A Research about Influence of Overlaying Speed Upon Electrical Parameters of The Process During Vibrating Arc Overlaying of Worn Parts of Transportational and Agricultural Machinery in A Shield of Argon

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***Abstract**: The influence of overlaying speed upon overlaying process and its electrical parameters is done. The voltage of short-circuit, voltage at the beginning and end of arc burning, amperage of short-circuit and amperage at the end of arc burning are accepted as main criteria of evaluation. The research is done through apparatus for vibrating arc overlaying and different wire electrodes (Sv 08G2S, Np 30 HGSA, DUR 500) with diameter at 1.6 mm in a shield of argon. It is established that overlaying speed has a significant influence upon overlaying process as minimal rates of both – voltage and amperage are obtained at rate of 0,94 m/min.*

***Ke words**: Vibrating arc overlaying, argon shield,* speed welding*, electrical parameters.*

INTRODUCTION

Argon is an inert gas who protects both – electric arc and molten metal in the welding pool against action of oxygen and nitrogen in the ambient atmosphere and thus, its ensure higher quality of overlaid coatings and reconditioned details at all, since the process of forming of oxides, nitrides and pores which leading to higher brittleness of the coating is close to zero. Thus, thanks to vibration arc overlaying process, the reconditioning of various details with different shape, size, configuration and metal of origin could be successfully done as well as it is possible to be treated not only outer, but inner surfaces [3, 4].

The overlaying speed is one of the main parameters of the regime which influences directly to the rest technological and kinematical parameters of the process. To ensure a higher productivity it is necessary to obtain as maximal as possible overlaying speed which allows forming of qualitative overlaid coating. Obtaining of higher overlaying speed is one of the main advantages of overlaying process in a gas shield, since it produces lower melting depth, lower thickness of the coating and limited possibility of pores in the deposited metal [1, 3].

The increasing of the voltage leads to increasing of duty-cycle timing, burning of alloying components and possibility of defects in the coating. At other side an increasing of short-circuit amperage leads to increasing of heat-affected zone and higher spattering of the metal transferred through the arc. The alteration of those parameters in relation with overlaying speed is not examined sufficiently and it requires more experiments within this direction [1, 2].

MATERIALS AND METHODS

The aim of the research is to establish a level of influence of overlaying speed upon electrical parameters of the process of vibrating arc overlaying in a shield of argon.

As objects of research are accepted reconditioning details of automotive and agricultural machinery, but as subject of research is the process of overlaying itself in order to obtain overlaid coatings in a shield of Ar.

Expose: The following parameters are chosen in a role of variables:

- speed of overlaying (Vn)
- base material of wire electrode (Mt)
- As main criteria of quality evaluation of the process of overlaying in a shield of Ar are considered the following according Fig.1:

- voltage parameters (U) and its components: voltage of short-circuit (Uks), voltage at the beginning of arc burning (Und) and voltage at the end of arc burning (Ukd);
- amperage parameters (I) and its components: amperage rate at short-circuit mode (Iks) and amperage rate at the end of arc burning (Ikd).

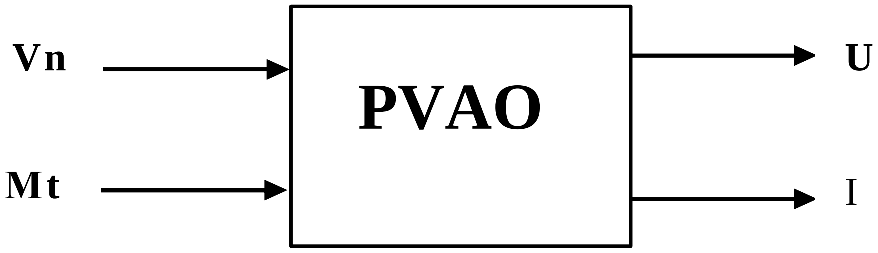

Fig.1 Cybernetic model of vibrating arc overlaying process (PVAO) in a shield of Ar: Vn – speed of overlaying; Mt – base material of wire electrode; U – voltage parameters; I – amperage parameters

