Analysis of the results of the experiments indicated that a fully spheroidized structure can be obtained in steel 45 as a result of prehardening within a broad temperature range (750–950°C). For this purpose, it is necessary that the hardened steel have a ferrite structure and products of a transformation governed by the shear mechanism (bainite or martensite)

Use of prehardening ensures a fully spheroidized structure; the ultimate strength, however, exceeds that required by technical specifications.

The strength properties and content of lamellar pearlite in the structure of the metal (initial hot-rolled state) decrease with increasing isothermal holding time to 24 h. As compared with the ultimate strength and content of lamellar pearlite after holding at 700°C for 6 h, therefore, the same properties diminished by ~30 MPa (to 520 MPa) and from 35 to 15%, respectively, after austenitizing at 750°C for 1 h and isothermal holding at 700°C for 24 h. Under these same conditions, the ultimate strength of the prehardened and annealed metal (melt 1) diminished by a total of 20 MPa; this suggests the expediency of increasing the isothermal holding time.

A reduction in the cooling rate from 150 to 20–50 degrees/h in the 720–700°C range has a significant effect on the properties and structure of steel 45. At austenitizing temperatures of 730–750°C and an isothermal-holding time of 8 h, the ultimate strength of the steel 45 specimens from melt 3 (initial hot-rolled state) decreased to 470–510 MPa; this satisfies the requirements of the technical specifications; lamellar pearlite, the content of which increases with increasing temperature and austenitizing time, is present in the structure. Use of prehardening with tempering effects a decrease in ultimate strength to 470–490 MPa after annealing on attaining the required structure.

Thus, the optimum heat-treatment regime for the structure and ultimate strength of steel 45 that satisfy the requirements of technical specifications on a flat rolled product for finish cutting has been established as a result of the investigations conducted — preliminary quenching in water from 750–850°C, tempering at 700°C for 1 h, and annealing in accordance with the following regime: austenitizing at 740–750°C for 30–120 min, cooling to 700°C at a rate of 20–50 degrees/h in the 720–700°C range, isothermal holding for 8 h at 700°C, and cooling in air.

METHOD OF HEAT TREATING MAGNETS IN AN INTERMITTENT EFFERVESCING LAYER

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Permanent magnets of isotropic alloys and also magnets of low mass and small thickness formed from anisotropic alloys, which are heat-treated in an effervescing layer, exhibit a low coercive force, since they are cooled at a rate above the critical owing to vigorous heat emission into the effervescing layer [1].

The heat treatment of these magnets under a reduced flow rate of rarefying air also makes it possible to obtain high and stable magnetic properties, since a significant non-uniformity of the temperature field and pseudorarefaction arises in the volume of the effervescing layer with pseudorarefaction at rates below optimum for which the heat-transfer coefficient is maximum [2].

A method*is proposed for heat treatment in an intermittent effervescing layer; with a periodically repeating feed and shut-off of rarefying air. One of the energy characteristics of an intermittent effervescing layer is the duty ratio of the air pulses as determined by the ratio of the period of repetition to the pulse duration. It is possible to ensure the selection and retention of the critical cooling rate for different magnets as a function of their chemical composition, size, and shape by regulating the duty ratio of the air feed, and, consequently, the mean heat-transfer coefficient.

*Inventor's certificate No. 637437.
Moreover, the uniformity of pseudorarefaction during the heat treatment of magnets in the poured form (the disposition of the magnets becomes more uniform) is increased with the use of an intermittent effervescing layer, and their portable condition in the effective space of the bath is even ensured during the charging of small magnets.

The frequency of the pulsating effervescing layer was selected (as a function of the mass of the molten charge and the density of the charge of magnets) so that the curve depicting the cooling of the magnets was sufficiently smooth.

In the Production Union "Magnit," permanent magnets of complex shape (for electric meters), produced from the isotropic alloy YuND4, were heat-treated in a testing machine with an effervescing layer formed from grade IKO2 quartz sand at a rarefying-air flow rate of 15 m³/h (which provided for vigorous layer effervescence). The dimensions of the magnets were 31 × 24 × 27 mm, and the mass of a single casting was 75 g. The charge of these magnets contained 0.5% of Ti. The diameter of the machine bath was 410 mm, and the height of the effective space of the effervescing layer 400 mm. The duty ratio of the intermittent effervescing layer was regulated using an electromagnetic valve in the air system and appropriate electrical control circuits.

A 20-kg charge of magnets heated to 1250°C (to attainment of a single-phase solid solution) was placed in the effervescing layer preheated to 660°C, and cooled in it to this temperature.

Eight charges of magnets were cooled in the intermittent (frequency of 0.1 Hz) effervescing layer at different air-duty ratios (3, 4, 5, 6, and 7).

Curves depicting the relationships between the average values of the residual magnetic induction $B_r$ and the coercive force $H_c$ and the duty ratio $\varepsilon$ of the intermittent effervescing layer are presented in Fig. 1. Also presented here are the results of an investigation, which were obtained during the heat treatment of two charges of magnets in an intermittently effervescent layer, i.e., when its duty ratio assumed the minimum value of unity. The horizontal dot–dash line is the level of the minimum allowable values of $H_c$ and $B_r$.

For a duty ratio $\varepsilon = 3$, the magnetic induction and coercive force are ~9% higher than the required values.

To ensure the maximum output of suitable magnets that can be controlled in terms of $B_r$ and $H_c$, and also considering that the magnetic induction of these magnets is increased by ~0.02 T ($B'_r$, see Fig. 1) after grinding the effective surfaces, it is recommended that the magnets be heat-treated in an intermittent effervescing layer with a duty ratio of 3.5. This increases the coercive force (a characteristic requiring more accurate regulation of process parameters) and reduces (by a permissible amount) the magnetic induction, which is lower than $H_c$, and depends on the variation of the chemical composition of the alloy and deviations from the regime of the casting process.