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HIGH PERFORMANCE EQUIPMENT FOR TANDEM MMA WELDING (SURFACING)

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ABSTRACT

In the paper special attention is given to application of pulsed-arc tandem welding by coated electrodes. Mock-ups of equipment for tandem welding and surfacing were developed and studied. A scheme was proposed for tandem arc welding by stick coated electrodes, including capacitive energy storage devices, as well as a device-attachment that allows using any welding current source to perform this kind of welding operations. The attachment operation is based on the principle of controlling the electrode melting rate that ensures their uniform mutual burnout. Also shown are time diagrams, which clarify the principle of operation of the device, photos of surfaced samples, oscillograms of currents supplied to the welding electrodes.

KEYWORDS: tandem arc welding, capacitive energy storage devices, pulse-time regulation of electrode melting rate

INTRODUCTION

Pulsed-arc welding now occupies one of the leading positions in engineering production and other industries. In this connection the questions of increasing the energy effectiveness of the power source for realization of various technological processes are becoming particularly relevant. At present more and more attention is given to design of equipment for tandem arc welding (TAW). As shown in [1], the main advantage of this welding process consists in improvement of the productivity and quality of the welded joints. At analysis of TAW a number of authors [2–4] pay special attention to the question of electromagnetic interaction of the electrode fields that influence the spatial state of the welding arcs. It is exactly their instability that leads to fluctuation of energy parameters of the process and thus influences the variation of welding parameters. As regards manual arc welding with stick electrodes, another advantage of the equipment for the tandem process should be noted which consists in a significant simplification of hardware realization of the equipment, in which electric energy storage devices based on supercapacitors are used.

The objective of this work is development and investigation of the electric and technological properties of the mock-up of the device for manual tandem arc welding (MTAW) with stick electrodes.

One of the first studies related to development of a device for MTAW, is a patent [5]. The disadvantages of equipment described in this patent are its bulkiness, need for two separate power sources, as well as inconvenience of operation. In this connection, we proposed a device [6] and a special kind of electrode holder, which do not have the above drawbacks.

One of the variants of application of such a structure is the hardware complex of the power source (PS)

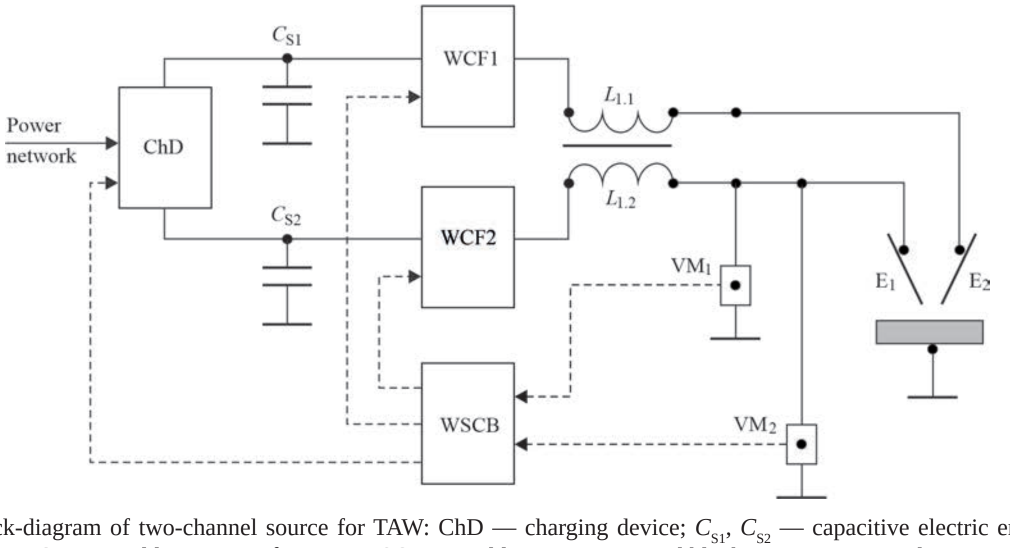

Figure 1. Block-diagram of two-channel source for TAW: ChD — charging device; C_{S1}, C_{S2} — capacitive electric energy storage devices; WCF1, WCF2 — welding current formers; WSCB — welding system control block; VM_1, VM_2 — voltage meter; $L_{1.1}$, $L_{1.2}$ — switching choke; E_1, E_2 — MMA welding electrodes

