Therefore as the result of calcium modification of the iron a significant decrease in the stability of the cementite, which decomposes in heating starting at 800°C, occurs. Since the temperature necessary for decomposition of cementite in the unmodified iron is significantly higher than 800°C, in annealing parts of iron treated with calcium the consumption of thermal energy is reduced.

Hardness measurement results showed that in the as-cast condition modified and unmodified irons have practically the same hardness (600 and 620 HB, respectively). With an increase in annealing temperature the hardness of the iron decreases and after heating to 950°C and a hold at this temperature for 4 h the hardness is 225 HB for the calcium-modified iron (Fig. 2) and 424 HB for the unmodified.

Therefore calcium modification of the iron promotes a significant decrease in the hardness of the iron in comparison with the hardness of the unmodified iron after annealing using the same cycle.

The annual saving from introduction of the annealing cycle developed (800°C for 3 h) for the calcium-modified iron in a single compressor manufacturing plant was about 50,000 rubles.

Conclusions. 1. Calcium modification of cast iron causes a decrease in the stability of cementite in annealing.

2. In the calcium-modified iron significant graphitization occurs in heating of it to 700°C with a hold of not less than 4 h.

3. For decomposition of cementite in calcium-modified iron in heating of it to 800°C a hold of 3 h and more is necessary. With an increase in heating temperature the hold must be reduced.

HARDBENABILITY OF WEAR-RESISTANT ALLOY CAST IRONS

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Hardenability is one of the basic properties determining the suitability of wear-resistant alloys for the production of castings, especially thick-walled ones [1].

Wear resistant alloys are used for heavy parts such as the linings of grinding mills. Parts of such a type must wear uniformly. Therefore it is necessary that the part material have uniform properties (hardness and wear resistance) across the whole cross section.

In this work an investigation was made of the influence of carbon and chromium on the hardenability of cast irons (1.68-4.0% C, 12.5-30% Cr, ≤1% Mn and Si, each). A method of thermal simulation based on programmed cooling of specimens reproducing the cooling of plates with dimensions of $a \times 4a \times 4a$, where $a$ is plate thickness, was used.

To determine the hardenability a low-inertia tubular furnace in which the specimens were placed was used. The temperature is the furnace was regulated with a platinum-platinum-rhodium thermo-couple. Programmed control of the furnace temperature cycle was with a potentiometer and a templet the profile of which corresponds to the temperature cycle of air hardening of plates with dimensions of $4a \times a \times a$ (heating, holding, cooling).

The cooling curves of the plates were obtained by calculation and verified experimentally. Experimental data obtained in cooling of 30, 50, 75, and 100 mm thick castings were used as the original data for the calculations. The cooling curves of 150, 200, 500, and 1000 mm thick plates were obtained by calculation. Experimental checking of the calculated cooling curve of 150 and 200 mm thick plates showed that the deviation from the cooling rate does not exceed 15%.

The hardenability is determined primarily by the stability of the austenite in the $A_{c1} - M_S$ range, and the stability of the austenite, in turn, depends upon the degree of its alloying.

The distribution of chromium in wear-resistant irons was investigated with the use of chemical phase analysis. Figure 1 shows a diagram with the use of which it is possible to determine the quantity and type of carbides in the structure of cast iron in relation to the carbon and chromium content in it (the solid lines on the diagram show the carbon and chromium content in irons with the same quantity of carbides, and the broken lines correspond to the boundaries of formation of carbides of different type). It may be seen that the quantity of carbides in the iron is determined primarily by the carbon content, and the type of carbides by the chromium content. The chromium is nonuniformly distributed between the carbides and the metallic matrix. The larger portion of the chromium is found in the carbides.

With an increase in the chromium content in the iron its weight % in the base steadily increases while with a decrease in carbon content it changes insignificantly (Fig. 2).

Figure 3a shows curves of the hardness of hardened $3 \times 12 \times 12$ mm castings. In this case a zone with a hardness of more than 60 HRC, which corresponds to alloys hardened from the single-phase (austenitic) area, may be seen. The structure of the metallic base consists of martensite and residual austenite. In the hardened structure of alloys with a carbon content of less than 2% and chromium of more than 20%, a ferritic constituent (hardness less than 60 HRC) significantly reducing the wear resistance of the iron is observed [1].

From a comparison of Figs. 1 and 3 it may be seen that alloys the structure of which contains $Cr_7C_3$ carbides correspond to the zone with the maximum hardness. Therefore the area of most promising irons containing from 20 to 40% $Cr_7C_3$ carbides with a microhardness of 1176-1274 H distributed in a martensitic-austenitic base is revealed. Such a structure provides the maximum wear resistance of irons [1]. In order to obtain it in hardening of heavy castings high hardenability is necessary. As the result of the low plasticity and thermal conductivity of chromium iron castings they cannot be hardened in water and therefore cooling of 30-200 mm thick plates in air was simulated. The hardness curves of the hardened...