

A device for automatic feeding of coated electrodes into a weld pool

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Abstract. The paper presents the specification of a device for automatic feeding of coated electrodes into a weld pool and the results of its application. It eliminates subjective assessment methods and professional skills of welders, which contributes to a more stable metal transfer into the weld pool. The research results have shown that automatic feeding of coated electrodes into a weld pool enables to reasonably assess their welding and technological properties. Any devices similar to the developed one and the results of their tests have not been found.

1. Introduction

Shielded metal arc welding (SMAW) is the most versatile way to obtain permanent joints of metal structures for various applications [1]. Until now, experimental joints have been welded manually without using any electrode feeding mechanisms [2]. The quality of the welded joints depends on many factors, but the qualifications of welders have a particularly strong effect. In order to obtain objective, reliable and repeatable results of conducted investigations in the field of SMAW, it is necessary to reduce the influence of the human factor as much as possible. This is especially true for testing equipment and consumables used for SMAW, where this effect is decisive [3, 5].

To exclude the influence of the professional skills of welders on the research results, various devices are typically used that enable to obtain welded joints without human participation. In the 1930s, a welding method with an inclined coated electrode has been invented in the USSR [7]. In this case, the electrode is supported mechanically and lowered into the weld pool under the action of gravity without human participation (Figure 1). Disadvantages of this method (and similar ones) include the impossibility of controlling the required arc length, as well as constant changes in both the electrode inclination angle and the weld pool coordinates on the horizontal plane. As a

result, there is no way to study the kinetics of the electrode melting process because it is difficult to tune focusing of a video camera synchronously with the electrode movement.

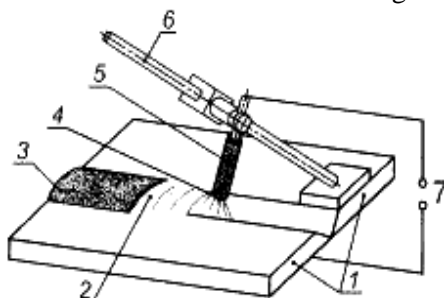


Figure 1. A scheme of SMAW with an inclined coated electrode: 1 – work-pieces, 2 – weld, 3 – slag, 4 – electric arc, 5 – coated electrode, 6 – guide, 7 – power source.



2. The device description

To solve this issue, a device for automatic feeding of coated electrodes has been developed, which enables to strike an arc by contacting with work-pieces, to control and stabilize the average arc length upon the electrode melting, as well as to turn it off by the arc elongation. A feature of the developed device is the electrode movement along its axis. As a result, the spatial electrode tip coordinates do not change during the welding process, which enables its video filming [4, 6]. The device (Figure 2) includes the following components: an electrode holder (a); a hull (b), a guide (c), a servo (d), a moving screw (e), and a control unit (does not shown in the figure).

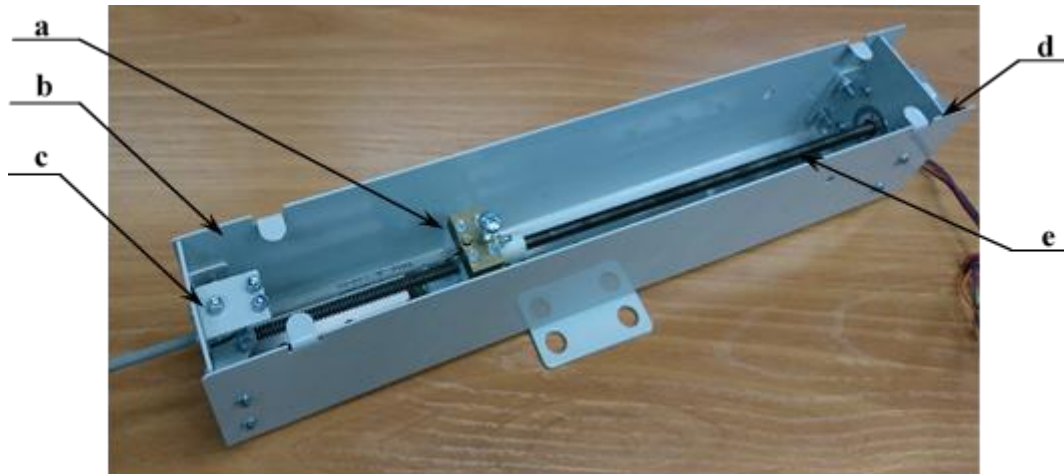


Figure 2. The device for automatic feeding of coated electrodes.

