A RESEARCH ABOUT INFLUENCE OF WIRE ELECTRODE VIBRATION'S AMPLITUDE UPON TECHNOLOGICAL PARAMETERS OF VIBRATING GAS METAL ARC OVERLAYING PROCESS IN A SHIELD OF ARGON

Assoc. Prof. Mitko Nikolov, PhD, University of Ruse, Bulgaria, E-mail: mnikolov@uni-ruse.bg

***Abstract**: A research about influence of wire electrode vibration's amplitude upon process of arc-cycle conduction and forming of overlaid coating is done in a shield of argon. Duty cycle frequency, times of short circuit and arc burning as well as roughness of the coating are used as quality criteria. It is established that wire electrode vibration's amplitude cause a significant influence as maximal value of arc cycles and lowest roughness of the coating are obtained at rate of 2 mm.*

***KEYWORDS**: VIBRATING GAS METAL ARC OVERLAYING PROCESS, ARGON, VIBRATIONS AMPLITUDE*

1. Introduction

Vibrating gas metal arc overlaying process ensure high qualitative overlaid coatings especially when it is related to reconditioning of excessively worn steel parts from agricultural machinery. The vibrations stabilizing the process of arc burning and allowing relatively low rates of working voltage (18…20V) which cause a significant reduction of carbon and alloying elements burning and small welding depth and head-affected zone. At other side they have a favorable influence regarding overlaid coatings forming process.

Although vibration's amplitude is one of the main parameters of the working regime there is not enough input data about its influence upon technological parameters of the process of vibrating gas metal arc overlaying in shield of argon.

The aim of the current work is to establish what is the level of influence of vibration's amplitude upon technological parameters of process of coating forming in shield of Ar.

As object of research are chosen reconditioned details of agricultural machinery. The subject of research is the process of vibrating gas arc metal overlaying process in a shield of argon.

2. Exposition

The technological parameters of the process of overlaying have a significant influence regarding transfer of molten metal from welding pool to the workpiece through the arc and forming of coating with very high quality. As main criteria for process evaluation are chosen the following:

- duty cycles frequency rate (νc);
- roughness of overlaid coatings (Rz).

As supporting criteria are accepted the following:

- duration of short-circuit (tks);
- duration of arc burning (td).

The vibration's amplitude is a main parameter of the working regime as it causing a significant influence upon parameters of the process and coatings; frequency and duration of arc cycles and their components; process of coatings forming and the roughness of the mentioned. The material of the wire also has an influence upon parameters of the process and overlaid coatings.

As variables for the cybernetic model of the process are chosen the following:

- wire electrode vibration's frequency (λ);
- material of the wire electrode (Mt).

The process of overlaying is conducted on welding apparatus "ENTON-60" equipped with axial non-inertial vibrating nozzle. As workpieces during experiments are chosen cylindrical details made of steel grade 45 with diameter of 50 mm and length of 250 mm. The dimension are determined through statistical research about the variety of details within agricultural machinery [5]. On each of the chosen workpieces are deposited five areas prolonged to 40 mm with different type of wire electrodes (Sv 08G2S, Np 30HGSA и DUR 500) with diameter of 1,6 mm. The working regime includes the following parameters: working voltage at rate of 20V; welding current at rates of 150-180A; coatings deposition speed at rate of 0,94 m/min; wire feeding speed at rate of 2,3 m/min; pace of overlaying at rate of 3mm/tr; wire electrode's egress at rate of 15 mm; vibration's frequency at rate of 46,7 Hz; shielding gas flow rate at 15 l/min; angle of arc burning tip - 45^0; angle of wire electrode handling in vertical plane - 30^0, angle of wire electrode handling in horizontal plane - 15^0. The amplitude is changed within limits between 0 to 2,5 mm during experiments through rate of 0,5 mm, i.e. 0; 0,5; 1; 1,5; 2; и 2,5 mm.

