PECULIARITIES OF BEHAVIOR OF MACROHETEROGENEITY PARAMETER OF ELEMENTS IN HETEROGENEOUS ALLOYS AND NEW TECHNOLOGIES IN ATOMIC EMISSION SPECTROSCOPY

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Abstract

Peculiarities of behavior of macroheterogeneity parameter of elements in heterogeneous alloys is established. They are developed through the wave character, the expressiveness of its, and the dependence of the F-parameter on the quantity of brittle structural constituents (BSC), causing the decrease of mechanical properties. It is developed new technologies in the atomic emission spectroscopy, due to found properties of the F-parameter.

Key words: ***atomic emission spectroscopy, liquated heterogeneity, F-parameter, homogenizing, prediction of mechanical properties, structure characterization of alloys.***

1. Introduction

The presence of crystalline structure defects, in particularly the liquated heterogeneity, is one of causes of reduction of precision of spectral analysis, decrease of mechanical properties, and increase of error of determination of heat treatment parameters of crystalline alloys. In order to control with this imperfection it is necessary to examine the behavior of the liquated heterogeneity. The present investigation is made with the aim to represent peculiarities of behavior of macroheterogeneity parameter of elements in heterogeneous alloys and new technologies in atomic emission spectroscopy (AES), developed on theirs base. They promote to the extension of possibilities of AES method.

2. Experimental

Tungsten-containing [1] and boron-containing [2] heterogeneous alloys were employed as objects of the present investigation. In the production process of these alloys second-order carbides of tungsten Me_6C (η–phase) [1] and alloyed carboborides of iron [2] were solidified both on the interface. They were brittle structural constituents (BSC) and their presence were highly undesired. The mechanical properties were evaluated with the relative wear resistance ε in relative units (r.u.) and the strength σ in MPa. They were measured [1,2] by standard procedures. The volumetric portion of structural constituents of alloys K was determined [2] by quantitative metallographical method. 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 liquated heterogeneity was expressed by the parameter of the macroheterogeneity F of BSC alloying elements. The F was determined [4] by comparison of dispersions of relative intensities of spectral lines of BSC s_1^2 and interface basic s_2^2 elements. 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. The F $_{0.95}$ was quintile of F – distribution at the level of the significance, equaled to 0.95.

3. Results and discussion

The behavior of the F-parameter of boron (the curve 1) and tungsten (the curve 2) distributions on the height of the bolster, deposited by Fe_2B and WC – alloys, is shown in Fig.1. At the same time, the $F_{0.95}$ changes between 3.97 and 4.17. As shown in the Fig. 1, the distribution of the F- parameter on deposited bolsters has the wave character. At the same time, the fundamental harmonic of demonstrated distribution $F_{0.95}^{exp.}$ = f (X) reaches out 110 – 180. It exceeds considerable the $F_{0.95}$ value. The comparison of experimental and table values of the F- parameter testifies about the significant chemical macrogeterogeneity of elements such as boron and tungsten on the interface of investigated alloys. The heterogeneity of elements in these alloys is developed though the big value of mean square - law deviation σ. So, the value of mean square- law deviation σ of measurements of mass part of elements in boron-containing alloys is increased to 0.46-1.31% on the dependence of the concentration level. While the regulated σ on the precision norms of AES and physical chemical analysis of the alloyed cast iron and ferroalloys fluctuates in the range of 0.018-0.063%. The established heterogeneity (Fig.1) is caused with the zone and dendritic liquation of elements. Moreover, the elimination of zone liquation is reached by homogenizing of alloys. However, the parameters of the heat treatment are measured with the great error if they are determined by Shewmon [5] solution of the diffusion problem. Therefore, it is proposed the use of manner of the predicted liquation control for the elimination of heterogeneity of chemical composition of heterogeneous alloys. It is found that the precision of determination of the heating time t at the homogenizing of alloys is increased as much as 3 times in comparison with the well-known technology [5]. The increase of accuracy of t measurements is caused by the wave character and the expressiveness of F – parameter because of nature of its:

$$F_{0.95}^{exp}(x,t) = F_q + F_{max} \times cos\ (\frac{\pi}{l} \cdot x) \times \exp(-\frac{\pi^2 Dt}{l^2}) \quad (1)$$

where $F_{0.95}^{exp}$(x,t) is the initial value of heterogeneity of the element at first parameters of x, t; F_q is the predicted value of homogeneity of the element at the selective level of significance q; F_{max} is a maximum of heterogeneity of the element; l is a half of wavelength of heterogeneity of the element in Mkm; x is a length of the sample; D is a diffusion coefficient of the element. Advantage of manner of the predicted liquation control is testified by Cohran criterion. The obtained results are agreed with the increase of homogeneity of hardness of the deposited metal, subjected to homogenizing. The data of microstructure, phase, micro X-ray spectral and optical atomic emission spectroscopy methods of analyses show that the appearance and the growth of BSC is accompanied by the increase of structural and chemical heterogeneity on the interface of alloys. Figure 2 demonstrates the dependence of F-parameter on the volumetric portion of BSC, K, of tungsten -containing (curve1) and boron-containing (curve2) alloys. The correlation relation fluctuates from 0.963 up to 0.989 at the $r_{0.95}$, equaled to 0.476. The increase of η-phase (Fig.2, curve1) and chromium carboborides (Fig.2, curve2) quantity promotes the growth of F-parameter of BSC alloying elements. At the same time, the F-parameter grows from 4 up to 100 at the $F_{0.95}$, equaled to 2.97. From here the structure characterization of alloys may be realized by the atomic emission spectroscopy measurement of F-parameter and with following utilization of the empirical model, such as F = f(K).

