DEVELOPMENT OF A PROCEDURE FOR SELECTION OF PARAMETERS OF STRIP ELECTRODE SURFACING WITH MECHANICAL FORCED TRANSFER OF LIQUID METAL

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A procedure and equipment for investigation of the process of strip electrode melting by an arc and scheme of selection of surfacing parameter with forced transfer of electrode metal have been developed.

Keywords: *surfacing, power source, mechanical forced transfer, strip electrode, deposited layer, quality*

Surfacing with a strip electrode which distributes heat energy wider in comparison with wire one is used for obtaining a necessary chemical composition in the first deposited layer. As a result, depth of penetration and dilution of deposited metal with base metal are reduced. However, a capability of the arc to destroy interferences such as spatters and oxides on its way decreases with reduction of the penetration depth due to which local lacks of fusion are formed [1].

A character of electrode melting can be various. The electrode can be melted by a drop sequentially layer by layer (Figure 1, *a*) or chaotically (Figure 1, *b*). In this case, transfer of heat energy takes place non-uniformly that provides an increase of the possibility of lacks of fusion formation. Quality of a welded joint can be influenced by the character of movement of arc and liquid metal drop. Forced transfer of electrode metal can stabilize the process of electrode melting.

Different methods of forced transfer of electrode metal were studied. Studies [2–5] determined that the forced transfer of electrode metal in wire electrode welding reduces electrode metal loss for spattering, improves conditions of arc process excitation and stabilizes current and voltage.

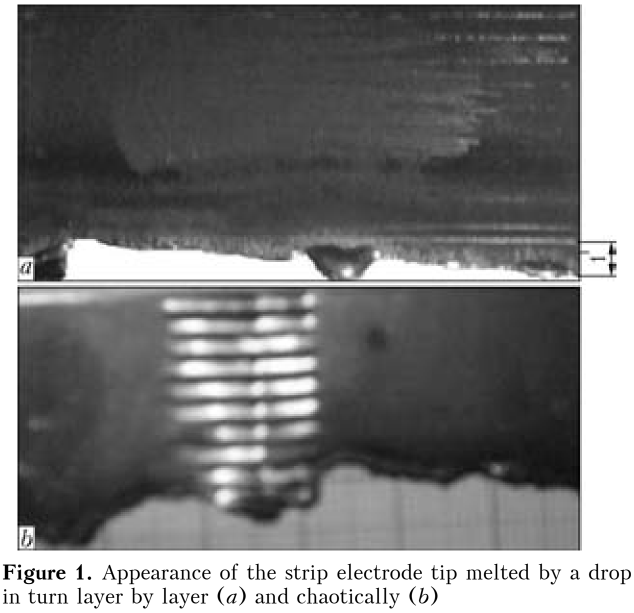

Figure 1. Appearance of the strip electrode tip melted by a drop in turn layer by layer (*a*) and chaotically (*b*)

However, existing methods of forced transfer relate only to wire electrode welding (surfacing). Data on influence of forced transfer on quality of a bead deposited by submerged arc method using strip electrode are absent. Therefore, development of a mechanism for transformation of transverse oscillations of a tip of strip electrode to longitudinal ones and investigation of influence of the oscillation parameters on the process of electrode meting and quality of deposited metal are seemed to be reasonable.

The aim of the present study is development of a procedure and equipment for determining the character of arc movement along the tip of strip electrode in submerged arc surfacing using strip electrode with mechanical forced transfer of liquid metal.

A device for mechanical forced transfer of electrode metal in submerged arc surfacing using strip electrode (Figure 2) was designed. A mechanism of transformation is situated close to the arc during automatic surfacing that reduces weight of the strip electrode performing reciprocating motions. This allows making the mechanism of transformation of transverse oscillations to longitudinal more simple. A principle of operation of presented mechanism lies in the following: shaft *7* is run by a drive; transverse movements of a strip electrode being transformed into longitudinal oscillations of its end take place due to reciprocating movement of the middle part of shaft-eccentric *9* and plates set with a gap along which the strip electrode is moved.

Proposed mechanism can be used for strips of solid section, the flux-cored electrodes cannot sustain multiple bends and vibrations since this result in uncontrolled charge spillage.

