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UTILIZATION OF THE OPTICAL RADIATION OF THE WELDING ARC FOR A CONTROL OF THE MAG WELDING PROCESS

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Perception of optical radiation of the welding arc by means of the KPX 81 photoelement is studied as well as the relation between the optical radiation and the technological parameters of the welding process. A power feedback system with an optical sensor to control the MAG welding process (welding with a consumable guide electrode in active gas atmosphere) is suggested.

I. INTRODUCTION

The introduction of flexible automation as a new stage of rationalization in small and mass — series productions in recent years has been common. New types of the welding equipment are being developed which are based on industrial robots. Sensors are an important precondition of the robot application to welding. Their task is to obtain information about the welding robot condition, about the selected properties of a weld and the welding process and to provide information in a proper form for the robot control system. The MAG welding process is suitable for the butt weld fabrication. This method is more and more associated with the use of optical sensors monitoring optical radiation of the arc plasma. This radiation contains information about the physical phenomena and the technological conditions of the welding process.

The work presented describes the attempts to stabilize the welding process by an arc radiation sensing and by a feedback control system [1].

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II. EXPERIMENTAL EQUIPMENT

Figure 1 [1], [2] shows a schematic representation of the automatic feedback control of the welding process. The equipment consists of: the welding process system including a welding torch, an electric arc and base metal, sensor I designed for sensing arc radiation and sensor II designed for tracking the voltage in the process together with control circuits, a high power electronic unit (based on power transistors) forming the basic element of the feedback, and a welding power source.

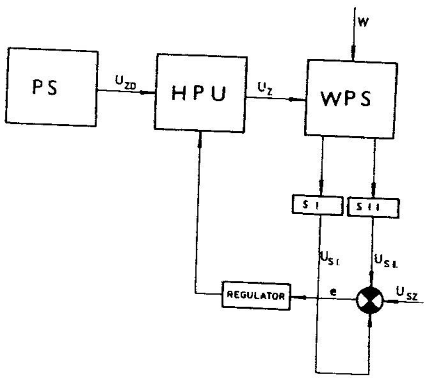

Fig. 1. Block scheme of the regulation circuit.

The mentioned control system with negative feedback operates as follows: random variation in radiation intensity is transferred by sensor I to the control input of the high-power transistor system. These transistors serve as an adjustable resistor in the welding circuit. Changing the voltage of the arc they compensate the effects of faulty variables W on optical radiation. They ensure the stable welding process and uniform weld bead formation. It follows from the above means that the welding voltage U_z is an active variable by which the welding process and its sensed radiation are stabilized. The action of the negative feedback derived from the voltage of the process does not differ from the previous radiation control, with the exception of the sensed variable. A control input was adapted so that it enables to vary independently the intensity of the output signals from both sensors in the whole range, i.e. from minimum to maximum. This adaptation has been realized in order to follow the effects of different optical and voltage control combinations on the process stability. The welding was carried out on specimens made of 10 mm thick low-carbon structural steel, with filler wire of 1 mm diameter, 15 mm outlet of wire, $4.2 \times 10^{-4}\, m^3 s^{-1}$ CO_2 gas flow, 120 A welding current, 4.2 mm . s^{-1} welding speed, 21.5 to 24 V welding voltage. A total view of the experimental welding equipment is shown in Fig. 2.

