NEW TYPE OF PULSE STABILIZER OF ALTERNATING CURRENT WELDING ARC

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Peculiarities of the methods used for pulse stabilization of welding arc are considered. The fundamentally new approach and design of the pulse stabilizer of AC welding arc are offered.

Keywords: *arc welding, arc discharge, arcing, pulse stabilization, welding transformer*

Instability of arcing is observed in consumable and non-consumable (tungsten) arc welding using AC of commercial frequency (50 Hz) during change of electrode polarity. The various type pulse stabilizers of arcing are often used in practice for elimination of this disadvantage. Their operation is based on a transfer of additional pulse of energy in a discharge gap during transition of voltage and current through zero value. It results in a delay of gas deionization in the gap and facilitation of further arc ignition [1].

The pulse energy in many pulse stabilizers is prestored in the capacitors which are charged by special current sources. These sources can be self-contained or manufactured in a form of additional windings on magnetic circuit of the main welding transformer. Storage capacity (capacitor) and power source is the main assemblies of pulse stabilizers of arcing applied in industry at present time. They determine the structure and cost of these devices.

Meanwhile, the pulse stabilization of welding arc can be provided without application of the charge devices and storage capacities using the energy of welding circuit and at that making no damage to manufacturing process. Basis of such a method is an application of EMF of self-induction which appears during breakage of the welding circuit with quick-break switchboard and agrees in direction with voltage of the main power source and sums with it providing the arc discharge between the electrode and part and supporting stable arcing.

For the first time, verification of the proposed principle and device [2] was performed by the E.O. Paton Electric Welding Institute applicable to excitation of low-amperage arc in microplasma welding.

Vacuum electromagnetic relay *4*, winding of which with stabilitron *5* and dinistor *6* were in series connected to the output terminals of a rectifier bridge was connected to the power source for microplasma welding consisting of transformer *1*, rectifier bridge, *2* and smoothing supply choke *3* (Figure 1). Contact *7* of the electromagnetic relay is connected in parallel to arc gap *8*. If there is no arcing, voltage in discharge gap *8* and contact *7* equals an open-circuit voltage of the power source. This voltage is not enough for a gap breakdown. A voltage pulse will be obtained if contact *7* is closed for some time and then rapidly opened. EMF of self-induction formed at that and having the same direction as voltage of the power source sums with the latter. The voltage pulse providing breakdown and arc ignition appears in the discharge gap (between the electrode and part). Resistor *10* regulates a value of high-voltage pulse. Capacitor *9* promotes keeping the contacts of relay from burning that increase life time of the device. Stabilitron *5* and dinistor *6* automatically switch on and off relay *4* depending on voltage at the output of power source. Voltage at the output of rectifier *2* will be equal the open-circuit voltage during the arc extinction that resulted in switching on of stabilitron *5* and dinistor *6*. Relay *4* switches on and closes contact *7*. Current, value of which depends on resistance of resistor *10*, will appear in the circuit. Voltage at the output of rectifier *2* will be reduced to the value providing opening of relay *4* which in turn opens contact *7*. Voltage pulse appearing at contact opening causes breakdown of discharge gap *8*. Ignition of the welding arc, feeding from transformer *1* and rectifier *2*, reduces the voltage in the discharge gap to value, at which relay *4* cannot switch on. A cycle will be automatically repeated at welding arc extinction.

Efficiency of the proposed principle of pulse stabilization of welding arc and appropriateness of its

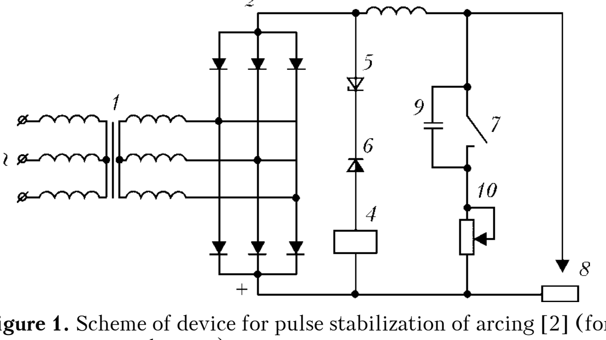

Figure 1. Scheme of device for pulse stabilization of arcing [2] (for designations see the text)

practical application, for example, at microplasma welding, i.e. DC welding, were verified by experimental results. Safe initial arc ignition and its re-ignition at accidental extinction were provided. Secure initial ignition and re-ignition of the arc gains meanwhile particular importance in welding on AC of commercial frequency (50 Hz) when arc ignites and extinct 100 times per second. Described device cannot be used for AC welding since a reaction on electrode polarity change was not provided for in it. Besides, the pulse voltage does not reach the required value because of insufficient rate of opening of electric circuit by the relay contacts in many cases.