It is necessary to know the character of arc movement along the electrode tip for determining the level of influence of forced transfer on heat distribution across the width of the strip electrode.

The following methods for investigation of character of arc movement along the tip of strip electrode

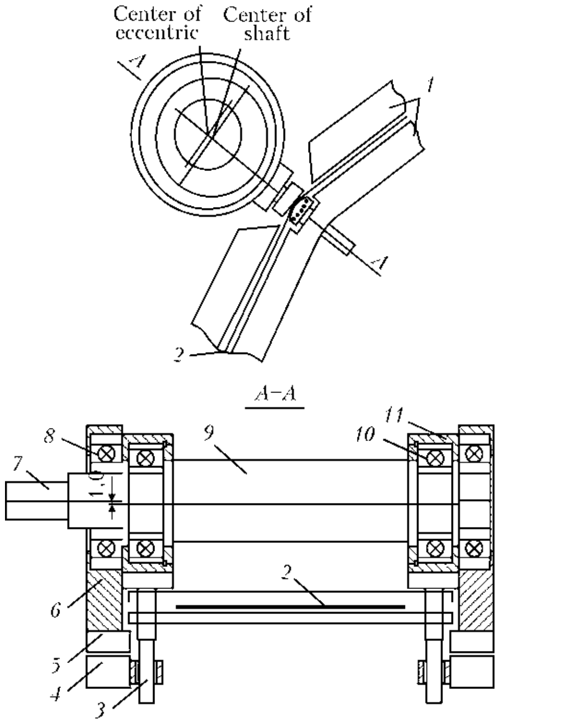

Figure 2. Scheme of transformation of transverse to longitudinal oscillations of the strip electrode tip: *1* — bent base; *2* — strip electrode; *3* — guide bolt; *4*, *5* — plate bodies; *6*, *11* — bearing bodies; *7* — shaft; *8* — shaft bearing; *9* — middle part of shaft-eccentric; *10* — eccentric bearing

are known: high-speed filming and measurement of distribution of current lines across the width of the strip electrode [1]. The letter is the most available. An attachment was developed using which a place of arcing on the tip of strip electrode (contacts) was simulated.

It is well-known [1] that arc place can be determined using the contacts situated across the width of the strip electrode. The sensors (Figure 3) were developed for control of voltage drop due current with oscillations of the tip of strip electrode and without them. A device was designed in which nine pairs of contacts (see Figure 3) are situated across the width of the strip electrode.

Strip electrodes 0.3 and 0.5 mm thick from 08A and 10Kh18N10T surfacing strips were used for practicing the procedure of performance of experimental investigations.

Arc position was simulated using the contact pressed to the tip of strip electrode. Possibility of

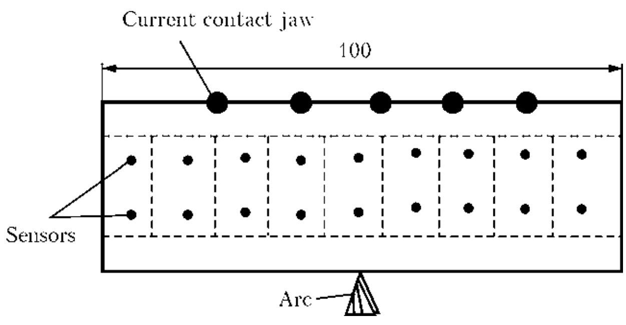

Figure 3. Scheme of position of sliding contacts (sensors) at extension of the strip electrode

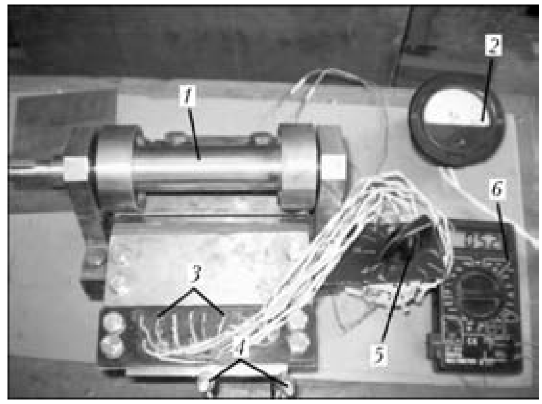

Figure 4. Appearance of device for transformation of transverse oscillations to longitudinal ones, and position of sensors of current distribution across the width of strip electrode: *1* — eccentric mechanism; *2* — ammeter; *3* — sensor of current reading; *4* — arc simulating contacts; *5* — switcher; *6* — millivoltmeter

switching-on of five sliding current contact jaws (one or combination of several) is provided for in design.

