საქართველოს მეცნიერებათა ეროვნული აკადემიის მოამბე, ტ. 15, №3, 2021
BULLETIN OF THE GEORGIAN NATIONAL ACADEMY OF SCIENCES, vol. 15, no. 3, 2021

Mechanics

Operational Characteristics of the Welding Joint and the Overlay at the Mechanized Arc Welding-Overlay with Pulse of the Electrode Wire Supply

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(Presented by Academy Member Aleksandre Didebulidze)

A short analysis of the weld equipment influence methods was executed, including the pulse algorithms of the function into the parameters of strength, the different systems of the automatic machines and the semi-automatic devices of the modern constructions. It is noted that the process with the pulse supply can be considered as the specific type of welding i.e. the overlay. Some directions in the theoretical and experimental studying with the use of the modern methods of research on the original equipment of the pulse supply influence into the strength characteristics of the weld construction or wear resistance of recovered or strengthened by overlay units and details have been noted. The effect of the influence of the controlled pulse supply into the geometrical dimensions of the weld beads, including the value of the increase, which must be specific for the support of the strength characteristics, has been noted. The influence of the pulse supply characteristics into the structure of the weld metal has been studied. It is theoretically showed and experimentally proved the existence of the effect of the crystallites growth limitation and their disorientation that affect into strength characteristics and wear resistance of construction. The effect of the alloying elements burning reduce has been analyzed during the pulse supply use and it is getting closer to the properties of the weld metal to the properties of the basic metal. *© 2021 Bull. Georg. Natl. Acad. Sci.*

Mechanized and automatic welding-overlay, strength problem, electrode wire, pulse supply

The mechanized and automatic electric arc welding and overlay for recovering or strengthening of it with the use of the consumable electrode are more essential technological processes. The solid and powder electrode wires are used during the execution of the works in different space positions. Welding and overlaying can be executed as in usual so as in special conditions, for example, in the water environment. The welded constructions can be made from steels of different types and goals and from Al alloys during this process [1].

One of the main problems, which appears at welding and overlaying, is the strength ensuring, wear resistance of the welding joint and the overlay. The solution of this task can be executed by some ways: the choice of the electrode materials, the setting of the acceptable regimes of the process running (current, stress, speed of the welding equipment movement), the use of the rational constructions (thickness, length, the position and the conditions of the process execution),the use of the additional external influences (electromagnetic fields, the flow of the shielding gas, the vibrations of the product and the electrode wire, the local cooling of the product).

strength limit and the limit of the fluidity not lower that it is in the main metal, and it has the sufficient reserve of the flexibility. It is important to solve the task for receiving of the high indices of the wear resistant for the overlaying.

The receiving of the qualitative in accordance with the strength joints and the overlays is the multicomponent problem with some criterion which can be satisfied by the solution of some tasks.

We consider the possibilities of the welding with pulse supply of the electrode wire concerning the increase of the strength indices and the wear resistance during the arc welding and the overlaying. Such method of welding in the

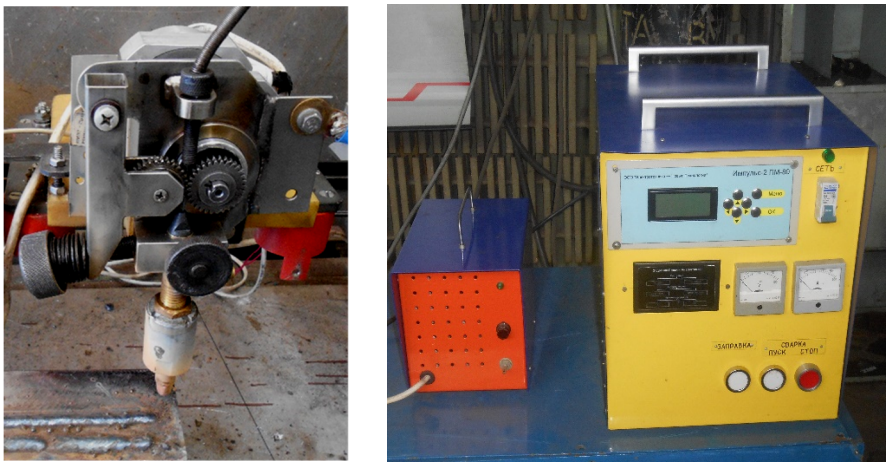

Fig. 1. System of the electrode wire pulse supply control: 1 – mechanism; 2 – control system.

