ELECTROMECHANICAL FAILURE OF ELECTRODES IN SPECTRAL SOURCES OF LIGHT

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Abstract

The electromechanical failure of electrodes in the spectral spark sources of the light is prsented. The rise of volumetric electrical spark erosion rate of refractory metals, rustles steels, boron-containing and tungsten-containing alloys and brittle structural constituents at the decreasing of their mechanical properties is established. At the ionic bombardment the electromechanical character of spark erosion of materials can be explained with the thermal shock.

Key words: spectral sources, electromechanical character of spark erosion, thermal shock.

1. Introduction

Usually, the electrical thermal nature of failure of electrodes at the thermal influence of plane sources of the heat sources of the light is considered. Moreover, the electrical mechanical character of failure of materials plays a significant part in the electrical erosion of electrodes. The study of laws of the electrical mechanical erosion presents of the interest as in the case of electrical spark alloying as in a practice of spectral analysis of alloys, distinguishing with the brittle failure. The present investigation is made with the aim to represent peculiarities of the electromechanical failure of electrodes in spectral sources of the light. They promote to the extension of the possibilities of the atomic emission spectroscopy (AES) method.

2. Experimental

Boron-containing [1] and tungsten-containing [2] alloys and rustles steels were employed as objects of the present investigation. The mechanical properties were evaluated with the relative wear resistance ε in relative units (r.u.), the compression strength σ and the bending strength σ in MPa, the impact strength KCY in MJ| m^2 and the microbrittleness of phases γ in r.u. They were measured [1] by standard procedures. The E was the related thermal stability, measured with developed procedure [3]. The atomic emission spectra record and the measurement of intensity (I) of the spectral lines were obtained by AES method. The volumetric electrical spark erosion rate v was determined by technology [3]. The high -voltage condensed spark (HCS) from the IVS-23 generator was a source of electrical erosion of the alloys interface [3] and the excitation of AES spectra. The pulse duration of HCS was approximately 7.56 Mks. The dispersion and correlation analyses were led by schemes, stated in the mathematical statistics. The comparison of dispersions was made by means of the F- distribution. If $\frac{s_1^2}{s_2^2} \geq F_{0.95}$ {f_1, f_2}, then the divergence between selective dispersions s_1^2 and s_2^2 was significant at the selective level of the significance 0.95. The $F_{0.95}$ was the quintile of the F – distribution. In contrary case the tested dispersions can be considered as belonging to the single general sample. The selective correlation coefficient was used as the indicator of the power connection between the parameters. It is known that if $r > r_{0.95}$ ($r_{0.95}$ is the quintile of r-distribution), then the correlation between observed values takes place. In the contrary case the correlation is absent.

3. Results and discussion

Fig. 1 shows the dependence of the volumetric electrical spark erosion rate υ on the yield stress (the curve1) and the breaking stress (the curve 2) of refractory metals. In addition, values of the volumetric electrical spark erosion rate and mechanical properties are adopted from the literature. In particularly, υ represents data, obtained by I. A. Grikit [4] in the high -voltage condensed spark (HCS) source of the light in the inert atmosphere. The yield stress (Fig.1, the curve 1) and the breaking stress (Fig.1, the curve 2) are the reference book [5] values. Fig. 2 demonstrates the dependence of volumetric electrical spark erosion rate v of tungsten-containing alloys (the curve 1), rustles steels (the curve 2) and boron-containing alloys (the curve 3,4) on their mechanical properties, such as the relative wear resistance, the impact strength, the compression strength, and the bending strength, respectively.

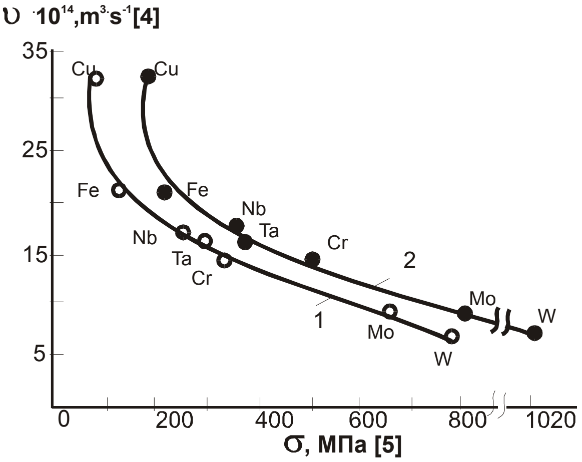

Fig.1.The dependence of the volumetric electrical spark erosion rate υ on the yield stress (the curve 1) and breaking stress (the curve 2) of metals

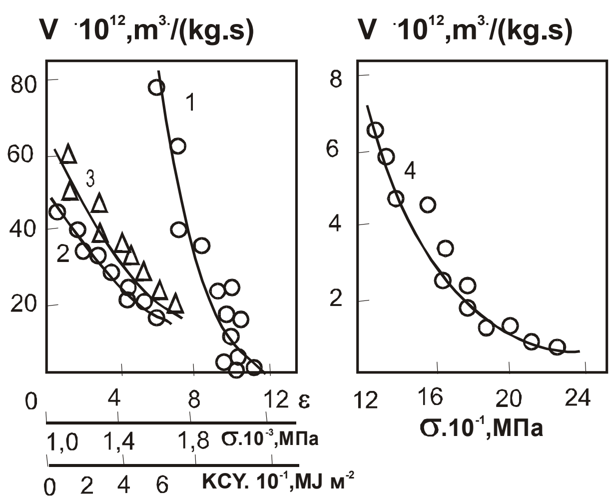

Fig.2. The dependence of the volumetric electrical spark erosion rate v on mechanical properties of tungsten-containing alloys (the curve 1), rustles steels (the curve 2), and boron-containing alloys (the curve3,4)

