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INFLUENCE OF THE ACTIVATING FLUX ON WELD JOINT PROPERTIES AT ARC STUD WELDING PROCESS

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In this paper, the influence of the activating flux on the weld joint properties at the drawn arc stud welding process with ceramic ferrule is analysed. In the experimental part of the paper, the arc stud welding process is applied with the application of the activating flux for ATIG process. In order to evaluate the influence of the activating flux on the welding process parameters variations, the main welding parameters were monitored by an on-line monitoring system. Besides monitoring of welding current and voltage, the influence of the activating flux on the weld joint appearance is investigated. The macrosections of the weld joints welded with the same parameters, but with and without the presence of activating flux are shown.

Key words: arc stud welding, activating flux, on-line monitoring, macrosection analysis

Utjecaj aktivirajućeg topitelja na svojstva zavarenog spoja kod elektrolučnog zavarivanja svornjaka. U radu je analiziran utjecaj aktivirajućeg topitelja na svojstva zavarenog spoja kod elektrolučnog zavarivanja svornjaka uz zaštitu keramičkog prstena. U eksperimentalnom dijelu rada izvršeno je zavarivanje svornjaka uz primjenu aktivirajućeg topitelja za ATIG postupak. Pri zavarivanju su praćeni glavni parametri zavarivanja, jakost struje i napon električnog luka uz pomoć on line monitoring sustava u cilju ocjene utjecaja prisustva topitelja na promjene glavnih parametara zavarivanja. Uz praćenje jakosti struje i napona zavarivanja u nastavku rada istraživan je utjecaj aktivirajućeg topitelja i parametara zavarivanja na izgled zavarenih spojeva te su prikazani makropresjeci spojeva zavarenih istim parametrima sa i bez prisustva aktivirajućeg topitelja.

Ključne riječi: elektrolučno zavarivanje svornjaka, aktivirajući topitelj, on line monitoring, analiza makropresjeka

INTRODUCTION

The first papers on the activating flux application appeared already in 1950's and 1960's, but the interest for this welding process has been activated again in the last ten years [1, 2]. In order to increase the efficiency and productivity of TIG process, a variant of process with the activating flux is applied (ATIG). With the presence of the activating flux and high temperature, the value of the surface tension of the melted metal is reduced, the electric arc is stabilised and summarised, and the weld bead width is reduced with increased penetration [2, 3]. The activating flux contains activating elements that ensure the necessary weld geometry and modifying elements that refine the weld metal structure (achieving small grained structure) [4]. The activating flux is the mixture of oxide and fluoride metal powders that approve microalloying and modification of the weld metal. It can be produced as a solid chemical substance (powder flux) or as the aerosol spray [3]. Very often, the activating flux is applied as a suspension (solvent of powder flux in acetone or alcohol) that is applied on a surface with a brush or as a spray with 10-20 % acetone. Evaporable liquid, (acetone or alcohol) functions as the solvent. A thin layer of the activating flux is applied on the width of 8-10 mm on both sides of the weld joint. Maximal current density in the electric arc is achieved when there is 4 mg/cm of the activating flux in the welding zone [5].

In order to monitor any possible stability changes at the arc stud welding process, in case of a layer of the activating flux for ATIG process on the surface of the base metal, the results of on-line monitoring of the main welding parameters during arc stud welding with a layer of the activating flux on the base metal, are presented in this paper.

SETUP OF EXPERIMENT

In the experimental part of the paper, the influence of the activating flux for ATIG process (developed at the E.O. Paton Electric Welding Institute, Kyiv) on the weld joint properties at the arc stud welding process is investigated. The applied activating flux for ATIG process is developed for welding of non alloyed steel and it is applied with a brush (as a suspension) on the base metal surface (the designation of the applied activating flux

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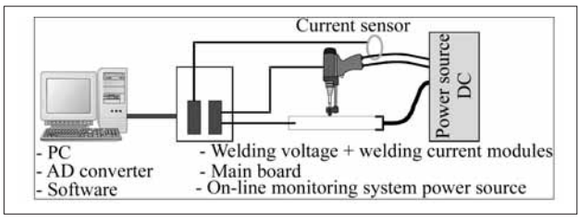


Figure 1 Setup of experiment

according to ТУ ИЭС №643-87 is ВС-2Э; or in Latin alphabet: VS-2E).

