EFFECT OF TECHNOLOGICAL PARAMETERS AT MAG WELDING ON ARC RADIATION

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The effect of a forced modulation of voltage and current in a short — circuit welding process on arc light radiation has been studied in the work presented.

I. INTRODUCTION

The welded joint quality depends on the optimum values of different parameters during the welding as well as on keeping these parameters at a constant level. In practice the elimination of the so often occuring random variations in joint geometry requires to control the process on the basis of a continuous evaluation of selected variables which give information about these variations.

The emitted welding arc radiation gives information on the welding process. That is why this information is used for sensing and process control purposes. In the case of the welding arc with a consumable guide electrode (the MAG process) variations in arc radiation cause difficulties in its application to the process control [1], [2]. This requires to find a correlation between random actual variations, the defined forced variations in the welding parameters and the arc radiation intensity.

II. TIME COURSE MEASUREMENT OF ARC RADIATION

In order to evaluate the correlation between the light radiation characteristics and the instantaneous arc state (during the stabilization of the welding process), the time course of the spectral line intensity, a continuous spectrum and integral radiation in the short-circuit GMA process in a CO_2 shielding atmosphere were studied with a simultaneous sensing of the basic parameters of the welding process (i.e. current and voltage). Modulation was employed in observing the

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photosignal responses to the forced voltage (and subsequently the current) modulation on the arc.

To study these parameters of the welding process a sufficiently powerful electronic unit (including a modulation circuit for the voltage between the arc electrodes) was built.

The welding part of the experimental equipment comprised a voltage modulator, an LSP-250 semi-automatic welding machine. The welding was carried out with a fixed torch. The specimen was placed on the moving rail carriage. The optical unit consisted of the PGS-2 spectrograph and the optical bench with lenses forming the image of the arc in the plane of the input spectrograph slot. The recording part of the system consisted of two photo-multipliers M 12 FOS 35 sensitive in the ultraviolet and the visible spectral zones (and/or the KPX 81 phototransistors for the visible and infrared spectral zone) and the memory oscilloscope Tektronix 7633. The integral radiation of the arc was recorded by the phototransistor and the osciloscope. The phototransistor was 1.5 m from the arc.

The measurements were performed at the following constant welding parameters:

5.8 mm . s^{-1} welding speed, 1 mm welding wire diameter, 10 mm specimen thickness and 2.5×10^{-4} m^3 . s^{-1} CO_2 gas flow. The welding current varied in the 90—160 A range, the modulation frequency was 30 Hz—5 kHz.

III. EXPERIMENTAL RESULTS AND DISCUSSION

The correlation between the light radiation parameters and the power characteristics of the welding arc has been studied experimentally. The registered light radiation parameters were as follows:

1 — electric current of the photomultiplier or phototransistor tracking the selected spectral lines of the base metal (iron)

2 — electric current of the photomultiplier tracking the continuous spectrum background.

3 — electric current of the phototransistor tracking the light radiation form the whole range of its spectral sensitivity (i.e. 0.6—1 μm, the so-called integral radiation).

The welding arc parameters were as follows:

1 — discharge current intensity

2 — voltage between the welding torch and the base metal.

The welding process with a consumable guide electrode in the CO_2 shielding atmosphere tends to be very unstable. Undesirable instantaneous extinction of the arc, the so-called "absence", is often observed. This was the reason for a more detailed study of the burning state and of transitions: arc — short-circuit,

