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The use of technogenic dispersed waste engineering to obtain compact forms of graphite in the materials of the system Fe-C-Al

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Abstract. Currently, the significant problem of domestic engineering is to improve the quality level of products based on efficient resource-saving technologies. In the paper the main emphasis has been placed on using in such a significant procurement industry of engineering, which is foundry, dispersed iron-containing with a different degree of oxidation of the designated waste element. Moreover, this use of waste is proposed to carry out both at the stage of preparation of the melt for blanks, and in the manufacture of a mold. We are talking about blanks of materials based on the system Fe-C-Al, the quality of which is largely determined by the shape of graphite inclusions.

1 Introduction

The proposed stable and economical technology of obtaining blanks from materials based on the Fe-C-Al system with a compact form of graphite inclusions is leant on the features of the structure formation processes during crystallization and cooling of alloys of materials based on the Fe-C-Al system.

The technical literature presents materials based on Fe-C-Si and / or Fe-C-Al systems with compact forms of graphite inclusions - these are high-strength materials based on Fe-C-Si and Fe-C-Al systems with spherical and "vermicular" graphite and malleable materials based on Fe-C-Si and Fe-C-Al systems with flaky graphite. The production of materials based on Fe-C-Si and Fe-C-Al systems with compact forms of graphite inclusions has a number of significant drawbacks. The technology for producing spherical shapes of graphite inclusions in cast irons is characterized by high process instability [1, 2] and requires careful adherence to the technological process. The task is achieved by graphitizing and spheroidizing modification of specially prepared liquid melt materials based on Fe-C-Si and / or Fe-C-Al systems with a given temperature and composition while limiting the content of surface-active substances. The process of obtaining materials based on Fe-C-Si and / or Fe-C-Al systems with compact forms of graphite is unstable due to the multi-factorial effect of a sufficient number of parameters (chemical composition of materials based on Fe-C-Si and / or Fe-C systems -Al, temperature of overheating and modification, particle size of the modifier, etc.). It causes instability of the modification process and, as a consequence, instability of the structure and properties of the resulting materials based on Fe-C-Si and / or Fe-C-Al systems.

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The cost of the technological process of obtaining materials based on Fe-C-Si and / or Fe-C-Al systems with compact forms when modifying it is rather high. In case of intraform modification it is necessary to apply a modifier with a fraction of 1 ... 4 mm. The amount of modifier with a fraction of 1 ... 4 mm is not more than 40%, the rest amount must be recycled, which increases the high cost of the modifier.

The technology of annealing of cast white cast iron has a more stable technology in terms of obtaining compact forms of graphite inclusions. When implementing this technology, the requirements for the chemical composition of the material being melted based on the Fe-C-Si and / or Fe-C-Al systems are less stringent than on the production of high-strength materials based on the Fe-C-Si and / or Fe-C-Al systems. Basically, they mean to limiting the content of graphitizing elements (carbon and silicon). The long duration of annealing (30 ... 60 h) leads to an increase in the cost of the process due to substantial energy consumption, which implies the replacement of the production of ductile iron blanks with high-strength cast iron [3, 4].

2 Technological process of making compact forms of graphite in the materials of the system Fe-C-Al

The proposed technological process of making compact forms of graphite inclusions in materials based on the Fe-C-Al system differs from the above described by high stability and cost-effectiveness in the absence of strict requirements to the composition of the melted material based on the Fe-C-Al system [5...7]. The gist of the technological process is shown in Figure 1. It is based on the rapid cooling of a liquid material based on the Fe-C-Al system in a casting mold, which corresponds in composition to gray cast iron with a sufficiently high silicon content, so that white cast iron is obtained. This is achieved due to the fact that the liquid material based on the Fe-C-Al system is poured into a thermally active metallized form that is in the quenching medium in the form of a melt of a mixture of nitrate and alkali. Thus, the pouring of materials based on the Fe – C – Al system into the casting mold is combined with its quenching from the liquid state, which favorably affects the growth of the quality of the cast metal, in particular, by reducing the grain size [8].