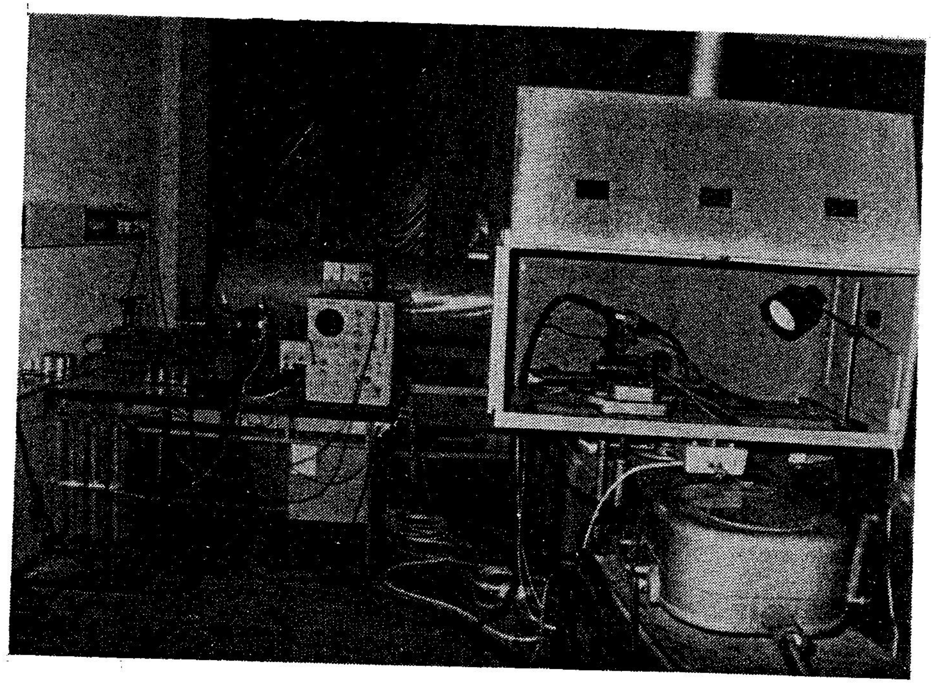

Fig. 2. The welding and electronic parts of the equipment.

III. RESULTS AND DISCUSSION

The results obtained in experiments with the proposed feedback system of the welding process control are given in the form of photographs from the fabricated bead-on-plates. Besides a visual evaluation, the effect of control on the welding process was observed also in the other sensed process variables (welding current and voltage, signal of the optical sensor).

Bead-on-plate of the non-controlled welding process deposited by the used welding source was chosen as a comparative basis. The bead-on-plate made at $I_z = 120$ A and $U_z = 21.5$ V is shown in Fig. 3. Fig. 4 shows two bead-on-plates made under controlled welding process conditions by means of sensor II. Technological conditions for the bead-on-plate A were as follows: $I_z = 120$ A, $U_z = 21.5$ V, for the bead-on-plate B $I_z = 120$ A, $U_z = 22.5$ V. The bead-on-plates made with a simultaneous effect of signals from both sensors are shown in Fig. 5. The signal from sensor I was exploited to the full extent and the signal from sensor II by one third. Technological conditions for the bead-on-plate A were $I_z = 120$ A, $U_z = 24$ V, for the bead-on-plate B $I_z = 120$ A, $U_z = 22$ V. Fig. 6 shows also two bead-on-plates made with a simultaneous control of the

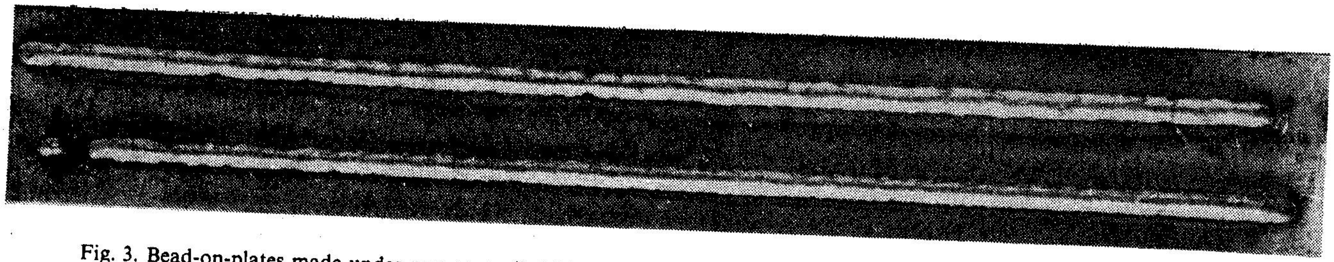

Fig. 3. Bead-on-plates made under non-controlled MAG process conditions at $I_z = 120$ A, $U_z = 21.5$ V (Fig. 3—6 scale 1 : 1.5)

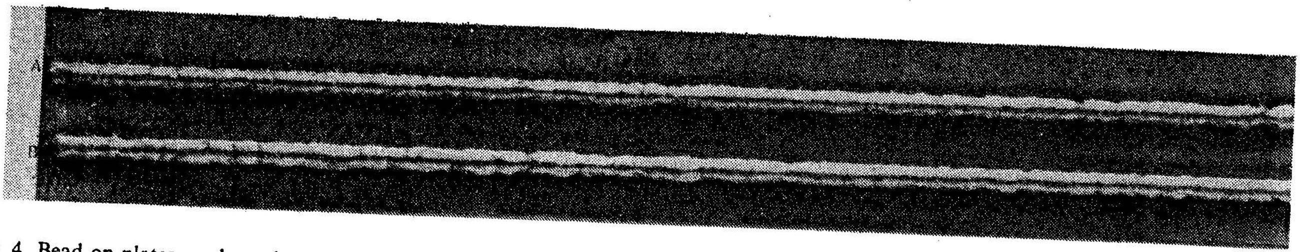

Fig. 4. Bead-on-plates made under controlled MAG process conditions by means of the signal from sensor II. Welding parameters for the bead-on-plate A: $I_z = 120$ A, $U_z = 21.5$ V, for the bead-on-plate B: $I_z = 120$ A, $U_z = 22.5$ V