The examination of the vibrating gas metal arc overlaying process is accompanied by recording and reporting of process parameters. For measuring and recording the input currents in the supply chain of the apparatus it includes an appropriate shunts connected to the contour. The dynamics of alteration of the process parameters is registered by analog-digital converter NATIONAL INSTUMENTS model NI USB 6210. The waveforms of the process are recorded in real time by "Lab View" software platform. For each change of the amplitude a three records are made and the recorded data is statistically defined through Microsoft Office Excel by using well known statistical methods.

The roughness of the overlaid coating surface (i.e. height of irregularities of the surface profile) is measured with help of special indicating device with accuracy of 0,01 mm. For each overlaid area are made 30 measures divided into 3 groups with 10 measures each. Each group of data is obtained as each group of measures are distributed into 3 planes located at 120^o each other. The average value of the roughness is calculated afterwards through the formula (1):

$$Rz = \frac{1}{n}\left(\sum_{i=1}^{n} h_{imax} - \sum_{i=1}^{n} h_{imin}\right),10^{-2}\,mm \qquad (1)$$

A graphical relations of amplitude's influence upon technological parameters of the process are shown on figures 1-4.

The wire electrode vibration's amplitude cause a significant influence upon duty cycle's frequency (fig.1). The number of arc cycles is related to the size of the droplets molten metal transferred through the arc. As much higher is the number of duty cycles as much small the size of the droplets will be. Increasing of duty cycle number will increase the number of short circuits which leads to better forming of the overlaid coating and low rate of the roughness.

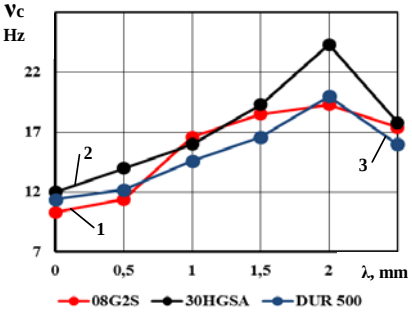

Fig.1. Graphical alteration of duty cycle's frequency (ν_c) *caused by amplitude's alteration for three different types of wire electrode during vibrating gas metal arc overlaying process in a shield of argon: 1 – 08G2S; 2 – 30HGSA; 3 - DUR500.*

The duty cycle's frequency obtained during experiments is located within 11 to 25 Hz which results on large-sized droplets transferred through the arc. The maximal rate of 25 Hz is obtained through amplitude's rate of 2 mm with trend of decreasing after-

wards. When a maximal rate of duty cycle's frequency is obtained it results on improving of arc burning process through decreasing the size of the droplets molten metal; evenly formed overlaid beams; obtaining of low grain sized structure and higher hardness of the coating. Higher frequency is obtained through overlaying with medium and high alloy wire electrodes Np 30HGSA and DUR-500 compared to low-carbon wire electrode Sv 08G2S .

At vibration's amplitude rate of 2 mm is obtained a minimal roughness of the overlaid coating because of better forming of the last due smaller size of the droplets molten metal (fig.2). The lowest roughness appears when medium-alloyed wire electrode Np 30HGSA is used which responding to maximal rate of the duty cycles. Evenly formed coating is a prerequisite for smaller reserve of metal before mechanical treatment of the coating and low cost price of the reconditioned details from agricultural machinery.

As indices for evaluation of the processes of arc burning and

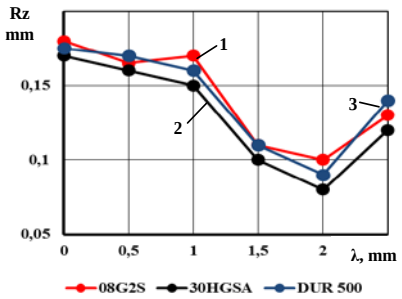

Fig.2 *Graphical alteration of surface roughness (Rz) caused by amplitude's alteration (λ) for three different types of wire electrode during vibrating gas metal arc overlaying process in a shield of argon: 1 – 08G2S; 2 – 30HGSA; 3 - DUR500*

metal transfer are used duration of short circuit and duration of arc burning which influencing significantly upon the size of droplets molten metal [3,5].

