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INTERRELATION OF THE FRACTAL CHARACTERISTICS OF THE METAL STRUCTURES AND THE TECHNOLOGY PARAMETERS

В статье рассматриваются поверхности различных металлоструктур и изменение их фрактальной размерности в зависимости от состава и параметров технологии. Построены эмпирические распределения локальных фрактальных размерностей структур.

У статті розглядаються поверхні різних металоструктур та зміна їх фрактальної розмірності в залежності від складу і параметрів технології. Побудовані емпіричні розподілення локальних фрактальних розмірностей структур.

The article discusses various surface metallostructure and changing their fractal dimension depending on the composition and technology parameters. Constructed empirical distribution of local fractal dimensions structures.

MAIN WORDS: METAL STRUCTURES, FRACTAL ANALYSIS, FRACTAL CHARACTERISTICS, FRACTAL DIMENSION, FRACTAL DISTRIBUTIONS.

Introduction. Scaling property of the fractal objects provides constancy of their basic geometrical peculiarities before the changing of the scale. To the objects, which are characterized by the fractal properties can be refer to the various metal structures [2]. In this connection it is interesting to study the methods of fractal behavior of structures rolling tape and molten alloys with the change of the composition and technology parameters.

The purpose of the given work is the analysis of the fractal characteristics of the surfaces of the metal structures according to the composition and technology parameters.

The materials and the techniques of the study. In the process of the study the photographs of the structure of the rolling tape are analyzed in the day of the receiving and after the artificial aging (figure 1); the photographs of the structure of the thin tape with the different content of the barium (figure 2); the photographs of the structures of the molten alloys with the different composition (figure 3).

In the process of the studies the fractal dimension microstructures was determined by the method BOX COUNTING [1], which can be applied to the images of the various structure. For fractal distributions the method of the sliding window was used [1].

The rolling production serves not only for receiving the necessary form of the product but for the formation at it of the determined structure and properties. One method of the receiving of the rolling tape with the determined properties and structure is the using of the aging of the materials it is the slow spontaneous irreversible change of properties of the materials. The aging occurs under the action of the thermal movement of the molecules and atoms of the light and the other radiation, of the mechanical impacts, gravitational and magnetic fields and the other factors. In the result the material moves to the more equilibrium state [2]. That's why the interest submits the study of the structure of the rolling tape directly since the day of the receiving (aging 0 hours) and after the aging 2800 hours (figure 1 a,b).

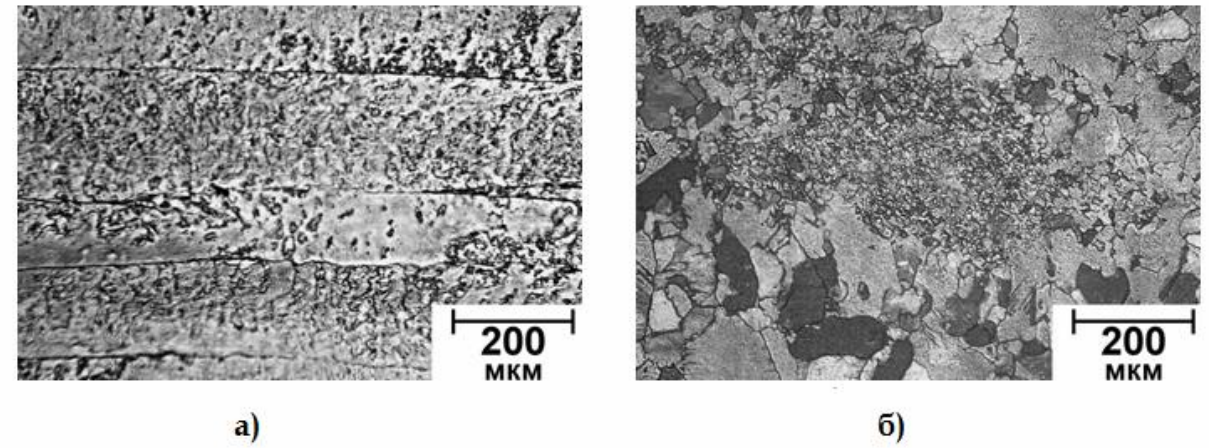


Figure 1 – Images of the structure of the rolling tape, degree of the deformation is 94%, and the scale is 200 micrometers: a) the time of the aging is 0 hours; b) the time of the aging is 2800 hours

The composition renders on the structure of the materials the significant effect. In this connection meaning has to explore the structure of the thin tape with the different content of the barium, which affects at the structure of the material significantly at the expense of the reduction of the sizes of the non-metallic inclusions and of the grinding of the primary grain of the molten metal (figure 2 a,b). The studies of the structures of the molten alloys with the different quantitative content of the potassium and the stannic conducted also in the work (figure 3 a, b).

