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UNIVERSAL SYSTEM OF ELECTRODE WIRE FEED CONTROL FOR MECHANIZED ELECTRIC ARC WELDING AND SURFACING EQUIPMENT

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Summary. *Arc mechanized and automatic welding and surfacing with melting electrode is constantly being improved. This improvement is carried out in several directions, including technical means, technological methods, electrode materials and protective media. Recently, special attention has been paid to pulse technologies of welding and surfacing, the development of which is based on modern achievements in the field of technical equipment. Using pulse algorithms of the welding equipment main systems, you can get controlled transfer of the electrode metal, which enables to control the shape of the welded joint, the penetration, the heat-affected zone, the energy costs of the process and the consumption of active materials. Inverter sources of welding current with various control algorithms are widely used to control the transfer of electrode metal. The experience and experimental investigations show that high level results of welding and surfacing processes can be obtained by applying feeders with pulsed control algorithms. At the same time there are several directions of this arc process type. These are pulsed processes with predetermined parameters of frequency, porousness, and amplitude of impulses formation of the electrode wire movement. In E. O. Paton EWI the new method of the pulse movement control of the electrode wire – with metered feed was developed. This process is carried out using feedback on the arc process parameters – current and voltage. At present, all designs of pulse feed systems are based on the use of the new development – gearless, high-speed computerized electric drive with the use of valve motors. Such electric drive provides pulse feed frequency up to 50 Hz, which makes it possible to control the transfer of electrode metal using solid steel and aluminum wires, as well as flux-cored wires in different spatial positions. The universal motion control system for electrode wire for mechanized and automatic welding and surfacing equipment has been developed, which allows to choose the method and all parameters of the pulse feed, as well as visually monitor the set parameters, as well as the parameters of the arc process. The developed system has no analogues.*

Key words: *mechanized welding – surfacing, electrode wire, transfer control, new equipment.*

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Introduction. Mecanized arc welding and surfacing, equipment and technologies for its implementation are constantly being improved along with the tasks of the application efficiency increase whereas the quality of work, expansion of condition use, reduction of energy and material costs are the basis for this.

Pulse technologies of the mechanized arc welding and surfacing based on the electrode metal transfer control by means the controlled pulse electrode movement are now being developed due to a number of properties which make it possible to improve considerably technical-technological characteristics of both equipment and results obtained by their means and they are extensively presented in papers [1, 2, 3] and depend on the structure possibilities of the applied feed system.

The objective and task. The objective of this paper is: to consider the new structure of the combined control system for conventional feed with the wide speed range as well as algorithm of controlled pulse feed; analysis of possible application of such system for welding process control as a whole.

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Main part. Welding – surfacing with electrode pulse feed having parameters performed according to the rigid program is presented graphically in Fig. 1. Such a program provides sufficiently high results in practical application, but the implementation of such algorithm for pulse generation has some difficulties in pulse parameters settings which are usually based on the results of the previous investigations or experiments. It should be noted that any change in energy characteristics of the arc process, for example, caused by the fluctuations of wire extension, changes in resistance of its movement into directive channel or current conductive tip affects the efficiency of welding – surfacing with pulse electrode feed on rigid program.

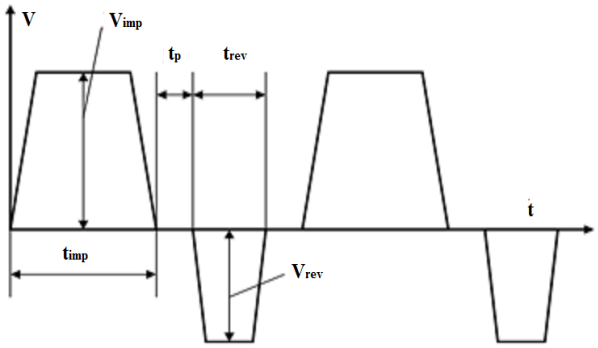

Figure 1. Graphical algorithm for impulse wire feed: V_{imp}, V_{rev} – velocity of motion in pulse and reverse; t_{imp}, t_{p}, t_{rev} – time of movement in pulse, pause and reverse

Welding – surfacing with pulse electrode feed on rigid program is carried out in two main ways – with unregulated or partially regulated [4] parameters and with regulated parameters [5]. In this case the results of the process performance are different.