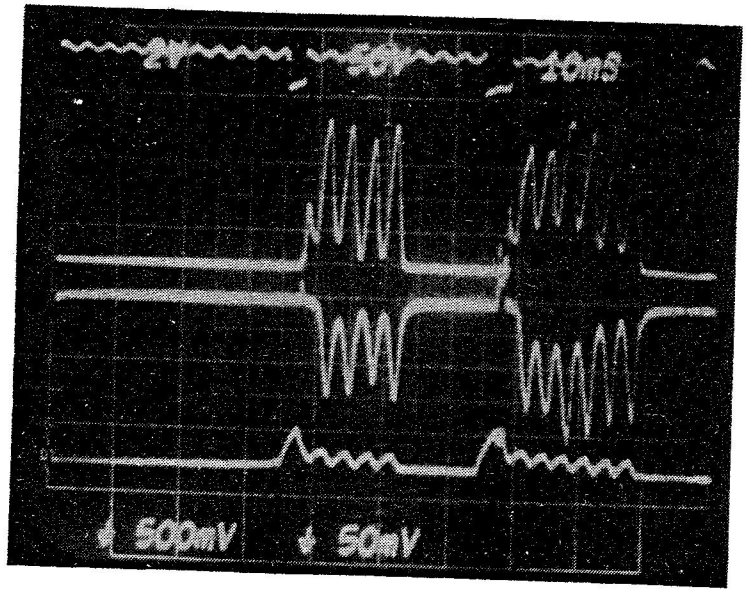


Fig. 1. Traces from upside down: Welding voltage U_z (50 V/div.), — integral arc radiation (2 V/div.), — spectral line FeI $\lambda = 426.876$ nm (500 mV/div., inverted input), — welding current I_z (500 A/div.), — welding voltage modulation $f = 300$ Hz.

short-circuit-arc, arc — absence-states and for the study of the effects of these states on the welding arc parameters. Instantaneous values of these parameters were registered because the time constants of the physical processes taking place in the arc atmosphere did not exceed 1 ms.

The oscilloscopic records showing the instantaneous values of the examined parameters indicate their quite randon variations influenced by phenomena which were not studied, e.g. the aerodynamics of the shielding atmosphere flow, temperature of the material, fluctuations in the feeding rate, the filler metal composition, etc. We have consequently stabilized the voltage between the electric contact of the welding wire and the base metal (the so-called welding voltage which is almost equal to the arc burning voltage) by means of the transistor modulator of the discharge current. The modulator was connected in series with the arc. Modulating the selected value of the welding voltage by a sine function at different frequencies and modulation depth.

The oscilloscopic records with and without modulation show the following findings.

a) *state of the arc burning*

1. intensity of the spectral line radiation of the material and integrally sensed light correlate with the arc current modulation (Fig. 1).

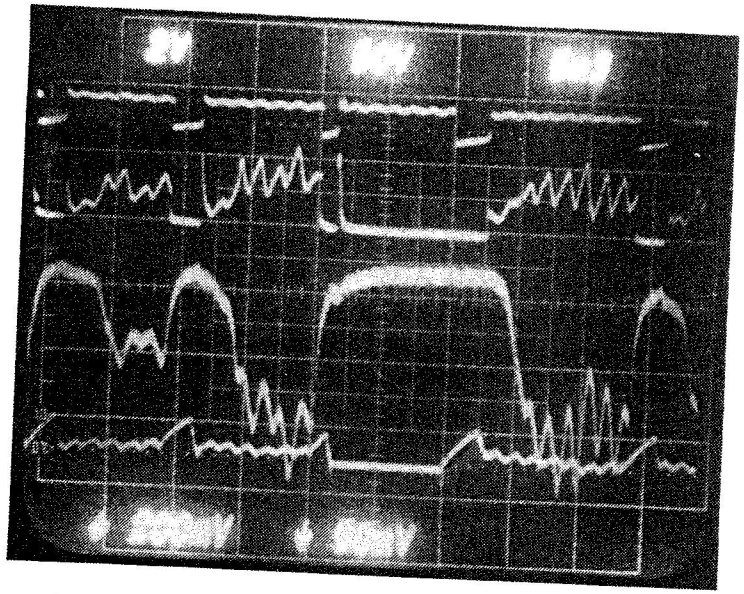


Fig. 2. Traces from upside down: Welding voltage U_z (50 V/div.), — integral arc radiation (2 V/div.), — spectral line FeI $\lambda = 475.758$ nm (200 mV/div., inverted input), — welding current I_z (500 A/div.), — welding voltage modulation $f = 700$ Hz.

