A Study of the Impact of Weld Overlay Speed on the Electrical Parameters of Vibroarc Weld Overlay in Argon on Worn Components of Transport and Agricultural Machinery

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***Abstract**: The paper studies the effect of weld overlay speed on the vibroarc process and its electrical parameters. The assessment criteria are the voltage of short circuit at the beginning and end of the arc; the size of the short circuit current at the end of the arc. The study is conducted by using a device for vibroarc weld overlay in argon with different electrode wires (Sv 08G of 2S, Np 30 HGSA, DUR 500) with a diameter of 1,6 mm. It was found out that weld overlay speed affects significantly the vibroarc process with minimal values of voltage and current magnitude being recorded at a weld overlay speed of 0,94 m/min. The evaluation criteria used in this study are the short circuit voltage at the beginning and end of the arc combustion and the magnitude of the short-circuit current at the end of the arc combustion. The study is conducted with the use of a device for vibroarc weld overlay in argon with different electrode wires (Sv 08G2S, Np 30 HGSA, DUR 500) with a diameter of 1,6 mm. It was found that the speed of welding affects significantly the vibroarc process where a welding speed of 0,94 m/min leads to minimal values of voltage and electrical current. .*

***Keywords**: Vibroarc weld overlay in argon,* speed of welding, *electrical parameters.*

INTRODUCTION

Argon is an inert gas, which protects reliably the arc and weld overlaid metal from the effects of oxygen and nitrogen in the air by providing high quality of repaired components. The formation of pores, oxides and nitrates, which increase the brittleness of the weld overlay, is reduced to zero. Vibroarc weld overlay in argon can be used to restore various, small and large - size components with simple and complex shapes, components with internal and external surfaces made of various metals and alloys [3, 4].

The speed of weld overlay is one of the main parameters of the vibroarc weld overlay procedure. This parameter determines the other kinematic and technological parameters of the electric arc process in weld overlay. To achieve high productivity, restoration has to be done at the highest possible speed of weld overlay, which provides quality vibroarc weld overlay coating. Weld overlay in a gas-protected environment can be done at a higher speed compared with other welding methods. By increasing the speed of weld overlay, we can reduce the weld penetration depth and layer thickness as well as the possibility of forming pores in the weld overlay metals [1, 3].

An increase in voltage leads to an increase in the arc interval, the time of the arc cycle, the burning of alloying elements and defects in the welded metals. An increase in the short – circuit current and particularly in the speed of this increase leads to increasing the heat – affected zone and spreading of electrode metal. The changes of these parameters with reference to weld overlay speed in vibroarc weld overlay in argon has not been researched enough [1, 2].

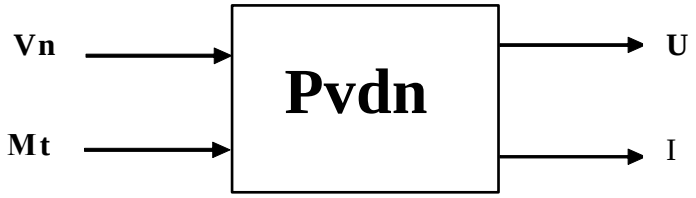

Fig. 1 A model for studying the process of vibroarc weld overlay in argon:
Vn is the weld overlay speed; Mt – the material of the electrode wire;
U – the voltage parameters; I – the parameters of current magnitude.

MATERIAL AND METHODS

The purpose of the study is to determine the effect of weld overlay speed on the electrical parameters of vibroarc weld overlay in argon. This is done by studying restored components of automobiles, tractors and other agricultural machinery by thoroughly researching the process of vibroarch weld overlaying in argon.

Research outline: The input parameters of the research model are as follows:

− Speed of weld overlay (Vn);

− Material of electrode wire (Mt).

− The basic criteria for evaluating the quality of the vibroarc weld-overlay process in carbon dioxide (Fig. 1) are:

− The voltage parameters (U), which include the short circuit voltage (Uks), the voltage at the beginning of the arc combustion (Und), and the voltage at the end of burning of the arc (Ukd);

− The parameters of the current magnitude (I), which include the magnitude of the electrical short-circuit current (Iks) and the current magnitude at the end of the electrical arc (Ikd).

