ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 10, Issue 2, February 2023

On the question of studying the influence of the type of electrode coating on the metal of the weld pool

A.S. Saidakhmatov, M.M. Abdurakhmonov , J.N. Sadikov, S.S. Khudoyorov, Z.D. Ermatov, N.S. Dunyashin

Assistant of the department of "Technological machines and equipment" of Tashkent State Technical University named Islam Karimov, Tashkent, Uzbekistan.
Assistant of the department of "Technological machines and equipment" of Tashkent State Technical University named Islam Karimov, Tashkent, Uzbekistan.
Associate Professor, Doctor of Philosophy in Technical Sciences (PhD), Department of Engineering technology, 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
Professor, Doctor of Technical Sciences, Department of Technological machines and equipment, Tashkent State Technical University named after Islam Karimov, Tashkent, Uzbekistan
Head of the Department, Doctor of Technical Sciences, Professor, Department of Technological machines and equipment, Tashkent State Technical University named after Islam Karimov, Tashkent, Uzbekistan

ABSTRACT: This article analyzes the physicochemical and technological features of the processes occurring during welding with acid, basic, rutile and cellulose coated electrodes. The main welding and technological properties of the developed electrodes are given.
This article presents a study of the interaction of molten metal with complex gases containing oxygen in manual arc welding in arc welding and surfacing of low-carbon and low-alloy steels

KEY WORDS: arc welding, low alloy steel, electrode, slag, oxide

I. INTRODUCTION

Welding is one of the leading technological processes for the manufacture of metal structures. The required properties and operational reliability of welded structures are determined primarily by the quality of the welding consumables used, the correct choice of them, and strict adherence to the application technology [1,2].
A large number of welding consumables are also used for the manufacture of welded structures, various surfacing operations. Of all the welding consumables produced in Uzbekistan, coated electrodes occupy a leading position in terms of application volume. They weld over 90% of manufactured metal structures.
This situation is explained by the simplicity, great maneuverability and versatility of the welding process with coated electrodes, as well as the high quality of the welds made by them. Thanks to the continuous improvement of the technical level and productivity of electrodes, welding with coated electrodes will be one of the main methods of fusion welding for a long time to come [3].

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 10, Issue 2, February 2023

II. LITERATURE SURVEY

In recent years, the number of brands of piece consumable electrodes used for welding and surfacing has amounted to several hundred. Of this number, about ten grades are widely used for the manufacture of structures from ordinary steels, accounting for 90% of production volume.

Other grades, used by individual small or medium batches, are used for specific welding and surfacing work. These include electrodes for welding medium-alloyed and especially high-alloyed steels, providing special physical properties of the weld metal, electrodes for welding various non-ferrous metals and alloys, surfacing and others [4].

Electrode coatings consist of slag-forming, gas-forming, deoxidizing, alloying, stabilizing and binding (adhesive) components and they are usually classified according to the type of basic substances included in them and determining the effect of the coating on the metal of the weld pool, into 4 groups: acidic, basic, rutile and cellulose [5].

III. METODOLOGY

Basic coated electrodes contain a large amount of carbonates, mainly marble $CaCO_3$, fluorspar CaF_2, a small amount of quartz or rutile. Deoxidizers are ferrotitanium, ferrosilicon, ferromanganese, sometimes ferroaluminum. Sodium or sodium-potassium liquid glass is used as a binder.

Sufficiently reliable gas protection is carried out due to the thermal decomposition of carbonates by the reaction $CaCO_3 \rightarrow CaO + CO_2$.

Strong deoxidizers (Ti, A1, Si) begin to interact with CO_2 even in the process of coating melting, for example, by reaction with titanium: $2CO_2+Ti=2CO+TiO_2$

Carbon dioxide, which has not reacted with deoxidizers, during the melting of the coating at a high temperature of the welding arc, dissociates with the release of active O_2 according to the reaction $CO_2 \rightarrow CO+ 1/2O_2$. Therefore, the arc atmosphere is oxidizing.

