A RESEARCH ABOUT WEAR-RESISTANCE OF APPLIED LAYERS OBTAINED BY GAS METAL ARC OVERLAYING PROCESS WITH INCREASED WIRE ELECTRODE VIBRATING FREQUENCY

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Abstract

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The aim of the research is related to the influence of the vibration's frequency increasing upon wear-resistance of the applied layers. Wear-resistance is one of the most important properties of the materials that is considered as criteria about durability and reliability of the details of agricultural equipment and machinery.

Keywords: friction, wear-resistance, overlaying, gas metal overlaying process

INTRODUCTION

Wear-resistance of the applied layers appears to be one of the most important properties for increasing of the durability of the agricultural, lifting and transporting equipment. The general factors influencing wear-resistance are related to few of qualitative indexes of the applied layers related to microstructure, chemical composition and surfacing hardness of the material (Garkunov, 2002). A wire electrode's vibrating frequency increasing is one of solutions about improvement the character of the process of forming an applied layers and its quality because of contraction of both – short-circuit and arc-burning duration as well as small-sized droplet metal transfer and fine-grained microstructure.

EXPOSE

The aim of the research is an establishing of wear index alteration for applied layers obtained by gas metal arc overlaying process during reconditioning of agricultural, lifting and transporting equipment.

As object for experimental research are accepted an used details from agricultural, lifting and transporting equipment which could be treated by vibrating gas metal arc overlaying process. The subject of the research is the processes of sliding friction during surfaces interaction and established wear of the applied layers.

The interaction of the fractioning pairs is an important part in the technological scheme of
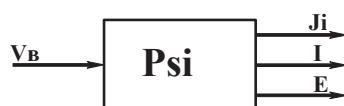
1: *A cybernetic model of the subject of research about interaction and wear of applied layers within conditions of sliding friction: V_B – wire electrode vibrating frequency, Ji – wear index parameter of the fractioning surfaces, I – wear intensity, E – wear resistance*

remanufacturing and it influences mostly upon durability of the agricultural, lifting and transporting equipment. Besides, this process is a complex requiring a higher values of operational time and labor cost. Normally, the duration of the process of interaction varying between 2 and 6 hours as there is a challenge about decreasing the duration and keeping a minimal wear index of the fractioning surfaces at the same time.

The wire electrode vibrating frequency has been chosen as input parameter of the cybernetic model for the process of interaction of both friction surfaces as is shown at Fig. 1.

The main output parameter accepted as main criteria is wear index J of both frictional surfaces – a summarized wear index Jdv, wear index of the roller – Jr and wear index of the sector Js. The wear intensity and wear-resistance (E – absolute wear-resistance and ε – relative wear-resistance) has been accepted as additional optional criteria.

A comparative experiments of frictional pairs are taken within "roller-sector" scheme, as the rollers of each pair were treated through vibrating arc overlaying process with wire electrode vibrating frequency of 47.6 Hz and 150 Hz. The results of the experiment were compared to the results of wear intensity of standard roller made of Steel 45 without deposited layers.

The treated rollers of Steel 45 has a deposited layers with both – DUR 500 and 30HGSA wire electrodes with diameters of 1.6 mm within vibrating frequency of 150 Hz quenched by conducted current at high frequency. The overlaying process is done through ENTON 60 overlaying apparatus and modified overlaying apparatus. The working regime parameters were accepted as follow – voltage of 20 V; welding current of 180 A, welding speed of 1.26 m/min; wire electrode feeding rate of 2.3 m/min; welding pace rate of 3 mm; wire electrode outlet rate of 15 mm; shielding gas rate of 15 l/min; wire electrode vibrating frequency rate of 46.7 Hz (Nikolov and Tonchev, 1995) and 150 Hz (Todorov and Nikolov, 2012).

The standard and overlayed rollers were mechanically and thermally treated. They were quenched and retorted to hardness of $55^{\pm 2}$ HRC (HV_5 = 6100 ± 400 HV) and grinded to final rate. The rollers are with diameter of $50^{+0.02}$ mm; misalignment and unperpendicularity not more than 0.01 mm; width of $12^{+0.05}$ mm; thickness of the applied layer of 0.5 mm measured on the radius; roughness Ra = 0.28–0.32 μm for overlayed with DUR 500 roller and Ra = 0.55–0.58 μm for overlayed with 30 HGSA roller. The weight of the rollers is varying between 160 and 170 g (Tonchev and Stanev, 1979).

The sectors are made of steel with applied anti-frictional layer of leaden bronze BO-30 hardened at rate of HV_5 = $490^{\pm 50}$ HV and thickness of 0.1–0.5 mm measured along the radius. The length of the frictional area of the sector is 20 mm with a width of $10^{+0.05}$ mm. The surface area of contact is 2 cm² and

the weight of the sectors is varying between 15 and 20 g. The outer surface of the sectors is grinded to diameter of $70^{+0.1}$ mm as well as the inner surface – to diameter of $50^{+0.06}$ mm. The roughness of the sectors is measured at rate of Ra = 2.0–2.8 μm. The radial distance between the roller and sector is at rate of 0.04–0.05 mm.