The aim of this work is the consideration of the peculiarities of the indices increase of the strength and wear resistance at the stable use in the welding process of the controlled vibration influences as the pulse movements of the electrode of the wire.

We should note that the mechanical properties of the welding joint and the overlay are determined by the complex characteristics, which depends on some items including the relation of the mechanical properties of the metals in the joint, the zone of the thermal influence and the main metal. We can note that the welding joint which is made of the construction steels, can be considered as the conditioned one, if it provides the values of the

mechanized and automatic equipment is solved during the use of the (designed by E.O. Paton Electric Welding Institute of the National Academy of Sciences of Ukraine) system of the electrode supply speed control, which is based on the computerized high-speed irreductor electrical drive with the valve electric motor [2]. Such electrical drive provides the sufficient difficult algorithm of the electrode movement with the possibility of the frequency regulation, the porosity, the amplitude, which allow to affect the characteristics of the weld joint, the weld bead, the metal structure in the characteristic zones. It all stipulated by the

controlled metal electrode supply with the specified parameters of the pulse supply.

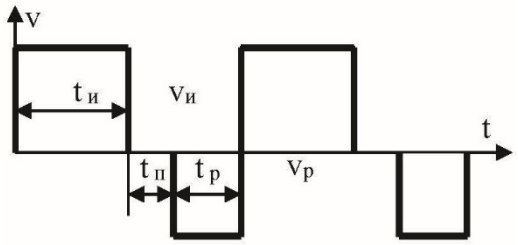

Fig. 2. Idealized graphical algorithm of the pulse supply of the electrode wire:$t_{и}$ and $v_{и}$ – time and speed in the pulse e; $t_{п}$ – time in pause; t_{p} and v_{p} time and speed in reverce.

In Fig. 1 the system for the control of the pulse movement of the electrode wire has been presented. In Figs. 2 and 3 the algorithm of the supply mechanism and the current and stress oscillogram has been given. We should note that each supply pulse is the appropriate act of the transfer of the electrode metal drop with the short circuit of the arc clearance. The control of the electrode metal transfer with the specific (set-up) parameters allow to solve the complex of the technical and technological tasks, which have been described partly in the scientific and engineering periodical press, for example [3-5].

We consider the effects, which concern the considering problem, i.e. the improvement of the strength and wear resistance of the constructions characteristics.

The influence of the welding with the electrode wire pulse supply method into the geometrical parameters of the weld bead. The geometrical

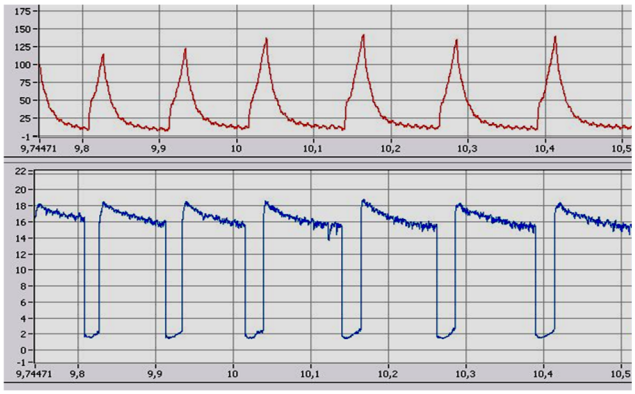

Fig. 3. Oscillogram of current (up) and stress of the arc process with the pulse supply of the electrode wire.

