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New Developments for Wet Underwater Mechanized and Automatic Arc Welding

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Electric welding in the aqueous medium was wet, developed in the E. O. Paton Electric Welding Institute, produced by automatic or semi-automatic equipment of the new type gets an increasing distribution when performing welding, surfacing, repair of ships, port equipment, and oil and gas pipelines. There is experience in conducting work at depths of more than 200 m. For this process, special electrode powder type electrode wires are worked out, which provide high-quality welding in all spatial positions. Semi-automatic and automatic welding machines are constantly improving. Currently, one of the main ways to improve the efficiency of equipment and the welding process is the use of pulsed supply of electrode wire with controlled motion parameters. The pulse feed is wicked by welded compound parameters, weld quality, the possibility of obtaining a qualitative result in the positions of different from the bottom and much more. An important result of the use of a pulsed feed is to obtain increased strength of the welded joint. The results of welding and surfacing in the aqueous medium are wettable depending on the parameters of the pulses (frequency, amplitude, form).

Key words: wet underwater welding, pulsed supply of electrode wire fed.

Мокре електрозварювання у водному середовищі, що розроблене в інституті електрозварювання ім. О. О. Патона, із застосуванням серійного автоматичного або напівавтоматичного обладнання нового типу, набуває все більшого поширення при виконанні зварювання, натоплення, ремонту суден, портового обладнання, нафто- та газопроводів. Є досвід ведення робіт на глибинах понад 200 м. Для цього процесу розроблені спеціяльні

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електродні дроти порошкового типу, що забезпечують якісне зварювання у всіх просторових положеннях. Зварювальні напівавтомати та автомати постійно вдосконалюються. В даний час одним з основних способів підвищення ефективности обладнання та процесу зварювання є використання імпульсної подачі електродного дроту з реґульованими параметрами руху. Імпульсна подача відрізняється параметрами зварюваного з'єднання, якістю шва, можливістю одержання якісного результату у різних положеннях ведення зварювання, відмінних від нижнього та ін. Важливим результатом застосування імпульсної подачі є одержання підвищеної міцности зварного з'єднання. Результати зварювання та натоплення у водному середовищі залежать від ступеню змочування, що залежить від параметрів імпульсів (частоти, амплітуди, форми).

Ключові слова: мокре підводне зварювання, імпульсне подавання електродного дроту.

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1. INTRODUCTION

Arc welding in an aquatic environment by mechanized or automatic equipment is one of the types of welding, which is becoming increasingly distributed in the different spheres of human activity, with problems inherent in it and various solutions in technical and technological areas, as well as the choice of electrode materials [1].

We indicate that hand-made arc wet welding with the use of special electrodes, as well as a method where the venue of work is localized by special devices (caissons) with water to pump water from the place of welding. In the latter case, manual and mechanized welding using conventional electrode materials are used. Wet manual arc welding is low and does not provide the desired quality of work. Welding under water in the caisson is very expensive and limited to use.

In E. O. Paton Electric Welding Institute, it was developed a method of mechanized wet-type welding with the use of submersible electrode wire supply devices. To implement this method of welding, a number of technical means have been developed—semi-automatic colours. The development of special powder electrode wires and technological techniques of their use is performed.

Developed at the E. O. Paton Electric Welding Institute Powder Wire (diameter of 1.2–2.0 mm) allows you to ensure stable burning of the arc and the preparation (on low carbon and low-alloy structural steels) of welded compounds, equal main metal. The wire is practically no analogues and to date is the main electrode material for semi-automatic and automatic, which are used for wet underwater welding.

Among the proposed designs of submersible devices can be allocated:

– with the placement of the feed node in the insulating-lubricating

fluid, and the entire feed system—in the aqueous medium;

– with the placement of the entire semi-automatic, including the source of the welding current, in the submersible unit.

Based on the above proposals in the E. O. Paton Electric Welding Institute developed a number of semi-automotive mats. The highest distribution was semi-automatic A-1660, A-1450, PSh-141 and PSh-156.

