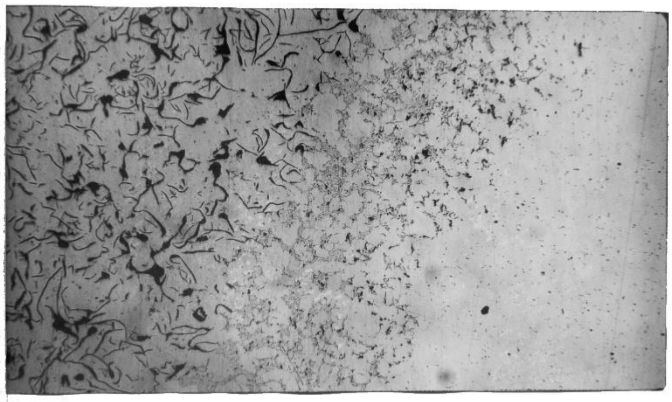


Figure 3 - Macrostructure of Weld Joints

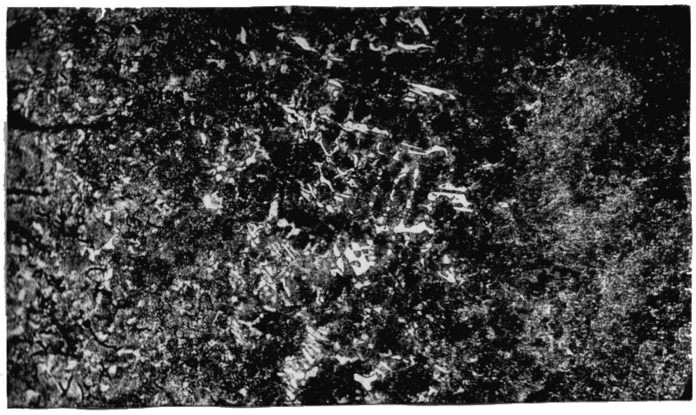
In the zone of thermal influence - troosto sorbitol and annealed graphite, Hμ = 297-420 (HRC = 29-43). Cement and ledeburitis needles are also observed (needle hardness Hμ = 742, HRC 61). The width of the section with the presence of needle structure is 0.1-0.2 mm.

The structure of the molten metal in the area immediately adjacent to the main one is a large grain of troto-sorbit with a hardness of Hμ = 420 (HRC = 43). Then troostosorbit Nμ = 322-420 (HRC 32-43) with light areas of troosto-martensite Nμ = 464 (HRC 46).



×100, not damaged

Figure 4 - Melting zone of cast iron-steel



×450

Figure 5 - Microstructure of cast iron-steel melting zone

With removal - troostosorbit and small ferrite inclusions Nμ = 254-350 (NRC 23-35).

Near the surface - a structure typical for cast low-carbon steel (Hμ = 170-254).

The results of chemical analysis of three-layer surfacing of cast iron plates СЧ 21, made by electrodes ZTM-UCH diameter of 4 mm at currents 140, 160 and 180 A in reverse polarity are presented in Fig. 6, 7.

As can be seen from the results of research with increasing current strength at welding at straight and reverse polarity the degree of carburization of weld metal increases, which is explained by an increase in melting of the main metal - cast iron. Depending on the number of welds, the carbon content of the weld decreases, which is explained by dilution of metal of previous welds with molten electrode metal. Similar dependencies are observed for Mn and Si.

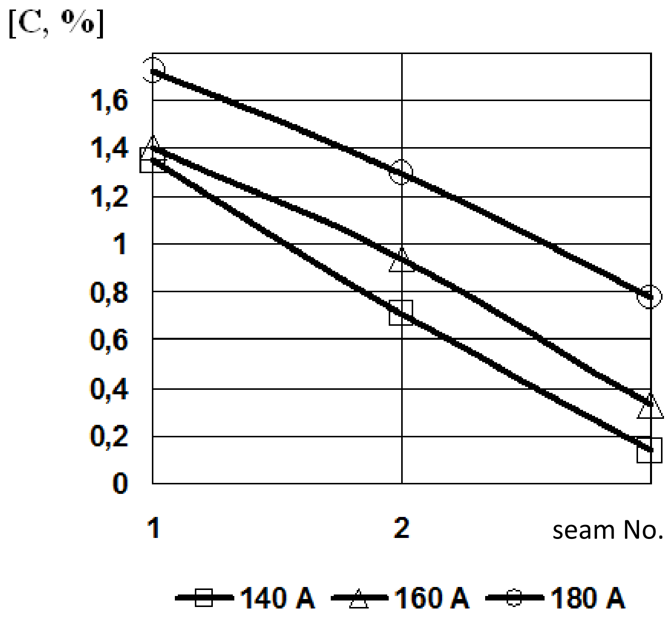



Figure 6 - Dependence of the carbon content in the weld metal on the current strength at reverse polarity welding

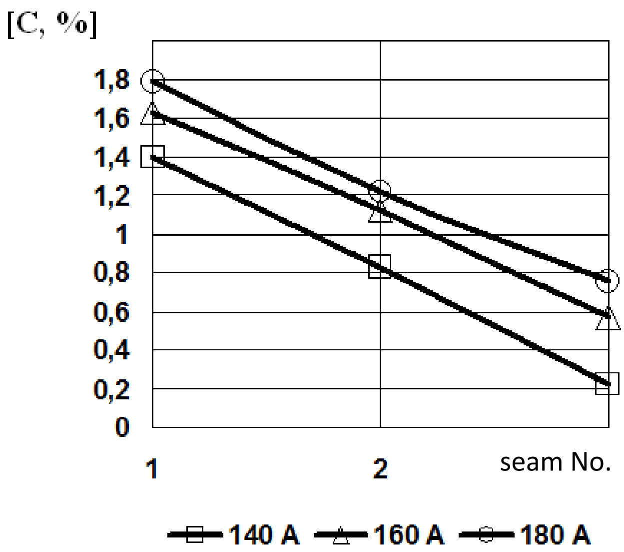



Figure 7 - Dependence of carbon content in the weld metal on the current strength at direct polarity welding

## Conclusions

1. Electrodes for cold welding of cast iron on Cv-08A wire with oxidizing coating have been developed.
2. The quality of the molten metal is high, without pores and cracks. Alloy line of steel-iron is smooth, with gradual change of carbon content.
3) The hardness of the molten metal varies in height of the molten metal from HB 200 in the upper layers to HRC up to 43 - near the alloy zone. In the thermal-influence zone, the hardness increases to 61 NRC. The width of the cement-ledeburite zone is 0.1-0.2 mm.
4. With increasing current strength at welding at straight and reverse polarity the degree of carburization of weld metal increases.

5. The technology of multilayer cold arc welding of cast iron parts and welding of defects in castings is developed.

6. Introduction of the developed electrodes will allow to correct foundry defects in castings and to restore the broken cast iron parts of various machines and mechanisms that will prolong their service life.

## Literature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