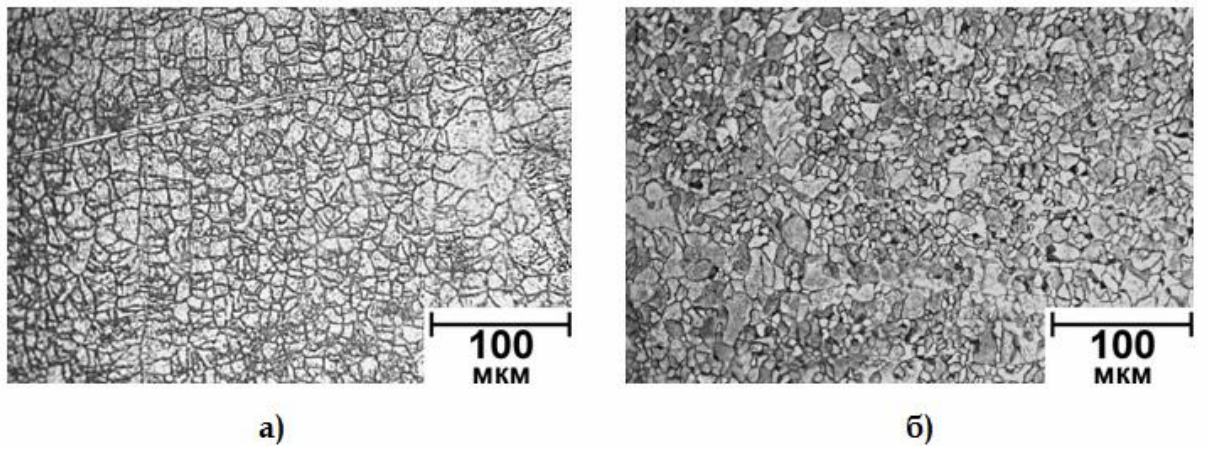


Figure 2 - Image of the structure of the thin tape out of alloy which received with the help of the cooling104 K/s, t=2800 h: a) $0.02\%Ba$; b) $0.03\%Ba$

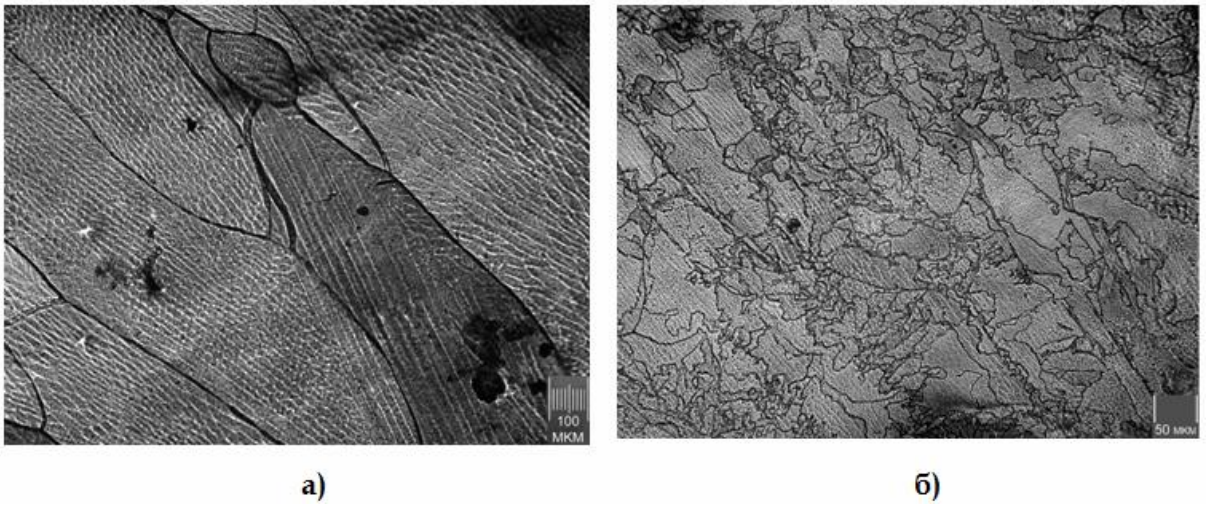


Figure 3 - Molten alloys: a) the plumbum is + 0.5% the potassium is + 1.1% Stannic; b) The plumbum + 1. 1% potassium +0.3% Stannic