The weld overlaying of the samples, used to study the influence of weld – overlay speed, was conducted by using a station for welding in shielded gases with the ENTON – 60 vibroarc apparatus, which is equipped with an axial non-inertial vibrator. The weld overlaying was performed on cylindrical, C45 samples with a diameter of 50 mm and a length of 250 mm. These dimensions correspond to the average dimensions and weight of the components that have to be restored [5, 6, 7]. On each sample we weld overlaid with different electrode wires (Sv 08G2S, Np 30HGSA, DUR 500) 5 layers with a width of 40 mm with a diameter of 1,6 mm. The weld overlay work mode was as follows: working voltage - 20 V; electric current - 150…180 A; vibration amplitude of the electrode wire - 2 mm; speed of feeding the electrode wire - 2,3 m/min; spacing between the weld overlay layers - 3 mm/tr; stick –out of the electrode wire - 15 mm; frequency of vibrations - 46,7 Hz and shielding gas consumption- 15 l/min. The speed of weld overlaying was changed gradually. Its values were 0,63, 0,94, 1,26 and 1,88 m/min.

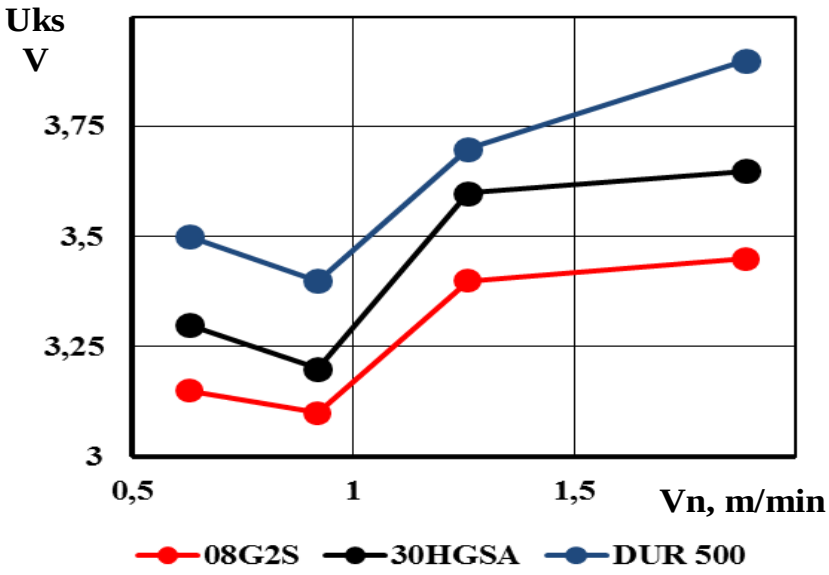

Fig. 2 Influence of weld-overlay speed (Vn) on the short – circuit voltage (Uks) in vibroarc weld-overlay in Ar with different electrode wires

The study of the vibroarc weld overlay process involves writing down and reporting the working voltage and electric current. The measurement and recording of the electric current in the supply chain of the vibroarc apparatus also involves the use of suitable shunts. The dynamics of changes in these parameters was recorded with an analog-to-digital converter produced by NATIONAL INSTUMENTS, model NI USB 6210. The process oscillograms were recorded in real time with the "Lab View" software. For each change in the amplitude of vibration and material of the electrode wire, we conducted 3 recordings and determined the average values of the output parameters. Recorded data were processed using Microsoft Office Excel. Obtained data concerning the electric parameters from the oscillography of the vibroarc process are processed with standard statistical methods.

According to [2], the voltage and magnitude of the electric current are of significant importance for the nature of the metal transfer process and the formation of the weld – overlay layer. Increasing the voltage leads to increasing the arc interval, the duration of the electric arc combustion cycle. It also affects the burning of part of the carbon and the alloying elements. Increases in the current affect mainly the geometrical parameters during the formation of the separate joints, the heat – affected zone and the degree of spreading of the electrode metal.

RESULTS AND DISCUSSION

The graphics, presenting the influence of weld – overlay speed on the electrical parameters of the vibroarc process, are created on after the statistical processing of data from the oscillograms of the process (Fig.2…Fig.6).

