DETERMINATION OF THE EFFECT OF TEMPERATURE ON THE GRAPHITIZATION PROCESS OF AMORPHOUS CARBON MATERIALS

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Abstract
In the article, changes in the degree of graphitization of amorphous carbon materials depending on temperature and time and their influence on the physical and mechanical properties of the material are studied.

Keywords: Technology, carbon, graphite, coke, oil, coefficient of friction, cryogenic, structural, electrical, molasses, electric machines, kaolin, specific electrical resistance, density, resin, voltmeter, thermocouple, anisotropy, anisotropy.

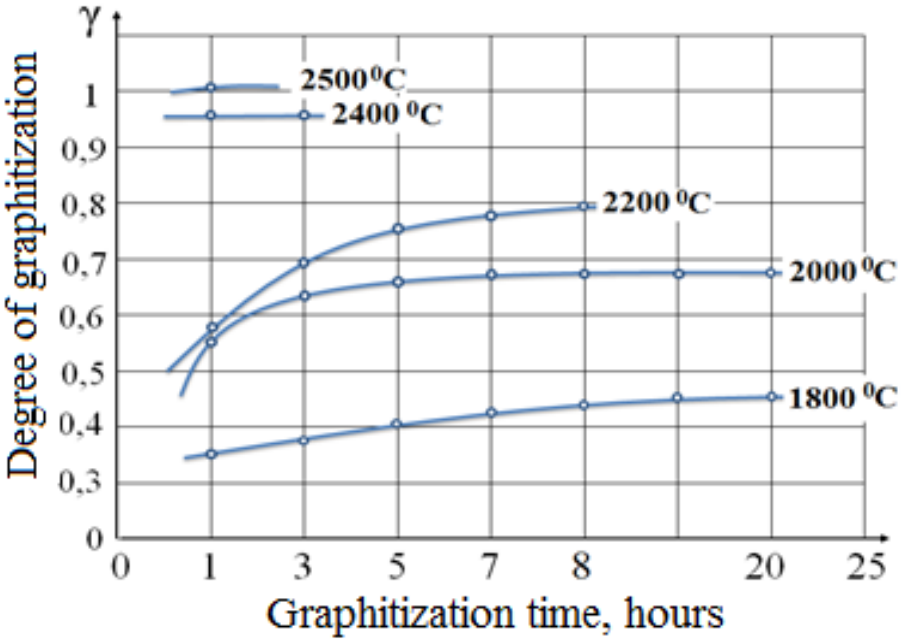
The degree of graphitization of carbon materials is evaluated by the reduction of the distance between the planes in the X-ray image, or by the ratio of acceleration of different lines, or by the size of the material crystals [1, 2].

According to the results of research conducted by scientists on the degree of graphitization of carbon materials, the degree of graphitization of amorphous carbon depends primarily on temperature [3, 4]. In this case, the degree of graphitization of amorphous carbon reaches a certain limit at a constant temperature. However, according to the data presented in a number of literature, kinetic studies of the graphitization of amorphous carbon showed that the graphitization of amorphous carbon depends on the duration of the process in addition to the temperature [5, 6].

During graphitization of amorphous carbon, the amorphous structure changes to the crystalline structure. One of the important indicators of the graphitization process is the process temperature. According to the literature analysis, graphitization of carbon with an amorphous structure by heating it at a temperature of 1600...2500 ^{o}C ensures the transition from an amorphous structure to a fully crystalline structure [7, 8].

According to the graph presented in Figure 1 below, the crystallization of amorphous carbon

materials increased depending on the temperature of the process and the time of holding at this temperature.



1 – picture. Influence of amorphous carbon on the degree of graphitization, the temperature of the graphitization process and the time of holding at this temperature.

Using this information, we carried out the graphitization process of a tube-shaped sample with the composition of coke + molasses made from local raw materials, the size: outer diameter 96 mm, inner diameter 76 mm, height 240 mm in the furnace at temperatures of 1600...2500 ^{0}C and at each value of these temperatures We did it by keeping it for 1 hour.

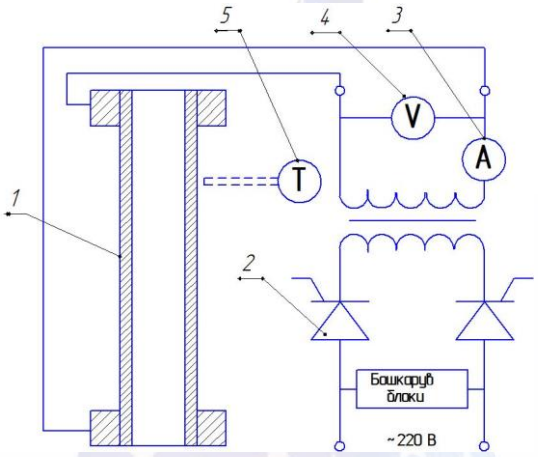
The chemical composition of the research samples and technological indicators of the graphitization process are presented in Table 1.

