HEAT TREATMENT AND PROPERTIES OF 10R6M5-MP HIGH-SPEED STEEL PRODUCED FROM GAS-DISPERSED POWDER AT HIGH HYDROSTATIC PRESSURES


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The high quality of sintered high-speed steel, obtained as a result of the presence of a fine-grain structure of the material with uniformly distributed carbides and high cleanness with respect to oxygen of the initial gas-dispersed powders, has stimulated the production of these powders.

Low-deformability powders can be compacted using various high-energy methods, such as hot isostatic pressing, hot extrusion, impact pressing, and hot stamping [1]. The quality of high-speed steel produced by hot extrusion of a capsule with a freely distributed powder, and of a steel produced by the ASP method, has been studied in a number of investigations [2-5]. Experimental investigations of the methods of producing components of high-speed steel powder show that it is promising to use high hydrostatic pressures for compacting blanks [3, 6]. Experience obtained in constructing high-pressure equipment with a working channel of containers of up to 200 mm, obtained at the Donetsk Institute of Technical Physics of the Academy of Sciences of the Ukrainian SSR [7, 8], and the results of experimental examination of hydrostatic treatment were utilized in developing a technology for producing blanks from high-speed steel powders without a metallic sheath [9].

Vacuum heat treatment in sintering and free distribution of the gas-dispersed powder with a fraction of 0-800 μm in multiple application molds, carried out at temperatures of up to 1150°C and holding time of 20°C per 1 mm of the cross-section of the blank, makes it possible to produce tablets with a residual porosity of 30-35% and the strength sufficient for carrying out transport and processing operations. After pressing from the mold, the powder blank is compacted in high-pressure equipment using a device for hydrostatic processing by the 'dry bag' method.

As a result of determining the dependence of the density and mechanical properties of the blanks on the hydrostatic pressure level it is possible to control the level of the inspected parameters of the powder blank. At a pressure of 700 MPa it was possible
to produce, without using a metallic sheath, blanks up to 150 mm in diameter, approximately 600 mm long, with a density of 0.88-0.90 of the theoretical values [9]. The strength of specimens in compression testing of 550-600 MPa enabled heating to be carried out in induction industrial furnaces of the IP-1501 type. Hot pressing with a drawing factor of 8-15 carried out in production conditions yielded batches of rods of profiled and round sections 25-60 mm in diameter without a metallic sheath (Fig. 1).

To determine the properties of rods produced by hot pressing gas-dispersed powders of 10R6M5-MP high-speed steel without a metallic sheath, investigations were carried out into the density, macro- and microstructure, the austenite grain size, secondary hardness, carbide heterogeneity, the thickness of the decarburized layer, heat resistance, bending strength, and impact toughness. After annealing under the standard conditions, the structure of the blanks consisted of sorbite-like pearlite with uniformly distributed carbide phases (Fig. 2a). The hardness of the rods was 229-255 HB. The density, determined by hydrostatic weighing the specimens cut out from the center and the surface layer of a hot-pressed rod along its entire length, was 8.12-8.14 g/cm³.

To determine the optimum heat treatment conditions, we examined the effect of quenching temperature on the austenite grain size, hardness, heat resistance, bending strength and impact toughness. The quenching temperature was varied in 20 deg steps from 1160 to 1240°C. Preheating of the specimens for quenching was carried out in a salt bath at 800-850°C for 10-20 min, depending on the diameter of the specimen. The duration of final heating was calculated as 8-10 sec/mm [10]. The quenched specimens were tempered three times at 560°C with holding for 1 h. The microstructure of the specimens after quenching and triple tempering is shown in Fig. 2b. To evaluate heat resistance, the hardness of the specimens was measured after heating at 620°C with a holding time of 4 h. The experimental results (Table 1) indicate that the hardness of the steel immediately after quenching decreases with an increase of quenching temperature and increases after triple tempering, whereas the mechanical properties decrease. Quenching from 1190-1210°C followed by triple tempering at 560°C are regarded as rational conditions of heat treatment of specimens for inspecting the mechanical properties, and of tools for durability tests. This result is in agreement with the results of examination of a high-speed powder steel produced by hot compacting a powder freely distributed in capsules [2-3]. Tests of the hot-pressed powder steel in static bending, impact toughness, and hardness in the condition after quenching and triple tempering were carried out in accordance with GOST 18228-85, GOST 26528-85, and GOST 9013-59, using five specimens per point.

10R6M5-MP high-speed steel in rods 25-60 mm in diameter produced by hot extrusion of powder blanks without capsules produced using hydrostatic pressure, is characterized by the higher bending strength, impact toughness, secondary hardness, and heat resistance value than those of the characteristics of R6M5 steel produced by the standard method and, according to literature data, is not inferior in a number of the examined parameters and exceeds the properties of the powder steels produced by other methods (Table 2). The oxygen content of the hot-pressed rods was 0.015-0.022%.

It is well-known that the mechanical properties of the steel in the heat treated condition provide indirect information on the efficiency of the tool under production conditions. The results of comparative durability tests confirm the advantages of powder steel. Tests of the cutting tools (taps, reamers, cutters) from rods of 10R6M5-MP high-speed steel showed that their durability in machining components of 45, 40KhN2MA, 25Kh2N4VA, and 18KhGT