In this experimental research, the welding was performed by drawn arc stud welding with a ceramic ferrule process (DAW with ceramic ferrule) with on-line monitoring of welding current and voltage during the welding process. Welding was performed with the equipment for the arc stud welding process: Nelson Stud Welding, Inc., Oh, USA (power source: ALPHA 850, stud welding gun NS 40 B), while the main welding parameters are monitored with a developed on-line monitoring system (sampling frequency was 5 kHz). Figure 1 shows a scheme of the on-line monitoring system during arc stud welding. Experimental welding was performed on the studs 'Nelson KS 10,0×50' with ceramic ferrule 'Nelson KW 10/5.5'. A stud was made from X10CrAl18 (EN 10095), and the base material was steel type 16 Mo 3 (EN 10028-2); with the following dimensions of the base metal sheets: 45×50×5.

In order to connect the arc stud welding process stability changes with the quality of the weld joint, the macrosections of the welded studs are also analyzed. The setup of selected welding parameters is shown in Table 1.

For further analysis of the weld joint appearance, the macrosections of the studs welded on the surface of the base metal with a layer of the activating flux, are compared with the macrosections of the weld joint performed on the clean surface of the base metal. Besides specimens welded according to welding parameters stated in Table 1, additional welding trials are performed according to the parameters setup in Table 2.

ANALYSIS OF RESULTS

After the experimental welding, the main welding parameters changes and macrosections of the weld joint are analyzed. In Figure 2, besides, the macrosections of the weld joints, the distribution of the welding current and voltage for the specimens welded according to the welding parameters stated in Table 1 is shown.

Stability variations of the electric arc for welding with lower values of the welding current (Trial No. 12), especially at the end of the electric arc duration time and during plunging of the stud into the molten base metal can be noticed in Figure 2. On the macrosection shown also in Figure 2 for the specimen welded with the activating flux (Trial No. 12) the considerable amount of porosity and the lack of fusion can be noticed. The variations in electric arc stability are less distinctive for the welding process with higher values of the welding current and time, and that can be connected with the weld joint quality for Trial No. 13. As it can be noticed for the specimens welded with higher welding parameters, the quality of the weld joint is acceptable and there is no porosity, but, in comparison with Trial No. 11 (the specimen welded on the clean surface of the base metal) the appearance of the weld fusion zone is considerably changed: for Trial No. 13 the fusion zone is more narrow and with increased height.

Figure 3 shows the specimens welded with the same welding parameters but with and without the activating

Table 1 **Welding parameters (weld process stability investigation)**

Trial No.	Welding current *I* / A	Welding time *t* / s	Plunge P_s / mm	Lift *L* / mm	Welding condition
11	600	0,4	2,9	2,5	Clean surface of the base metal
12	400	0,55	1,5	2	Activating flux (VS-2E) on the surface of the base metal
13	600	0,55	1,5	2	Activating flux (VS-2E) on the surface of the base metal

Table 2 **Welding parameters (investigation of the acitvating flux influence on weld macrosection)**

Trial No.	Welding current *I* / A	Welding time *t* / s	Welding condition
21	500	0,35	Clean surface of the base metal
22			Activating flux (VS-2E) on the surface of the base metal
23	600	0,35	Clean surface of the base metal
24			Activating flux (VS-2E) on the surface of the base metal
25	500	0,45	Clean surface of the base metal
26			Activating flux (VS-2E) on the surface of the base metal
27	600	0,45	Clean surface of the base metal
28			Activating flux (VS-2E) on the surface of the base metal