2. a) the light modulation depth decreases with the increasing frequency of the discharge current modulation and is at frequencies higher than 300 Hz (Figs. 2, 3).

   b) *the short-circuit-arc transition*

   1. the integrally sensed light exhibits the same behaviour as at the instantaneous arc. burning;

   2. the intensity of the material spectral line increases to its full value in approx. 3—10 ms (Figs. 1, 2);

   c) *the are-short-circuit transition*

   1. it is possible to determine the next short-circuit in the spectral line radiation and the integrally sensed radiation from the decrease in the radiation intensity immediately before the short-circuit occurs (Fig. 4).

   d) *the arc-absence transition*

   1. though the value of the burning voltage is stabilized it increases by about 1 V immediately before an absence (approx. 1 ms), Fig. 5;

   2. the arc is extinguished when the discharge current level has sufficiently decreased;

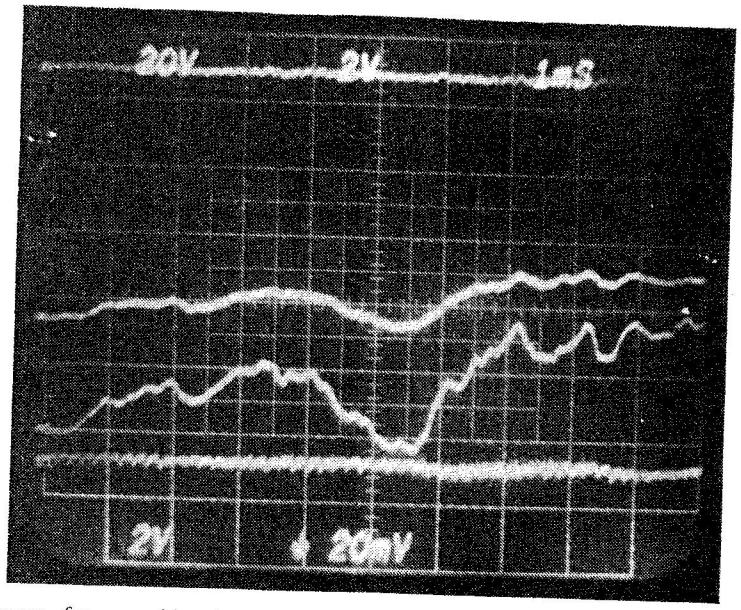
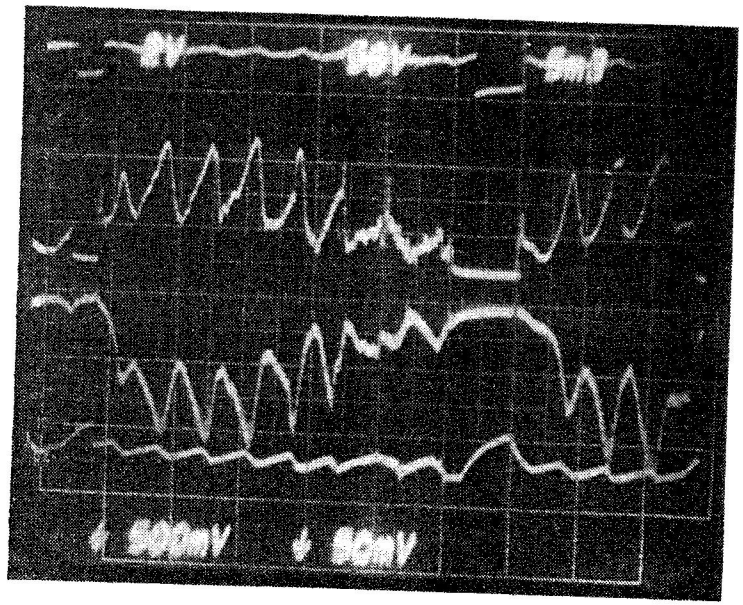


Fig. 3. Traces from upside down: Welding voltage U_z (20 V/div.), — spectral line FeI $\lambda = 301.148$ nm (2 V/div.), — spectral line FeI $\lambda = 349.057$ nm (2 V/div.), — welding current I_z (200 A/div.), — welding voltage modulation $f = 5$ kHz.



