with an oil temperature of 20°. The samples were heated as shown in Fig. 2, with the holding time calculated by the method given in [6].

We measured the hardness, examined the microstructure, and evaluated the condition of the surface visually on samples 12 mm in diameter and 20 mm long. The distortion was determined with T-shaped samples from the difference in the length of the upper and lower sections [7].

A bright surface was obtained after quenching in vacuum (1.10^-1 mm Hg) and cooling in vacuum at the same pressure in argon and VM-1 oil. With cooling in nitrogen and VM-3 oil the surface was blue-gray, and with cooling in VM-4 oil it was brown. The hardness after quenching was HRC 63-64 irrespective of the cooling medium.

The microstructure was identical after quenching in all media tested. Carbides were unevenly distributed. The carbide heterogeneity was grade 6-7 (GOST 5950-63) (Fig. 3). The microhardness of the carbides was H 1000.

The austenite grain size after quenching was grade 10 according to GOST 5639-65 (Fig. 3). The microhardness of austenite was H 170-220.

The distortion of T-shaped samples after quenching in the oils tested and after standard quenching is given in Table 1.

Vacuum quenching of steel Kh12M can be conducted in domestic furnaces—the SSHV.3.3/13G shaft furnace (cooling in gas), the SSV-3.3/11.5 FM2 elevator furnace (cooling in gas and oil), and the SNV-5.10.5/11, 5F, and SNV-5.10.5/13G chamber furnaces.

CONCLUSIONS

Vacuum quenching of die steel Kh12M in argon and in VM-1 vacuum oil after heating to 1030° (10^-1 mm Hg) ensures a hardness of HRC 63-64 with retention of a bright surface and reduction of distortion.

LITERATURE CITED


* Determined with the assistance of L. Vdovina.

QUENCHING OF SPRINGS MADE OF STEEL 60S2KhA IN FOAM

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Cylindrical coil compression springs of steel 60S2KhA are quenched in mineral oil, although complete hardenability to martensite is not attained in springs of large diameter, which has a negative effect on the durability of springs [1].
It was shown in [2-4] that it is possible to improve the hardenability and the properties of metallic parts by quenching in foam instead of oil.

This work* concerns the basic characteristics of hot coiled springs of steel 60S2KhA (0.57% C, 1.44-1.67% Si, 0.56-0.59% Mn, 0.88-0.95% Cr, 0.15-0.16% S, 0.02% P) after quenching in foam, and in oil for comparison, and tempering. The foam consisted of 20-25% water in films and 75-80% air in bubbles 2-5 mm in diameter; it cooled the surface of the part in the range of 700-300°C at a rate 2.5-3 times faster than oil and at lower temperatures 2.5 times slower than water. Thus, foam consisting of 20-25% water is intermediate in cooling capacity between oil and water.

Quenching in foam was conducted in stationary factory equipment placed in a production line for manufacturing springs including a slot furnace for heating, coiling apparatus, quenching apparatus, and tempering furnace. Rod heated to 950-1000°C was fed into the coiling device. After coiling, straightening, bending of the

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