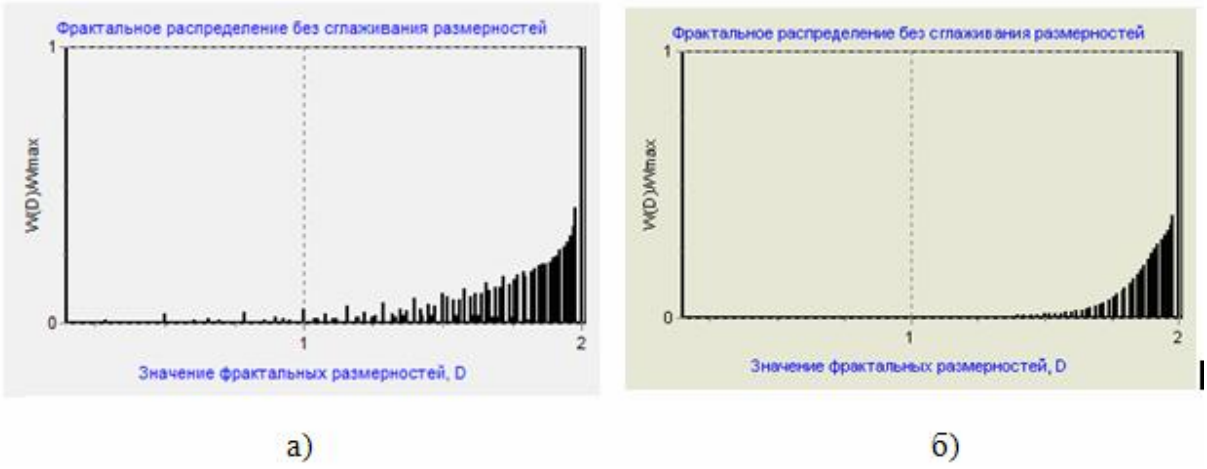
The results of the studies and their discussion.

The meanings of the fractal dimension and the fractal distributions were received in the process of the conducting of the fractal analysis of the images of the structure of the rolling tape with the different time of the aging.

The fractal dimensions differ insignificantly: the fractal dimension for the rolling tape with the time of the aging is 0 hours is 1.9759 and with the time of the aging is 2800 hours, the fractal dimension is 1.9888. According to the results we can say that the image data are characterized by the same material and are made in the same brightness range [3].

The fractal distributions of the data images have the significant qualitative differences. The image was submitted on the drawing 1a has a multimodal distribution, i.e. it has 4 modes, so it has 4 clusters (figure 4a). Wherein the fractal distribution of

the image was submitted on the drawing 1b is uniform (figure 4b). It indicates about that the quality of the material improved. It is worth noting that such characteristics as the limit of the strength, fluidity, hardness of the date alloy are in the surrounding of their maximum. The further procedure of the aging will lead to the overageing of the material and the reduction of the date characteristics. Overageing also can see on the fractal distribution the modes again appeared.



а) б)

Figure 4 - Fractal distribution of the structure of the rolling tape:
a) 0 hours of the aging; b) 2800 hours of the aging

In the process of the conducting of the fractal analysis of the structures of the thin tape out of the alloy, which received with the help of the cooling 10 4 K/s with the different content of Barium the meanings of the fractal dimension were received and the fractal distributions were received.

The fractal dimensions differ from each other insignificantly: for the structure, which contains $0.02\%Ba$, the fractal dimension is 1.9552 and the structure, which contains $0.03\%Ba$ has the fractal dimension 1.9698. Therefore we can say that the image data are characterized by the same material and formed in a luminance range.

The fractal distributions of the images of the structures, which were submitted on the figure 2, have the qualitative differences. The structure on the figure 2a has a multimodal distribution, which consists of 5 modes (figure 5a). Wherein the fractal distribution of the structure on the figure 2b is more uniform and contains only 3 modes (figure 5b). It indicates that the quality of the material improved but is not ideal. It is worth noting that such results indicate that barium substantially affects at the structure of the material by reducing the size of the non-metallic inclusions and a primary grain milling of the cast metal but hardly increasing barium content can increase the quality of the alloy to the maximum possible. Thus can indicate that

barium in the given case is not showed the quality of the effective reducing agent but it is played the role of the modifier.