The increasing of wire electrode's vibration's amplitude leads to decreasing of short circuit duration for all three wire electrodes as lowest rate is obtained at rate of 2 mm followed by further increasing (fig.3). Shortest duration at rate of 3,27 ms is obtained with medium alloy wire electrode Np 30HGSA. Highest rates of short-circuit duration are obtained with wire electrode DUR 500 as the rates corresponding to the appropriate rates of vibration's amplitude.

The duration of short circuit influencing upon overlaying process stability and level of scattering of alloying elements during arc burning. Consequently, as much shorter is the mentioned period as much stable is the arc and metal spattering is less. When shorter period of short-circuit is obtained it results on low-sized droplet metal transfer which affect to better forming of the coating and lower roughness [1, 2, 4].

The duration of arc burning period has a significant influence regarding droplet formation and quality of the molten metal [1,4]. It characterizing the growing of the droplet from the moment when

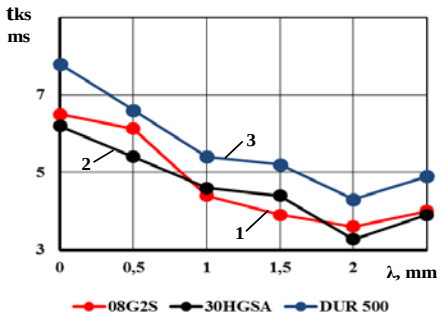

Fig.3 *Influence of vibration's amplitude (λ) upon duration of short-circuit (tks)for three different types of wire electrode during vibrating gas metal arc overlaying process in a shield of Ar: 1 – 08G2S; 2 – 30HGSA; 3 - DUR500.*

the tip of wire electrode touching the surface until the moment of detachment of the droplet itself. At this point, as much shorter is the period of arc burning for each duty cycle as much smaller is the size of the droplets. Thus, there are a prerequisites for reducing of alloying elements spattering, improving of the conditions for appropriate mixing between basc and additional metal and forming of low-grain overlaid coatings.

The alteration of arc burning duration caused by alteration of vibration's amplitude has an extreme character (fig.4) as the shortest duration is obtained again at rate of 2 mm for the three wire electrodes and the rate of 38 ms is obtained with Np 30HGSA wire

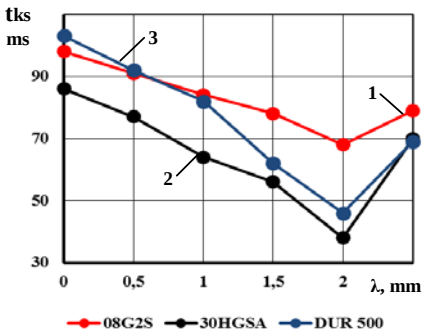

Fig.4 *Influence of vibration's amplitude (λ) upon duration of arc burning period (td) during vibrating gas metal arc overlaying process in a shield of Ar with three different types of wire electrode: 1 – 08G2S; 2 – 30HGSA; 3 - DUR500.*

electrode. Highest rates of arc burning duration are obtained with low-carbon wire electrode Sv 08G2S. The trend of increasing of vibration's amplitude after rate of 2 mm leads to increasing of relative duration of arc burning and short-circuit periods which affecting to worse forming and low quality of the overlaid coating obtained in a shield of argon.

3. Conclusion

From the essence of the research about determination the level of influence of vibration's amplitude upon technological process parameters and quality of the overlaid coating could be found the following inferences:

1. Vibration's amplitude causing a significant influence upon essence of overlaying process and its technological parameters (duty cycles frequency; roughness of the coating; duration of short-circuit and arc burning periods) in a shield of argon.
2. Lowest roughness of the coating and maximal rate of duty cycles frequency within shortest duration of short-circuit and arc burning periods are obtained through vibration's amplitude at rate of 2 mm.
3. With medium alloy wire electrode Np 30HGSA, higher duty cycles frequency, lower roughness and arc burning voltage are obtained during experiments.

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