INTRODUCTION

One of the methods for obtaining cast iron castings is continuous-cycle freeze casting (CCFC) [1]. It is based on the principle of directional crystallization of cast iron, wherein the external surface of a casting is formed by the working cavity of a crystallizer and the inner surface is obtained directly from the melt and is determined by the crystallization front only. By virtue of this method, it is possible to form gray iron castings for fabrication of parts of cylinder–piston blocks of internal-combustion engines, compressors, and hydro-mechanical transmission boxes of car-and-tractor units. The high performance reliability and service life of the given units and machines are due to the considerably steep requirements concerning the structure and properties of the formed castings: a perlite matrix (ferrite content less than 5%), fine flake graphite (25–95 µm), hardness of ~100 HRB, tensile strength ≥25 kg/mm², and high wear resistance. The CCFC method allows high physicochemical and operation properties of the castings; high efficiency, economic feasibility, and environmental safety of the process; relatively simple and rapid transfer from one standard size of castings to another; and the possibility to control the mode of their secondary cooling. However, this method is characterized by some disadvantages such as the availability of the chilling effect on the external surface and of the inverse chill in the near-surface layer inside the casting, the availability of a high content of ferrite and spotted interdendritic graphite (graphite of supercooling), and nonuniformity in the distribution of the dispersion of the phase components and the metal matrix over the cross section of a casting. The application of traditional methods of thermal aftertreatment of castings for elimination of these disadvantages requires additional energy consumption leading to rise in the production cost. In addition, the problem of obtaining a uniform structure by the heat treatment methods is, as a rule, inadequately solved [2].

Promising methods for changing in structure and properties of metals and alloys are involve exposure to pulse nonthermal energies [3]; among them, a special position is held by magnetic-pulse treatment (MPT) [4–5]. Magnetic fields are widely used for modification of structure and properties of various materials such as water–electrolyte solutions [6], crystallized melts, biological objects [7–8], polymer materials, and fibers [9–11]. The simple technology and high efficiency of the applied devices and installations allows recommending this method of treatment for various domains of economic activity, yet the most significant results were obtained in the mechanical engineering industry. In particular, the use of MPT made it possible to improve the characteristics of iron–carbon alloys [12] and nonferrous metal alloys [13], to decrease the residual and fatigue stresses in pieces and constructions, and
to improve cutting tool life [14]. It should be noted that, despite the considerably wide practical introduction of MPT, it is still of keen interest to researchers and representatives of industry. The study of the influence of magnetic fields on metals and alloys is in progress and it is considered to be one of the promising directions in general metallurgy and solid state physics. However, almost in all the works, strong (with an intensity of $H \sim kA/m$) [15] and superstrong ($H \sim MA/m$) [16] magnetic fields are applied; it is not a simple engineering problem to obtain them [17]. The effect on metals and alloys exerted by easily established weak magnetic fields with an intensity $H$ of the order of several hundreds of A/m is poorly known, although the results obtained by some authors show that this treatment is promising. Thus, for example, in work [18], the influence of treatment in a magnetic field of low intensity on the properties of steel 4X5MФК is studied. Changes in the structure and properties of beryllium bronze Cu-2%Be under the action of a magnetic field with an intensity of $900 \text{ A/m}$ are investigated in [19]. Specific features of the influence of a low-intensity magnetic field on the structure of condensed media are considered by the author of [20].

The obtained results allow us to suppose that low-intensity MPT can be efficient for structural rearrangement in gray cast iron.

In this work, we study the possibilities to change the structure of CЧ-25 cast iron by the action of an amplitude-modulated high-frequency magnetic field of low intensity on samples formed by CCFC.

**EXPERIMENTAL**

Low-intensity high-frequency magnetic-pulse treatment (WFMPT) of cast iron was carried out by means of an experimental installation constructed on the basis of a ВЧИ-62-5-ИГ-101 alternating current generator. The installation allowed establishing an electromagnetic field with the power-line frequency $f = 5.28 \text{ MHz}$ localized in a water-cooled three-turn inductor with length $L = 90 \text{ mm}$ and the inner diameter $D = 80 \text{ mm}$, which is connected, as an inductance load, to the output of the ВЧИ-62-5-ИГ-101 generator (Fig. 1). Samples 1 were placed into dielectric matrix 2 and were introduced into the axial zone of inductor 3 at a distance of 40 mm from its upper face.

The treatment was exercised in the air at atmospheric pressure according to the cyclogram depicted in Fig. 2. Each sample was subjected to the action of a high-frequency sinusoidal magnetic field modulated in amplitude within the range from 0 to 835 A/m. The modulation period was $\Delta t \approx 3 \text{ s}$; it formed an ordinary cycle of the