The possibility of control efficiency for electrode metal transfer process and, thus, welding – surfacing process can be arranged by means of monitoring at least one of the arc process energy parameters – current or voltage. It is evident that electrode feed control should be constructed applying synergetic algorithm [6]. Such welding process control method was developed and was called in accordance with essence of the pulse electrode movement arrangement – dosed feed. Algorithm of the dosed feed control is presented graphically in Fig. 2 and described in details in [7]. Here it can be added that while applying the welding method with electrode dosed feed three parameters are set:

- current level $I_{зв\ min}$ ($I_{wel.min}$), where feed is switched on;
- current leve струму $I_{зв\ max}$ ($I_{wel.max}$) where ythe feed stops;
- the speed of the electrode wire feed in impulse (Vf.r.).

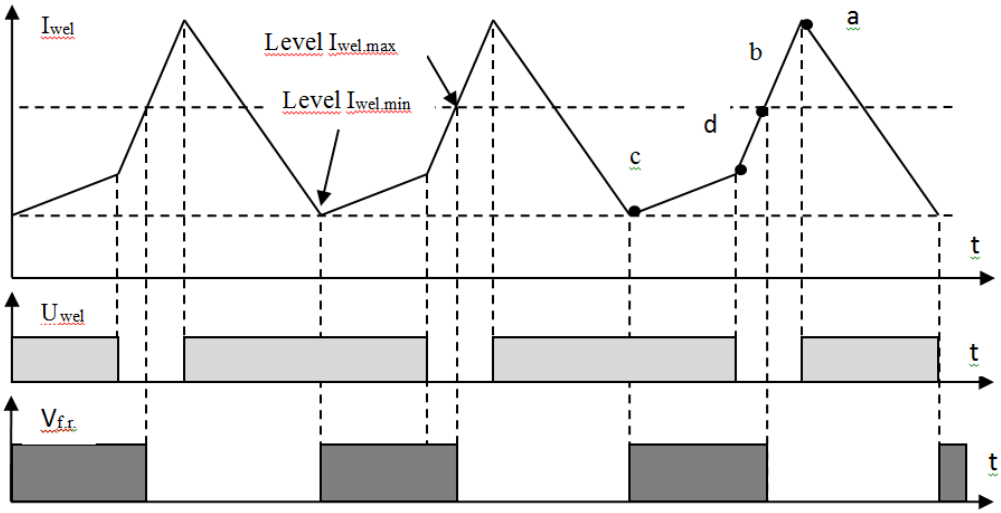

Figure 2. Algorithm of the control system for electrode material dosed transfer with arc process current parameters: I_{wel} is welding current; U_{wel} is welding voltage; a is drop immersion into the bath; b is pause at the feed rate; c is feed start; d is short circuit

The combination of these parameters determines the electrode metal transfer character including those with short circuit of arc gap and without it with forced drop immersion into the bath, etc.

The method was tested and perfected in comparative experiments in automatic mode during surfacing of the low, vertical (horizontal and vertical rollers) overhead position using solid (in CO2) and powder self-protected electrodes. Welding of thin-sheet aluminum alloy (electrode AMg with diameter 1.0 mm, product with thickness 0.9 mm) with efficiency 2 times greater than the efficiency of welding with non-consumable electrode was performed. The surfacing process was performed on both reverse and direct polarities. In all cases sufficiently significant results were obtained:

- low loss of electrode metal (2...4 times less than in traditional welding methods);
- less energy consumption (by 10...25% in comparison with traditional methods of electrode feed);
- the possibility to control the geometric dimensions of weld and weld bead.

The package of high-speed rectifier drive with direct-driven feed mechanism and computerized control was used in this paper [8]. Electric drive and control system were specially designed for use in welding equipment. This package for dosed electrode feed was refitted by newly developed devices for measuring the arc process current, connection with electric drive, setting and checking of introduced parameters $I_{зв\ min}$ ($I_{wel.min}$), $I_{зв\ max}$ ($I_{wel.max}$), V_e (Vf.r.). It should be specified that synthesis of the electric drive regulator was carried out with the possibility of obtaining maximum high-speed operation with minimum overshoot. In this case the intelligent control unit providing necessary high-speed operation is introduced into the regulator. The electronic motor with permanent magnet of domestic development (one of the most efficient motor structures of this type) providing acceptable for problem solution at maximum operation speed the shaft torque with feed roller is used in the feed system.

On the basis of the previous developments and experimental investigations complex the universal control system for electrode feed providing the implementation of the listed below feeds was developed:

- classic electrode feed with the wide range of speed regulation;
- pulse feed velocity with regulation of all pulse movement parameters;
- dosed feed with feedback coupling on the arc process current;
- dosed feed with feedback coupling on the arc process voltage.

