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The Influence of Modes of Deposition of Coatings on the Corrosion Resistance of Welded Joints of Steels in Acidic Media*

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Abstract. In this work, effect of welding on corrosion of welded joints of austenitic steel 12KH18N10T. It is shown that the use of pulsed - arc welding steel 12KH18N10T allows you to create a protective coating with dispersed structure with less thermal impact on the zone of the welded joint. Coating is of such structure allows 1.5 to 6 times to reduce the corrosion rate of welded joints of steel 12KH18N10T in active chemical environments. Pulse the process of deposition of coatings on welded joint of steels can be effectively used for the protection against corrosion in the repair of equipment of chemical industry. The results obtained can be recommended for use when welding a protective corrosion - resistant coatings on working surfaces of equipment of chemical productions.

Introduction

Method of welding allows increasing the productivity and quality of products thanks to the strengthening and restoration of worn working surfaces in contact with corrosive environments [1]. However, coatings formed by this method, characterized by the appearance of various defects. The increase in the depth of melting increases the area of sensitization and lack of fusion leads to incomplete fusion of the formed coating from the protected surface [2]. It is necessary to conduct search for new ways of addressing issues of eliminating emerging gaps.

When welding melts the coated electrode and partial melting of the processed surface. On this surface is formed by surfacing a bath, and as you move the heat source relative to the surface is the crystallization of the molten metal in the deposited bead, the geometric size of which is largely determined by the processes occurring in the bath. When welding in pulsed mode chart changes in the welding current (figure 1) differs significantly from the chart using the DC.

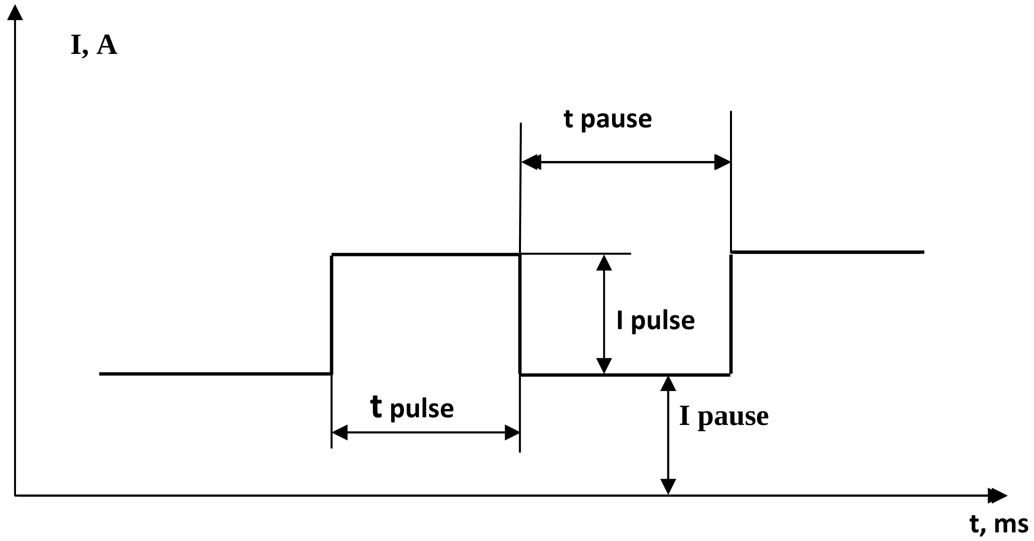

Figure 1. The scheme of change of current surfacing: AI - a working pulse current; IB - base current; t - time of the pulse; tп - the pause time.