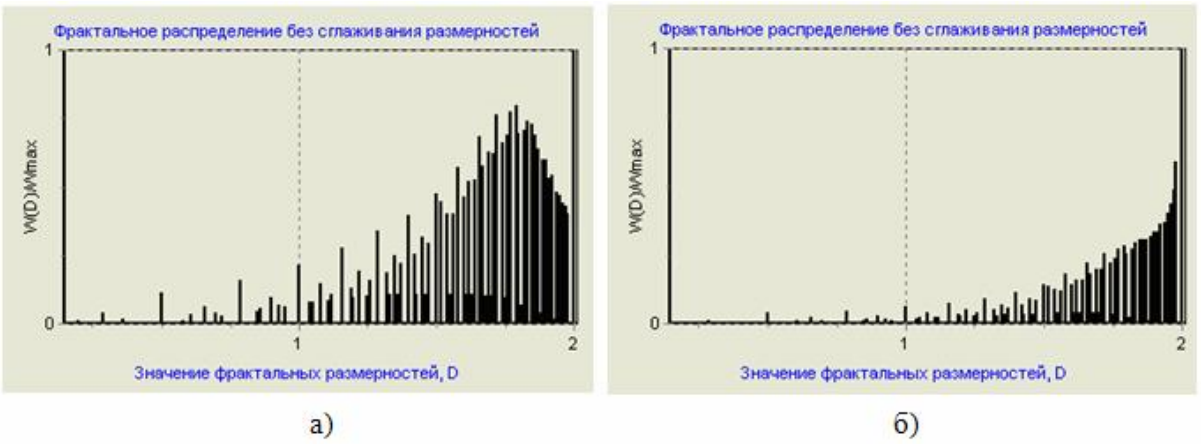
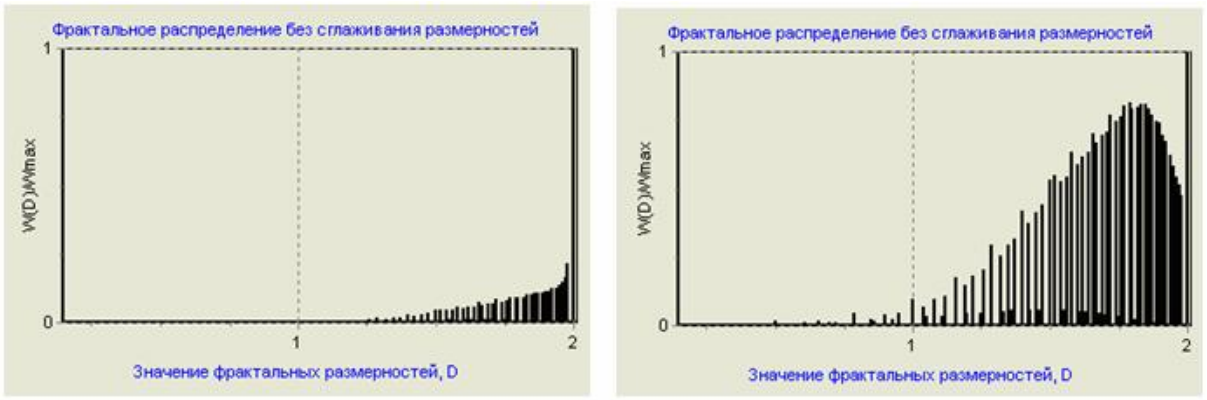


Figure 5 - Fractal distribution of the thin tape: a) $0.02\%Ba$;b) $0.03\%Ba$

The meanings of the fractal dimension and the fractal distributions were received in the process of the conducting of the fractal analysis of the structures of the molten alloys with the different quantitative composition.

The fractal dimension of the data images differs significantly: for the alloy with the composition Plumbum + 0.5 % Potassium +1.1% Stannic the meaning of the fractal dimension is 1.9604 and for the alloy with the composition Plumbum +1.1% Potassium +0.3% Stannic the fractal dimension is 1.9306 that is clearly expresses the different composition of the alloys.

The distributions for the images, which were submitted on the figure 3, show the following: for the alloy, which was submitted on the figure 3a the distribution has a more uniform character that contains not more two modes (figure 6a); for the alloy that was submitted on the figure 3b the distribution has 3 modes (figure 6b). It can witness about the different scale. Wherein at increasing of the scale yet one type of the cluster identifies the appearing third mode of the distribution indicates on it.



а) б)

Figure 6 - Fractal distribution of the structure of the molten alloy:
a) Plumbum +0.5% Potassium 1.1% Stannic; b) Plumbum +1.1% Potassium +0.3% Stannic

Conclusiones

In this work we studied the change of the fractal characteristics metal structures depending on quantitative and qualitative composition of the alloys and technology parameters.

In the work the fractal characteristics were estimated such as the fractal dimension and the fractal distribution.

It was found that the meaning of the fractal dimension allows you to track changes in the quantitative composition of the alloy and the natures of the fractal distribution are the qualitative changes in the structure.

Minor fluctuations in the meanings of the fractal dimension allow to conclude that the quantitative composition of the studied structures has not changed. If the meanings of the fractal dimension have significant differences in this case we can conclude that the number of members of the studied structure changes.

The calculation of the local fractal dimensions and construction of the fractal distributions give multimodal distributions of content in the case of the structure of the clusters of the different sizes. Uniform fractal distributions of indicate about a uniform structure. It was determined that a change in the fractal distribution of a multimodal to homogeneous the quality characteristics of the structure significantly improve.

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