COOLING MEDIA

USE OF MODIFIED AQUEOUS POLYMERIC SOLUTIONS FOR QUENCHING BLANKS OF STEEL 9KhFM CIRCULAR SAWS

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The replacement of quenching oils by ecologically pure polymeric quenching media that exhibit the necessary service properties and cooling capacity is an urgent problem of the heat treatment of machine and tool components.

The purpose of this study is to develop a procedure for the deformation-free quenching of circular-saw blanks in polymeric quenching media in place of industrial oil 1-20.

The blanks are heated to 880 ± 15°C in the electric furnace, held for 20-25 min, cooled for 50-60 sec in hot (60-100°C) 1-20 oil between the plates of the press-bath, and then introduced to the air (blank temperature \( T_b \) of (170-180°C) < \( M_s \); continuous quenching) using the slab-hoist, and rapid transfer by telpher onto the roller conveyer of the tempering press, where they are subjected to tempering at 540-580°C for 10-12 min. After tempering, the blanks pass 100% acceptance for hardness and deviation from a true plane. The hardness of the blanks should be 40-45 HRC, after heat treatment (a hardness of 42-47 HRC is permitted for blanks with an oxide film); in that case, the difference in hardness at different points of the same blank is not more than 4 HRC (40 HB).

The deviation from rectilinearity of the end surfaces of the blanks should not exceed 2-3 min after heat treatment. Blanks suitable for circular saws are subjected to grinding, gear cutting, tooth cutting and acceptance testing in accordance with GOST 23726-79.

Selection of the UZSP-1 polymeric quenching medium [2] as the base for the quenching steel 9KhFM circular-saw blanks [2] was governed by the widespread use of this medium for the quenching of components formed from 40Kh, 42KhMFA, 60KhFA, U10, and other steels. Use of UZSP-1 is possible for the quenching of thin-wall components fashioned from carbon steels [1, 3]. UZSP-1 has an adjustable cooling capacity over the range of cooling rates in water and quenching oil, depending on its concentration and temperature. The cooling capacity of aqueous UZSP-1 solutions with concentrations of 0.5-5.0% and temperature of 20-60°C is rather well understood. Based on the results of studies that we conducted earlier, for example, a 2.5-3.5% aqueous solution of this medium, can be recommended to replace quenching oils and Osmanil-E2 for the quenching of the necks of large-dimension steel 30Kh3VA crankshafts with high-frequency-current heating and sprayer cooling. Vorontsov and Pechurina [4] have investigated the cooling capacity of UZSP-1 and PK-2 solutions. For example, aqueous solutions of UZSP-1 with a concentration of 2.5-3.0% exhibit a smoother change in cooling rates in the martensitic
Fig. 1. Curve of cooling rate versus temperature of center of steel 08Kh18N9T thermal probe during cooling in 1-20 oil (1), in aqueous UZSP-1 solutions with concentration of 2% (2), 2.5% (3), and 3.0% (4), as well as in 1% aqueous solution of PK-2 (5). Temperature of quenching medium was 20°C.

interval as compared with a 1% solution of PK-2, whereas the cooling rate in these solutions is higher than but in oil 1-20 (Fig. 1). As we know, these differences exert a major influence on the level of quenching stresses in components, particularly those fabricated from steels with a high carbon content and high degree of martensite tetragonality.

Preliminary investigations of quenching in UZSP-1 solutions were conducted on rectangular 100 × 25 × 5-mm specimens formed from steels 9KhF, 9KhFM, and 7KhN2MFA to determine the optimal concentration of the effective aqueous solution providing the required hardness and minimal post-quench deformation of the specimens (see Table 1). The specimens were heated for quenching in a type SNOL 1, 6.2, 0.0, 8/9M-1 laboratory electric furnace at 800°C (8 min), and were then placed upright in a tank with the quenching medium at room temperature, where they were cooled for 4.5-5.0 min.

The specimens were observed to have cracked after quenching in the 2% solution for 1.2 min: Crack initiation originated at the corners of the plate specimens (stress risers), and crack growth continued through the middle of short (25 mm) side. The specimens either split in half, or the crack reached the midpoint of their length. After burnishing the sharp edges at the corners of the specimens prior to quenching and increasing the solution’s concentration to 2.5%, the opening of cracks did not occur, but deformation of the specimens was retained over the length (100 mm), and amounted to 3-4 mm. In quenching the specimens in the 3.0% solution, no cracks were observed, and deformation decreased to 1.5-2.5 mm; in that case, however, the scatter of hardness across the width of the specimens reached 3-6 HRC; this is greater than the permissible value.

Using the results of preliminary investigations, it is recommended that UZSP-1 with concentration of 5.9-10.0% at an initial temperature of 40°C be used for the quenching of circular-saw blanks 1250 and 1500 mm in diameter and 5.5-6.5 mm thick; this makes it possible to lower the internal quenching stresses of the components, and to reduce the possibility of crack formation and deformation.

Experimental-industrial tests of circular-saw blanks were conducted after heating to 880 ± 15°C for 20 min in an electric furnace and cooling in a quenching tank with a volume of 280 dm³. The required concentration of the medium was achieved by diluting and agitating a 20% UZSP-1 solution with a mechanical mixer (since bubbling of the water-base medium leads to its oxidation and to the dissolution of air in the water). Under normal conditions, 18.26 cm³ of air is contained in 1 dm³ of water; this may exert a significant effect on the uniformity of cooling and result in the appearance of segments with reduced hardness on the surface of the components after quenching. The solubility of air is decreased to zero when the temperature of the aqueous solutions is raised from 20 to 100°C.

The required amount of water and UZSP-1 concentrate for preparation of the working solution can be determined from the equation:

\[ X = B \left( 1 - \frac{JT}{M} \right), \]