At high temperatures, Si, Ti, and Mn coexist with O_2 dissolved in the metal. As the temperature decreases, depending on the concentration and type of deoxidizers, O_2 reacts with them, forming oxides of the corresponding elements. Usually these are the most active elements Ti and Si.

The resulting acid oxides TiO_2 and SiO_2 have a high affinity for slag with high basicity, containing a large amount of CaO. Washing the weld pool, such slag binds acidic oxides into strong compounds of $CaO \cdot TiO_2$ and $CaO \cdot SiO_2$, thereby purifying the metal from non-metallic inclusions. As a result, subject to the observance of the manufacturing technology and the use of electrodes with a basic coating, the O_2 content in the deposited metal is about 0.02–0.03%.

The low content of O_2 and, consequently, a small amount of oxide inclusions provide very high plastic properties of welds both at positive and negative temperatures. Coated electrodes of the type in question make it possible to weld in almost all spatial positions using direct current; mostly reverse polarity.

Basic coated electrodes are used for welding thick metals, for products operating in difficult operating conditions or transporting gases, as well as for welding cast carbon, low-alloy high-strength steels and steels with a high content of sulfur and carbon. Basic coated electrodes are very sensitive to the formation of pores during welding if the edges of the workpieces to be welded are covered with scale, rust, oil, and also if the electrode coating is moistened and the arc length is long. The mechanical properties of the weld metal are controlled by introducing chromium, molybdenum, ferromanganese and ferrosilicon into the coating.

Acid-coated electrodes contain a large amount of iron oxides Fe_2O_3 or manganese MnO_2 and various silicates with a high content of SiO_2; ilmenite or titanium concentrate may also be present in the coating. The deoxidizer is usually ferromanganese. Gas protection is carried out by the introduction of electrode cellulose (EC) in an amount of up to 5% [3,4].

As a result of the dissociation of iron or manganese oxides, as well as hygroscopic and constitutional water, the arc atmosphere is oxidizing. The slag formed during the melting of the electrode contains a large amount of iron oxides. Therefore, the melting metal at high temperature is oxidized both due to the arc atmosphere and due to O_2 passing from the slag.

Used as a deoxidizer, Mn begins to oxidize in the consumable coating when interacting with iron oxides and partly due to O_2 of the arc atmosphere. Mn passes into the liquid metal in a very moderate amount.

At a high process temperature, a small amount of Si (0.07–0.12%) is usually reduced from SiO_2 according to the reaction $SiO_2+2Mn=2MnO+Si$. At such temperatures, the reaction between C and O_2 also proceeds with the formation of CO.

In the tail section of the bath, which has a relatively low temperature, the reduced Si and Mn transferred from the coating react with O_2 dissolved in the liquid metal. As a result, inclusions of SiO_2 and MnO are formed, which can partially form between themselves a chemical compound SiO_2· MnO with a melting point of 1270°C. Such compounds are able to grow larger due to the fusion of several molecules. The deposited metal is very heavily contaminated with both large and fine inclusions.

The metal deposited with acid-coated electrodes most often corresponds in composition to boiling steel and contains from 0.12% C, 0.10% Si, 0.6-0.9% Mn to 0.05% S and P each. The electrodes of this group are suitable for welding in all spatial positions with alternating and direct current and are characterized by a fairly high melting rate. They are not recommended for welding steels that have a high content of sulfur and carbon, since the weld metal made by these electrodes is sensitive to the formation of crystallization cracks.

Acid-coated electrodes can weld metal with rusty edges, scale (at a significant arc voltage), while obtaining tight seams. The disadvantages of these electrodes are reduced resistance to the formation of crystallization cracks, increased spattering of the metal and the release of manganese compounds during the surfacing process, which adversely affect the human body [4,5].

Rutile coated electrodes contain a large amount of rutile (TiO_2 content ≈95%), aluminosilicates (potassium mica, kaolin, feldspar), a moderate amount of carbonates (marble, magnesite). The deoxidizer is ferromanganese. In addition to carbonates, gas shielding is provided by cellulose (EC) introduced into the electrode coating up to 4–5%.