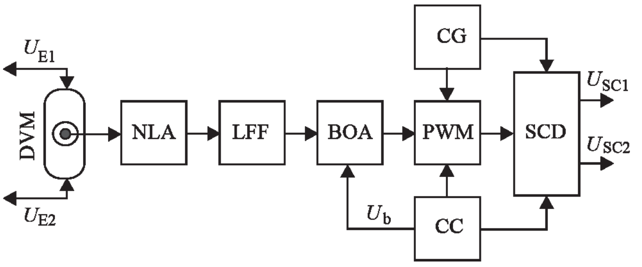

Figure 2. Block-diagram of the controller of electrode burnout rate equalizer at tandem MMA welding; DVM — differential voltage meter; NLA — normalizing logarithmic amplifier; LFF — lower frequency filter; BOA — balancing operating amplifier; PWM — pulse-width modulator; SCD — switch control driver; CG — clock generator; CC — control controller; U_{E1}, U_{E2} — voltages of welding electrodes; U_b — balancing voltages; U_{SC1}, U_{SC2} — switch control voltages

for tandem-MMA welding by a twin electrode, as well as its application for effective surfacing. A feature of such a PS is the possibility of a separate current supply to each of the electrodes. Here, regulation of this current can be independent or mutually synchronized. The block-diagram of such a PS is shown in Figure 1.

DESCRIPTION OF THE DESIGN OF THE DEVELOPED MOCK-UP

PS mock-up consists of the charging device block (ChD) which jointly implements the function of power factor correction (PFC). Its main purpose is transfer of the energy flow in the controlled mode to capacitive energy storage devices C_{S1}, C_{S2}, which are made of high-capacitance powerful capacitors, as well as current shape correction. The above-mentioned capacitors at the same time are energy sources for two welding current formers WCF1, WCF2, which are exactly the devices these forming currents I and I_2. The device operating algorithm is set by the welding system control block (WSCB). WSCB performs equalizing of currents of each of the electrodes by signals of voltage sensors VS_1, VS_2, which read the signals from the outputs of switching chokes $L_{1.1}$, $L_{1.2}$.

The scheme described in Figure 1 uses PFC, which is part of ChD module. This module is made by the classical scheme of step-up voltage converter [7], the load for which are storage capacitors C_{S1}, C_{S2}. On the other hand, connected to these capacitors are WCF1, WCF2 users of stored energy, which are voltage inverters designed by "skew bridge" scheme. Such a topology of the mock-up ensures galvanic decoupling of the output circuits of generation of mutually-independent welding currents.

CONTROL OF ELECTRODE MELTING RATE

At tandem-MMA welding the question of mutual equalizing of electrode melting rate is relevant. Usually, the electrode melting rate can be different, as a result of the influence of various destabilizing factors, leading to violation of the technological process and deterioration of the weld quality. Such defects are usually found at application of local PS for each electrode. It is particularly obvious in the case, when PS have steeply-falling VAC, or if not the same electrodes with different parameters are used. Therefore, at development of PS for tandem welding-surfacing (TWS) a relevant issue is monitoring and control of the electrode melting rate, which depends on electric power, supplied to the welding arc. Pulsed modulation of welding current is one of the methods to regulate the electrode melting rate. Regulation of power supplied to the welding arc is performed by selection of the pulse amplitude, pulse duration and pause duration.

In case of powering twin electrodes (tandem-welding) from locally independent welding PS with variable modulation of welding current pulses, the electrode melting rate can be regulated on the base of control of voltage difference across the welding electrodes. Realisation of the described algorithm is shown in Figure 2.