Currently, semi-automatic arc welding of arc welding appeared in the Russian Federation, which practically repeat the developments of the E. O. Paton Electric Welding Institute of the 70s last century. Behind rubbles, as far as we know, the mechanized and automatic welding under water-wet gesture is practically not applied. The exception is PRC, where based on contractual relations with E. O. Paton Electric Welding Institute develops techniques and technology of mechanized welding under water-wet method. Mechanized welding in an aqueous medium using powder electrode wires found quite widespread use [2, 3]. In the process of developing this welding method, interesting and very useful areas of its use were proposed with the provision of appropriate technical means to implement mechanized welding with a wet method. Among them, for example, the following:

– welding of the underwater part of ships and shipping ships (body formation) [4];

– a specialized mechanized device for welding under water pipes;

– automated welding for sealing compound pipes, including at high depth on oil and gas objects and when creating complexes with thermal pumps [5];

– welding and cutting during emergency rescue work in the aquatic environment;

– automated welding at large depths using coordinate-programmable systems based on computerized controls and regulation;

– use of mechanized and automatic equipment for recycling cutting under water, including when closing the used oil and gas wells.

Some of the systems are used on industrial facilities. For example, the machine for welding plugs inside the pipes developed in the E. O. Paton Electric Welding Institute successfully operates at 230 m depths. Part of the developments need to be improved.

2. BASE PROBLEMS AND SOLVES OF ITS

The problem with the use of mechanized and automated technologies of arc methods of underwater welding with a wet method and equipment for them really exists and at present. However, only individual specific tasks were previously solved, the results of which to some extent satisfied manufacturers. However, as known, universal solutions in technical and technological systems do not exist, so it is important to find such solutions to this problem that would generally fully meet the re-

quirements.

One of the significant problems for submersible assemblies of the SIS-topic of the supply of electrode wire of mechanized equipment and systems of welding displacement of automatic equipment for wet underwater welding is the reliability of the bots of DC drive electric motors with a collector-brush node. In the development of E. O. Paton Electric Welding Institute, this problem has been solved using undercounter electric motors—stepping industrial production and special valve electric motors, the use of which with computerized control and regulation gives additional advantages [6]:

– small dimensions, mass and inertia, including due to the lack of need to use mechanical gearboxes (feed roller directly on the motor shaft);

– the possibility of programming the movement of the electrode wire with a sufficiently high frequency.

That testing is the setting of the task or the coordinate movement of the welding tool on the plane or in space.

Special attention should be paid to constructs in which the assemblies of the submersible block are placed. In the latest semi-automotive constructions for underwater welding, the electric motor is concluded in a stainless-steel compensator with a pressure compensator, and the system of feed rollers, made of special steels, is protected from conventional corrosion and electroerosion with special means. The overall body is formed from plastic, which is usually used in the construction of yachts and other small vessels. One of the latest semi-automatic developments in a strong plastic case with an outer drive based on a high-generable step electric motor is shown in Fig. 1. Such semi-automatic can be operated in fresh and salt water at depths of up to 40 m, *i.e.*, the

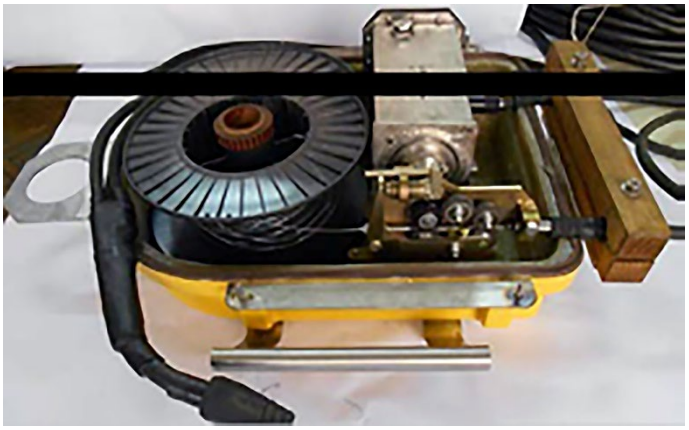

Fig. 1. The semi-automatic latter generation (with an open lid) for underwater welding with wet method.

depths where diver-welders can work. In addition, besides welding, using special electrode wires, it is possible to conduct effective cutting of the metal.