The choice of the feed method as well as parameters regulation for selected electrode movement is performed by the switch, herein in each switch position there is the possibility to determine necessary movement parameters.

All setting motions of pulse feed are controlled on the display during the control system setup, and arc process parameters are displayed during the welding process.

Current sensor on the basis of Hall effect with dual supply providing accurate and fast measurement of in-line (set) value of welding current is used in the control system.

Remote control of the welding current source is carried out either by the relay open contact or by means of special switch included in control unit construction.

Figure 3. Universal control unit for electrode feed: 1 – switch for selecting and setting the chosen feed methods; 2 – display; 3 – setpoint controller of feed parameters

The control unit includes power supply, rectifier drive regulator, as well as computerized control unit with required interface. Physical configuration of the universal unit of electrode feed control is shown in Fig. 3. The ease if installation of any feed mode with required parameters is provided only by two control elements – parameters setting regulator and selection switch and installation of arc process selected methods with parameters reproduction on the display. The display additionally represents the arc process parameters – current and voltage with specially selected characteristics of visual control, particularly for processes with pulse electrode feed.

Unit tests were carried out on the basis of the mechanized device (semiautomatic device) with power source of simple construction with step switching of open circuit voltage. In order to prevent significant levels of pulse amplitude decline in guide channel, the hose holder with 1.8 m length was used.

The structural diagram of the mechanized device (semiautomatic device) with the universal control unit application which makes it possible to consider the semiautomatic device structure, units and systems connections is presented in Fig. 4.

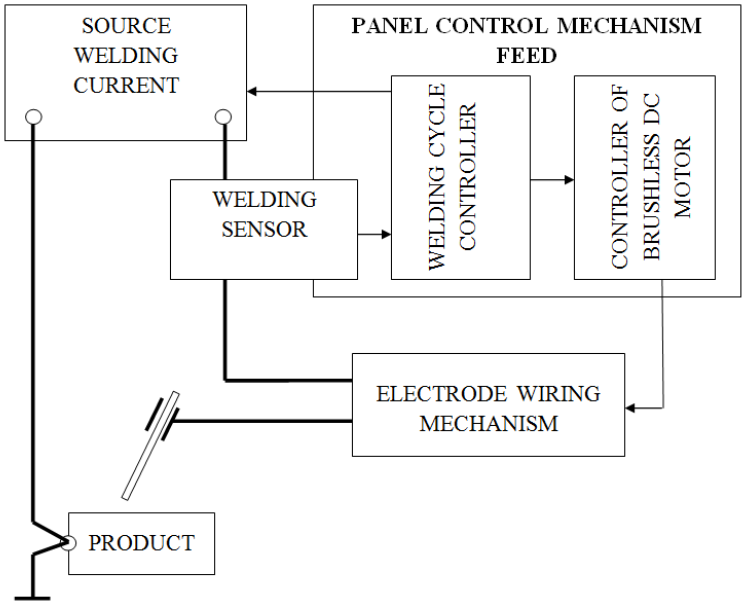

Figure 4. Flow chart of the mechanized device (semiautomatic device) with universal control unit application

As the result of testing the semiautomatic device with universal feed control unit it is determined that structurally introduced possibilities for electrode feed parameters are practically realized. This refers particularly to conventional feed (velocity range 60 ... 960 m/h) as well as pulse feed where the maximum speed in impulse is not less than 960 m/h. In this case the regulated frequency of pulse feed is the range 5 … 60 Hz. It is easy to calculate that acceleration of electrode movement during pulse feed can reach 15 ... 18 m/s2. These parameters according to engineering literature [9] can provide controlled transfer of electrode metal without short circuits of the arc gap (periodical drop release), particularly, during aluminum and its alloys welding.