The overlaying of the objects of research is done by axial non-inertial apparatus ENTON-60 equipped with conical vibrator. The objects of research are made of steel 45 as they have a cylindrical shape and dimensions – diameter at rate of 50 mm and length at rate of 250 mm. The dimensions of the workpieces are determined according research done by previous work teams [5, 6]. On the surface of each workpiece are deposited five layers with width of 40 mm. The base material of each type wire electrode is as follow, but the diameter of each one is the same – 1,6 mm (08G2S, Np 30HGSA и DUR 500). The working regime during overlaying includes the following parameters: voltage at rate of 20 V, amperage at rates within 150…180 A; wire electrode vibrations amplitude at rate of 2 mm; wire feeding speed at rate of 2,3 m/min; step of overlaying at rate of 3 mm/tr; outlet of wire electrode at rate of 15 mm; wire electrode vibrating frequency at rate of 46,7 Hz and shielding gas flow at rate of 15 l/min. The speed of overlaying was changed through experiments within rates of 0,63; 0,94; 1,26 and 1,88 m/min.

RESULTS AND DISCUSSION

The research of the process of overlaying was accompanied through indicating and registering of the rates of both – voltage and amperage by additionally connected resistance in the power supply. The dynamics of alteration of these parameters was registered by electronic device NI USB 6210 by National Instruments. The graphs of the process are obtained in real time through Lab View software as each change of the overlaying speed and base material of wire electrode is accompanied by three separate data sheets. The registered data is calculated statistically through Microsoft Office Excel based on well known statistical methods and the results are presented on the graphs (fig.2 to fig 6).

According [2], the voltage and amperage cause a significant influence upon process of droplet’s transfer through the arc column and forming of overlaid coating. The increase of the voltage leads to increase of short-circuit timing, prolongation of arc burning period and particular burning of carbon and alloying elements. An increase of amperage leads to change in the geometrical shape of the deposited layers, heat-affected zone and spattering of the wire electrode.

The alteration of short-circuit voltage Uks is shown on fig.2 as the overall trend is to have an extreme character. When overlaying speed increases up to 0,94 m/min, the rate of Uks is minimal as it is noticed for all three types of wire electrodes as most significant it is for 30 HGSA wire electrode. The lowest rate of short-circuit voltage at rate of 3,1 V is obtained with 08G2C wire electrode, but highest rate of 3,4V – with DUR 500 wire electrode. Further increasing of overlaying speed leads to increase of Uks reaching rates of 3,45 V to 3,9 V as this trend is noticed for all three wire electrodes. Lower rates of short-circuit voltage is preposition to lesser heating of the surface, lower melting depth and heat-affected zone as well as lower possibility of deformations upon overlaid surfaces [1].

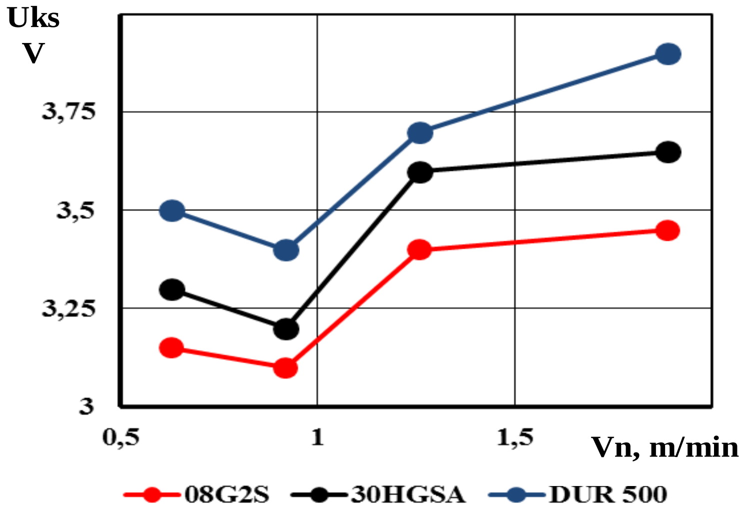

Fig.2 Influence of overlaying speed (Vn) upon amperage of short-circuit (Uks) during vibrating arc overlaying in a shield of Ar