The authors of this work had a task to develop a device for stabilization of welding arc of 50 Hz AC, for which no special power sources with charging capacitor was necessary, and transfer of sufficiently powerful energy pulse in the discharge gap was provided at the moments of initial excitation of the arc, change of electrode polarity and at random arc extinctions.

A key was developed for this, which can respond (open and close secondary circuits of the transformer) in several microseconds and provide necessary rate of current change during opening. The key is developed based on high-voltage transistor of BU508DF type with high response speed. Since EMF of self-induction, appearing in the secondary circuit of the transformer, achieves several kilovolts, the two suppressors (1.5E440A) limiting the voltage value on power transistor to 880 V are connected in parallel to the latter for protection from a surge. Current protection of the transistor is also provided. If specified value 1.4 V of voltage drop on the resistor in transistor circuit is exceeded then the power transistor would be forcedly closed by the controller. Besides, the controller allows also regulating and selecting the whole range of device parameters (amount of ignition and stabilization pulses, duration of the first or the second, time gap period between them and others).

The main point of new device [3] for initial ignition and re-ignition of AC welding arc and stabilization of its arcing lies in an additional switching unit, embedded in its scheme, providing switching on and off of the transistor after previously specified period of time. The device is actuated during the polarity change. The pulse being transmitted in this moment is followed by a repeated pulse generated after previously determined time interval.

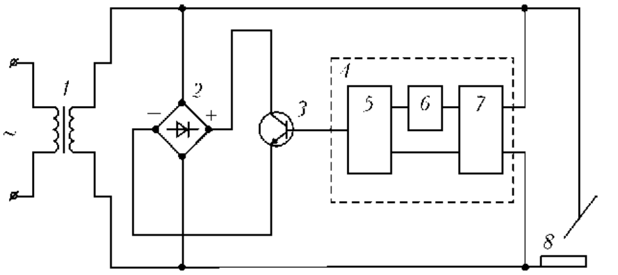

Figure 2. Structural scheme of device connected to welding transformer for excitation and stabilization of AC welding arc (for designations see the text)

Figure 2 shows a structural scheme of the device being connected in parallel to welding transformer *1* and discharge gap — welding arc *8*. The scheme includes rectifier bridge *2*, high-voltage power transistor *3* and control unit *4* consisting of pulse former *5*, delay unit *6* and synchronization unit *7*. Additional elements of the scheme (surge protection, pulse current regulation, its duration and others) are not given here. The scheme provides a voltage control in the discharge gap and delivers a controlling signal for switching on and off of the high-power transistor at the moment of polarity change. The signal consists of two parts following one after another with a time gap determined by operator. It makes one fourth of a period of 50 Hz AC in our case.

Functioning of the high-voltage power transistor (switching on and off during several microseconds) takes place for the period of controlling signal activity that results in voltage surge in the discharge gap, its breakdown and welding arc ignition. If voltage of the power source increases to the required value (ignition voltage U_{ign}) at that, then secure arcing will proceed during the whole part of semi-period. Otherwise, the arcing is established by the second pulse which follows after one fourth of the period and almost equals the maximum value of voltage of the power source, due to which secure excitation and further arcing are provided.

Switching on of welding transformer *1* provides appearance of open-circuit voltage $U_{o.-c}$, changed according to a sine law, at the output terminals of the transformer as well as in discharge gap *8*. Control unit *4* switches in use high-voltage transistor *3* at the moment of reaching of zero value ($U_{o.-c} = 0$) that results in appearance of the surge, breakdown of discharge gap *8* and arc ignition. If pulse energy or voltage of the power source at this moment of time are not sufficient for support of arc discharge, then the stable arc ignition is provided by the second pulse, which will appear at the moment close to maximum voltage of the power source. Monitoring of arc voltage and feeding of the energy pulses in the discharge gap during polarity change are continuously performed by the control unit.

