Hydrostatic extrusion has been put to practical use in recent years [1, 2], especially for manufacturing metal-cutting tools (taps, broaches, milling cutters, and so on [3]). Under optimal conditions it is possible to conduct cold hydrostatic extrusion of tool steels with deformation as high as 60-70%.

We investigated the effect of cold hydrostatic extrusion conditions on the structure and some properties of high-speed and die steels. The samples were prepared and hydrostatically extruded by techniques described previously [4, 5].

Cold hydrostatic extrusion results in breaking up of carbides and redistribution of refined particles in the bulk of the piece. In bars of rolled steel Kh12M in the original annealed condition one observes large carbides of elongated form, but sharp-angled fragments of carbides after hydrostatic extrusion (Fig. 1a and b). A similar structure is observed with deformation of high-speed steels. Quantitative metallographic analysis of rolled bars of steel R18 with carbide heterogeneity of grade 4-5 showed that the area of the carbides decreases with hydrostatic extrusion almost proportionally with the deformation (carbides 2 μ in size were counted). Since the deformation through the section of the bar during hydrostatic extrusion is practically even, the carbides can be broken up through the entire section.

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Fig. 1. Carbide heterogeneity of steels in the original (a, c, e) and hydrostatically extruded (b, d, f) conditions. a, b, e, f) Steel Kh12M; c, d) R18; a, b) 800 x; c-f) 120 x.

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Fig. 2. Austenite grains in the original annealed condition (a, c, d) and after hydrostatic extrusion (b, d, f). a, b) Steel R18; c, d) R12F2K8M3; e, f) R18 (sintered); a, b, e, f) 450×; c, d) 1000×.

The extent to which the carbide heterogeneity of the steels decreases during hydrostatic extrusion depends on the grade of carbide heterogeneity in the original rolled bar and the degree of deformation of the extrusion. The higher the carbide heterogeneity of the original material and the larger the deformation, the more the carbide phase is broken up and the better it is distributed. With hydrostatic extrusion of bars 40-60 mm in diameter the carbide heterogeneity of high-speed steels R18, R12, and R6M5 decreases from grade 5-4 to grade 3-2. Lowering the carbide heterogeneity below grade 2 is difficult, since the linear arrangement of carbides is retained, despite their breaking up. Figure 1 (a-f) shows the carbide heterogeneity of steels R18 and Kh12M in the original and extruded conditions.

The austenite grain size is finer after hydrostatic extrusion than in the original condition (Fig. 2).

When the grains are finer the carbide heterogeneity generally decreases [6]. However, a substantial difference in the grain size of the original and the hydrostatically extruded steels is also observed in the case where the distribution of the carbide phase changes negligibly after hydrostatic extrusion — where the carbide heterogeneity of the original material is grade 2, for example. Also, sintered steel R18 with evenly distributed very fine carbides (the average size is 0.3-1.0 μ) after cold hydrostatic extrusion also has finer grains...