In the technique and technology of arc welding, the main direction of improvement in the present time is the use of impulse algorithms for the functioning of the main active equipment systems. In particular, inverter sources with impulse formation of output parameters, including synergistic ones, are widely used.

Recently, the development of modulation methods with modulation of modes and selected (partially based on theoretical surveys with the solution of the formation of the formation and crystallization of the weld metal, partially based on experimental studies) frequency and wellness of the modulated parameters, are obtained. Such a technology, for example, turns out to be applied with underwater arc welding with a wet method when performing vertical compounds, the execution of which represents a certain complexity, both on the formation of the seam and the quality of the metal. Figure 2 shows an example of performing the surfacing of structural steels in an aqueous medium on a vertical plane with a powder electrode wire with parameters: current—170–180 A; voltage—26–27 V.

The feed rate is modulated with time: the pulse—0.6 s and pause—0.4 s. The process is carried out by the feeding mechanism with any types of drive electric motors, both collective and unbattotor, including stepper and valve with modulation frequencies 0.2–2.0 Hz.

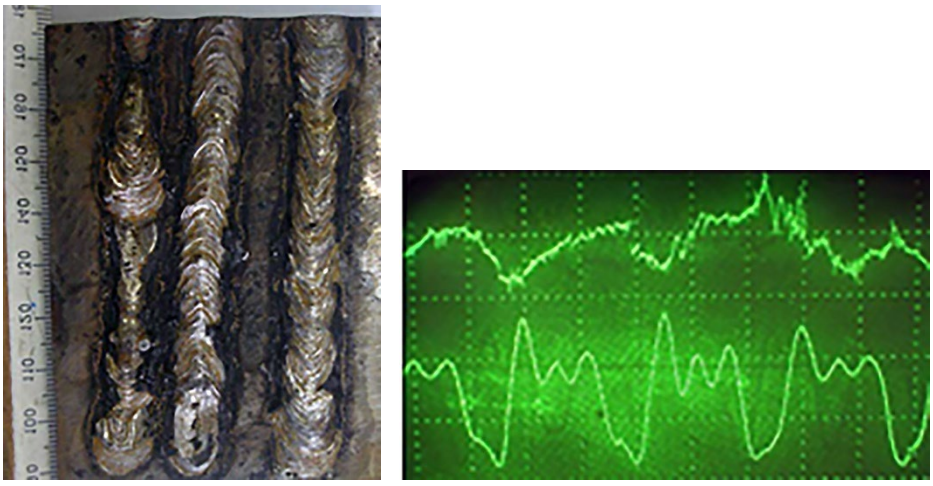

Fig. 2. The vertical plane under water rollers and voltage oscillograms *U* and current *I* when surfacing with modulation of wire feed speed: *1*—formulation without modulation; *2*, *3* are rollers with modulation with different directions of processing.

The application of the process with the modulation of the feed rate of the electrode wire allows solving the welding task on the vertical plane to obtain the formed rollers. Such a process, according to metallographic studies, has practically no significant effect on the structure of the weld metal obtained in the aquatic environment. This, in our opinion, is a consequence of an increased rate of crystallization of the deposited metal in an aqueous medium in comparison with welding in atmospheric conditions.

Investigation of the process of underwater welding with a wet method using the sources of the inverter welding current having the ability to generate current pulses with controlled parameters, noticeable effects, as far as we know, did not give, in particular, by changing the metal seam or roller metal structure. We believe that this circumstance can be explained by special high-speed conditions for crystallization of the metal of the seam.

Recently, relying on the study of electrode wire supply systems, as well as the latest developments in the field of electrical engineering and computerized management, considered as complete mechatronic systems, is being developed for pulsed in duct, according to a specific electrode program in semi-automatic agents and arc welding machines. In addition, the automatic welding is developed and used by an outer-leaf drive based on serially produced stepper and specially designed valve electric motors with a computerized control system, which allows you to implement practically to any electrode of the electrode wire. At the same time, the recent electric drive is provided by frequency, well and amplitude pulsed power wire with maximum frequencies 50–60 Hz. The specified electric drive was studied as part of automatic and mechanized equipment during welding—surfacing in an aqueous medium was wet.

