Ultra-met
carbide technologies

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Modern high-speed machining of metals is possible only because of cemented carbides. Because of their singular combination of hardness, strength, and other physical and chemical properties, they are superior to all other tools in general. In addition to their applications to machining tools, cemented carbides are used for rock and coal drilling equipment, for dies, and for an increasing number of other applications where resistance to wear and corrosion is important.

The hardmetals used in metal-cutting today are almost exclusively sintered carbides. Carbides of elements in group 4,5, and 6 of the periodic table and a binder metal of the iron group, predominately cobalt are produced by a powder metallurgy process. The powdered metal process is best described as mixing very fine grains or crystals of the various carbides with the binder cobalt to produce a powder that is pressed into unlimited geometries or shapes of inserts. The "as pressed" insert is then sintered into a hard dense tool. Sintering can be thought of as a type of heat treatment which takes place at a temperature lower than the melting point of carbides, but higher than the melting point of the binders.

The major carbides are tungsten carbide (WC), titanium carbide (TIC), tantalum carbide (TaC), and niobium carbide (NbC). Binders are predominatley cobalt (Co) and to a lesser extent nickel (Ni).

Carbide cutting tool material must meet the following minimum requirements to be used successfully for metal cutting applications.

1. High hardness and abrasion resistance at the tool - work material contact area.
2. Sufficient toughness to withstand friction and mechanical shock.
3. High - temperature strength and hardness to counter plastic deformation.
4. Low tendency towards sticking or welding to the work material.

These requirements are satisfied by the various carbide and binders as follows:

1. Cobalt / Nickel imparts toughness or strength.
2. Tungsten carbide is important in strength, hardness, and edge stability.
3. Titanium carbide reduces the diffusion of iron into the tool. Titanium carbide imparts good resistance to wear at elevated temperatures and exhibits a low tendency to sticking or welding. However, the toughness of the cutting tool is reduced by the addition of titanium carbide.
4. Tantalum / Niobium carbide additions, like titanium carbide imparts increased resistance to wear at elevated temperatures. Tanalum carbide bearing tools are tougher than tools containing only tungsten carbide / titanium carbide. Furthermore, tantalum / niobium carbide additions impart considerably more resistance to thermal shock.

In recent years there have been two developments that have had a significant effect upon Cemented Carbide Cutting Tool composition and performance.

The term "micro grain" has become a catchall phrase in the metal cutting industry to mean fine grain size composed tool material. Since "micro grain" is not specific and is interpreted differently, the term needs to be better explained. Very fine tungsten carbide grains having an average diameter less than 1.0 microns can be termed to be "micro grain". The actual diameter ranges from 0.7 to 0.95 microns.

There is a more recent advance toward lower grain size tungsten carbide in the 0.4 to 0.6 micron range called "ultra grain" material; and even further to "nano grain" size (less than 0.2 microns). The impact that these very fine grain size materials have upon the metal cutting industry is that they allow the tool to possess a higher hardness for the same content of binder. In most applications, "micro grain" materials exhibit better wear characteristics.

The following terms are commonly utilized to describe WC grain size.

Description	Range of Grain Sizes
Extra Coarse	over 5.0 microns
Coarse	3.5 up to 5.0 microns
Medium Coarse	2.0 up to 3.5 microns
Medium	1.5 up to 2.0 microns
Fine	1.1 up to 1.4 microns
Extra Fine or Micrograin	0.6 up to 1.0 microns
Ultra Fine or Nanograin	below 0.6 microns

The other significant development is a processing technique of sintering under pressure instead of vacuum or an ambient pressure atmosphere. This process is the Hot Isostatic Pressing or better defined Sinter HIP process.

During sintering the cobalt or nickel binder "melts" around the various carbides to produce a densified tool. Often there are very small voids or pores left remaining in the product that can weaken the tool by producing localized "stress risers". The Sinter HIP process eliminates nearly 100% of porosity, thus producing a tougher stronger tool. The strengthening effect is more pronounced with lower binder content tool material.

As one can see from all this information, it is technically impossible to achieve the optimum combination of all the above characteristic properties into a single grade. The properties counteract each other in some areas and overlap in others. This is the predominate factor in the seemingly unlimited number of grades on the market today.

It is therefore useful and sensible to define cemented carbides into groups according to properties and applications for which it is best suited. This grouping has resulted into the American "C" and the European "ISO" classifications.

During metalcutting, the machine, the workpiece, and the cutting tool work together as a system, influencing each other. The degree of rigidity, the geometry, and the surface preparations of the cutting tool effect the useful life of the cutting tool. The cutting tool is therefore dependent upon all the above factors and not solely determined by its own properties.