Implementation for surfacing this chart allows the periodization of the physical processes proceeding in the weld pool. As a result of alternating pressure of the arc during formation of the deposited coating metal bath surfacing performs reciprocating motion [3-5]. Such a flow of the process allows surfacing to ensure the circularity of physical processes at the stages of formation of the fused bath and metal crystallization from the melt, which promotes active mixing. The active stirring of weld pool contributes to the alignment of its heat content and establishes required amount of molten metal under the arc to the beginning of the current pulse thereby reducing the depth of melting. Analysis of the factors affecting the formation of deposited coatings shows that they can be divided into two groups. The first group is expressed by the indicator, which in the process of deposition cannot be changed, - the spatial position of the surface to be protected. The second group is associated with parameters of surfacing mode that can be modified during the manufacturing process. In this case, it becomes possible to change the geometrical dimensions of the deposited coating: the height and width of the cushion cover.

New opportunities to control parameters of the second group of factors inherent in the method of overlaying coating by modulated current. In this scenario, you receive and more control over the geometric dimensions of the deposited coating than for welding on direct current with a limited number of adjustable settings.

Additional adjustment parameters - the amplitude of the oscillations of the pulse and pause duration, and repetition rate enables control over the size of surfacing the bath, change the nature of melting and transfer of metal, which contributes to the stability of the formation of the deposited coating. In this case the forces acting at surfacing tub, periodically vary from the maximum (on the interval of the pulse) to a minimum (on the interval of the pause) that provides reciprocating motion of the molten metal.

Thus, movement of the surfacing metal in the bath can effectively control the variation in amperage on the welding interval pulse. With the increase of the current pulse increases the pressure of the arc. As a result, the molten metal is more actively displaced from under the arc in the caudal part of the fused bath. On the interval pause when reducing the arc pressure is proportional to the current pause weld pool tends to return under the arc. It promotes active periodic movement of the metal in the weld pool, the alignment of its heat content and a more uniform distribution of alloying elements throughout the volume of metal deposited. By changing the parameters of the process of surfacing directly in its course, can affect the geometrical dimensions of the formed coating: the surface curvature, the height and width of the cushion.

Corrosion tests of steels used for the manufacture of the equipment working in the conditions of application of acid media, were initiated by the perceived need for replacement of out of order fragments and thereby extend the life of the equipment as a whole. Especially prone to rust and corrosion welded joint of the walls of these units are made of stainless steel. To date the industry uses items of process equipment with welded joints, obtained by manual arc welding by consumable electrodes and mechanized welding. By the aforementioned processes of transfer of deposited metal is performed by a series of short circuits. In this case, the droplet of molten metal from the end face of the electrode and its transfer to the weld pool occurs at high welding current. This leads to the instability processes in the arc gap and the increased splashing of electrode metal, which ultimately worsens operational properties of welded joints. Experience has shown that during long-term operation of the specified equipment operating in an active acidic media, corrosion of metal is about 0.1 mm/year. Corrosion destruction of welded connections reach 4 - 5 mm/year. They are usually expressed in the form of dangerous varieties of intergranular corrosion knife, observed in the HAZ of the base metal and the weld metal. In some cases, corrosion leads to the through destruction of the wall units. Currently rabotosposobnosti the restoration of damaged welded joints of steels at the operating equipment is manual TIG welding with non-consumable electrode. Refurbishment of corroded sections of welded joints is to apply to them a method of overlaying a protective coating. This technological process is accompanied by a large heat input in the weld joint area, reduces the protective effect of the coating deposited coating contributes to the corrosion damage in this zone knife corrosion.

For the purpose of increase of operational properties of welded joints of steels in the work was used the method of pulsed arc welding in the weld joint. It is known that this method of surfacing dramatically reduces the heat input in the weld joint area, affects the structure and properties of welded joints of different steels [6-9]. However, in the literature there are no data on the structure of the deposited metal coating and welded joints of stainless steels and their corrosion properties in nitric acid media.

The aim of this work is to analysed the influence of the used processing methods and pulse coating method for increasing corrosion resistance of welded joints of stainless steels in nitric acid media.

Materials and methods study

Were used a welded joint of plates of rolled austenitic steel 12KH18N10T sizes 300×150×10 mm. Formation of welded joints was carried out using manual arc welding electrodes RLA - 36 with a diameter of 3 mm in three passes welding machine MAGMA 315.

