19  Further refinement of the cutting materials

19.1  High-speed steels

The outstanding characteristics of high-speed steels are:
- Great toughness,
- Low-cost,
- Sound machinability of the cutting material.

Even today, twist drills, taps, dies, gear cutting- and broaching tools are predominantly made of high-speed steel.

Significant improvements can be made through the coating of high-speed steels. The coating is performed with the physical vapour deposition (PVD method).

During the coating of high-speed steel, the coating temperature is approx. 500 °C. At this temperature, it is still possible to coat heat-treated tools without distortion. The materials used as hard deposits are
- titanium nitride (TiN),
- titanium carbonitride (TiCN),
- titanium aluminium nitride (TiAlN) or titanium aluminium oxinitride (TiAlON),

which are coated at a thickness of 2 to 4 μm. Coated high-speed steels make possible an increase in power during machining due to longer tool life or higher cutting speeds:

- tool life increase: 100 % to 500 %,
- increase in cutting speed: 50 %

with the same tool life, in comparison to uncoated tools.

19.2  Cemented carbides

19.2.1  Uncoated cemented carbides

Cemented carbides are cutting materials produced by powder metallurgy. The main components are tungsten carbide (TC), incorporating hardness, and cobalt (Co) as binder. For grades to machine steel, additional hard materials are added – mostly composite carbides based on titanium, tantalum and niobium – in lower percentages. The carbides are responsible for hardness and wear resistance, whereas the binder determines the toughness characteristics. Cemented carbides are naturally hard, which means that their characteristics cannot be altered like those of steel can be by means of heat treatment.

In comparison with high-speed steel, the most essential parameters of cemented carbides are their fundamentally greater hardness, on the one hand, and lower level of toughness, on the other hand:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>High-speed steels</th>
<th>Cemented carbides¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness (HV 30)</td>
<td>700 … 900</td>
<td>1300 … 1800</td>
</tr>
<tr>
<td>Flexural strength (N/mm²)</td>
<td>2500 … 3800</td>
<td>1000 … 2500</td>
</tr>
<tr>
<td>Heat resistance to</td>
<td>600 °C</td>
<td>&gt; 1000 °C</td>
</tr>
</tbody>
</table>

¹) Cemented carbide sorts for machining
Cemented carbide is available in many varieties with very different properties. Consequently, a suitable variant is available for almost all types of machining, from easy finishing to machining of hard work materials. In addition to this spectrum, varieties for all workpiece materials are available.

At present, the performance of cemented carbides is being significantly improved due to the use of finer and finer grain sizes. Traditional grades of cemented carbide grades for machining make use of medium grain sizes from 1 to 2 μm; today, for ultra-fine grains, grits of 0.2 to 0.4 μm are being used. The significance of this trend is the simultaneous and tremendous increase in the principal (and opposing) parameters “hardness – tool life” and “toughness – reliability”.

19.2.2 Cermets

Cermets are cemented carbides, in which titanium carbonitride (TiCN) is used to provide the majority of the hardness instead of tungsten carbide, and a compound of nickel and cobalt serves as the binder. This difference in composition makes the cermets more heat resistant, on the one hand. On the other hand, it diminishes the material’s toughness.

Consequently, cermets are used for finishing and for operations with minimal requirements in terms of cutting edge toughness, preferentially for machining of steel.

19.2.3 Coated cemented carbides

An additional coating offers a significant increase in the performance of the cemented carbides, resulting in much higher tool life and/or increased cutting speeds.

![Micrograph of a multi-layer coating](Figure 19.1)