The control unit recognizes its states (no-load, arcing, or short circuit) by measuring the voltage drop in the gap between an electrode and work-pieces and, in accordance with the operator's commands, controls the servo motor. The average arc length is stabilized by comparing the preset value with the actual one. The resulting difference is transmitted to input of a proportional-integral-derivative (PID) controller, which output signal determines both speed and direction of the servo motor rotation.

In order to identify advantages and drawbacks of the developed device, experimental studies have been carried out. Their results have been compared with the data obtained for similar conditions with manually feeding of coated electrodes into a weld pool.

3. Experimental technique, materials and equipment

A scheme of the experiment is shown in Figure 3a. Surfacing of horizontal beads on the 0.12% C – 1.5% Mn – 0.6% Si steel plate with a thickness of 10 mm has been carried out with the OK46.00 and OK74.70 coated electrodes 4 mm in diameter. Welding current (DCEP) has been supplied with a 'VD-306E' conventional three-phase welding rectifier. The θ inclination angle between the electrodes and the plate has been 70° , the arc length has been maintained as low as possible for the both electrode feeding methods. The V_{welding} welding speed has been maintained at 180 mm/min using a special mechanism that has moved the plate. After the arc striking and the surfacing process stabilization, welding current and arc voltage have been recorded for 10 s using a research setup [4]. Obtained oscillograms (Figure 3b) have been analyzed according to the criteria characterizing the welding process stability. The results of the analysis for the OK46.00 and OK74.70 electrodes are presented in Tables 1 and 2, respectively, where U_{rms} is rms arc voltage, I_{rms} is rms welding current, N_{sc} is a number of short circuits during the registration period, t_{mean} is average duration of the short circuits, t_{rsd} is the variation coefficient

for the short-circuit durations, T_{mean} is average duration between short circuits, and T_{rsd} is the variation coefficient for the durations between the short circuits.

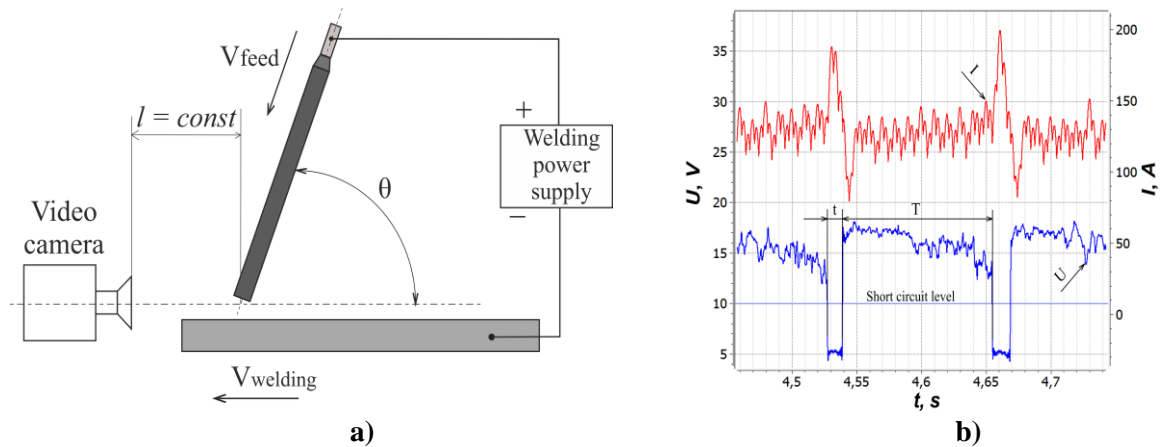


Figure 3. The scheme of the experiment, as well as welding current and arc voltage oscillograms obtained upon SMAW with automatic feeding of the OK46.00 electrode.