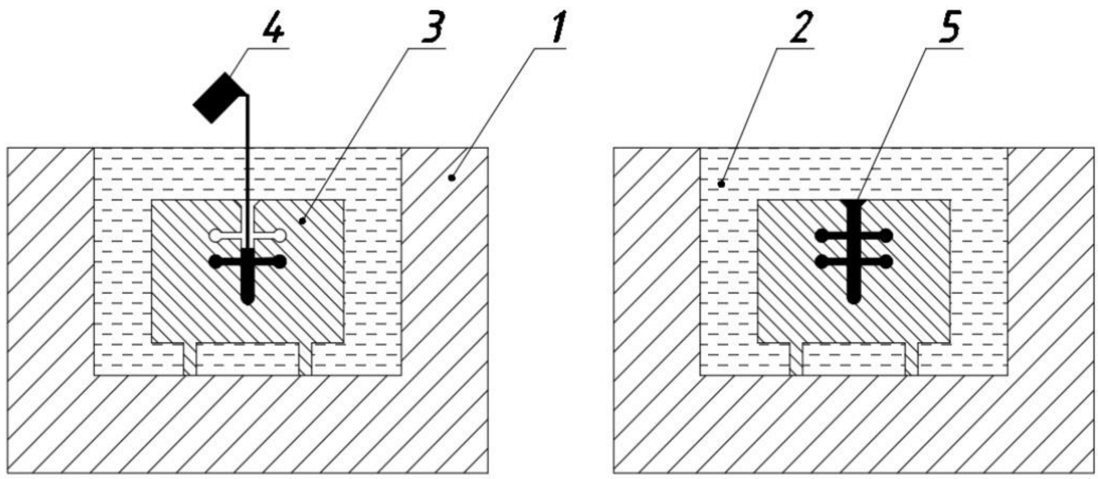


Figure 1 - Scheme of the technological process of obtaining blanks from materials based on the Fe-C-Al system with compact graphite: 1- metal pallet; 2 - melt quenching medium T = 1223-1273K; 3 - metallized form; 4 - liquid cast iron T = 1773K; 5 - casting

In the structure of materials based on the Fe-C-Al system, it is necessary to obtain white cast iron, as well as in the production of ductile iron. In the material based on the system Fe-C-Al at a concentration of> 9% Al, it becomes bleached. Sulfur in materials based on the Fe-C-Al system in the production of white iron is a desirable element. Based on the work [9, 10], guaranteed production of white cast iron is also achieved when beryllium and tellurium are introduced into the melt.

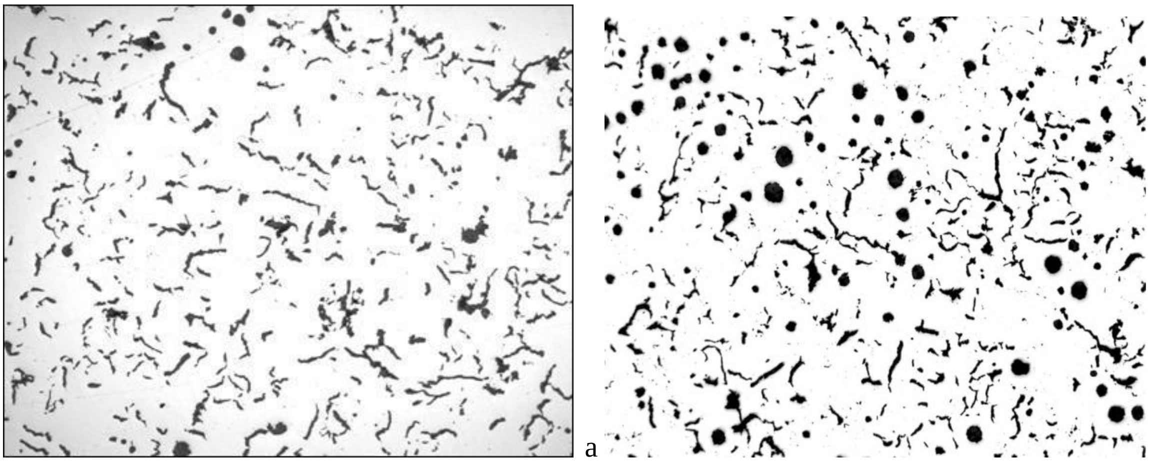
As can be seen from Figure 1, the temperature of the quenching medium in the left bath is maintained at 1223 ... 1273 K. This type of heat treatment involves the exposure of materials based on the Fe-C-Al system in the quenching medium to conduct the 1st graphitization step in it. Experiments have shown that the duration of this stage of graphitization is much lower than in the technological process of manufacturing ductile iron.

