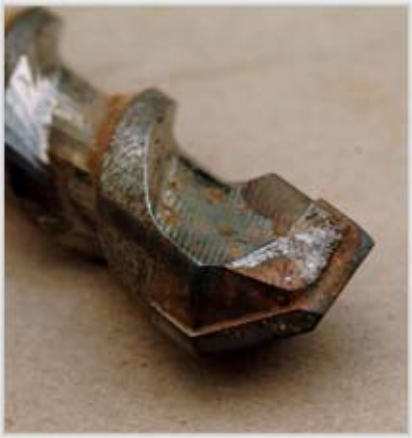
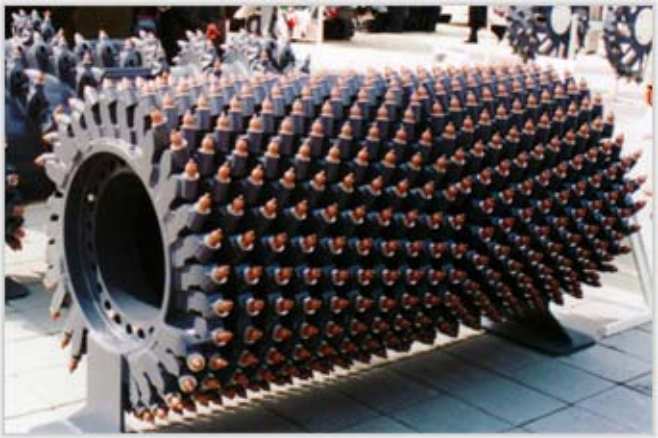
Tungsten carbides

Description

Image

Caption

1. Tungsten carbide tool tip. © images-of-elements.com - (CC BY-SA 3.0) 2. Masonry drill bit tip. A tungsten carbide insert is brazed to the steel drill body. © Emrys2 at en.wikipedia - (CC BY-SA 3.0) 3. Tungsten Carbide tipped cutter drum of a road rec

The material

Tungsten carbide (WC) is most commonly used in the form of a 'cemented' carbide, or cermet: particles of WC held by a small amount (5-20%) of metallic binder, usually cobalt. Its exceptional hardness and stability make it an attractive material when wear resistance is essential. Properties depend on grain size and shape and the proportion of carbide to metal. Cermets are expensive but, as cutting tools, they survive cutting speeds 10 times those of the best tool steel. Shaping is usually done by pressing, sintering and then grinding; the tool bit is brazed to a shank or blade made from a cheaper steel. Cermets can be vapor-coated with titanium nitride to improve wear resistance even further.

Composition (summary)

WC/ 2 - 10%Co

General properties

Density		952	- 991	lb/ft^3
Price	*	8.46	- 13.2	USD/lb
Date first used		1923		

Mechanical properties

Young's modulus	*	90.6	- 102	10^6 psi
Shear modulus	*	35.2	- 41	10^6 psi
Bulk modulus		52.2	- 59.5	10^6 psi
Poisson's ratio		0.18	- 0.21	
Yield strength (elastic limit)	*	48.6	- 79.8	ksi
Tensile strength		53.7	- 79.8	ksi
Compressive strength	*	485	- 991	ksi
Elongation		0		% strain
Hardness - Vickers		2.2e3	- 3.6e3	HV
Fatigue strength at 10^7 cycles	*	41.3	- 60.9	ksi
Fracture toughness		1.82	- 3.46	ksi.in^0.5
Mechanical loss coefficient (tan delta)	*	5e-5	- 1e-4	

Thermal properties

Melting point		5.12e3	- 5.29e3	°F
Maximum service temperature	*	1.38e3	- 1.83e3	°F
Minimum service temperature		-460		°F

Thermal conductor or insulator?	Good conductor			
Thermal conductivity	31.8	-	50.8	BTU.ft/h.ft^2.F
Specific heat capacity	0.0439	-	0.0697	BTU/lb.°F
Thermal expansion coefficient	2.89	-	3.94	µstrain/°F

Electrical properties

Electrical conductor or insulator?	Poor conductor			
Electrical resistivity	20	-	100	µohm.cm

Optical properties

Transparency	Opaque

Processability

Moldability	2	-	3	
Machinability	1	-	2	

Eco properties

Embodied energy, primary production	8.93e3	-	9.87e3	kcal/lb
CO2 footprint, primary production	4.44	-	4.9	lb/lb
Recycle	✗			

Supporting information

Design guidelines

Tungsten carbide (WC) and cermets - which are 80 to 95% WC - can only be shaped by slitting with diamond tools and by grinding, liming the shapes to which they can economically be formed. They are used only where needed: the tips (but not the shanks) of cutting tools for drilling, sawing, rock cutting. Only diamond-tipped tools are more wear resistant. Technical ceramics are formed by the following steps.(a) Pressing, isostatic pressing, powder extrusion (for bars and tubes) or powder injection molding (for intricate, high-volume parts).(b) Green-machining in the unfired state, using standard tools.(c) Firing or "sintering" typically at 1550 - 1700 C for 12 to 20 hours; the part shrinks by about 20%.(d) Diamond grinding to achieve tighter tolerance and surface finish: +/- 10 microns is achievable. The cost of a ceramic part is greatly increased if it has to be diamond-ground. Thus design for net-shape sintering, eliminating step (d) is highly desirable. The standard tolerance for as-fired dimensions is +/- 1% or 125 microns, whichever is greater.

Technical notes

Tungsten carbide starts as a powder, is pressed with up to 10% of cobalt to the desired shape, then fired at a high temperature under pressure, causing the cobalt to melt and bond the powder particles together.

Typical uses

Cutting tool tips; abrasives; cermets, oil-drilling and stone-cutting equipment, dental drills.

Tradenames

Cermet, Cemented carbide.

Links

Reference

ProcessUniverse

Producers