A protective coating was applied on the welded connection by welding - direct current and pulse. Estimation of corrosive wear of the investigated welded joints were conducted according to the accelerated method. Such tests are recommended for quality control of welded joints and evaluation of its tendency to stab corrosion. Test environment served as an aqueous solution of 10 % HNO3 + 3 % HF. The tests were performed at ambient temperature of 95° C. In these conditions, increases the mixing speed of the solution and facilitates the supply of the oxidizing components to the surface of the samples.

The test consisted of 8 cycles of 6 hours each. In real operation conditions of the welded joint corrosion products constantly diverted from the working solution, so in laboratory tests in each cycle was used freshly prepared solution. Corrosion tests of samples of size 80×15×10 mm with welded seams was performed in the equipment operation conditions of partial immersion of samples of each welded joint in fluids at their impact in the area of the waterline. Conducted corrosion tests of samples of welded joints after removal of the deposited coatings by mechanical means. This ensured maximum contact welds with a corrosive medium. Test duration was 30 hours. The corrosion resistance was evaluated by weight change of the samples using an analytical balance type VLR - 200. Registration

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of corrosive destruction of the surface layers of the samples was conducted on the change in the macrostructures of welds and heat-affected zone (HAZ). The research of structures of welded joints and deposited surfaces was assessed using an optical microscope Axiovert 200 MAT and camera AxioCam HRc Carl Zeiss, were recorded by AxioVision Rel 4.4 software. Structure of welded joints and deposited surfaces was revealed using the reagent: 10 ml of nitric acid, 20 ml of hydrochloric acid, 20 ml of glycerol and 10 ml of 30 % hydrogen peroxide.

Results and discussion

In consideration of the reasons for the resistance of welds to corrosion, it is necessary to highlight the nature of the components of the welded joint as a major factor determining its phase composition and structure. The passivity of chromium steel 12KH18N10T due to the formation on the surface of a thin film of Cr2O3 oxide, soluble in acid and water. As is known, the magnitude of sensitization depends on the amount of heat input during the formation of the welded connection.

Studies of the microstructure of the initial samples showed that the investigated steel has a austenitic structure (figure 2).

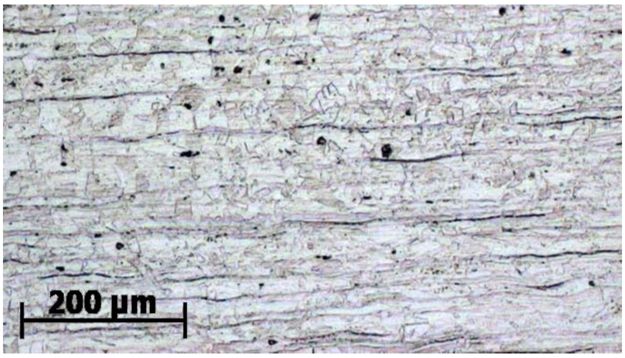

Figure 2. The microstructure of the steel 12KH18N10T.

Ferritic phase is present as separate lines and as a thin layer on the boundaries of polyhedral grains of austenite. The structure of the weld metal is a columnar dendrites (figure 3).

The width and length of the dendrites can reach 20 μm and 500 μm, respectively. The weld metal of samples of samples of welded joints, performed at a constant current, during corrosion tests showed relatively low resistance (figure 4).

Analysis of the dependency of the corrosion rate of the zone of fusion to the time of the tests showed that the corrosion of the samples, deposited at a constant current (figure 6). These samples greatly affected knife corrosion in HAZ of deposited coatings and in the weld metal (figure 7). Corrosion damage occur mainly in the HAZ metal of welded joints. The use of pulsed mode reduces up to 6 times the corrosion rate of connections compared to DC. Analysis of the results of corrosion tests of samples of welded joints after removal of the deposited coatings also showed improved corrosion resistance of the seam area in the coating, made of a pulsed arc method. Most of the corrosion destruction of welded joints of steel are localized in the HAZ (see figure 7).

