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CONTENTS

FEATURES OF CURRENT PROTECTION OF POWER SOURCES FOR EBW

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The purpose of investigations was elaboration of recommendations to reduce disturbances of weld formation during EBW, if current protection of accelerating voltage source has operated because of vacuum breakdown in the welding gun, or if specified value of beam current was exceeded because of short-circuiting in the control electrode–cathode circuit. In view of the random nature of development of the mentioned transient processes, normally-open shorting plug of control electrode–cathode circuit and discharger with adjustable interelectrode gap were temporarily built into the accelerating voltage source between the cable conductor connected to control electrode and ground. This allowed closing any of the circuits and recording load current and accelerating voltage directly during welding, which was followed by comparison of oscillograms with the occurring disturbance of weld formation. It is found that in order to reduce the disturbances of weld formation at breakdown in the gun, the high-voltage source should go into the mode of automatic re-starting during the time of about 0.1 ms. The current threshold of this transition should 3–4 times exceed the maximum load current of the source, allowing for starting current at asynchronous switching on of the power source, and charging currents of capacitances of high-voltage cable and output filter. At short-circuiting in the control electrode–cathode circuit, the accelerating voltage source should automatically go into the mode of beam current stabilization after exceeding its set value by 20–30 % for 3–5 ms. 3 Ref., 1 Table, 4 Figures.

Keywords: *electron beam welding, accelerating voltage source, three-electrode emission system, accelerating gap breakdowns, short-circuiting of control electrode to the cathode, physical modelling, requirements to current protection*

In welding gun emission system breakdowns can develop in vacuum insulation between control electrode and anode. Gap between control electrode and cathode is often bridged by drops of molten metal from the weld pool. Violation of electrical insulation between the high-voltage cable conductors connected to cathode and control electrode is also possible. In all these cases an uncontrolled beam current rise takes place, disturbing weld formation.

Abrupt switching off of accelerating voltage source at operation of maximum current protection is highly undesirable, as it causes a serious weld defect in the form of a through-thickness crater, unfilled with liquid metal. Therefore, it is first of all necessary to minimize disturbance of weld formation, and only after that disconnect accelerating voltage source. If the source was switched off, then in case of its asynchronous restarting current protection operation is inadmissible, because of power source starting current, which is much higher than the operating current, because of a surge of magnetization current of the power source [1], and charging current of capacitances of high-voltage cable and output filter. These are exactly the currents, which at automatic re-starting of the source, even in the mode of the so-called soft, i.e. delayed start, can cause false operation of current protection, if its time delay is absent and too low operation threshold is set.

This work is devoted to experimental study of algorithms and dynamics of current protection operation at breakdowns and current overload in the gun, in order to reduce disturbances of weld formation.

Investigation procedure. High-voltage inverter power source of 6 kW power with 60 kV accelerating voltage was used in the study. It was created as a result of cooperation of the teams of PWI and «Torsion» Company (Kharkov). At up to 0.1 A load currents the source operates in the mode of accelerating voltage stabilization. Because of the presence of current sensor in the load circuit, at short-circuiting the voltage stabilizer can go into current stabilization mode, thus limiting the load current. Connected at high-voltage filter output is a ballast resistor, limiting the maximum amplitude of current through output high-voltage rectifier at short-circuiting in the load and preventing development of parasitic resonance processes in output cable [2].

Random nature of vacuum breakdown development makes it difficult to record its electric