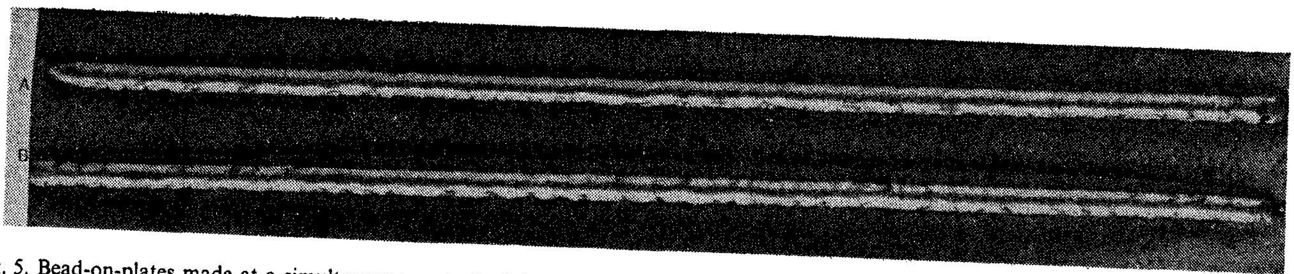

Fig. 5. Bead-on-plates made at a simultaneous control of the MAG process by the signals from sensors I and II. Welding parameters for the bead-on-plate A: $I_z = 120$ A, $U_z = 24$ V, for the bead-on-plate B: $I_z = 120$ A, $U_z = 22$ V

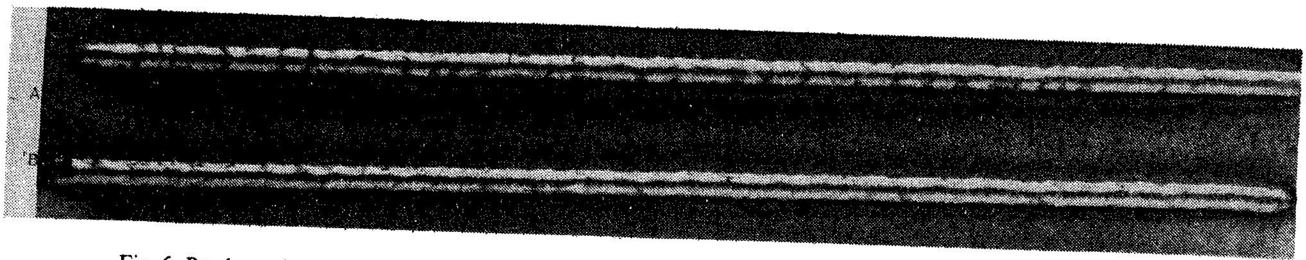

Fig. 6. Bead-on-plates made at a simultaneous control of the MAG process by the signals from sensors I and II.

welding process by the signals from both sensors. These differ from the previous bead-on-plates in the level of the signal effect which was reduced to 1/3 in sensor I and to 1/4 in sensor II. The bead-on-plate A was made at $I_z = 120$ A, $U_z = 23$ V, the bead-on-plate B at $I_z = 120$ A, $U_z = 22$ V.

Comparison of the outlook of these bead-on-plates indicates that control derived only from the process voltage (sensor II) does not improve the quality of the bead-on-plate.

Such an improvement is obtained only after the application of the signal from sensor I monitoring the integral radiation of the welding arc. A descreasing spatter tendency confirms the increased process stability exhibited by a higher quality bead-on-plates (see Figs. 5 and 6).

Summarizing the obtained results it can be concluded that the proposed and partially tested control of the short-circuit welding process enables to interfere in the process. Improved process stability and beads of higher quality were obtained first of all by the use of information on the arc radiation. The dominant role of the optical information in a control loop is an inevitable precondition for such an improvement.

III. CONCLUSION

The carried out experiments proved the possibility of the welding process control by information obtained from the integral radiation of the arc.

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ИСПОЛЬЗОВАНИЕ ОПТИЧЕСКОГО ИЗЛУЧЕНИЯ ДУГИ ДЛЯ УПРАВЛЕНИЯ ПРОЦЕССОМ СВАРКИ С РАСХОДУЕМЫМ ПЕРЕНОСЯЩИМ ЭЛЕКТРОДОМ В АКТИВНОЙ ГАЗОВОЙ АТМОСФЕРЕ

В работе приводятся результаты исследований регистрации оптического излучения дуги при помощи фотоэлемента КРХ 81, а также взаимосвязь между оптическим излучением и технологическими параметрами процесса сварки. Предложена энергосистема обратной связи с оптическим сензором, которая позволяет управлять процессом сварки с расходуемым переносящим электродом в активной газовой атмосфере.