One of the most important modes of the process of vibrating arc overlaying is arc burning period as it is characterized by its components – voltage at the beginning and at the end of arc burning. The alteration of voltage at the beginning of arc burning Und is presented on fig.3 as it has a minimal rate where overlaying speed is rated at 0,94 m/min. After calculation of the data sheet results is established that the voltage at the beginning of arc burning is changing within rates from 26,8 to 29,6 V for all types wire electrodes as within 0,94 m/min they ranges within very short diapason – 26,2 V with 30HGSA wire electrode to 27 V with 08G2C wire electrode.

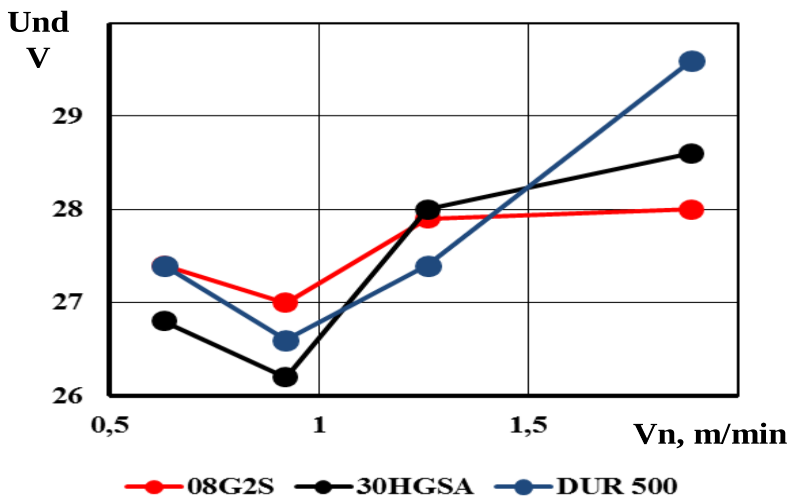

Fig.3. Influence of overlaying speed (Vn) upon voltage at the beginning of arc burning (Und) during vibrating arc overlaying with different used wire electrodes in a shield of Ar

The voltage rates at the beginning of arc burning within overlaying speed of 1,88 m/min is much higher than rates within 0,63 m/min as this difference is much significant when DUR 500 wire electrode is used and it reaches a rate of 2,4 V. The increase of arc burning voltage rate leads to deterioration of the conditions of coat forming and reducing of both – coefficients of overlaying and mixing caused by lower heating of wire electrode tip, higher level of warmth distraction, increased arc length and intensive spattering of alloying elements. The reducing of arc burning voltage rate leads to decreasing of the percent of base material in the coat and lower cross section of the weld which allows forming of even overlaid coatings with lower thickness. The overlaying speed is causing a significant influence upon voltage rate at the end of arc burning (Ukd). The alteration of this parameter as a function of overlaying speed has an extreme loop as minimal rates are obtained within 0,94 m/min as it trends to all types of wire electrodes (fig.4). The lowest rates at 18,5 V of arc burning voltage are obtained with Np 30HGSA and Sv 08G2C wire electrodes.