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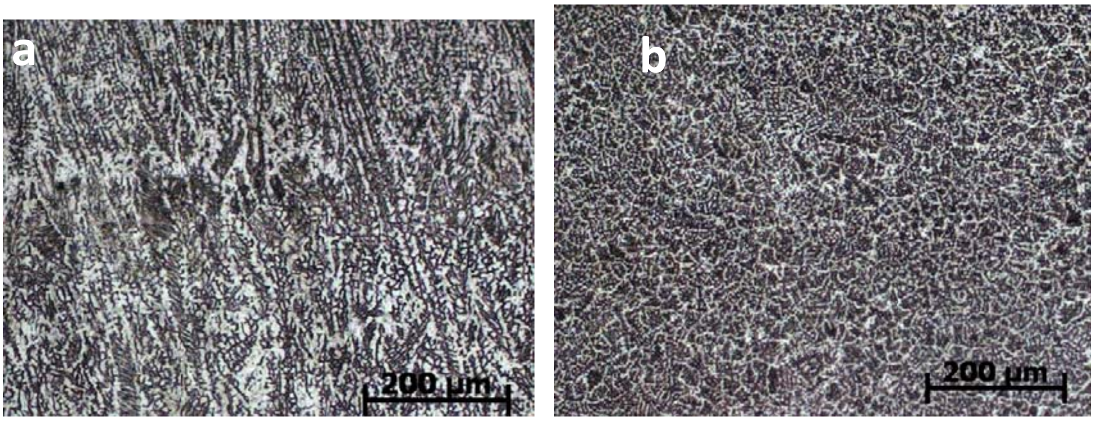
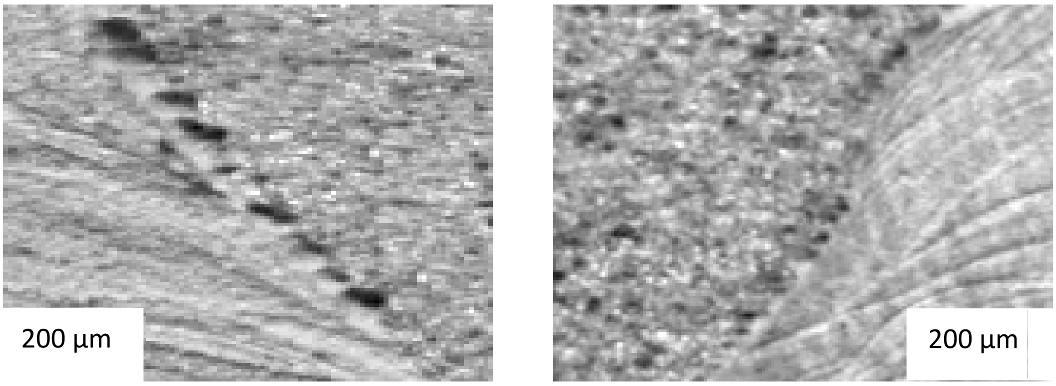


Figure 3. The structure of the deposited metal coating: a) DC b) pulse - arc method.



a b

Figure 4. Character of the corrosion destruction of welded joints of steel 12KH18N10T, are obtained: a) DC; b) pulsed arc method.

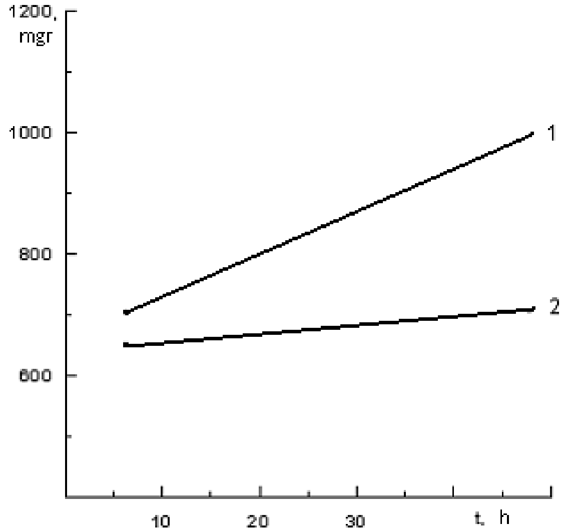


Figure 5. The dependence of the corrosion rate from the time of trial after surfacing coatings: 1 (○) DC, 2 (+) pulsed arc method