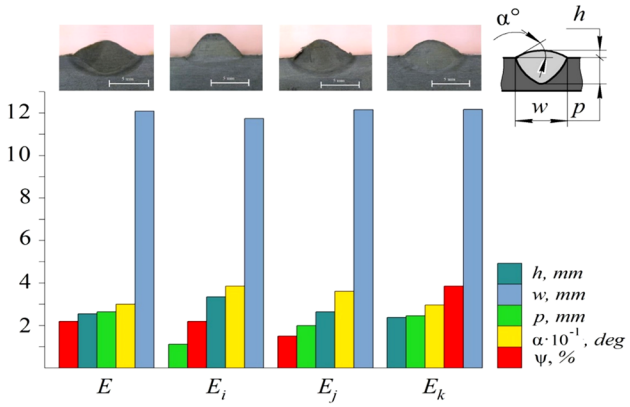

Fig. 4. Histograms of the overlay parameters at S=5 depending on f: E (f =0 Hz E_i (f = 10 Hz), E_j (f = 35 Hz), E_k (f =60 Hz).

parameters of the weld bead are: hump (*h*), width (*w*), penetration depth (*p*). The additional parameters for the bead characteristics can be used the following: the angle of coupling (α) of the weld bead with the product (Fig. 4). These parameters have been determined with the sufficient level of accuracy by use of Software Coreldraw 2010 on the received microsections.

In Fig. 4, as the example, there are the histograms in one of the specified points of the characteristics of the weld beads by use of the electrode wire Св08Г2С with diameter of 1.2 mm on the constructional steel in the lower position in CO_2. The regimes have been used: current of the process is 160…170 A; power of the process is 24…25 B. The determined porosity of the pulse supply is S = 5, the established frequencies *f* are in the following range: 0…60 Гц. At the histograms there are additionally the losses of the electrode metal for waste and the splashing Ψ.

The experimental and calculated data [6] show that by use of the electrode pulse supply at the fixed porosity, in the considered case, $S = 5$ units, and at the increase of the pulse supply frequency from 10 Hz up to 60 Hz, there are such regularities: the depth of the melting is increasing and the height of the weld bead increase is decreasing; the conditions of the weld metal external surface formation start to be better.

The periodical arc stretching has the most influence into the geometry of the weld metal bead, but without current strength and power. At the pulse supply the length of the arc depends on the porosity and frequency. The periodical lengthening of the arc has the less pressure force on the bath of the molten metal comparing with the arc at the constant supply. That's why the molten metal of the bath moves less intensively in its tail end, and the liquid layer under arc is increasing, it leads to the reduce of the melting depth. The bead width is not increased at the increase of the arc length, because the wire is fixed in this period and the power is not increased.

It is clear that the electrode pulse supply allows to control the geometrical parameters of the welded joint by choice of the porosity and the pulse supply frequency.

In the recited work [6] the influence of the joint increase *h* has been considered at the welding of the edge joint into the tension during the loads action, and the conditions of choice *h* are determined, which allow to receive the optimal strength properties of the joint.

$$h = 0{,}5 \cdot \left(\frac{k_{пер}}{k_{пер}} - 1 \right),$$

where $k_{пер}$, $k_{мш}$ – are the coefficients of the inequality of the stresses distribution in the joint metal; and the reduce of the strength of the joint metal comparing with the basic material accordingly.

We should say that the coefficients $k_{пер} \geq 1$, a $k_{мш} \leq 1$ and they are valued by special methods for the specific types of joints. It is important to note that out of relation from the stated welding regimes (current, stress, speed of the process conduct), which effects into the joint increase or the weld bead. The possibility to manage this parameter and strength of the welded joint is appeared, by use of welding with the controlled electrode pulse supply. Its parameters can be found.