Plunge $P_s = 2$ mm, lift $L = 1,5$ mm

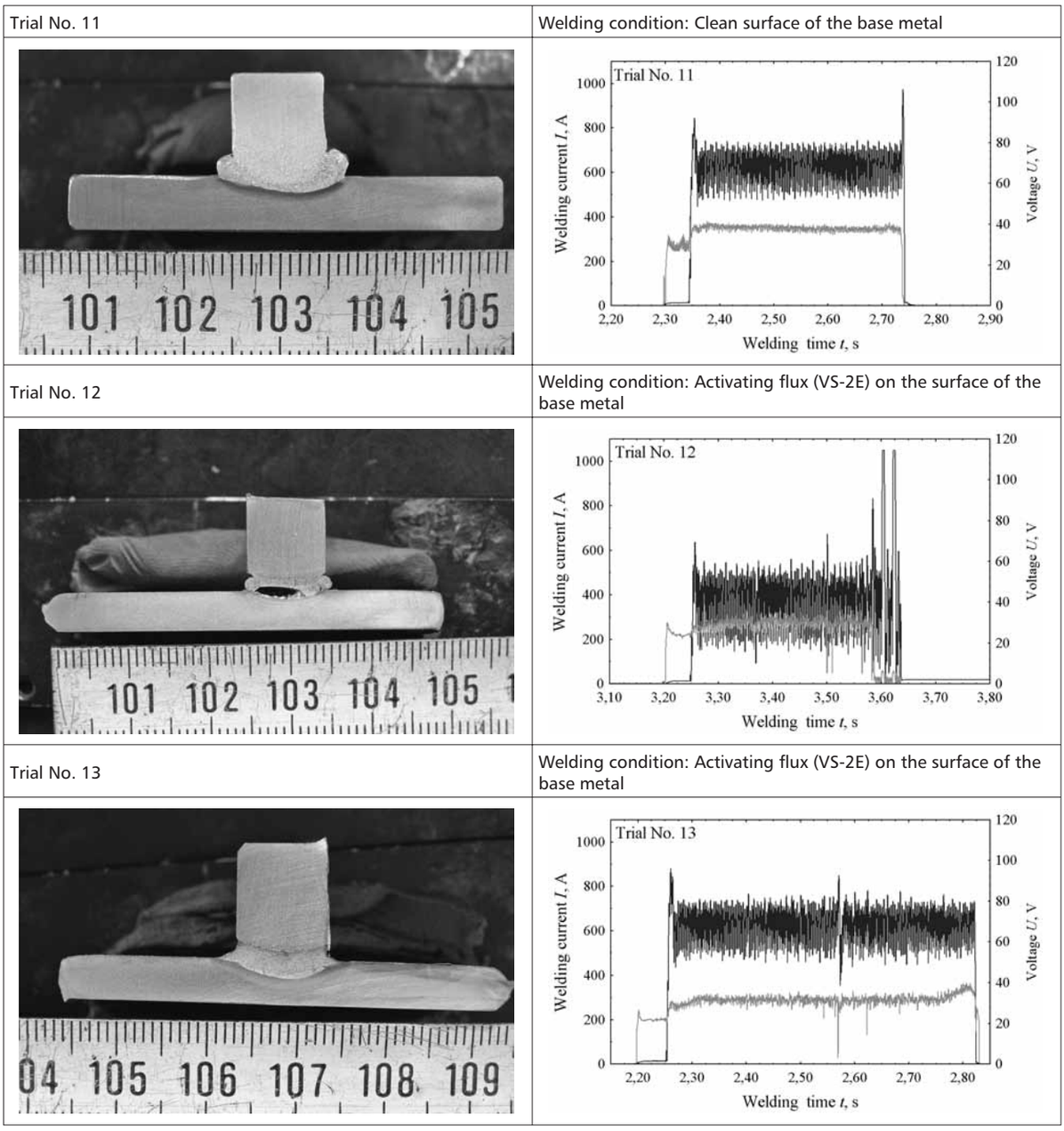


Figure 2 Weld joint macrosections and welding parameters distribution for weldments with and without the activating flux VS-2E (setup of experiment in Table 1)

flux for ATIG on the surface of the base metal (welding setup according to Table 2). The differences in the appearance of the weld joints are evident. During welding with lower welding parameters, the porosity appears for the specimens welded with the activating flux. Besides the macrosections for Trials No. 22, 24 and 26, this appearance of the porosity was already evident for the Trail No.12 in Figure 2. During welding with higher values of the welding current (600 A) and welding time of 0,45 and 0,55 s, the appearance of porosity is avoided for the studs welded on the base metal with the layer of the activating flux (Trial No. 13 for setup of the experiment in Table 1 and Trial No. 28 for the experimental setup in Table 2).

CONCLUSIONS

The activating flux for ATIG welding process VS-2E, foreseen for the application on non alloyed steels, is applied for the analysis of the activating flux influence on the properties of the joint welded with the arc stud welding process. These analyses have confirmed the influence of the activating flux for ATIG process on the changes of the electric arc stability but also