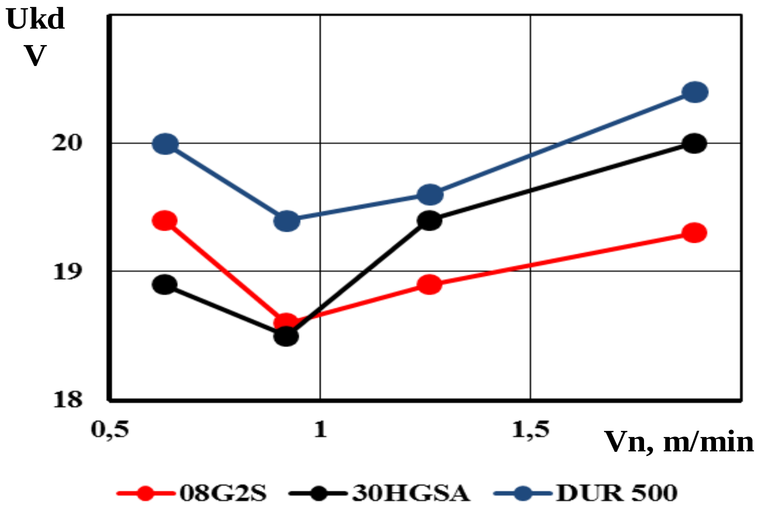

Fig.4. Influence of overlaying speed (Vn) upon voltage at the end of arc burning (Ukd) during vibrating arc overlaying with different used wire electrodes in a shield of Ar

According [3], the difference between voltage rates at the beginning and end of arc burning could be related to overlaying coatings quality evaluation. As much as higher is the difference of voltage rates so higher is the molten metal cooling speed which leads to increasing of possibility of hot cracking. The main reasons affecting process of hot cracking are fast-growing inner stresses during solidification where the metal passes through so-called zone of fragility where the amount of liquid metal is not sufficient to fill the spaces between solidifying molten metal which are opened by shrinkage stresses. Since the metal is in semi-solid condition its ductility is much lower than the one in absolutely solid mode as its plastic deformation is based on mutual displacement of metal dendrites. Because of constantly changing amplitude of shrinkage stresses which become more intensive when the temperature is decreasing, some of the crystals do not stand against process of plastic deformation and trend to separate each other due crack formation. The results is showing that the lowest rates from 7,2 to 8 V are obtained within 0,94 m/min for all three wire electrodes as the lowest rate of the difference between voltage rates at the beginning and end of arc burning is obtained with 08G2C wire electrode. These rates is showing that shrinkage stresses and possibility of hot cracking will be the lowest ones during vibrating arc overlaying process in a shield of argon with 08G2C wire electrode.

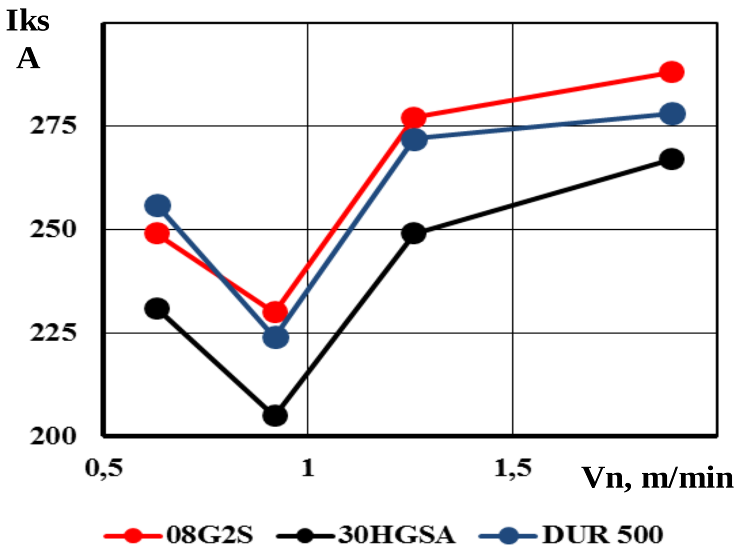

Fig.5. Influence of overlaying speed (Vn) upon short-circuit amperage (Iks) during vibrating arc overlaying with different used wire electrodes in a shield of Ar

The values of both – short-circuit amperage and amperage at the end of arc burning depends of overlaying speed significantly as is shown on fig.5 and fig.6. The rate of short-circuit amperage and its step of increasing causes a major influence upon size of heat-affected zone, transfer of the molten metal through arc column as well as its formation on the electrode tip and spatter loss.