As a standard is accepted the process of interaction of pair of roller and sector made of steel 45 and leaden bronze BO-30 according their wide application as materials within the area of agricultural, lifting and transporting machinery equipment. The processes of wear and interaction of both – standard and overlayed frictional pairs are led within cooling area of SEA 30 oil.

The loading upon the frictional pairs is led with rate of 1 MPa/min; squeezing force of the sectors to the rollers at rate of 100 daN; pressure at rate of 5 MPa and tribological characteristic PV = 425 MPa.m/min. These rates are determined according working conditions presented at (Kangalov, 2012).

The wear index of the roller Jp and sector Jc is determined by measuring of the weight through analytical scales „WA-33" with accuracy to 0.05 mg. All frictional pairs are treated with technical petrol, dried and measured at the beginning and end of each experiment. The change in the pairs weight allows a determination of the character of the wear index alteration during the processes of interaction and established wear. It is determined according the following formula:

$$J_i = m_{iH} - m_{iK}, \text{mg} \qquad\qquad [1]$$

wherein
J_i .... wear index, mg,
m_{iH} ... weight of i-numbered roller or sector at the beginning of the experiment, mg,
m_{iK} ... weight of i-numbered roller or sector at the end of the experiment, mg.

The process of interaction of frictional surfaces is one of the most complex and labor cost processes within manufacturing and remanufacturing. When this process is applying to agricultural, lifting and transporting machinery equipment it takes about 2 to 6 hrs to evaluate the character of process of interaction of frictional surfaces. At this point, the aim of the engineers and researchers is to reduce the duration of the process of interaction as well to ensure its appropriate level of quality and minimal wear intensity during the processes of interaction and established wear. The beginning, development and intensity of the process of interaction of frictional surfaces depend of the mechanical properties of the materials as well as cooling area and loading regime parameters.

The dynamics of alteration of wear index of both – standard and overlayed frictional pairs is presented graphically on Fig. 2 to Fig. 4.

A wear index and duration of the process of interaction is determinate of the character of interaction and wear of the sector itself because
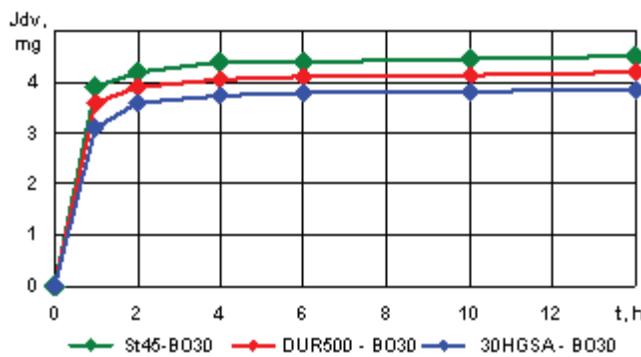
2: *Alteration of the summarized wear index of both – standard and overlayed frictional pairs of rollers and sectors during process of interaction under sliding friction conditions*
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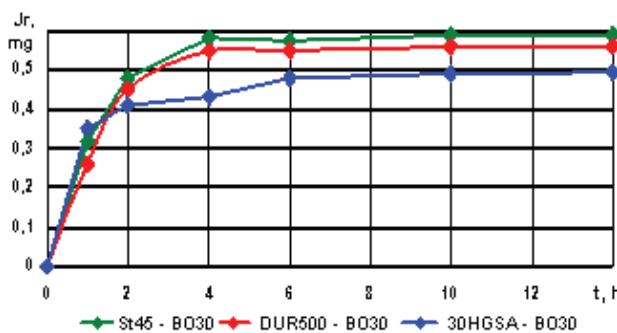
3: *Alteration of the wear index of the roller from all frictional pairs – standard and overlayed during process of interaction under sliding friction conditions*
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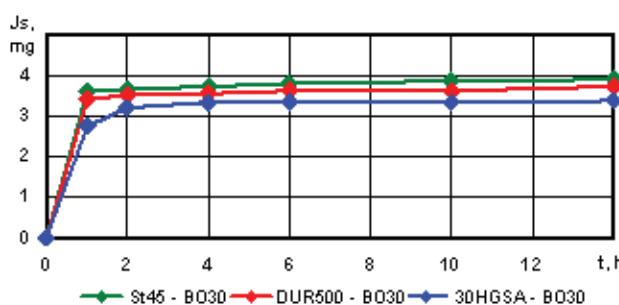
4: *Alteration of the wear index of the sector from all frictional pairs – standard and overlayed during process of interaction under sliding friction conditions*
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of its 10 times less hardness of its frictional surface than hardness of the roller. Fig. 2 showing a summarized wear index of standard and overlayed frictional pairs. Obviously, the process of interaction is more intensive during first 2 hrs while it keeps much lower intensity till the end of the 14-th hour of the experiment proving a process of established wear. The summarized wear index of the pair overlayed through wire electrode vibrating frequency at rate of 150 Hz is about 1.2 to 1.4 times less than the roller overlayed at 47.6 Hz and standard roller made of Steel 45 without deposited layers. The reason about such effect could be explained because of the positive influence of the wire electrode frequency alteration into improving the character of forming of the deposited layers (Todorov and Nikolov, 2012; Tonchev, Nikolov, Stojanov and Kangalov, 1996).

