USE OF HIGH FREQUENCY HEATING FOR HEAT TREATMENT OF DRILLING AND CASING PIPES AND TURBODRILL SHAFTS AND BODIES

(UDC 621.785.545.45; 662.992.2; 622.243.92)

N. V. Zimin and V. G. Shevchenko

Translated from Metallovedenie i Termicheskaya Obrabotka Metallov, No. 6, pp. 11-15, June, 1965

The increasing depth of gas and oil wells requires high-strength drilling and casing pipes. In the USA the pipes used for drilling down to 8000 m have a yield strength of 60-80 kg/mm². This strength is achieved by heat treatment consisting of quenching and tempering.

The pipes are usually heated in furnaces. Recently, high-frequency induction heating has been used for this purpose.

We have investigated the heat treatment of casing pipes in a continuous operation with heating in an inductor, quenching with a water spray, and induction tempering.

Pipes 168 and 141 mm in diameter with wall thicknesses of 8-14 mm were used in this investigation. We determined the rate of motion of the pipes, the length of the inductor, and other parameters which almost completely eliminate the temperature difference between the inner and outer walls.

The pipes were quenched in a sprayer with a rotating stream of water, which provided more uniform cooling. The effective cooling area of the sprayer was 150-170 mm long. To increase the length of this area we used additional cones to direct the streams of water to the surface of the pipe. The amount of water used was 50-60 m³/h under a pressure of 4-5 atm.

We treated 40 casing pipes with the laboratory apparatus. The pipes were made of the following steels: No. 45, 36G2S (0.33-0.39% C, 1.6-1.85% Mn, 0.5-0.7% Si), 38KhNM (0.5-0.7% Ni, 0.2-0.35% Mo, 0.36-0.40% C, 0.5-0.7% Cr), and 40Kh. Microscopic examination of samples of pipes which were subjected to mechanical tests showed that in steels 38KhNM, 40Kh, and 36G2S the walls are quenched through when they are no thicker than 14 mm. In pipes of No. 45 steel with a wall thickness greater than 10 mm ferrite is precipitated on the inner surface, but it has little effect on the mechanical properties of the pipe after tempering.

We drew curves representing the variation of the mechanical properties with tempering temperatures for the steels investigated (Fig. 1). The ultimate strengths obtained as the result of the heat treatment are somewhat below the specifications for the ultimate strength of the L and M categories of pipes (GOST 632-57). After treatment with induction heating, steels No. 45 and 36G2S come up to the specifications for these two categories. However, the values of σₚ and σ₀.₂ required by the specifications result in very low σ₀.₂/σₚ ratios which cannot be attained by high-quality heat treatment. Steel No. 45 satisfies the requirements of the specifications for drilling and casing pipes of 35KhG2SM and 35KhG2SV steels delivered to experimental-industrial concerns for which σₚ ≥ 76 kg/mm² (ChMTU/TsNIIChM 260-60). It is necessary to adopt these specifications in the new specifications, since artificial increase of σₚ to values corresponding to the present specifications leads to a decrease of ductility.

Plant investigations of 70 casing pipes at the Taganrog Metallurgical Plant confirmed the possibility of producing high-quality pipes by heat treatment with the use of induction heating. The mechanical properties of the pipes are given in Table 1.

The warping of the heat treated pipes is greater than the specifications allow (GOST 632-57), and therefore the pipes must be straightened.
According to the preliminary calculations, the electrical energy per ton of pipes heat treated with the TGM3 experimental apparatus is 450 kwh. The investigation allowed us to determine the acceptable limits of the difference in the wall thickness. It turned out that the difference specified (GOST 632-57) is not an obstacle in heat treatment.

We investigated bodies and shafts made of 40Kh and 40KhNMA steels. The diameters of the shafts were 60–134 mm and the diameters of the bodies were 140–265 mm, the wall thickness being 20–40 mm. The heat treatment included continuous heating in the inductor to the quenching temperature, quenching with water sprays, and tempering. The samples were heated at a frequency of 2500 Hz in special inductors in which the heating rate is high; this made it possible to decrease the heating time by a factor of 2–2.5 as compared to the ordinary heating time. The pipes were quenched in sprays with a rotating stream of water. The quenching temperature was varied between 900 and 1000°C for shafts, and from 850 to 950°C for bodies. The tempering temperature for the bodies and shafts was varied from 600 to 720°C.

Shafts of 40KhNMA steel 134 mm in diameter were quenched through after the treatment.

The drawback of the conditions used is a somewhat lower tempering temperature which resulted in a hardness of HB 800–820 after tempering, i.e., the hardness was closer to the upper limit of the hardness required by the specifications for 40KhNMA steel shafts (GOST 4543-48).

To determine the mechanical properties at a depth of half the radius of the shaft we cut Menage and Gagarin samples out of the shafts. It was found that the mechanical properties after heat treatment in which high frequency