The carried out correlation analysis testifies about the correlation between observed values. Selective correlation coefficients fluctuate between 0.991 and 0.993 at the $r_{0.95}$, equaled to 0.441. Hence, it follows the rise of the volumetric electrical spark erosion rate of refractory metals, rustles steels and boron-containing and tungsten-containing alloys as much as 3 times at the decreasing of their mechanical properties. It testifies the presence of the mechanical failure. This tendency is observed (Fig.3) for brittle structural constituents (BSC), causing mechanical properties of materials, in particularly carboborides and borides of iron. Namely, it is obtained the increase of the volumetric electric erosion rate of alloyed borides of iron at least three and more times in comparison with the v of alloyed carboborides of iron. Moreover, results of the dispersion analysis show the predominance of electromechanical character of the spark erosion (Table 1). Markers in Table 1 are listed lower. The s_0^2, s_γ^2, s_E^2 are dispersions, connected with the accidental error, factors of the microbrittleness γ and the related thermal stability E, respectively. At the same time, the $F_{0.95}(\gamma)$ equals to 19.20, the $F_{0.95}(E)$ equals to 18.50. The σ_γ and σ_E are the dispersions of influence of the γ and the E factors on the I and the v values. Tabulated results have been testified about the dominant of the γ contribution in forming as the intensity of the spectral line as the volumetric electrical erosion rate (Table1) of boron-containing alloys with borides of iron. Apparently, at the influence of the thermal shock the separation of ultimate particles takes place as a result of the brittle failure of BSC, such as borides of iron, before of their melting. Then they are transported by the shock wave in the column of the discharge. Hence, the presence of brittle alloyed iron borides is promoted to the shift of relation of liquid – vapor and solid phases in the side of rise of the solid phase. It must be taken account for the control of phase's composition of working surfaces of details to the required trend.

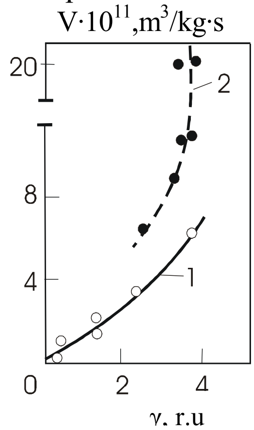

Fig.3. The dependence of the volumetric electrical spark erosion rate v on the micro-brittleness γ of carboborides (the curve1) and borides (the curve2) of iron of boron-containing alloys

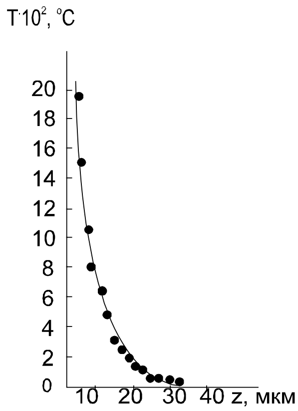

Fig.4. The spreading of the heat from plane sources of limited dimensions in the depth of the electrode (axis Z)

Table 1. Contribution of the γ and the E factors in the forming of intensity (I) of boron spectral line and volumetric electrical spark erosion rate (v) of alloys with boride eutectics.

The parameter	Dispersions						
	s_0^2	s_γ^2	s_E^2	s_γ^2 / s_0^2 / $F_{0.95}(\gamma)$	s_E^2 / s_0^2 / $F_{0.95}(E)$	σ_γ^2	σ_E^2
I, related units (r.u.)	0.100	7.41	2.39	73.38 / 19.20	23.68 / 18.50	1.83	1.10
v, m^3| (kg· s)	$0.033 \cdot 10^{-22}$	$2,52 \cdot 10^{-22}$	$1,24 \cdot 10^{-22}$	76,27 / 19.20	37,72 / 18.50	$1,24 \cdot 10^{-22}$	$0,40 \cdot 10^{-22}$

As to low-voltage spark discharge with the pulse duration, equaled to 0.5 Mks, the torch mechanism of the electrical erosion intensifies the mechanical failure of the BSC. So, the v is increased as much as 2 times in comparison with the v of borides of iron in HCS. The obtained data testify that surface layers of electrodes are subjected to mechanical influences, besides the thermal loading. Results of thermal calculation of influence of the single spark discharge on surface of iron electrode are listed on Fig. 4. The range of temperatures, exceeded the melting temperature across the time of the single spark discharge do not spread over Z axis (in the depth of the electrode) more than 4 Mkm. The influence of plane source of the heat on the surface of alloys promotes to large gradient of temperatures. It makes up $2 \cdot 10^6$ grad/cm on the depth of the single crater. Namely, it is taken place the typical accident of the thermal shock. So, at the ionic bombardment the electromechanical character of spark erosion of alloys can be explained with the thermal shock. The obtained results are agreed with data, given by B. N. Zolotykh [6] for the impulse discharge in the liquid environment. As to the spectral analysis, the preference of electromechanical failure of electrodes promotes to the appearance of the systematic error. At the same time, t-criterion of Student makes up 42.16 at the quintile of t-distribution $t_{0.95}$, equaled to 2.23. It takes place at the decoding of value of the analytical signal on the standards, unidentified to analyzed probes.

4. Conclusions

The electromechanical failure of electrodes in spectral sources of the light is presented. The rise of the volumetric electrical spark erosion rate of refractory metals, rustles steels, boron-containing and tungsten-containing alloys and brittle structural constituents at the decreasing of their mechanical properties is established. At the ionic bombardment the electromechanical character of spark erosion of materials can be explained with the thermal shock. Apparently, at the influence of the thermal shock the separation of ultimate particles takes place as a result of brittle failure of the BSC, such as borides of iron, before of their melting. Then they are transported by the shock wave in the column of the discharge.

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