Fig. 2 shows the changes in the short-circuit voltage. Basically, the change of Uks is extreme. When the speed of weld – overlay is increased to 0,94 m/min the voltage is decreased for the three electrode wires. The most significant decrease is for the 30HGSA electrode wire. The smallest reduction of short –circuit voltage is recorded for the electrode wire 08G2S for 3,1 V, while the biggest reduction is for electrode wire DUR 500 for 3,4 V. When the values of the weld – overlay speed are higher, Uks increases and reaches values from of 3,45 V to 3,9 V for all electrode wires. This trend is preserved for all weld – overlay speed values and for a speed of 0,94 m/min the difference is the smallest, i.e. 0,3 V. Lower values of short – circuit voltage are a prerequisite for a less strong heat effect on the base metal. This in turn results in smaller welding penetration depth, smaller heat – affected zone and smaller deformations of components that are to be restored [1].

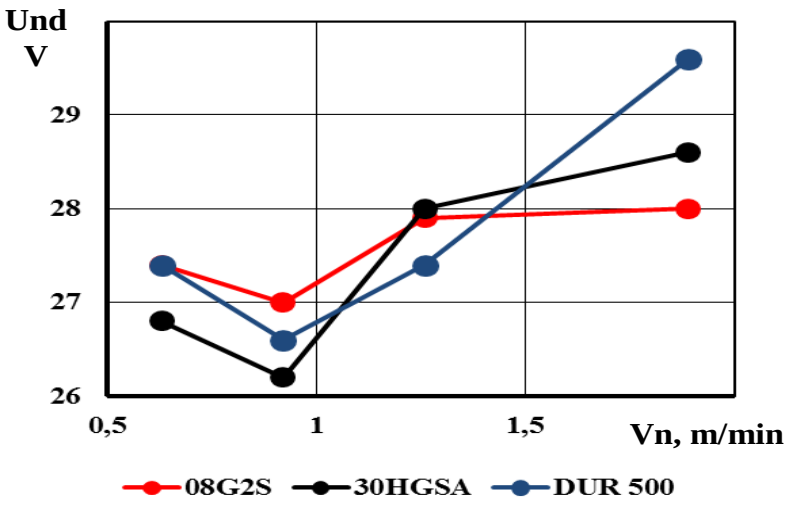

Fig. 3 Effect of weld overlay speed (Vn) on voltage at the start of arc combustion (Und) in

vibroarc weld overlay in Ar with different electrode wires

One of the most important parameters of vibroarc weld overlaying is the voltage at the beginning and end of the electric arc. The changes in voltage at the beginning of arc combustionare shown on Fig. 3. The graph reveals that the nature of voltage change (Und), as a function of weld – overlay speed, has a marked minimum at a speed of 0,94 m/min. After processing recorded data it was found out that voltage change at the start of arc combustions varies within a range of 26,8 to 29,6 V for the three electrode wires. At a weld – overlay speed of 0,94 m/min, the voltage values at the beginning of arc combustion for the three electrode wires are within very narrow boundaries of 26,2 V for the 30HGSA wire to 27 V for the 08G2S wire. The voltage values at the beginning of arc combustions at a weld – overlay speed of 1,88 m/min are much higher than the same voltage values at a speed of 0,63 m/min. This difference is the most pronounced for electrode wire 500, i.e. of 2,4 V. The increase of voltage of arc combustion leads to deterioration of the conditions for forming the weld – overlay layer and decreases the coefficients of welding and alloying. This is due to several factors: decrease in the degree of pre-heating of the electrode wire tip; higher degree of heat loss in the environment; increased length of the electric arc and higher degree of burning of the carbon and alloying elements. The reduction of voltage of arc combustion decreases the share with which the base metal participates in the weld – overlay layer. In addition, this decreases the cross section of the weld - overlay layer and allows for obtaining thin and evenly spread restorative coatings.