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The samples welded by the method of adaptive pulse - arc welding of corrosion pattern of destruction changes. Knife-corrosive. Corrosion in the form of pitingo, localiza-bathrooms on the border of the weld.

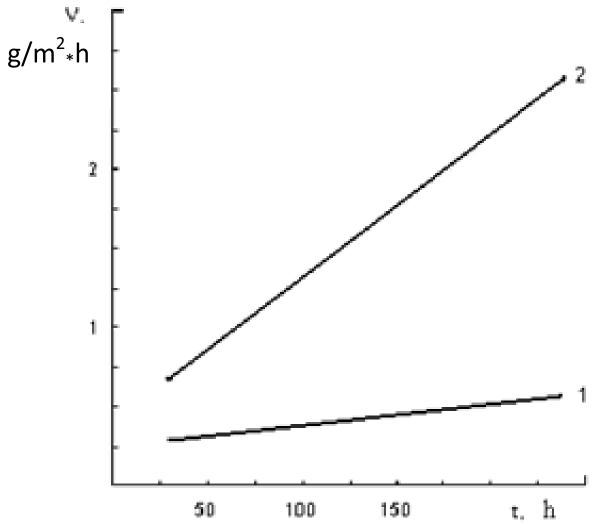

Figure 6. The dependence of corrosion rate of deposited coatings from the time of trial after: 1) direct current 2) pulsed arc method.

The samples welded by the method of adaptive pulse - arc welding of corrosion pattern of destruction changes. Knife-corrosive. Corrosion in the form of pitingo, localiza-bathrooms on the border of the weld.

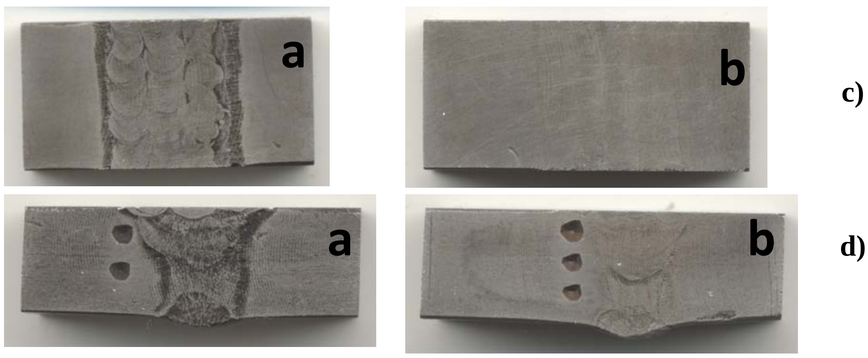

Figure 7. The macrostructures of welds under coatings deposited: a) DC; b) the pulsed - arc method, c) longitudinal section, d) cross-section.

Conclusions

1. Using the technological process of pulse - arc welding steel 12KH18N10T allows for less heat exposure for joint and HAZ of welded joints of steels to form a protective coating with dispersed structure.
2. Surfacing of coatings with dispersed structure obtained by pulsed - arc method, allows in 1.5 - 6 times to reduce the corrosion rate of welded joints of steel 12KH18N10T in active chemical environments.

3. The results of these studies can be recommended for use when welding a protective corrosion - resistant coatings on working surfaces of equipment of chemical productions. Pulsed technological process of deposition of coatings on welded joint of steels can be effectively used for the protection against corrosion in the repair of equipment of chemical industry.

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