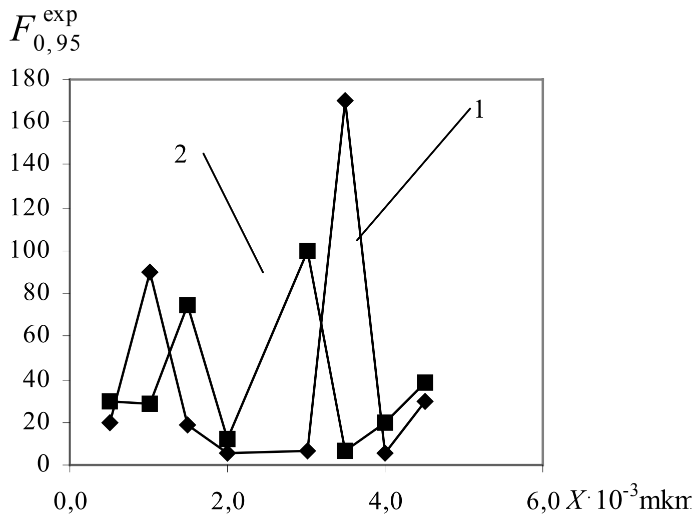

Fig.1. The distribution of chemical macroheterogeneity, $F^{exp}_{0.95}$, of boron (the curve 1) and tungsten (the curve 2) across bolsters, X, deposited by Fe_2B and WC – alloys

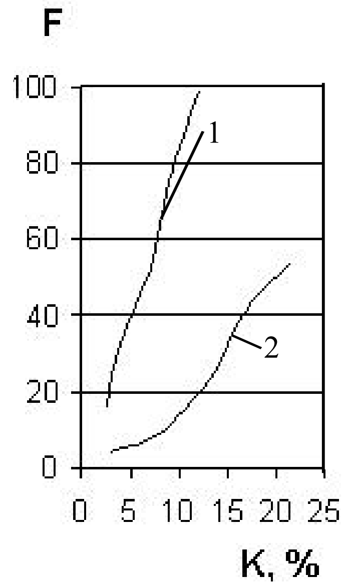

Fig.2. The dependence of the F-parameter on the K of the η -phase (curve1) and chromium carboborides (curve2) of tungsten-containing and boron-containing alloys, respectively.

Moreover, AES method is proposed for the prediction of mechanical properties of alloys, caused by presence of the BSC on the interface. Accordingly to the failure theory, the observed heterogeneity of investigated elements of alloys must change the aspect of distribution function of the failure probability at the defined value of the tension as compared with such for the Vejbull homogeneity parameter. In fact, we have established the correlation between the mechanical properties of alloys and the F -parameter for BSC elements of the interface. The correlation relation fluctuates from 0.936 up to 0.992. On the base of the obtained dependencies σ, ε = f (F) the empirical models for the prediction of mechanical properties of alloys through the F-parameter of BSC elements, such as: tungsten (1), boron (2) and chromium (3) have been established (Table 1).

Table 1. Developed models for the prediction of mechanical properties of heterogeneous alloys of systems: Fe-W-C (1); Fe-B-C (2); Fe-C-Cr-B (3).

Empirical models	S_r of regressions	S_r of the accidental observations
$\varepsilon = 0.00014\cdot F^2 - 0.045\cdot F + 11.61$, r.u. (1)	0.051	0.037
$\sigma_1 = 0.014\cdot F^2 - 6.3\cdot F + 1657$, MPa (2)	0.021	0.020
$\sigma_2 = 0.055\cdot F^2 - 6\cdot F + 272.87$, MPa (3)	0.082	0.056

The empirical models (Table 1) are the adequate to results of direct experiments. Developed models have been utilized in Paton Electric Welding Institute of Ukrainian Academy of Sciences. The reliability of the proposed inspection equals to 79 %. The productivity of the process inspection is increased as much as 2.6 times in comparison with well-known technology – micro- X-ray spectroscopy because of absence of operation of polishing of the sample. The developed new technologies promote to the extension of possibilities of AES method.

4. Conclusions

Peculiarities of behavior of macroheterogeneity parameter of elements in heterogeneous alloys is established. They are developed through the wave character, the expressiveness of its, and the dependence of the F-parameter on the quantity of brittle structural constituents (BSC), causing the decrease of mechanical properties. It is developed new technologies in the atomic emission spectroscopy, due to found properties of the F-parameter. The spectral (AES) approach is favored when it is necessary to obtain the structure characterization and the prediction of mechanical properties of materials, distinguishing with labor-consuming mechanical treatment.

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