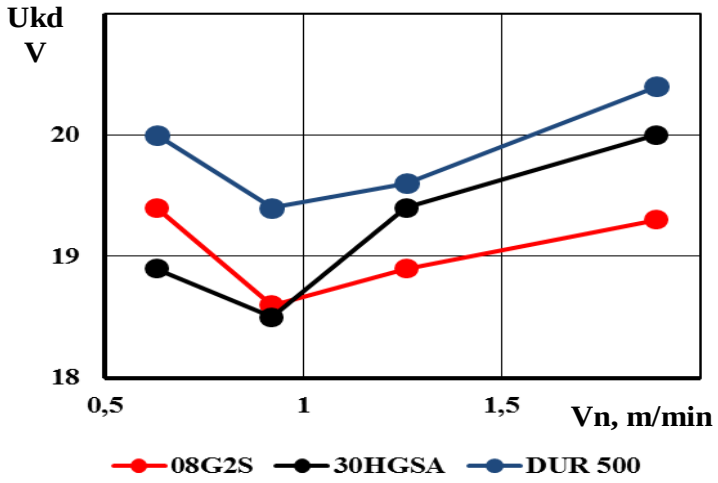

Fig. 4 Effect of weld overlay speed (Vn) on voltage at the end of arc combustion (Ukd) in vibroarc weld overlay in Ar with different electrode wires

The weld – overlay speed affects seriously the voltage at the end of arc combustion (Ukd). The change of this voltage as function of weld overlay speed has extreme nature. Its minimal values for each of the three electrode wires are obtained at a speed of 0,94 m/min (Fig. 4). The lowest voltage values of 18,5 V at the end of arc combustion are recorded for two of the electrode wires, i.e. Np 30HGSA and Sv 08G2S. The voltage values at the end of arc combustion at a weld overlay speed of 0,63 m/min and 1,88 m/min for the different wires is 1,5 V.

Table 1 Differences in voltage at the beginning and end of arc combustion

Electrode wires	Values of weld overlay speed Vn, m/min			
	0,63	0,94	1,26	1,88
08G2S	7,6	7,2	7,8	8,7
30HGSA	7,9	7,7	8,6	8,6
DUR 500	8,4	8	9	9,2

According to [3], the difference in voltage values at the beginning and end of arc combustion affects significantly the quality of the weld - overlaid coatings. The bigger the difference between voltage at the beginning and end of arc combustions, the higher the speed of cooling the metal. This also increases the risk of hot cracks. This is caused by the fast increase of inner tensions during crystallization of liquid phase. In addition, the process undergoes the so called temperature interval of embrittlement which encompasses the interval at the beginning of dendrites hardening until it reaches solid state. During this interval, metal is in a semi- liquid, semi – solid state and its ductility sharply decreases compared to its ductility in solid state. Under these conditions, the plastic deformation of metals is expressed through mutual displacement of crystals and their deformation. Since metal crystallization is accompanied by continuously changing inner tensions whose intensity increases with the lowering of temperature, crystals cannot withstand plastic deformation and they separate because of appearing cracks. Based on the conducted studies and the results presented in Table 1, we can conclude that this difference is the smallest at a weld – overlay speed of 0,94 m/min for the three electrode wires in the interval 7,2 … 8 V. The difference in voltage at the beginning and end of arc combustion in vibroarc weld overlay in argon is the smallest for electrode wire 08G2S. These values show that voltage values in the weld overlaid layer and the possibility of cracks in restoring components from tractors and other agricultural machinery by vibroarc weld overlaying in argon will be the lowest if we use the electrode wire 08G2S.

The short – circuit current and the current at the end of arc combustion depend significantly on the weld overlay speed (see Fig. 5 and Fig. 6). One of the main parameters of the electric arc process is the magnitude of short – circuit current. The value of this magnitude and particularly the speed of its increase have a serious impact on a number some aspects of the weld overlay process such as the heat – affected zone; the transfer of molten metal, its shaping and losses from spreading the electrode metal from the moment when the drop is detached from the tip of the electrode wire until it is transferred onto the metal surface the weld overlaid detail.