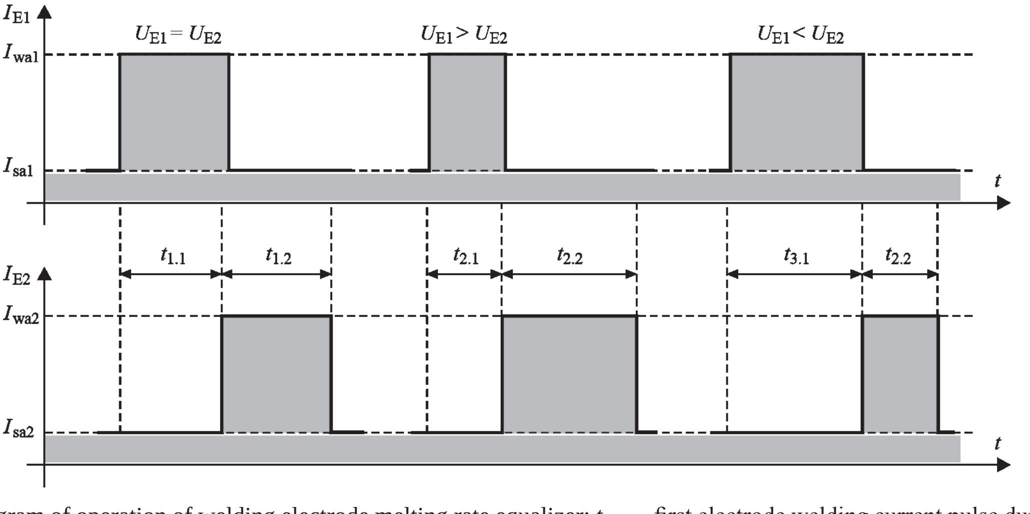

Figure 3. Diagram of operation of welding electrode melting rate equalizer: $t_{x.1}$ — first electrode welding current pulse duration; $t_{x.2}$ — second electrode welding current pulse duration; I_{wa1}, I_{wa2} — amplitudes of welding current pulses of the first and second electrodes ($I_{wa1} + I_{wa2}$); I_{sa1}, I_{sa2} — amplitude values of standby current of the first and second electrodes ($I_{sa1} + I_{sa2}$)

Figure 4. Photo of electrode holder with independent power source

Signals acting on the electrodes, are fed to the differential voltage meter (DVM), mounted at the device input. This signal proportional to voltage difference on welding electrodes $U_{E1} - U_{E2} = \Delta U_E$ is fed to the input of the normalizing logarithmic amplifier (NLA) which generates the required difference signal, and then it is applied to the input of balancing operating device (BOA), from the output of which the control signal comes to the input of pulse-width modulator (PWM).

Balancing of PWM operation is performed by voltage U_b applied to one of BOA inputs. Clock generator (CG) assigns the frequency of PWM operation and also controls the operation of power key switch control drivers (SCD). The latter generates the pulses of power key control voltage at its outputs. The diagram of SCD module operation is shown in Figure 3.

EXPERIMENTAL TRIALS OF PS MOCK-UP

A special electrode holder (Figure 4) with separate connections of each of the electrodes to different power sources was made to study the developed device (see Figure 1).

Experimental verification of operation of PS laboratory mock-up was performed in the following modes.

Figure 5. Surfaced samples produced with twin electrodes with independent power supply (for description of *a, b* see the text)

1. Welding mode — tandem movement of the electrodes (Figure 5, *a*).
2. Melting mode — frontal movement of the electrodes (Figure 5, *b*).

The modes of tandem welding with electrodes of the same or different grades were studied. The oscillograms of welding currents at application of different electrodes are shown in Figure 6, *b* and those with the same electrodes in Figure 6, *a*.

The oscillogram in Figure 6, *a* shows the mode, when the currents of the first and second electrodes are the same, and thus the total current (upper diagram) is a practically constant value.

The second oscillogram corresponds to the mode of different currents of individual electrodes. In this case, as one can see from Figure 6, *b*, the total current is pulsed with the frequency of 5 Hz. As was already noted, this frequency can be easily changed in real-time in a broad range of frequencies.

These surfacing current diagrams were derived, allowing for mode stabilization at technological procedures, which was performed by superposition of constant standby current on the arcs.

The technology of tandem arc welding (surfacing) can be realized using practically any standard welding machine. It requires developing an additional device,