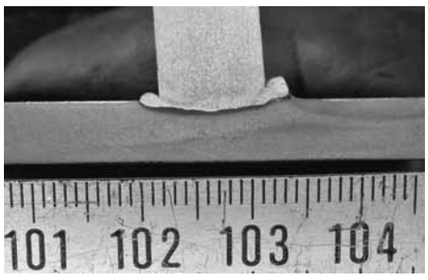
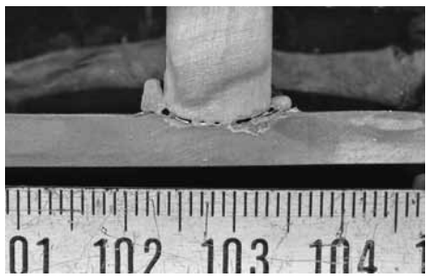
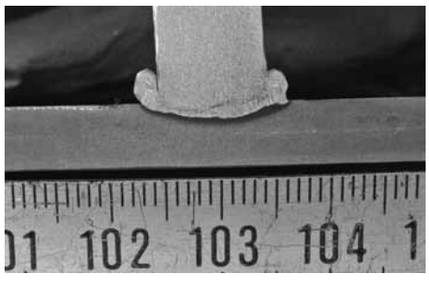
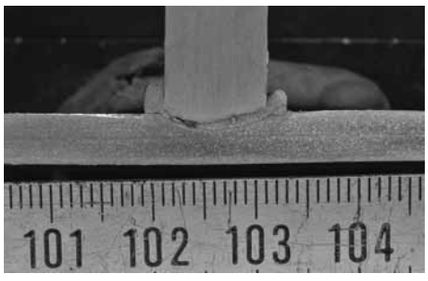
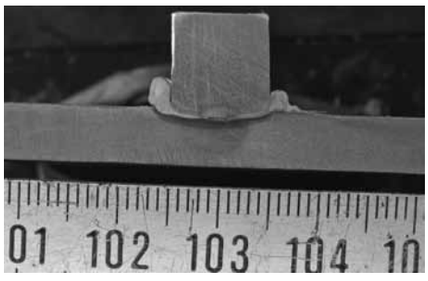
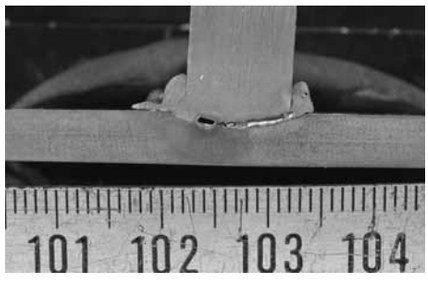
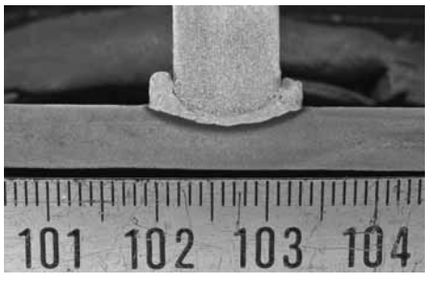
a) Trial No. 21 Clean surface of the base metal		b) Trial No. 22 Activating flux (VS-2E) on the surface of the base metal	
c) Trial No. 23 Clean surface of the base metal		d) Trial No. 24 Activating flux (VS-2E) on the surface of the base metal	
e) Trial No. 25 Clean surface of the base metal		f) Trial No. 26 Activating flux (VS-2E) on the surface of the base metal	
g) Trial No. 27 Clean surface of the base metal		h) Trial No. 28 Activating flux (VS-2E) on the surface of the base metal	

Figure 3 Weld joint macrosections for weldments with and without the activating flux VS-2E (setup of experiment in Table 2)

on the weld joint properties for welding with the arc stud welding process.

For lower welding parameters, the stability changes and resulted porosity during welding with the activating flux have also manifested through the variations of the monitored main welding parameters (welding current and voltage). For welding with higher values of welding current and time, the result was a better quality of the weld joint, which is confirmed with the macrosection appearance and also with considerably less oscillation of the monitored welding parameters. So, the important precondition for achieving the quality weld joint with application of the activating flux is the adequate value of welding current that ensures melting of the activating flux. If the activating flux is not melted, it is imported in the melted weld pool and it induces porosity in the weld joint. It is evident that the welding time of 0,35 s is too short, and the higher value of the welding current is necessary at welding times of 0,45 s and 0,55 s.

Also, a further analysis of the macrosections has shown that during welding with the activating flux at higher welding parameters, the weld joints with larger amount of melted metal, compared to welding without the layer of the activating flux on the surface of the base metal, are created.

Since the influence of the mentioned activating flux on the appearance of the weld joint is presented in this paper, the influence of the activating flux on the me-

chanical properties (possible hardness and strength changes) will be investigated in the following research. Taking into consideration that the applied activating flux is developed for ATIG process, where electric arc is shielded by inert gas, the following experimental welding will be directed to determine the influence of the activating flux on the geometrical and mechanical properties of the weld joint at the drawn arc stud welding process with shielding gas. This experimental research welding was performed with two different types of steel. Therefore, the influence of the activating flux on the weld joint properties is planned to be investigated during the arc stud welding process with the stud and the base metal belonging to the same steel group.

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