It is of particular interest to obtain vertical and horizontal welds on a vertical plane with sufficient characteristics for the formation and quality of the weld metal. The use of a pulse supply of electrode wire with efficiently selected parameters allows you to solve this task. With a pulsed supply of electrode wire with rationally selected parameters, a controlled transfer of the electrode metal is implemented according to the principle: each pulse corresponds to the transfer of a molten metal drop of a certain size. Acceleration, which in pulsed movement is attached drop, contributes to accurate transportation of the drop in the molten bath, which is very effective when conducting a process on the vertical plane. The features of the transfer of the electrode metal during underwater welding with a wet method with the use of pulsed feed require a separate consideration.

Figure 3 shows samples of rollers deposited in an aqueous medium using a pulsed wire supply with different characteristics of the pulse movement, but with almost the same current values, voltage and pro-

Fig. 3. Rolls that are welded in an aqueous medium using a pulse feed.

cess speed. The current and voltage of the arc process is 160–170 A and 26–28 V, respectively. The speed of surfacing is 10–12 m/h.

It can be noted that the formation of rollers is significantly more evenly filled, has a more regular character. An important is the possibility of fairly intensive influence on the parameters of the rollers: width, amplification, the depth of the regulation. Characteristic micro-fluffs of some rollers presented in Fig. 3 are given in Fig. 4.

It should be noted that the tendencies of changes in the geometric sizes of the deposited rollers correspond to those obtained when surfacing under normal conditions, although less pronounced, which is generally explained by a significantly higher cooling rate of the liquid bath.

Special attention is paid to the qualitative analysis of the metal welded in an aqueous medium, which was carried out based on the

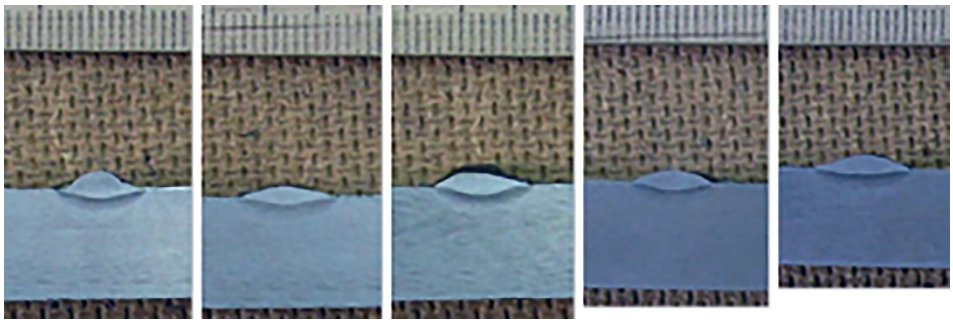

Fig. 4. Microsection of rollers, weld-using control pulses of supply electrode wire.

study of microcycles of cross sections of rollers, strength (mechanical) characteristics, roller metal composition and the near-view zone. In practically all the parameters, the electrode wires that are welded with pulsed supply exceeds the rollers obtained using the conventional feed with the trends of improvement characteristic with the processes obtained on open spaces during welding-surfacing with a pulsed powder electrode wire. However, there are differences. For example, the volume fraction of non-metallic inclusions in the metal roller metal decreases only after increasing the frequency of feed pulses, which can be seen on the graph. Figure 5 obtained in experimental studies.

This again, it seems to us, is associated with the peculiarities of the characteristics of the crystallization of the weld metal and the nearby zone in the aquatic environment. Some improvement in the mechanical properties of the seams obtained under comparative welding studies using the conventional and pulsed supply of electrode wire with controlled parameters, the graphs shown in Fig. 6.

These results indirectly confirm the fact that in the metal of seams or appliances in the aqueous medium of rollers using the pulsed supply of electrode wire, a change in the crystal structure associated with some disorientation of crystallites occurs. This process is less intense than it happens under normal conditions, which, as already noted, is associated with the special conditions for cooling the liquid bath in water.

It should be noted that most of the positive effects of the pulsed supply of the electrode wire are noticeably manifested at a certain increase in the frequency of the pulse movement.

