In recent years various methods of modifying the structure of high-speed steel have been recommended to eliminate the heterogeneous distribution of carbides. It has been reported [1] that high-temperature annealing (950°C) produces a "broken" eutectic network in place of a continuous network and increases the strength of cast steel from 80-100 to 150-180 kg/mm².

Heating at very high temperatures (up to 1300°C) with soaking 0.5-4 h has also been recommended [2, 3]. Heating at such temperatures, as shown by our investigations, eliminates the eutectic network completely. However, the effect of this treatment on other characteristics of the structure of high-speed steel and on the properties has hardly been studied.

Fig. 1. Effect of heating conditions on the microstructure of R18 ingots 60 mm in diameter (×100). a–c) Cast steel; d–f) forged steel; a, d) annealed 3 h at 850°C; b, e) annealed 3 h at 850°C three times; c, f) 30 min at 1300°C.
The present work was undertaken to determine the possibility of improving the distribution of carbides in cast and wrought high-speed steel. R18 steel was melted in an induction furnace and poured at 1520-1500°C in ingots 60 and 80 mm in diameter in metal molds and also in cloverleaf samples poured in sand molds. The chemical analysis of the ingots is given in Table 1.

Three heat treatments were used for the ingots: 1) At 850-950°C for 3 h (single and multiple heating); 2) at 1150-1250°C for 45 min to 3 h; 3) at 1300-1310°C for 30 min. Except for the single heating to 850°C, the ingots were cooled in air to 500-600°C after each heating.

After heat treatment the ingots 60 mm in diameter were forged into bars 12 mm square at 1200-950°C; ingots 80 mm in diameter were forged into bars from 10 to 32 mm square. The bars were cooled in air after forging.

To obtain comparative data for the cast steel and the heat treated and forged steel, both were annealed under the usual conditions at 840-850°C for 3 h, cooled to 740°C at the rate of 30-40°C/h, soaked 6 h, cooled to 600-620°C in the furnace, and then cooled in air.

Samples subjected to various preliminary treatments were quenched from 1260, 1280, and 1300°C, with soaking for 10 sec/mm of cross section, and cooled in oil, then triple tempered at 560°C with soaking for 1 h.

Microanalysis showed (Fig. 1) that increasing the temperature of single heating from 850 to 1250°C (soaking no more than 45 min in the latter case) has little effect on the structure of the small or large ingots, although the network becomes smaller and thinner. At 1250°C large carbides occur in the structure.

Heating to 1300°C for 30 min completely eliminates the eutectic network; the carbides become large and angular (Fig. 1a). Annealing the ingots affects the structure of the wrought steel. Heating at high temperature (1300°C), which eliminates the eutectic network, prevents the formation of the carbide banding which is characteristic of rolled (forged) steel (Fig. 1e). The distribution of carbides is uniform but, as in the cast steel, the carbides are large and angular.

After a single heating of the ingot to 850°C the forged steel has the characteristic carbide banding, the carbides being of grade 4-5.