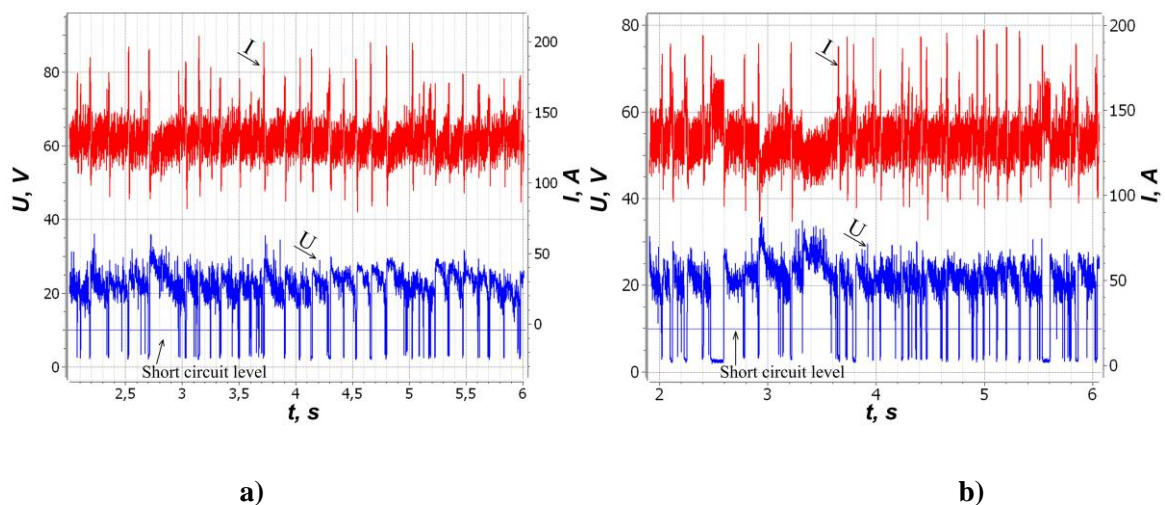


Figure 4. Current and arc voltage oscillograms in various methods of supplying coated electrodes (a – automatic, b – manual).

Table 1. The parameters of the surfacing process stability with the OK46.00 electrodes.

Electrode feeding methods	U_{rms}, V	I_{rms}, A	N_{sc}	$t_{\text{mean}}, \text{ms}$	t_{rsd}	$T_{\text{mean}}, \text{ms}$	T_{rsd}
Automatic	21.4	132	74	7.4	0.58	123	0.32
Manual	19.7	134	95	8.9	1.30	121	0.42

Table 2. The parameters of the surfacing process stability with the OK74.70 electrodes.

Electrode feeding methods	U_{rms} , V	I_{rms} , A	N_{sc}	t_{mean} , ms	t_{rsd}	T_{mean} , ms	T_{rsd}
Automatic	22.8	129	26	13.6	0.22	313	0.22
Manual	21.8	139	29	14.9	0.31	360	0.35

The results of the experimental data analysis have showed that the use of the developed device increases the stability parameters of the surfacing process with the coated electrodes. In particular, the deviation from the average values has been significantly reduced while maintaining the values of the average duration between short circuits and their frequency (figure 4). Thus, the use of automatic electrode feeding has caused a decrease in both the variation coefficient for the durations between the short circuits and their frequency by 1.5 times for the OK74.70 basic coated electrodes. Automatic feeding of the OK46.00 rutile-cellulose coated electrodes into the weld pool has reduced the variation coefficient for the durations between the short circuits by 2.24 times, and their frequency by 1.3 times. In this case, both the welding current and arc voltage values have been almost unchanged.

4. Conclusions

The use of the developed device for automatic feeding of coated electrodes (instead of a welder) results in the increase in the stability of the metal transfer to the weld pool, while it gives almost no effect on the energy performance of the welding process. It can be assumed that applying the device improves the mechanical properties of the weld metal. However, more research is required to verify this assumption.

Acknowledgement

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