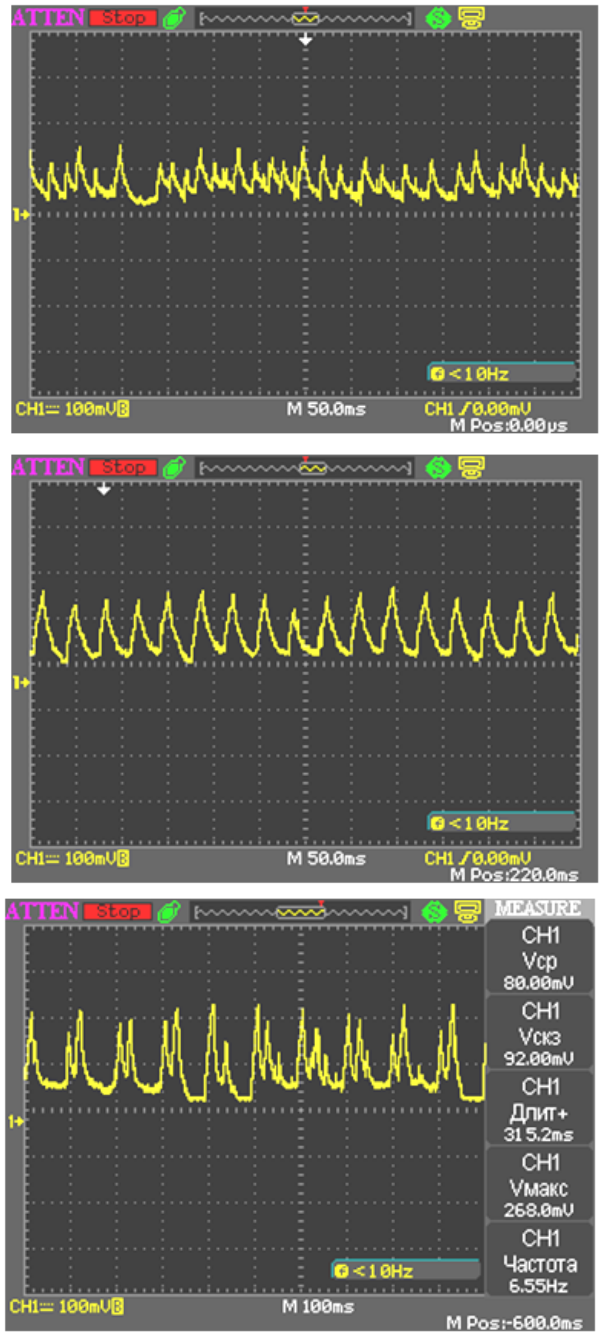

Figure 5. Oscillograms of the arc process current at semi-automatic welding during feed: 1 – conventional; 2 – pulse; 3 – dosed

Characteristic oscillograms of the arc process current during semiautomatic welding in CO2 in lower position of coppered electrode Св08Г2С with diameter 1,2 mm are presented in Fig. 5. What calls attention to itself is the fact of distinctness of current pulses followed with the frequency of the given pulse feed. In this case the feed is also characterized by definite current pulses but with certain deviation of frequencies and porousness.

The results of welding and surfacing in different spatial positions, particularly, while forming the joints and weld beads are presented in the above mentioned references.

Circuit techniques provided high interference protection tested under intense industrial conditions. More detailed investigation of the possibility of universal control system application was carried out on automated installation enabling welding performance – surfacing in lower position, on vertical plane (horizontal and vertical welds and rollers). The installation presented in Fig. 6 is equipped with the mechanism for horizontal and vertical movement of welding solderer with regulated electric drives as well as set of setting and corrective devices.

It should be noted that the new development is technical prototype for industrial replication.

