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AUTOMATED TELEVISION CONTROL SYSTEM OF LASER-ARC WELDER

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Abstract: *It is described and defined the purpose of the analysis of two combined systems that automatically control the process of arc (or laser-arc) welding of metals.of presented in the paper.*

Key words: *arc welding, laser-arc welding, automatically control, welding seam, welding joint, piezoconverter.*

Consider two systems of automatic process control of metal welding, namely:

- TV system, that manages the process of dosed supply of electricity for hybrid laser-arc welder by tracking the growth of the droplets of molten metal, flowing from the electrode or wire during automated arc welding (TSTD) [1, 2];
- TV system that automatically tracks a welding joints (TSTJ) and positions the welding head over the joint or coordinate table (to the welding electrode), where welded metal parts are located.

The idea to merge these two systems allows the use of one television camera, which serves as the television sensor (TS), for both systems. For the first system, TS is used to track the process of forming droplets of molten metal from electrode or wire, which is supplied to the junction during automated arc welding of metals. For the second, TS is used to automate tracking and directing electrode to the welding joint, or inversely - welding joint to the electrode.

The functional circuit of two merged systems is shown in Fig.1.

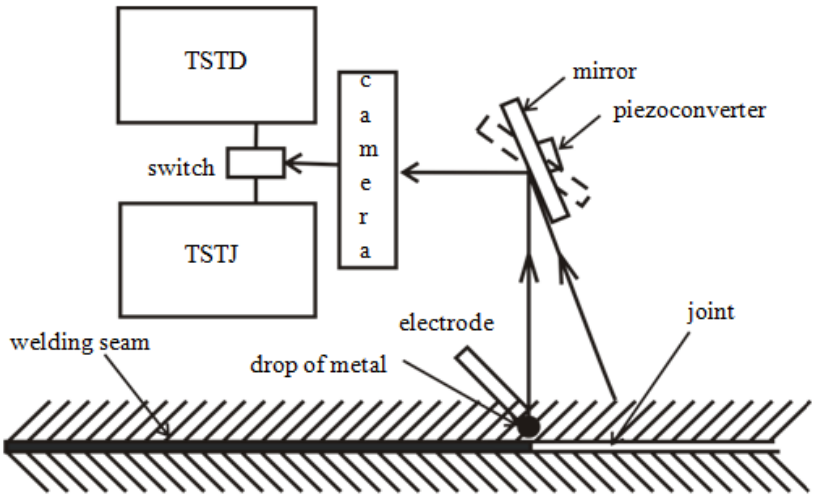

Fig.1. The functional circuit of the system tracking a drop and welding joint

The usage of TS simultaneously for two systems is possible by using high-frequency rod deflector, based on the piezoelectric converter (PC) and a rotating mirror, which forwards to the input of the TS by turn the drops of molten metal and welding metal junction. The essence of this method: through periodic inclination of PC, whose frequency is synchronized by damper impulses of TS horizontal deflection, the mirror performs periodic oscillations. As a result, through an automatic filter, the image is being projected on TS, by turn: the image of molten metal drops and the metal junction. Then TS forms the signals of horizontal scanning. The switch (S) is being operated by impulses formed during the trailing edge of damper impulses. S directs odd signals to the system that tracks a drop (in the first PC cycle), and pair signals – to the system that tracks a welding joints. (second PC cycle).

It is important to note that the alternate mirror slops proceed only during the dumper impulses, which are determined by horizontal deflection of TS. Therefore the images of the junction or metal drop don't move during horizontal scanning. To achieve this effect PC is synchronized by leading edge of a pulse and switch S by trailing edge. As a result, on the input of TSTD the first frame is formed from the odd signals (with drop images), and on the input of TSTJ - second frame formed from the pair signals (images with junction).

During the classic process of welding using electric arc, the electrode melts with a constant heat input capacity. Metal drops occur in the welding bath where they form splashes. As a result, the welded parts require further processing – grinding. To avoid additional processing, it is proposed to use method of arc welding with television tracking of metal drops growing and flowing down from a metal wire or electrode [1]. Using TS to track the process of molten metal droplets, it is possible at the time of maximum expansion before the falling to reduce the power supply for laser-arc welder. As a result, the drop smoothly lies on the welding seam, not forming splashes. Also, the energy is being saved, that increases facility efficiency.

The method of arc welding with television drops grow tracking, provides rapid control of welding current strength to hundreds of amperes, that comes from the power source – semiconductor converter. During the formation of the electric arc, the converter current is growing rapidly, up to 200A. The television sensor (TS) constantly monitors the growth of the droplets of electrode molten metal, and measured the width, calculating the speed of its change. When the rate of width change and its size reaches a certain level, which signals the television sensor, and the drop is about to fall, the current is reduced in microseconds, for example up to 50A, making the process of drop separation smooth and decreases its spray. During the closure of a drop and the material or molten weld pool, the current of the converter

reduces, for example from 100 to 10A. This process is necessary for adhesion of the drop and the surface of the weld pool. Then the current rises again to the nominal value.

The implementation of the method of dosed supply of electricity to the welding area during the arc welding is realized through automated system. It tracks the droplets growing and filters the images of molten electrode. Also it registers the signal of horizontal deflection that captures the width of video pulses, which gradually increase and become maximum wide, before the drop falls. Then the video signal is converted into dc signal that gradually increases. When the amplitude of this signal coincides with a predetermined setting corresponding to the maximum width of the drop, the system automatically generates an impulse control that reduces the power of semiconductor converter.

The functional circuit of the control system of dosed supply of electricity includes power semiconductor converter (SC), system that controls the parameters of the converter (SPC), arc welder (AW), television sensor (TS), pulse shaper (PS), converter controller (CC), filter of low frequencies (FLF) and the comparison scheme (CS).