Instability of the welding process can be caused by polarity charge as well as arc extinctions and other reasons. The proposed device also allows performing re-ignition in these cases. Time of re-ignition depends on the moment of arc extinction. Switching on of the transformer at the beginning of the process takes place in any moment of the period, however, the switching unit is actuated only during the polarity change. Excitation of the arc may not take place at once since sufficient amount of energy is not yet stored in the welding circuit at the beginning of the process. The discharge gap has no residual ionization at that and

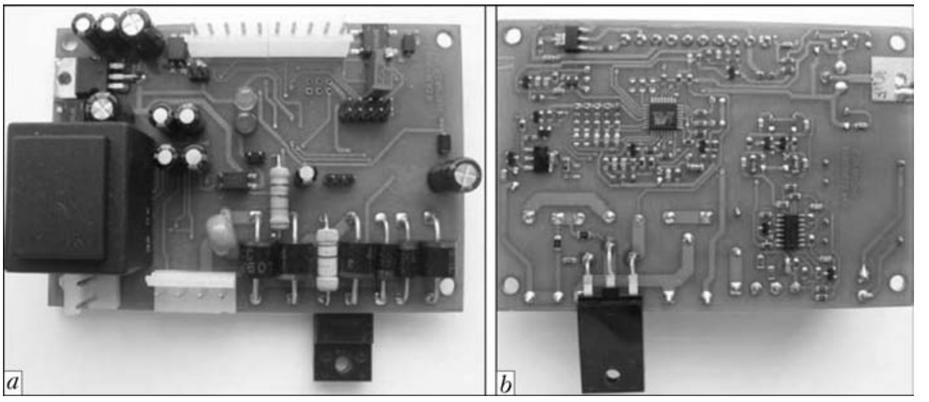

Figure 3. General view of front (*a*) and rear (*b*) side of board for pulse stabilizer of AC welding arc

voltage in it can be equal zero in this moment. However, the second pulse coinciding with the maximum value of open-circuit voltage and summing with the latter follows the first one after one fourth of the period (the time is stated by operator) and provides safe arc ignition. It should be noted that appearance of the energy pulse during arcing will make no notable influence on the process of welding due to short-term activity of the pulse.

If the arc extinction takes place during the first fourth of the period it can be easily ignited due to pulse following the first after one fourth of the period and coinciding with the amplitude value of open-circuit voltage. Arc ignition will take some time if its extinction takes place during the part of the period with sine drop of voltage. There can be no arc ignition at polarity change but it will be ignited by second pulse also summing with the maximum of open-circuit voltage.

New pulse devices (Figure 3) have already find commercial application as AC arc stabilizers and oscillators for argon-arc welding and other cases.

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ELECTRODE COMPRESSION DRIVE FOR RESISTANCE SPOT MICROWELDING

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Electrode compression drive for resistance spot microwelding was developed on a base of a step motor for spring dosing of the compression force. The drive allows implementation of complex cyclograms of compression of electrodes and programmed variation of their feed speeds.

Keywords: *resistance spot microwelding, electrode compression drive, microcontrol*

The electrode compression drive for resistance spot welding should provide displacement of the upper electrode relative to the fixed lower one and compression of the workpieces welded at a preset force. In resistance spot welding machines the stroke of the movable electrode is usually 5–20 mm, and the electrode compression force is adjustable from 1 to 80 N [1].

Based on the peculiarities of the process of resistance spot welding, its optimal cyclogram should correspond to that shown in Figure 1 [2]. The cyclogram has three stages: *I*, *II* and *III*. In stage *I*, preliminary reduction F_r serves to remove gaps between the workpieces and provide the required values of electrode–workpiece contact resistances in the cold state. Monotonous growth of F_w in stage *II* allows maintaining the stable pressure between the workpieces, despite increase in the contact area and liquid nugget diameter. Two regions *a* and *b* can be distinguished in stage *III*: F_w in a small first region is kept constant (usually for 0.03–0.10 s) to provide some cooling of the external metal layers of the workpieces and prevent deep dents in forging; and forging force F_f is applied and maintained in the second region to decrease tensile stresses and buckling of the joints, and to prevent hot cracks and cavities. However, in practice the force cyclogram is made simpler depending on the thickness, properties, configuration and degree of criticality of