Movement of arc along the tip of strip electrode was simulated by changing contact position.

Figure 4 shows an appearance of the device for transformation of transverse oscillation to longitudinal and position of sensors for current distribution across the width of the strip electrode.

Power source with smooth regulation of voltage was used. It is three-phase autotransformer, reducing isolating transformer, to output of which a three-phase bridge rectifier is connected providing minimum pulsing of rectified voltage. Current was measured using ammeter *2* with shunt, switcher *5* switched sensors *3* by pair. Voltage drop on each sensor was measured with the help of millivoltmeter *6*.

Place for grounding must be selected for secure operation of analog-to-digital converter (ADC). For that, the current contact jaws or medium contact of low series of the sensors were grounded. Measurement results are given in Figure 5. Influence on voltage drop is insignificant in grounding of medium contact of low series of the sensors. Therefore, in future the measurements were carried out with grounded low contact of the medium sensor.

Arc (contact) position and place of current contact jaw were changed for practicing measurement proce-

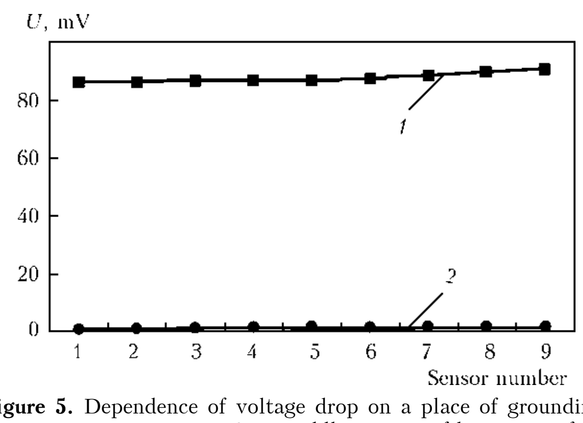

Figure 5. Dependence of voltage drop on a place of grounding: *1* — current contact jaw; *2* — middle contact of low series of the sensors

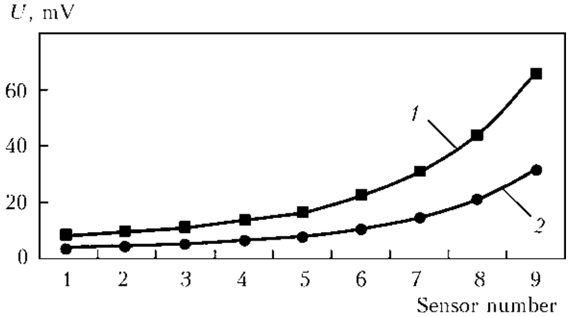

Figure 6. Dependence of voltage drop across the width of strip electrode 0.2 mm thick from 10Kh18N10T steel for different current values: *1* — 40; *2* — 20 A

dure. Measurement results are shown in Figures 6–10. As can be seen from Figure 6, the maximum of voltage drop distribution across the width of the strip electrode is situated over the contact simulating arc position at switching-on of all current contact jaws and arc position on the right end of the electrode.

Results of measurement for 0.5 mm thick strip are shown in Figure 7. Useful signal is significantly higher applying 10Kh18N10T steel in comparison with Sv-08A surfacing material. It can be seen from Figure 8 that the position as well as number of connected current contact jaws make no significant influence on character of current distribution. Experiment results, shown in Figure 9, indicate that the arc movement along the tip of strip electrode corresponds with the movement of current maximum. It is observed that the character of curves is similar using strip electrode from 10Kh18N10T and 08A, but voltage drop is significantly lower applying 08A since specific resistance of 10Kh18N10T steel is higher than that of 08A steel.