The influence of the electrode pulse supply method into the joint metal structure. The strength characteristics of the joint metal are determined by the presence of the column crystals, the growth of them is stipulated by overheat of the melted bath, and the condition of the elimination of the column crystals is the reduce of overheat, i.e. the reduce of its heat content [7].

The use of the pulse algorithms of the electrode wire supply control and its vibrations can effect into the effective coefficient η of the process of the product heat by arc. It states that the effective coefficient of the product heat by arc at welding without electrode pulse supply and with pulse

algorithms are different from each other: at pulse supply it is not less but it is higher, i.e.(20-25%).

The reduce of the energy consumptions at one speed and the electrode melting speed is the real method of the overheat temperature reduce, and the limitation of the column crystals growth without the reduce of the productivity of the processes of welding and overlaying but with more high indices of strength.

We can note that the process of the reduce of the overheat temperature is controlled and it depends on the parameters of the arc process (current, stress), the characteristics of the electrode wire pulse movement (frequency, porosity). These characteristics are considered in detail in the work [8].

The associated at the electrode wire pulse supply is the disorientation of the crystals in the joint metal structure which affects the strength. The change of the joint metal structure at the electrode wire pulse supply have been received by change of the thermal field characteristics and the mechanical vibrations of the bath as the result of the electrodynamic forces action at the current pulses and the supply pulses too.

The influence of the electrode pulse supply into the alloying element conversion. We note that the electrode pulse supply can regulate the frequency of the short circuit and the electrode metal drop transfer in the welding bath. The frequency of the short circuit with pulse supply is often less than with the conventional supply. It leads to the increase of the transportable drop volume at the constant energy parameters. It is known [9], that the large-drop transfer of the electrode metal is undesirable, because it is possible the reduce of the quality of the overlay due to the big own square of the drop surface through which the alloying elements burning and oxidation at their contact with oxygen, i.e. the product of CO_2 dissociation. It is the additional disadvantage. The researches of the frequency and the porosity influence of the pulse supply have been executed into the alloying elements transfer in the metal overlay at the range of the frequency 10…30 Hz, and the porosity range: 3…5 units, which is the most suitable for the process of the overlaying [10] for reduce of the melting depth of the basic metal, the formation of the convexity, the increase of the electrode metal stability and the reduce of the electrode metal losses. At the researches of 30ХГСА wire on the following regimes: current is 220 A, power is U = 26 V, the transfer of C, Si, Mn, Cr and for ЭП-690 – Cr, Ni, Mn, Mo has been controlled into the overlaying metal. For Нп-30ХГСА the monolayer and five-layer overlaying has been executed and for ЭП-690 – five-layer overlaying has been done on

Table. Mass part of the alloying elements in the overlay

Нп-30ХГСА wire (1 layer)				
(*f*/*S*)	*C*, %	*Cr*, %	*Mn*, %	*Si*, %
(20/5)	0.17	0.55	1.06	0.80
Convent. supply	0.17	0.63	1.10	0.87
п-30ХГСА wire (5 layers)				
(20/5)	0.21	0.98	0.84	0.78
Convent. supply	0.20	0.90	0.81	0.70
ЭП-690 wire (5 layers)				
(*f*/*S*)	*Ni*, %	*Cr*, %	*Mn*, %	*Mo*, %
1 (20/3)	15.9	18.5	6.5	3.2
2 (60/3)	15.5	18.3	6.5	3.2
3 (20/5)	15.7	18.4	6.4	3.2
4 (60/5)	15.6	18.2	6.5	3.2
Convent.supply	15.6	18.4	6.6	3.2

the plates from 09Г2С steel в CO_2 at the conventional and pulse supply of the electrode. The chemical content of the overlay has been calculated by use of the atomic emission method of the spectroscopy on the equipment of the analytical research laboratory of E.O. Paton Electric Welding Institute of the National Academy of Sciences of Ukraine. The results of the researches are at table.

It is clear from the received results that the reduce of the alloying elements transfer into the layer of the melted metal is not appeared at the pulse supply, in spite of some increase of the drop volume and the duration of its presence on the edge of the electrode wire.