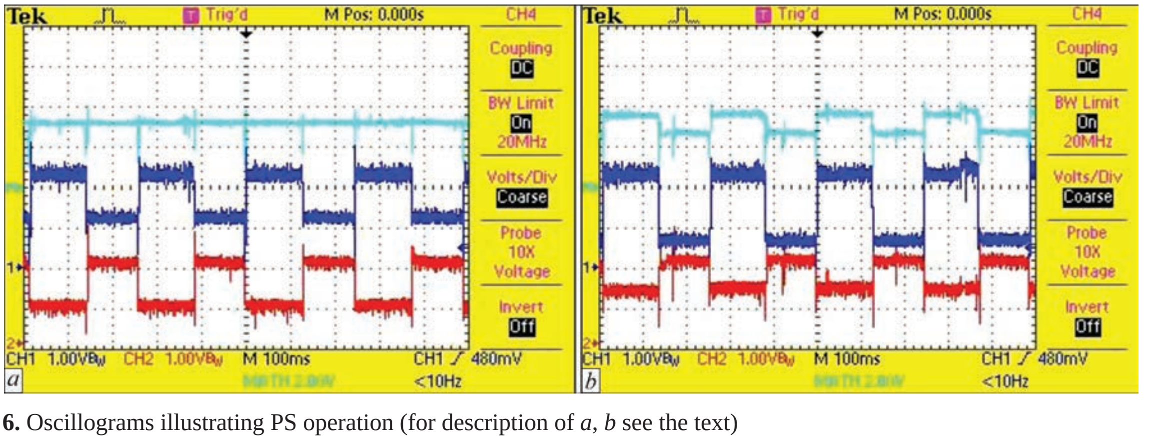

Figure 6. Oscillograms illustrating PS operation (for description of *a*, *b* see the text)

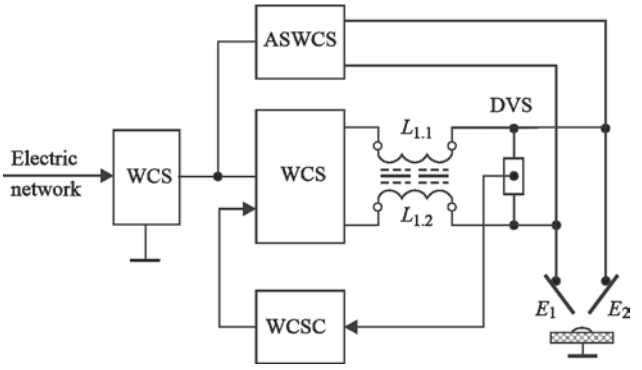

Figure 7. Functional block-diagram of the device-attachment for tandem MMA welding: WCS — welding current source; ASWCS — arc standby welding current source; WCS — welding current switch; WCSC — welding current switch controller; $L_{1.1}$, $L_{1.2}$ — switching inductances; DVS – differential voltage sensor; E_1, E_2 — MMA welding electrodes

which would generate two welding currents powering the respective stick electrodes.

Based on the results of technological tests of the developed mock-up (see Figure 1), we proposed, made and tested a special device for inverter power source of any type, which allows realization of the mode of pulsed-dosed tandem arc welding or surfacing by coated electrodes. Its block-diagram is shown in Figure 7, and its appearance — in Figure 8.

Here, stabilization and control of energy parameters of the technological process are performed by the welding current source, which can be any batch-produced welding system selected by the user. This greatly enhances the capabilities of the described process of tandem arc welding.

The main module of this device which realizes the technological process of tandem welding is welding current switch (WCS). Current distribution by the respective electrodes is performed by a specialized controller WCSC (welding current switch controller), as part of which the device operates (Figure 2). In order to ensure the high stability of welding arc burning, an additional block is envisaged in the developed device — the welding arc standby current source (WASCS).

Testing of this module was performed together with the batch-produced source, made by the ”skew” bridge scheme. Proceeding from the results of the performed work, it should be noted that the mode of pulsed-dosed energy transfer to the welding arc is quite promising for repair-restoration technologies.

CONCLUSIONS

1. A scheme of welding power source for TAW with stick electrodes is proposed in the work, which uses a rather simple control algorithm, based on the principle of time-pulse transformation of welding current.

2. Proceeding from the conducted studies, an original device for control of welding electrode melting rate was developed, for which a Ukrainian patent was obtained.

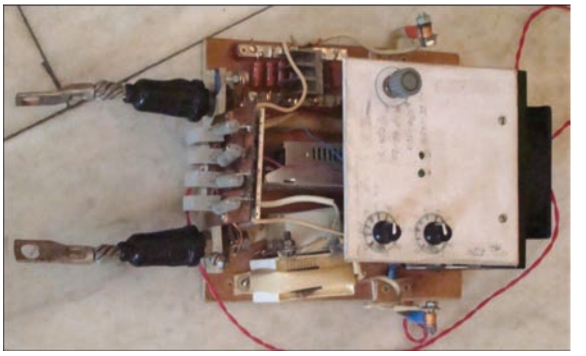

Figure 8. Device-attachment for tandem MMA welding

3. Experimental results of electric and technological tests of the developed power source are given, which confirm its high technical characteristics.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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