Changing of voltage drop at two contacts connected in the center and on the right end of the electrode was investigated for determining influence of shunt current or two simultaneously existing arcs. As can be seen from Figure 10, curve has two maximums at two existing arcs (contacts). A value of useful signal is higher using 10Kh18N10T material than using 08A steel.

ADC (E14-140) having 16 differential inputs or 32 inputs with common grounding is used for measurement of the parameters (Figure 11). There are 9

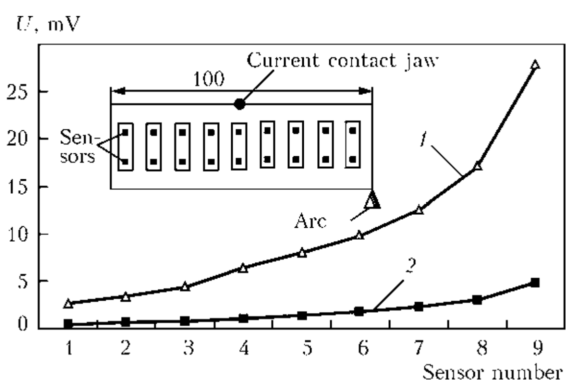

Figure 7. Dependence of voltage drop for 40 A current across the width of strip electrode 0.5 mm thick for various materials: *1* — 10Kh18N10T; *2* — 08A steel

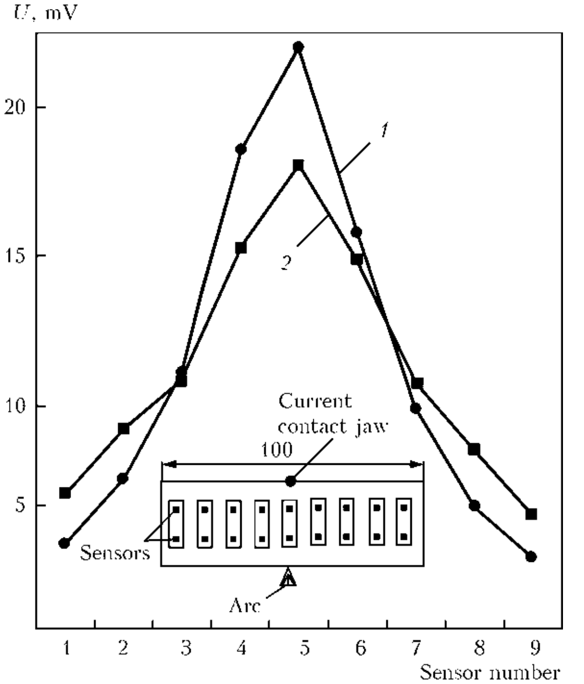

Figure 8. Dependence of voltage drop for 40 A current across the width of strip electrode 0.5 mm thick from 10Kh18N10T steel for different positions of current contact jaw: *1* — central current contact jaw is switched on; *2* — all five current contact jaw are switched on

differential sensors (Figure 11), therefore, a scheme of connection of differential inputs was used.

Shunt for 1000 A, 75 mV can be used for recording the value of arc current besides sensors of distribution of voltage drop across the width of the strip electrode. A voltage divider, parameters of which are taken in