1 – table

Chemical composition of research samples and technological indicators of graphitization

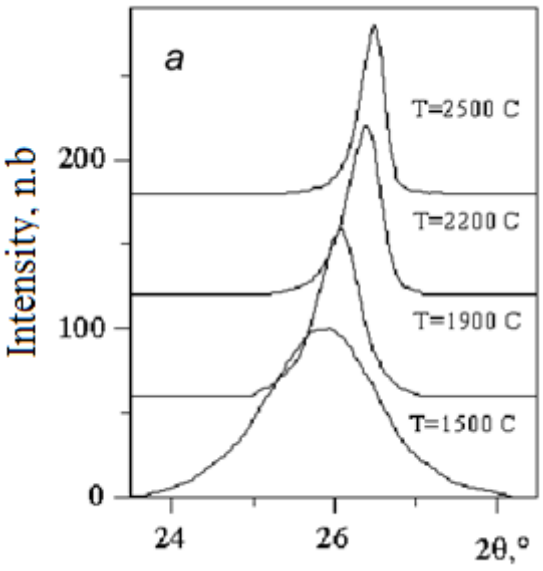
T/p	Chemical composition, %	Graphitization temperature, °C	Duration of the procedure, hour
1	Coke + molasses	1600	1
2		1800	
3		2200	
4		2500	

The electrical scheme of the oven developed for the graphitization of samples is shown in Fig. 2.



1 - sample; 2 - thyristor; 3 – ammeter; 4 – voltmeter; 5 - thermocouple.
2 – picture. Schematic view of the graphitization process.

In order to determine the degree of graphitization of amorphous carbon samples, we cut fragments from the graphitized samples and analyzed their structure-phase composition in "MiniFlex 600" X-ray diffractometer (XRD). Fig. 3 shows the maxima of the diffraction profiles of the 002 crystallographic planes of the studied carbon samples.

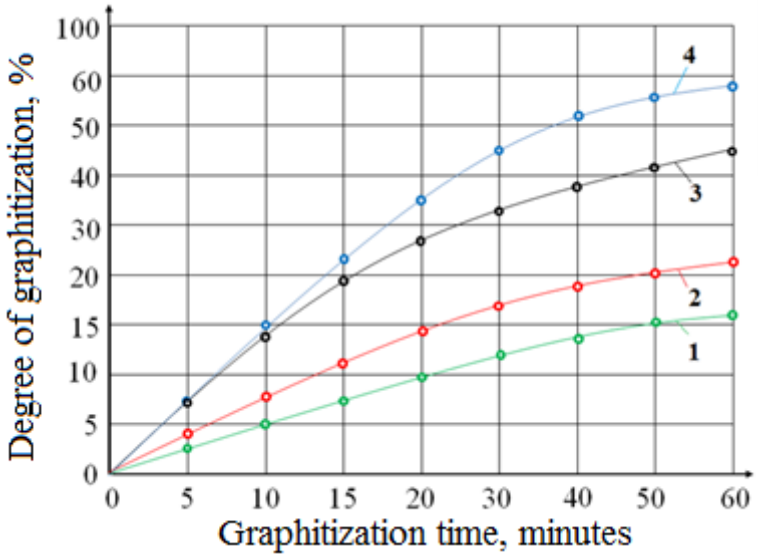


3 – picture. 002 crystallographic planes diffraction profiles maxima of carbon samples subjected to the graphitization process at different temperatures

In this case, the β-integral width of the 002 diffraction line decreased from 1.56 to 0.2° as the processing temperature increased. The change of the integral width in this order is primarily due to the change of the average size of the coherence scattering regions of X-rays towards the direction of the Ls - crystallographic "s" axis, and with the increase of the processing temperature, Ls gradually increased by 5 nm at a temperature of 1500 °S and 45 nm at a

temperature of 2500 ºS. . With an increase in the processing temperature, the size of the coherence scattering regions increased, and the center of the diffraction profiles of the 002 crystallographic planes shifted to the right (larger angles) (Fig. 4.8). This is due to the fact that the distance between d_{002} crystallographic planes decreases from 0.344 nm at a temperature of 1500 ºS to 0.33 nm at a temperature of 2500 ºS.

Data obtained by processing the results of quantitative X-ray structural-phase analysis on the samples subjected to the graphitization process at different temperatures using relative units are presented graphically in Figure 4.



1 – 1600 0S; 2 – 1800 0S; 3 –2200 0S; 4 – 2500 0C.

4 – picture. Effect of process temperature on the degree of graphitization of amorphous carbon

According to the obtained experimental results, the degree of graphitization of the amorphous carbon sample increases from 0% to 58% within 1 hour with the increase of the temperature of the graphitization process and the time of holding at this temperature. For example, the degree of graphitization of the sample at a temperature of 1600 ºS for 1 hour is 17%, at a temperature of 1800 ºS it is 22%, at a temperature of 2200 ºS it is 45% and at a temperature of 2500 ºS it is 58%. It can be seen that the higher the temperature in carbon materials, the higher their degree of graphitization. In addition, it can be seen from Figure 4 that even treatment at 2500 ºS for 1 hour is not enough to completely graphitize the carbon samples by volume.

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