It takes two hours to complete making of the structure of austenite + graphite. The increased Al content in materials based on the Fe-C-Al system and its hardened state causes a high process rate.

It should be noted that sulfur has a positive effect in the acceleration of the 1st stage of graphitization. At this stage, compact forms of graphite in the form of small inclusions are formed. This process has no metal loss with scale.

3 Metallographic studies

Figure 2(a) and 2(b) show the microstructures of materials based on the Fe-C-Al system containing C - 3.6...4.0; Al - 2.4...3.0; Mn - 0.5...0.8; Cr - ≤0.3; Cu - ≤0.3; S - <0.02; P - <0.03 and 3.6 % C; 9.6 % Al; 0.4 % Mn; 0.017 % S; 0.019 P., respectively, obtained from iron-containing dispersed waste engineering in a specialized melting unit. This material based on the Fe-C-Al system was smelted with an overheat of the liquid phase equal to 1773 K. From the melt of the material based on the Fe-C-Al system, samples with a reduced thickness of 5 mm were obtained by pouring into a sandy and metallized form which was placed in a bath with a molten quenching medium at a temperature of 1223 K.



a b

Figure 2 - Microstructure of the material based on the Fe-C-Al system: a – in the cast state during solidification in the sand form; b - metallized in the melt of the quenching medium, respectively (a, b – x 100)

Metallographic studies of structural States of iron-carbon alloys were done on microscopes "Neofot-32" and "Apatin-2" (Germany) at magnification of 100 to 1000*. As an Etchant, a 4% solution of HNO_3 in alcohol was used. Assessment of the graphite inclusions in the materials on the basis of Fe-C-Al was carried out according to GOST 3443-87.

Figures 3...6 show the phase composition of materials based on the Fe-C-Al system containing 9.5% aluminum, 3.7% carbon depending on the silicon content, section thickness and exposure time in the metallized form: 1-1 hour; 2 - 2 hours ◊- 0.8% Si; □ - 1.3% Si; ∆- 1.8% Si.

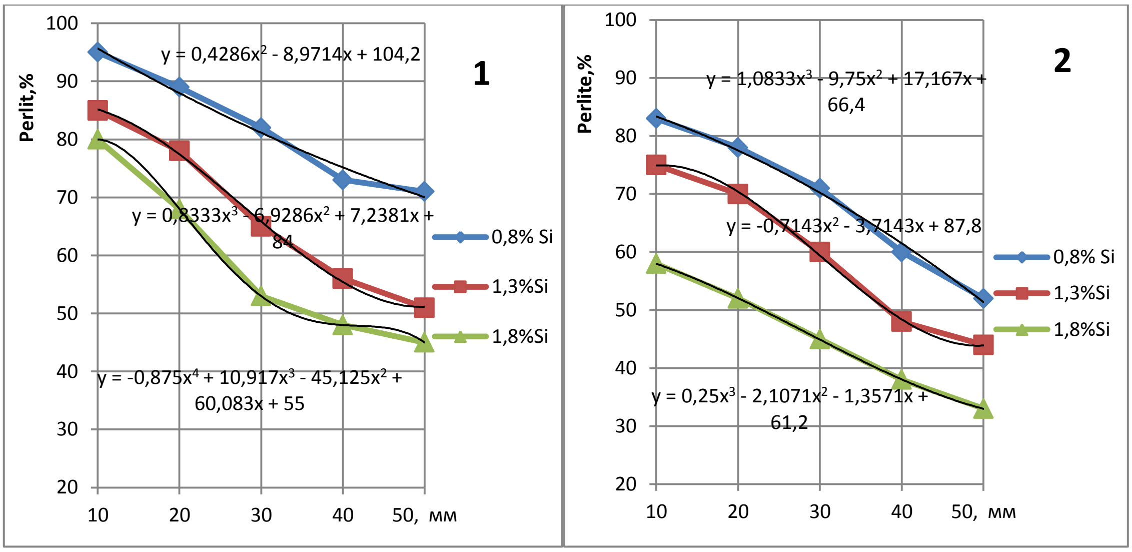


Figure 3 - The amount of perlite in materials based on the Fe-C-Al system, containing 9.5% Al and 3.7% C, depending on the silicon content, section thickness and holding time: 1-1 hour; 2 - 2 hours ◊- 0.8% Si; □ - 1.3% Si; Δ- 1.8% Si