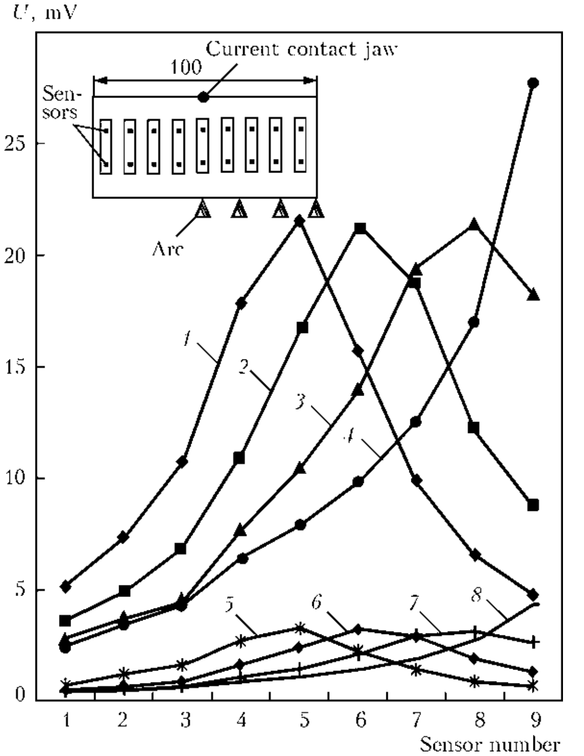

Figure 9. Distribution of voltage drop for 40 A current across the width of strip electrode 0.5 mm thick for different positions of current contact jaw: *1*–*4* — 10Kh18N10T; *5*–*8* — Sv-08A steel

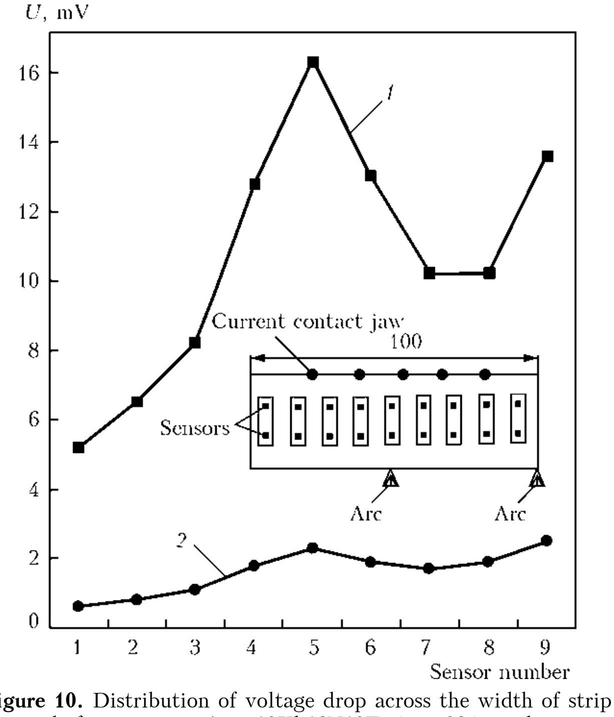

Figure 10. Distribution of voltage drop across the width of strip electrode for two arcs: *1* — 10Kh18N10T; *2* — 08A steel

account, is used for voltage measurement. Voltage drop at the electrode extension and shunt are close and arc voltage is significantly higher that is considered during programming of the device on PC.

CONCLUSIONS

1. The procedure was developed for measurement of distribution of current lines across the width of the strip electrode. It allows determining character of arc movement along the tip of strip electrode in submerged-arc strip-electrode surfacing with mechanical forced transfer of liquid metal.

2. Voltage drop distribution across the width of the strip electrode is shown.

3. Influence of the material and current on the value of useful signal was determined. It should be taken into account during processing of measurement results.

4. It is determined that grounding of current contact jaw and movable contacts has significant influence on the value of useful signal. The middle contact in lower series of the sensors should be grounded for increase of measurement sensitivity and accuracy.

5. Distribution of voltage drop has two maximums at existence of two simultaneous arcs.

6. It is proved that the position of maximum of voltage drop matches with arc position at the tip of strip electrode. Consequently, the arc movement along the tip of strip electrode can be recorded using developed devices and ADC.

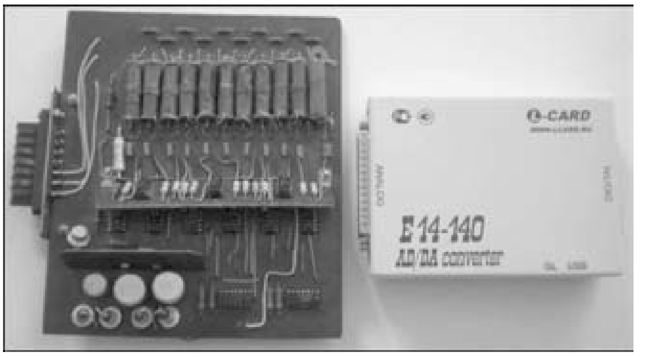

Figure 11. Device for data reading

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