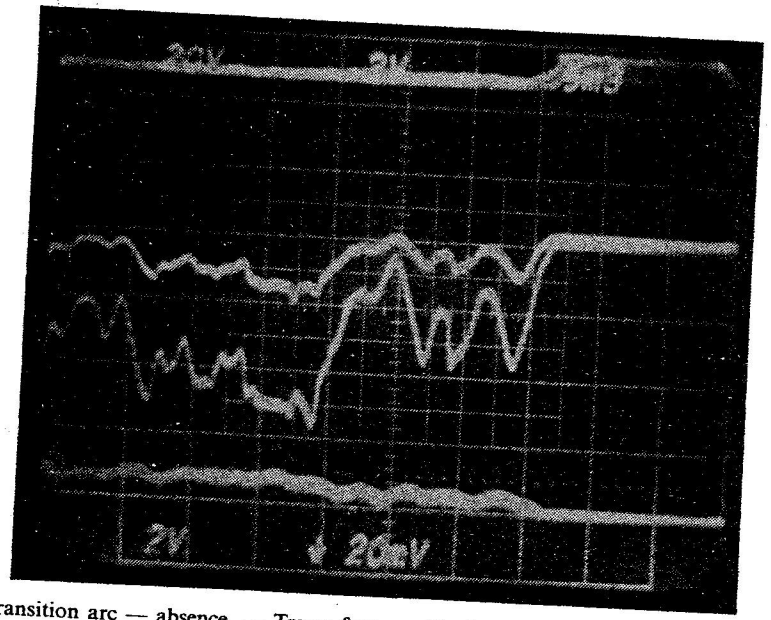


Fig. 5. Transition arc — absence. — Traces from upside down: Welding voltage U_z (20 V/div.), — spectral line FeI $\lambda = 301.148$ nm (2 V/div.), — spectral line FeI $\lambda = 349.057$ nm (2 V/div.), — welding current (200 A/div.), — without modulation.

3. the absence occurs only at a minimum discharge current during the discharge current modulation (Fig. 1);
4. the light radiation of the arc welding correlates with the instantaneous value of the discharge current only.

The mean values of the studied parameters do not exhibit a correlation with the studied transitions and it is not possible to predict these parameters from them.

On the basis of the found indications it can be concluded:

— the existence of a time delay concerning the light emission in the material spectral line confirms that the arc atmosphere becomes gradually saturated with material vapours after the short-circuit has expired.
— the given procedures of the burning voltage stabilization do not prevent the undesirable absence of the arc;

Fig. 4. Traces from upside down: Welding voltage U_z (50 V/div.), — integral arc radiation (2 V/div.), — spectral line FeI $\lambda = 445.438$ nm (500 mV/div., inverted input), — welding current (500 A/div.), — welding voltage modulation $f = 300$ Hz.

— the absence of the arc is always associated with a previous decrease in the discharge current;
— the time constant of the observed random fluctuations in the electric parameters of the welding arc decrease down to 100 s. That is why their stabilization by the mean values of the studied variables is not reasonable. A contribution can be expected mainly in the control derived from the instantaneous values of the studied parameters.

IV. CONCLUSIONS

It can be stated on the basis of the preliminary analysis of the optical radiation of the GMA welding process that for purposes of further application the integral radiation of the welding arc seems to be suitable, because the integral radiation intensity depends on the arc dimensions and thus on the electric parameters (current, voltage) of the process. Welding process parameters can be controlled by means of a sufficiently quick feedback system utilizing the integral radiation. This kind of control can improve the stability of the process.

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ВЛИЯНИЕ ТЕХНОЛОГИЧЕСКИХ ПАРАМЕТРОВ СВАРКИ НА ИЗЛУЧЕНИЕ ДУГИ В ПРОЦЕССЕ СВАРКИ С РАСХОДУЕМЫМ ПЕРЕНОСЯЩИМ ЭЛЕКТРОДОМ В АКТИВНОЙ ГАЗОВОЙ СРЕДЕ

В работе изучается влияние вынужденной модуляции напряжения и тока в цепи короткого замыкания на излучение света дуги в процесе сварки.