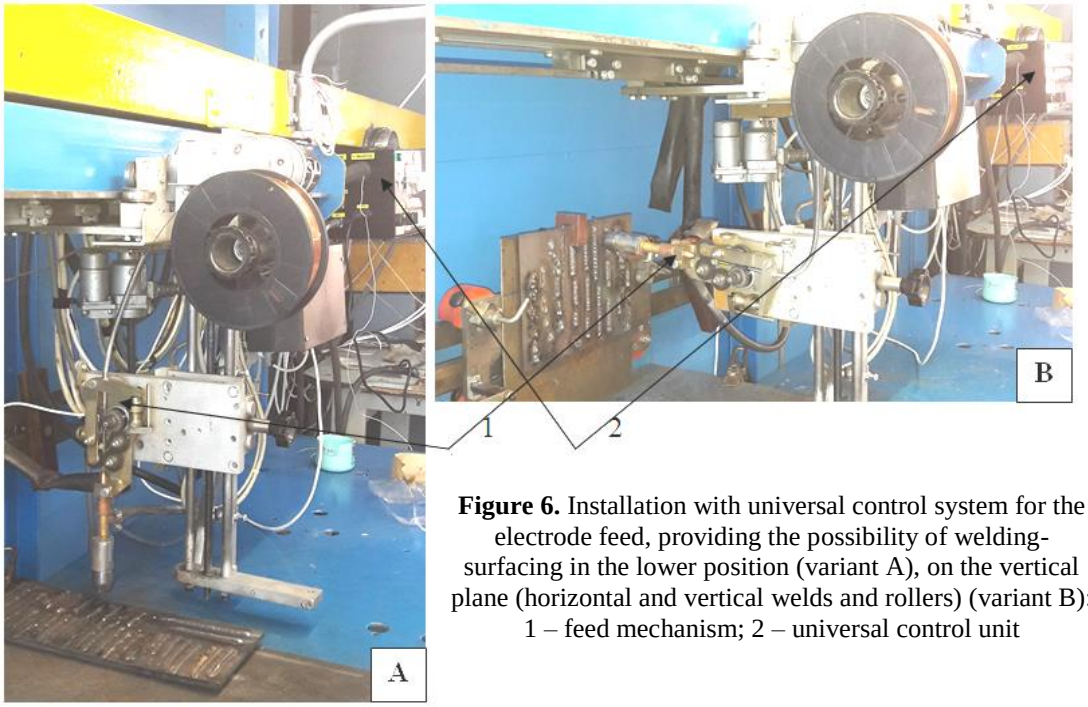

Figure 6. Installation with universal control system for the electrode feed, providing the possibility of welding-surfacing in the lower position (variant A), on the vertical plane (horizontal and vertical welds and rollers) (variant B): 1 – feed mechanism; 2 – universal control unit

Conclusions. The universal electrode feed control system with different movement character is an original development with extensive possibilities and has no analogues. It makes it possible to solve a wide range of engineering-technological problems of welding and restoring (surfacing) production. While applying the new method of the electrode metal transfer control, significant results – low level of electrode metal loss (2…4 times less compared with traditional welding methods); less energy consumption (by 10…25% compared with traditional welding methods); possibility to control the geometrical dimensions of weld or weld bead, etc. were obtained. Successful tests of the new electrode feed control system in the structure of both welding semiautomatic device and automated installation make it possible to conclude that it can be used in the manufactured industrial equipment.

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УНІВЕРСАЛЬНА СИСТЕМА УПРАВЛІННЯ ПОДАЧІ ЕЛЕКТРОДНОГО ДРОТУ ДЛЯ МЕХАНІЗОВАНОГО ОБЛАДНАННЯ ЕЛЕКТРОДУГОВОГО ЗВАРЮВАННЯ І НАПЛАВЛЕННЯ

Геннадій Жук

ІЕЗ імені Є. О. Патона НАН України, Київ, Україна

Резюме. *Дугове механізоване й автоматичне зварювання та наплавлення електродом, який плавиться, постійно вдосконалюється. Удосконалення йде за кількома напрямками, що містить технічні засоби, технологічні прийоми, електродні матеріали й захисні середовища. Останнім часом особлива увага приділяється імпульсним технологіям зварювання й наплавлення, розвиток яких базується на сучасних досягненнях у галузі технічних засобів. Використовуючи імпульсні алгоритми роботи основних систем зварювального обладнання, можна отримати кероване перенесення електродного металу, який дозволяє управляти формою зварного з'єднання, проплавленням, зоною термічного впливу, енергетичними затратами на процес і витрати активних матеріалів. Для управління перенесенням електродного металу широко застосовуються інверторні джерела зварювального струму з різними алгоритмами управління. Як показує досвід й експериментальні дослідження високого рівня результатів при веденні зварювальних та наплавлювальних процесів можна отримати, застосовуючи механізми подачі з імпульсними алгоритмами управління. При цьому існують кілька напрямків цього виду дугового процесу. Це – імпульсні процеси з заздалегідь заданими параметрами, частотою, шпаруватістю й амплітудою формування імпульсів руху електродного дроту. В ІЕЗ ім. Є. О. Патона розроблено новий спосіб управління імпульсним рухом електродного дроту – з дозованою подачею. Цей процес здійснюється із застосуванням зворотних зв'язків за параметрами дугового процесу – струму і напруги. В даний час усі конструкції систем імпульсної подачі базуються на застосуванні нової розробки – безредукторному, швидкодіючому комп'ютеризованому електроприводі із застосуванням вентильних електродвигунів. Такий електропривод забезпечує частоту імпульсної подачі до 50 Гц, що дозволяє забезпечити управління перенесенням електродного металу при використанні суцільних сталевих і алюмінієвих дротів, а також порошкових дротів у різних просторових положеннях. Розроблено універсальну систему управління рухом електродного дроту для механізованого та автоматичного зварювального й наплавочого обладнання, що дозволяє вибирати спосіб і всі параметри імпульсної подачі, а також візуально контролювати встановлені параметри та параметри дугового процесу. Аналогів розроблена система не має.*

Ключові слова: *механізоване зварювання – наплавлення, електродний дріт, управління перенесенням, нове обладнання.*

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