Potassium-sodium or sodium-potassium liquid glass is used as a binder. The atmosphere of the arc is weakly oxidizing due to oxygen formed during the dissociation of carbonates ($CaCO_3 \rightarrow CaO+CO+1/2O_2$); decomposition of cellulose; dissociation of coating moisture.

In addition to the oxidation of liquid metal with oxygen from the arc atmosphere, oxidation is possible as a result of the silicon reduction process, due to the presence of a large amount of acid oxides (TiO_2, SiO_2) in the coating. This reaction proceeds as follows: $SiO_2+2Fe=Si+2FeO$.

Iron oxides partially pass into slag, partially dissolve in liquid metal.

The concentration of reduced Si reaches 0.13-0.20%, which is noticeably higher than in welding with acid-coated electrodes, and the O_2 content is usually at the level of 0.04-0.07%. At high temperatures, Mn transferred from the coating and reduced Si do not react with O_2 dissolved in the liquid metal. In this case, only the reaction of carbon oxidation is possible.

As the temperature decreases, Si and Mn begin to react with O_2. At a high concentration of reduced Si ($Si \geq 0.02\%$) and a low content of Mn ($Mn \leq 0.5\%$), the welds will contain mainly fine inclusions of silicon oxides, which adversely affect the plastic properties of the welds. Therefore, it is expedient to limit the development of the silicon reduction process with the Si content to 0.13–0.15%.

This is usually done by introducing carbonates ($CaCO_3$, $MgCO_3$) into the coating composition, which, when the coating melts, decompose into CO_2 and oxides of the basic type CaO and MgO. Due to the lower O_2 content in the weld metal and fewer oxide inclusions, rutile coated electrodes provide better service characteristics of welds compared to acid coated electrodes.

Rutile coated electrodes also have high welding and technological properties. They make it easy to weld not only on direct, but also on alternating current, in almost all spatial positions, provide good formation of welds, easy separation of slag. An important characteristic is their relatively low toxicity during welding. The metal deposited with rutile-coated electrodes contains up to 0.12% C; 0.4–0.7% Mn; 0.10-0.30% Si; 0.04% S and P each [3,4].

Cellulosic coated electrodes contain a large amount of electrode cellulose - up to 40-45%. Slag-forming materials are rutile, talc, asbestos, sometimes manganese ore or hematite. Ferromanganese is used to deoxidize the metal, sodium or sodium-potassium liquid glass serves as a binder. Due to the high content of cellulose, the electrode coating provides powerful gas protection of the deposited metal, despite the low value of the mass coefficient of the coating, which does not exceed 20–25%. The gases released during the decomposition of cellulose contain a large amount of H_2, CO and a moderate amount of O_2.

In connection with the above, the atmosphere of the arc is weakly oxidizing. When welding with cellulose electrodes, the silicon reduction process proceeds intensively. To partially suppress it, manganese ore MnO_2 is sometimes introduced into the coating, less often hematite Fe_2O_3. For the same purpose, the electrodes are dried at a temperature of about 120–130°C, which partially retains moisture in the coating and thereby increases its oxidation potential.

Under these conditions, the deposited metal has the following chemical composition: C≤0.12%; Mn≤0.5%; Si≤0.2%. These electrodes provide little metal spatter and little slag. A distinctive feature of the electrodes is the ability to perform welding in all spatial positions with both alternating and direct current, and ensuring deep penetration of the base metal.

Thus, based on the above analysis, electrodes with a basic coating were selected and developed based on local raw materials. The authors obtained the optimal concentrations of ferroalloys in the composition of the coating, which are in the following ranges: ferromanganese 1.9-2.1 wt. %, ferrosilicon 3.2-3.8 wt. %, ferrotitanium 11.0-15.0 wt. %. The results of the chemical analysis of the slag are shown in Table 1.