The parameters of electricity supply are defined by the characteristics of SC. TS – the specialized television camera with a light filter for the formation and registration of drop size. FLF separates constant component that is proportional to the width of pre-formed PS pulses, and cuts off the unnecessary upper harmonics. CS receives the smoothly increasing voltage from the output of FLF and the preset reference voltage. The managing pulse, formed from comparing these two voltages, together with SPC controls the parameters of power semiconductor converters. This allows regulate and modulate a SC current supply by special law, increasing overall efficiency of welding device.

The periodic reduction of power supply to the arc device increases the efficiency of welding, and also improves the quality of the filled molten metal junction.

Switch S (Fig. 1) forms image signals to TSTJ and switches at the end of damper impulse from TS. Mirror tilts by using miniature high-frequency rod deflector during the duper impulse from TS at the time (about up to 6 ms), which is determined by its horizontal deflection.

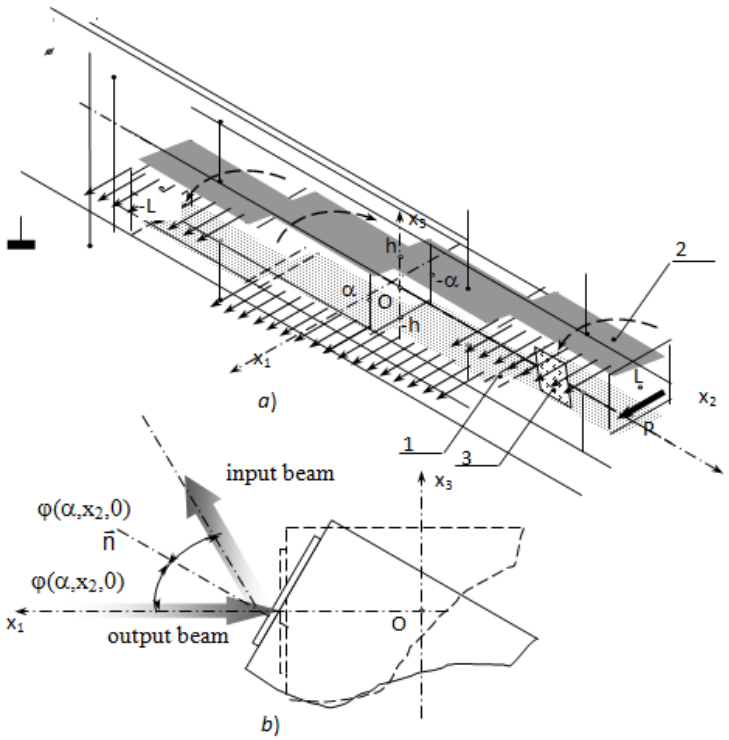

Fig.2. Calculation circuit (a) and rod deflector operation circuit (b)

High-frequency deflector [3], which forms the image of metal drops and the junction is a thin rod of rectangular cross-section (position 1 in Fig.2, a) of the polarized piezoelectric ceramics. On the opposite side of the rod surface x_3, parallel to the polarization direction P, three pairs of electrodes are put. When the electrodes are connected to a power source with potential difference $u(t) = U_0 e^{i\omega t}$ (U_0 – amplitude; $i = \sqrt{-1}$; ω - circular frequency; t - time) that varies harmonically in time (Fig.2, a) in the rod the mechanical shear stress occur. The direction of these stresses on the surfaces $x_3 = \pm h$ in a fixed time is shown in Fig.2, a, by arrows. The total effect of the shift of rod material leads to the fact, that central and peripheral parts of the rod twist around the axis of symmetry, which coincides with the coordinate axis Ox_2 of the right-hand coordinate system (Fig.2 a). The direction of twisting of individual sections of piezoceramic rod is shown by dashed arrows.

At the end of the rod on the surface $x_1 = \alpha$ the miniature reflector (mirror) is located. It transmits optical images of drops or junction of welding metals (position 3 in Fig.2, a). If the image of the drop, oriented along the coordinate axis Ox_1, is sent on the mirror, then turns of the mirror, made by the turns of peripheral parts of the rod, entail rejection of the laser beam at two corners $\pm 2\varphi$ (α,x_2,0) (Fig.2, b) in plane $x_1 x_2^0 x_3$.

The deviation of optical beam is a function of deflector. For this reason, the deflector can be seen as the converter, which transforms the difference of electric potentials in the rotation angle of the mirror. Let us assume the potential difference u (t) as input signal, and the rotation unit normal $\vec{n}$ (Fig. 2, b) to the surface of mirrors and mirror angle $\varphi(\alpha,x_2,x_3,t)$ - as a response or output signal of deflector as an image of drops or junction.

An analytical description of the mirror rotation angle (Fig.2, b) is given in [2], and enables to calculate the technical parameters of the deflector when determining the components of the vector of material plots displacement of the rod deflector.

Conclusions. During the welding process using electric arc, the metal of electrode melts due to the constant heat input capacity. Drops of metal are served with acceleration in the welding bath and form splashes. As a result, welded parts require further processing (grinding) and the welding device has a low efficiency. To avoid additional processing, it is proposed an automated system with high-speed TS. The system will reduce the power supply for laser-arc welder by controlling the formation of droplets of molten metal and fixing the moment of its maximum extension before the fall. As a result, a drop smoothly lies in the welding seam, not forming the splashes. The power consumption is reduced, that greatly increases welder efficiency.

It is proposed to use a high-frequency rod deflector with a mirror to get by turn the images of drops and the junction of welding metals. Images provide alternate operation of two automatic control systems TSTD and TSTJ. In addition, visual information, received by television camera, allows regulate the position of the guide channel, to determine the position of the electrode and its shape, the position of processed sides, the shape of welding pool.

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