Conclusions

The use of the welding with the electrode wire controlled pulse supply is the progressive achievement, which has the multiply influence into the technological of the arc process properties and the improvement of the engineering equipment for the mechanized and automatic electric arc welding and overlay. The pulse supply, which is used in the equipment for the welding-overlay by the melted electrode is the efficient and universal tool for the increase of the strength characteristics indices of the constructions, which are weld or overlay by the electrode wires of the different types and diameters (solid, powder). The main results which have been received at the pulse supply of the electrode wire which affect into the weld joint strength and wear resistance of the overlay are the following: the possibility of the weld bead geometrical dimensions control, the limitation of the crystallites growth and their disorientation; the reduce of the alloying elements burning level in the joint metal and the overlay. The different characteristics of the electrode wire supply pulses have the different influence into the characteristics of strength of the weld joint or the weld bead and it stipulates the next stage of the research of the pulse supply influence into strength, i.e. the search of the range of the optimal parameters of the process for the supply of the maximum result from all effects of the pulse influences.

მექანიკა

ელექტროდის მავთულის იმპულსური მიწოდების პირობებში მექანიზებული რკალური შედუღება-დადუღებისას შენადუღისა და დანადუღის საექსპლუატაციო მახასიათებლები

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**ბათუმის ნავიგაციის სასწავლო უნივერსიტეტი, ბათუმი, საქართველო
§უკრაინის მეცნიერებათა ეროვნული აკადემიის ე. ო. პატონის სახ. ელექტროშედუღების ინსტიტუტი, უკრაინა

(წარმოდგენილია აკადემიის წევრის ა. დიდებულიძის მიერ)

ჩატარდა შედუღების მოწყობილობის ზემოქმედების მეთოდების მოკლე ანალიზი, სიძლიერის პარამეტრებში, ფუნქციის იმპულსის ალგორითმების, ავტომატური მანქანების სხვადასხვა სისტემებისა და თანამედროვე კონსტრუქციების ნახევრად ავტომატური მოწყობილობების ჩათვლით. აღინიშნა, რომ იმპულსური მიწოდების პროცესი შეიძლება განხილულ იქნეს, როგორც შედუღების განსაკუთრებული ტიპი ანუ, როგორც დადუღება. განხილულ იქნა თეორიული და ექსპერიმენტული შესწავლის ზოგიერთი მიმართულება ორიგინალ აღჭურვილობაზე იმპულსური მიწოდების ზემოქმედების კვლევის თანამედროვე მეთოდების გამოყენებით, ზედა ფენის ერთეულებისა და დეტალების მიერ აღდგენილ ან გამაგრებული შედუღების კონსტრუქციისა თუ ცვეთამედეგობის მდგრადობის მახასიათებლების პირობებში. აღინიშნა შედუღებული ხიწვების გეომეტრიულ პარამეტრებში კონტროლირებადი იმპულსის მიწოდების გავლენის ეფექტი, ზრდის მაჩვენებლის ჩათვლით, რაც სპეციფიკური უნდა იყოს სიძლიერის მახასიათებლების მხარდაჭერისთვის. შესწავლილ იქნა იმპულსის მიწოდების მახასიათებლების გავლენა შედუღების მეტალზე. თეორიულად თვალნათელია და ექსპერიმენტულად დამტკიცებულია კრისტალიტების ზრდის შეზღუდვის ზემოქმედების არსებობა და დეზორიენტაცია, რაც გავლენას ახდენს კონსტრუქციის სიძლიერისა და ცვეთამედეგობის მდგრადობაზე. გამოკვლეულ იქნა მალეგირებელი ელემენტის წვის შემცირების ეფექტი იმპულსური მიწოდების გამოყენებისას და ის უახლოვდება შედუღების მეტალის თვისებებს ძირითადი მეტალის თვისებებამდე.

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Received March, 2020