Table 1
The main components of the slag, %

Fe	TiO_2	MnO	SiO_2
2,02	3,52	6,36	30,24

The results of the chemical analysis of the base metal and the metal of the electrode rod, as well as the metal of the weld and the deposited electrode with a diameter of 4.0 mm are shown in Table 2.

Table 2

Researched metal	Elements, wt. %		
	silicon	manganese	carbon
The base metal is steel st3sp	0,192	0,495	0,205
Electrode rod - Sv08A	0,027	0,432	0,417
weld	0,139	0,758	0,109
weld metal	0,148	0,972	0,082

Welding and surfacing with these electrodes is carried out on direct current of reverse polarity and alternating current. Productivity (for a diameter of 4.0 mm) 10.5 g / (A · h); 1.6 kg/h. The consumption of electrodes per 1 kg of deposited metal is 1.8 kg.

IV.CONCLUSION

The analysis of the physicochemical and technological features of the processes occurring during welding with acid, basic, rutile and cellulose coated electrodes made it possible to develop electrodes for manual arc welding with improved welding and technological properties.

ACKNOWLEDGMENT:

This work was carried out within the framework of a business agreement with the Tashkent Pipe Plant named after V.L. Galperin No. 3/21 on the topic: «Development of the coating composition and technology for the production of electrodes for surfacing a layer of low-alloy steel».

REFERENCES

[1]. Dunyashin N.S. Development of a multicomponent coating of electrodes for manual arc welding of low-carbon and low-alloy steels. - T .: Fan va texnologiya, 2019 - 160 p.
[2]. Ermatov Z.D. Development of scientific bases for creating multicomponent electrode coatings for manual arc surfacing. Monograph. T: Fan va texnologiyalar nashriyot-matbaa uyi, 2021 – 140p.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 10, Issue 2, February 2023

[3]. Pokhodnya I.K. Metallurgy of arc welding of structural steels and welding materials // Welding production. - 2009. - No. 4. - P. 3-15.
[4]. Kuznetsov M.A. Nanotechnologies and nanomaterials in welding production (Review) / M.A. Kuznetsov, E.A. Zernin // Welding production. - 2010. - No. 12. - P.23-26.
[5]. Verkhoturov A.D. Methodology for the creation of welding consumables: monograph - Khabarovsk: Publishing House of the Far Eastern State University of Railway Engineering, 2009. - 128 p.

AUTHOR'S BIOGRAPHY

	**Saidakhmatov Asrorhon Saidakbar ugli**, Assistant, was born November 15, 1993 year in Tashkent city, Republic of Uzbekistan. Has more than 15 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.
	**Abdurahmonov Mansurjon Muridjon ugli**, Assistant, was born May 3, 1993 year in Tashkent city, Republic of Uzbekistan. He has more than 15 published scientific works in the form of articles, theses and tutorials. Currently works at the department of "Technological machines and equipment" in Tashkent State Technical University as an assistant teacher, Tashkent, Uzbekistan.
	**Sadikov Jaxongir Nasirdjanovich** , Associate Professor, Doctor of Philosophy in Technical Sciences (PhD), was born March 10, 1975 year in Tashkent 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 "Engineering texnology" in Tashkent State Technical University
	**Khudoyorov Sardor Sadullaevich** , Associate Professor, Doctor of Philosophy in Technical Sciences (PhD), was born March 7, 1989 year in Tashkent city, Republic of Uzbekistan. Has more than 40 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.

ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 10, Issue 2, February 2023

	**Ermatov Ziyadulla Dosmatovich,** Doctor of Science, Professor was born in May 16, 1978th year in Tashkent city, Republic of Uzbekistan. He has more than 110 published scientific works in the form of articles, these and tutorials. Currently Professor of the department of "Technological machines and equipment" in Tashkent State Technical University, Tashkent, Uzbekistan.
	**Dunyashin Nikolay Sergeyeevich** , Head of Department, Doctor of Science, Professor was born February 13, 1978 year in Tashkent city, Republic of Uzbekistan. Has more than 140 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.