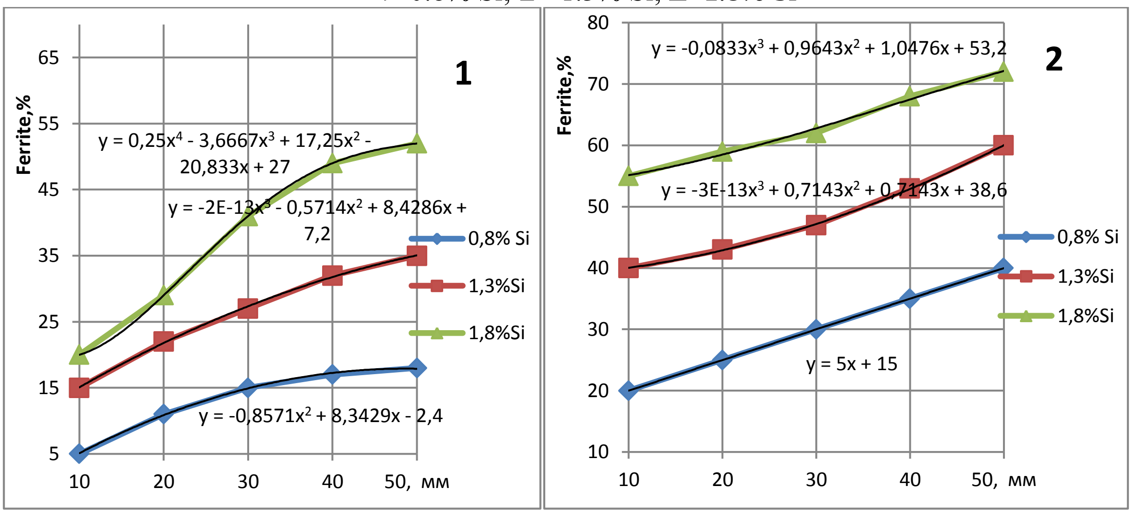


Figure 4 - Amount of ferrite in materials based on the Fe-C-Al system, containing 9.5% Al and 3.7% C, depending on silicon content, section thickness and holding time: 1-1 hour; 2 - 2 hours; ◊ - 0.8% Si; □ - 1.3% Si; Δ- 1.8% Si

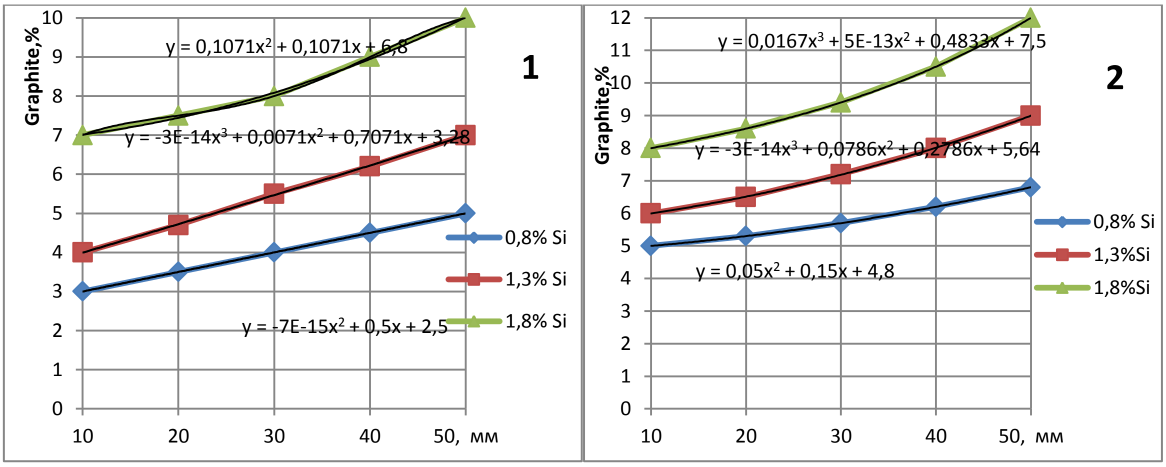


Figure 5 - The amount of graphite in materials based on the Fe-C-Al system, containing 9.5% Al and 3.7% C, depending on the silicon content, section thickness and holding time: 1-1 hour; 2 - 2 hours; ◊ - 0.8% Si; □ - 1.3% Si; Δ- 1.8% Si