It is well known that high-quality welding with minimizing deformations of various types is possible if minimal thermal investments in the implementation of the process are provided. The welding with a

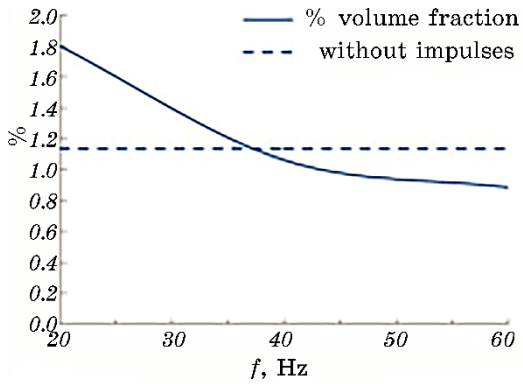

Fig. 5. Graphs for the presence of non-metallic inclusions in the metal of the faces when surfacing with different ways of supplying the wire.

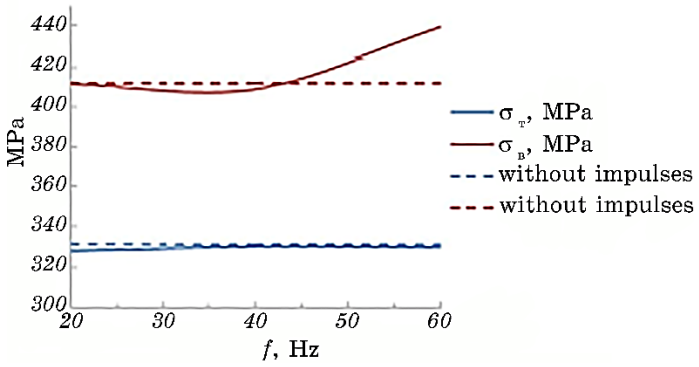

Fig. 6. Regulations between the pre-cases of fluidity and time resistance.

pulsed supply of electrode wire is characterized by low energy consumption, which in combination with intensive cooling provides small deformations of the weldable structure, in particular from thin-leaf materials.

Welding methods with pulsed power wires are constantly being improved and developed. Some of them, according to our beliefs, based on the experience of studying the development of such systems, can be successfully applied to implement highly efficient welding in aquatic environment of structures with different spatial positions.

To the number of promising welding methods with a pulsed supply of electrode wire applicable in an aqueous medium, include:

– sharing a pulse feed and modulation of modes (current and welding voltage of both synchronization and without synchronization of influences);

– use of a new welding method with dosage supply of electrode wire;

– synchronized by a certain algorithm. Pulse effects of pulsed filing.

New welding methods with the application of new development.

Technical means make it possible to largely improve both the results of the arc process, and ensure the new quality of the equipment—to reduce its mastery characteristics and increase its reliability, which is very important for the equipment of underwater welding.

Each of the indicated new methods of underwater welding with the use of an adjustable pulsed supply of electrode wire can solve a certain complex of tasks when conducting a water welding process with a wet method, while in most ways almost any type of welding current source can be applied, including the easiest constructions and WHO capabilities.

It should be noted that electric drives with computerized valve and stepper electric drives are used to equip welding and adjustment systems in automated equipment for underwater welding with a wet method.

3. CONCLUSIONS

1. To date, several different semi-automatic with powder self-protecting electrode wire are wet, but the highest distribution of both general purposes, and to solve specific tasks, equipment with an isolated feed knot, whose cavity is filled with insultingly lubricating liquid.
2. The semi-automatic and machine guns for underwater welding are constantly improved, and the main direction of their improvement is the use of electrode wire supply systems with controlled pulse motion parameters, the rational choice of which provides possible highly efficient welding in the lower and vertical positions with the possibility of regulating the geometric sizes of seams and rollers, obtaining a compound with improved mechanical characteristics.
3. The complexity of the use of pulsed technologies when welding in an aqueous medium was wet, both due to pulsed algorithms for the functioning of the sources of the welding current and due to the pulsed supply of the electrode wire lies in the high cooling rate of the weld bath, which significantly exceeds the speed under normal conditions.

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