EFFECT OF TITANIUM CARBIDE ADDITIONS ON THE MILLING, PRESSING, AND SINTERING OF TUNGSTEN-MOLYBDENUM-VANADIUM STEEL POWDER

S. S. Kiparishov, V. S. Panov, V. I. Tret'yakov, and M. M. Smirnova

The properties of high-alloy tool steels are determined primarily by the presence in their structure of inclusions of complex carbides based on Groups IV-VI metals (V, W, Cr, Ti, etc.). The finer the grains of these carbide phases and the more uniform their distribution, the higher are the wear resistance and red hardness of the steels and the better are their cutting qualities [1]. However, the melting and casting technique is not suited for the alloying of steels with significant amounts of powders of refractory and hard carbides, which are only sparingly soluble in molten steels and, furthermore, substantially differ from them in specific gravity.

By contrast, the combination of the powder metallurgy process and moderate plastic working enables virtually nonporous parts with evenly distributed finely divided refractory phases to be produced in materials whose components cannot be melted together [2]. In this connection, the present work was undertaken with the aim of determining the effects of titanium carbide additions (5-10 vol. %) upon the comminution of tungsten-molybdenum-vanadium steel (type R18*) swarf and upon the pressing and sintering behavior of resultant powders, and of studying the structure and properties of sintered blanks obtained from these powders.

As starting materials R18 steel swarf and a titanium carbide powder of 2- to 3-μ mean particle size were used. Milling was performed in hard-alloyball mills by the procedure normally employed in the hard-alloy industry, for 48 h under alcohol. The main characteristics of the powders produced are given in Table 1, from which it follows that titanium carbide additions intensified the milling process, increasing the percentage amounts of fine fractions in the powder and decreasing the mean sizes of both the steel particles and the carbide grains. With rise in titanium carbide content the yield of fine fractions grew, i.e., the process of swarf comminution became more intense (Table 1). During the milling of the swarf the carbide grains, too, rapidly decreased in size. While in the starting swarf the mean carbide grain size was 6-12 μ, in the powder milled for 48 h it was only 1.0-3.0 μ (depending on the titanium carbide content). During comminution the

<table>
<thead>
<tr>
<th>Amt. of TiC in R18 steel, vol. %</th>
<th>Particle size analysis of powder, wt. %</th>
<th>Amt. of fractions, wt. %</th>
<th>Mean powder particle size, μ</th>
<th>Mean size of carbide grains in powder, μ</th>
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<tbody>
<tr>
<td>+625</td>
<td>+325</td>
<td>+200</td>
<td>+100</td>
<td>+63</td>
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*Nominal composition: 0.7-8% C, 3.8-4.4% Cr, 0.3% Mo, 17.5-19.5% W, and 1.0-1.4% V — Translator.

TABLE 2. Variation of Properties of Sintered Compacts, Mean Sizes of Carbide Grains, and Amounts of Oxygen in R18 Steel Alloyed with TiC

<table>
<thead>
<tr>
<th>Temp, °C</th>
<th>Holding time, min</th>
<th>Rel. density, %</th>
<th>Mean carbide grain size, μ</th>
<th>Hardness HRC</th>
<th>Mean oxygen content, wt. %</th>
<th>Structure</th>
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<tr>
<td></td>
<td>R18+5% TiC</td>
<td>R18+7.5% TiC</td>
<td>R18+10% TiC</td>
<td>R18+5% TiC</td>
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<td>53.4</td>
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(eutectic ~ 10% by volume)