The quantity of the metal removed during the process of established wear increasing slowly

and relatively equal for all frictional pairs which is a sign about prediction of the beginning of the process of repairing of the equipment based on minimizing of the possibility of rough wear intensity and maximal saving of the dimensions of frictional surfaces.

The summarized wear index itself is not the only criteria about the character of process of interaction and it evaluates the process at point of common wear of the pair itself, but it does not give an evaluation about the wear of each – roller and sector. The results showing that all 3 of the rollers from each pair has similar character of wearing during the experiments. The process of interaction takes 4 hrs for both – standard and overlayed through wire electrode vibrating frequency at rate of 47.6 Hz rollers, while it needs about 6 hrs to complete the process for the roller overlayed at 150 Hz as is shown at Fig. 3. In conclusion, the process of interaction of roller overlayed at rate of 150 Hz is prolonged, but the quantity of removed metal is about 10% less because of gradually cutting of the edges of the rough surface and forming of areas to undertake the loading. The character of alteration of wear index of the sectors is identical to the one of the rollers shown at Fig. 3. The interaction of the sectors of standard and overlayed at rate of 47.6 Hz pairs is completed at the end of 1st hour of the experiment while it takes 2 hrs to complete the interaction of the sector from pair overlayed at rate of 150 Hz. A minimal summarized wear index is obtained to the pair overlayed at rate of 150 Hz.

Beside wear index rate, the wear intensity is important criteria for evaluation of the process of interaction and established wear. Being a tribological characteristic it gives an opportunity to compare the process of interaction and wear of frictional pairs of rollers and sectors made of different metal under equal friction conditions and gives an information about metal loss depending of the number of turnovers transformed into prolonged circumference index. It can be determined through formula:

$$I = \frac{Ji}{S}, mg/m \qquad [2]$$

wherein
S .... circumference index obtained on the base of number of turnovers of the roller during the experiments. $S = 71215.2 \, m$.

The evaluation of the properties of applied layers through gas metal overlaying process through increased wire electrode vibrating frequency is done as a complex method is used. The complex method is related to the properties of the reliability of the agricultural, lifting and transporting machinery equipment and one of the most important properties is durability of the equipment. The durability of the equipment is determined by the remainder of the resource. The wear-resistance of the frictional surfaces is important parameter to evaluate their durability because of the fact that most of the equipment loosing its working efficiency because of wear. The wear-resistance of the frictional surfaces depends of several factors as hardness, roughness, ductility, fragility, microstructure, etc. The wear-resistance appears to be a reciprocal value of the wear intensity and it is determinate through following formula:

$$E = \frac{1}{I}, m/mg \qquad [3]$$

The relative wear-resistance of applied layers is determinate through formula 4:

$$\varepsilon = \frac{E_H}{E_e}, \qquad [4]$$

wherein
E_H ..... wear-resistance of frictional surface of the roller overlayed at rate of 150 Hz,
E_e ...... wear-resistance of frictional surface of standard roller without applied layers.

The results of relative wear-resistance experiments are shown at Tab. I, as the results about wear-resistance of standard roller are done by previous researchers.

From the results presented at Tab. I is visible that highest relative wear-resistance at rate of 1.47 is obtained to overlayed roller at rate of 150 Hz done by researchers in [4]. It is confirmed by the alteration of the wear index for the rollers and pairs itself shown at Fig. 2 and Fig. 4. Consequently, the resource of equipment overlayed under the same conditions could be increased at rate of 50% compared to the resource of equipment that does not have a deposited layers and at rate of 20% compared to the resource of equipment overlayed at rate of 47.6 Hz.

I: *Wear intensity and relative wear-resistance of the rollers from all frictional pairs*

No.	Frictional pairs	Wear index Ji, g	Wear intensity I, mg/m	Wear-resistance E, m/mg	Relative wear-resistance ε
1	St.45-BO30	0.72×10^{-3}	1.01×10^{-8}	98910000	1
2	DUR 500-BO30	0.56×10^{-3}	7.86×10^{-9}	127169642.86	1.29
3	30HGSA-BO30	0.49×10^{-3}	6.88×10^{-9}	145337142.86	1.47

Sourse: own

CONCLUSION

1. The character of the process of interaction and wear index of rollers with applied layers obtained through arc metal overlaying process with increased wire electrode vibrating frequency at rates of 47.6 Hz and 150 Hz is similar to the ones of standard rollers. The summarized wear index of the roller overlayed at rate of 150 Hz is about 1.2 to 1.4 times less than the one of roller overlayed at rate of 47.6 Hz.

2. The process of interaction of rollers overlayed at rate of 150 Hz is prolonged, but its summarized wear index is about 10% less.

3. Applied layers at rate of 150 Hz are characterized by higher relative wear-resistance. From the results presented at Tab. I is established that the resource of equipment overlayed under the same conditions could be increased at rate of 50% compared to the resource of equipment that does not have a deposited layers.

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