The changes of the short – circuit current is shown on Fig. 5. When the speed of weld overlay increases, the magnitude of short – circuit current (Iks) decreases considerably from 231…256 A to 205…224 A for the different electrode wires. It reaches a minimum at a weld overlay speed of 0, 94 m/min. If we continue to increase the speed until it reaches 1,88 m/min, the magnitude of short – circuit current increases significantly and its value is within the interval of 267…288 A. In weld overlaying with the medium carbon Np 30 HGSA electrode wire, the magnitude of the short – circuit current remains lower throughout the entire range of weld – overlay – speed change compared to weld overlaying with the low Sv08G2S and the high carbon alloyed DUR – 500 wires. The highest values (starting, minimal and end) of the short – circuit current are recorded in weld overlaying with the low carbon alloyed electrode wire Sv 08G2S.

The change of current at the end of the arc combustion Ikd has a marked extreme nature. The graph shows that the increase of weld – overlay speed affects seriously the

change of Ikd (Fig. 6). The lowest values for all three electrode wires are obtained at a weld – overlay speed of 0,94 m/min for the range of 117 - 132 A. The lowest current value at the end of the arc combustion is recorded for the DUR 500 electrode wire, i.e. 117 A. The current values at the end of the arc combustion for the three electrode wires fluctuate within narrow boundaries for the different weld – overlay speeds. The Ikd values for a speed of 0,94 m/min are considerably lower compared to the Ikd values for a maximum weld – overlay speed of 1,88 m/min. This difference is the most pronounced for electrode wire DUR 500, i.e. of almost 11 A.

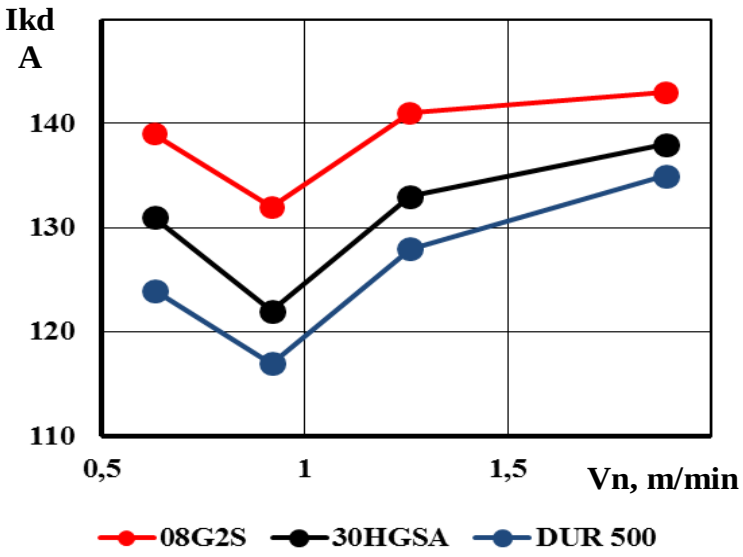

Fig. 5 Effect of weld overlay speed (Vn) on currency at the end of arc combustion (Ikd) in vibroarc weld overlay in Ar with different electrode wires

The difference in the short – circuit current values at the end of arc combustion, as well, for the particular values of weld - overlay – speed changes, affect the degree of heating of the base metal, the possibility for deformations in the weld-overlaid component and the uneven formation of weld-overlaid layer. The analysis of results shows that at a weld overlay speed of 0,94 m/min for the 08G2S electrode wire the difference in the values of Iks and Ikd is the smallest, i.e. 2 A. This is a prerequisite for a lower degree of heating of components and spreading of the electrode material. On the contrary, at a weld overlay speed of 1,88 m/min this difference is almost 7 times bigger, i.e. 15 A. This can lead to an increased spreading and burning of the electrode material as well as bad formation of the weld - overlaid metal, high roughness and danger of deformation of restored components.

CONCLUSIONS

− The speed of weld overlay affects significantly the vibroarc process and its electrical parameters (voltage and current magnitude) when the weld overlay is done in argon.

− The lowest voltage of short – circuit and arc combustion as well as short – circuit current at the end of arc combustion are achieved at weld – overlay speed of 0,94 m/min.

− Vibroarc weld overlay with electrode wire 08G2S in argon provides lower heat effect on the base metal; smaller deformations; lower voltage in the weld-overlaid layer. These parameters also decrease the possibility of cracks in the restored components of the tractors and other agricultural machinery.

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