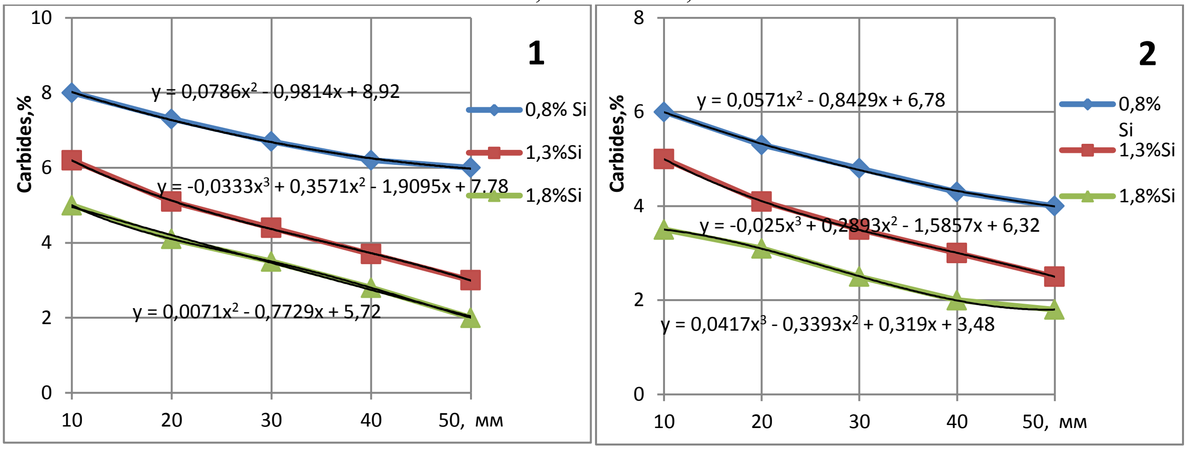


Figure 6 - The amount of carbides in materials based on the Fe-C-Al system, containing 9.5% Al and 3.7% C, depending on the silicon content, section thickness and holding time: 1-1 hour; 2 - 2 hours; ◊ - 0.8% Si; □ - 1.3% Si; Δ- 1.8% Si

The structure of the sample material on the basis of Fe-C-Al system cast in sand form is characterized by a plate straight shape of graphite with a small amount of swirling graphite form (10 %). The size of graphite inclusions varies in a wide range from 15 to 120 μm, but the preferred length is estimated at 50 μm. Graphite occupies about 6...7 % of the area.

The structure of a metal sample poured into a metallized form that is in a molten quenching medium immediately after crystallization acquires a finely dispersed austenitic-cementite structure of white iron. Heat treatment of samples in the form of an isothermal extract at a temperature of 1223 K for 2 hours, quenched from the liquid state, leads to accelerated graphitization of cementite. The released graphite is like a small inclusion of compact form with a diameter of 15 ... 60 microns or less.

An increase in the exposure time in the metallized form leads to an increase in the share of graphite due to a more complete decomposition of carbides, a decrease in perlite, an increase in ferrite, a decrease in carbides.

4 Conclusions and perspectives

This technology, which assumes the production of compact forms of graphite inclusions, is distinguished by stability with respect to the quality of graphite inclusions and metal matrix from other technological processes for producing materials based on the Fe-C-Al system currently used in the foundry industry. The stability of obtaining a compact form of graphite is provided by the specific features of the pouring of materials based on the Fe-C-Al system and the formation of the preform in a protective quenching medium. At the same time, there is no modification of materials based on the Fe-C-Al system and, as a consequence, the use of modifiers, which makes the proposed technological process economically effective. The problems associated with the provision of stringent requirements for the chemical composition of materials based on the Fe-C-Al system, in particular, the content of surfactants, are also eliminated.

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