Table 1 Difference between amperage rates at the beginning and end of arc burning

Type of wire electrode	Overlaying speed rates 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

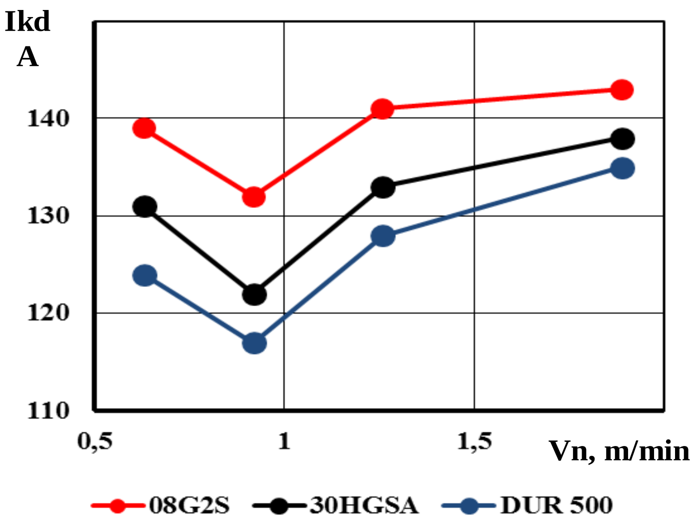

Fig.6. Influence of overlaying speed (Vn) upon amperage at the end of arc burning (Ikd) during vibrating arc overlaying with different used wire electrodes in a shield of Ar

The alteration of Iks is shown on fig.5 as it trends to decrease significantly from 231-256 A to 205-224 A within increasing of overlaying speed and reaches its minimum at 0,94 m/min. Further increasing of overlaying speed at 1,88 m/min leads to very excessive increase of short-circuit amperage up to 267-288 A. When a medium-carbonized wire electrode Np 30 HGSA is used the rate of Iks remains lower during whole diapason of changing of overlaying speed compared to the rates obtained by using both other types of wire electrode – low-carbonized Sv 08G2S and high-carbonized DUR-500.

The alteration of amperage at the end of arc burning is shown at fig.6 as it is visible that lowest rates of Ikd from 117 to 132 A for all types of used wire electrodes are obtained within overlaying speed at rate of 0,94 m/min. The lowest rate at 117 A is obtained with high-carbonized wire electrode DUR 500, but generally all rates could define into very short diapason of ranges. The rates of Ikd within overlaying speed of 0,94 m/min are lower than rates obtained within 1,88 m/min as such trend is most defined when high-carbonized wire electrode DUR 500 is used as the difference between both rates is almost 11 A. The difference between rates of short-circuit amperage and amperage at the end of arc burning within appropriate rate of overlaying speed cause a significant influence in regards to heating of the base material, possibility of deformations in overlaid details and uneven formation of the coating. The analysis of the obtained results is showing that the difference between Iks and Ikd is most lowest within overlaying speed at rate of 0,94 m/min reaching a rate of 2 A only which is a precondition for lowest rates of heating of base material and spatter loss. Contrariwise, when overlaying speed is changing up to 1,88 m/min the difference between both rates increases 7,5 times reaching a rate of 15 A which is a precondition for higher spattering and burning of wire metal, worse conditions for coat forming, higher level of roughness and increased possibility of deformation of overlaid details from agricultural and automotive machinery.

CONCLUSION

The overlaying speed is causing a significant influence upon stability of vibrating arc overlaying process and its electrical parameters (voltage and amperage) in a shield of argon.

The lowest rates of short-circuit amperage and voltage as well as voltage and amperage of arc burning are obtained within overlaying speed of 0,94 m/min.

The usage of low-carbonized wire electrode 08G2S during vibrating arc overlaying process in a shield of argon is a precondition for less heating of base material, lower possibility of deformations, lower shrinkage stresses in the coating and possibility of cracking during reconditioning of details from agricultural and automotive machinery.

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