

Cutting Tools

Salient Properties of Cutting Tool Materials

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	Carbon and Low-/Medium-Alloy Steels	High-Speed Steels	Sintered Cemented Carbides	Coated HSS	Coated Carbides	Ceramics	Polycrystalline CBN	Diamond
Toughness	Decreasing							
Hot hardness	Increasing							
Impact strength	Decreasing							
Wear resistance	Increasing							
Chipping resistance	Decreasing							
Cutting speed	Increasing							
Depth of cut	Light to medium	Light to heavy	Light to heavy	Light to heavy	Light to heavy	Light to heavy	Light to heavy	Very light for single-crystal diamond
Finish obtainable	Rough	Rough	Good	Good	Good	Very good	Very good	Excellent
Method of manufacture	Wrought	Wrought cast, HIP sintering	Cold pressing and sintering, PM	PVD ^b after forming	CVD ^c	Cold pressing and sintering or HIP sintering	High-pressure-high-temperature sintering	High-pressure-high-temperature sintering
Fabrication	Machining and grinding	Machining and grinding	Grinding	Machining and grinding, coating	Grinding before coating	Grinding	Grinding and polishing	Grinding and polishing
Thermal shock resistance	Increasing							
Tool material cost	Increasing							

^aOverlapping characteristics exist in many cases. Exceptions to the rule are very common. In many classes of tool materials, a wide range of compositions and properties are obtainable.

^bPhysical vapor deposition.

^cChemical vapor deposition.

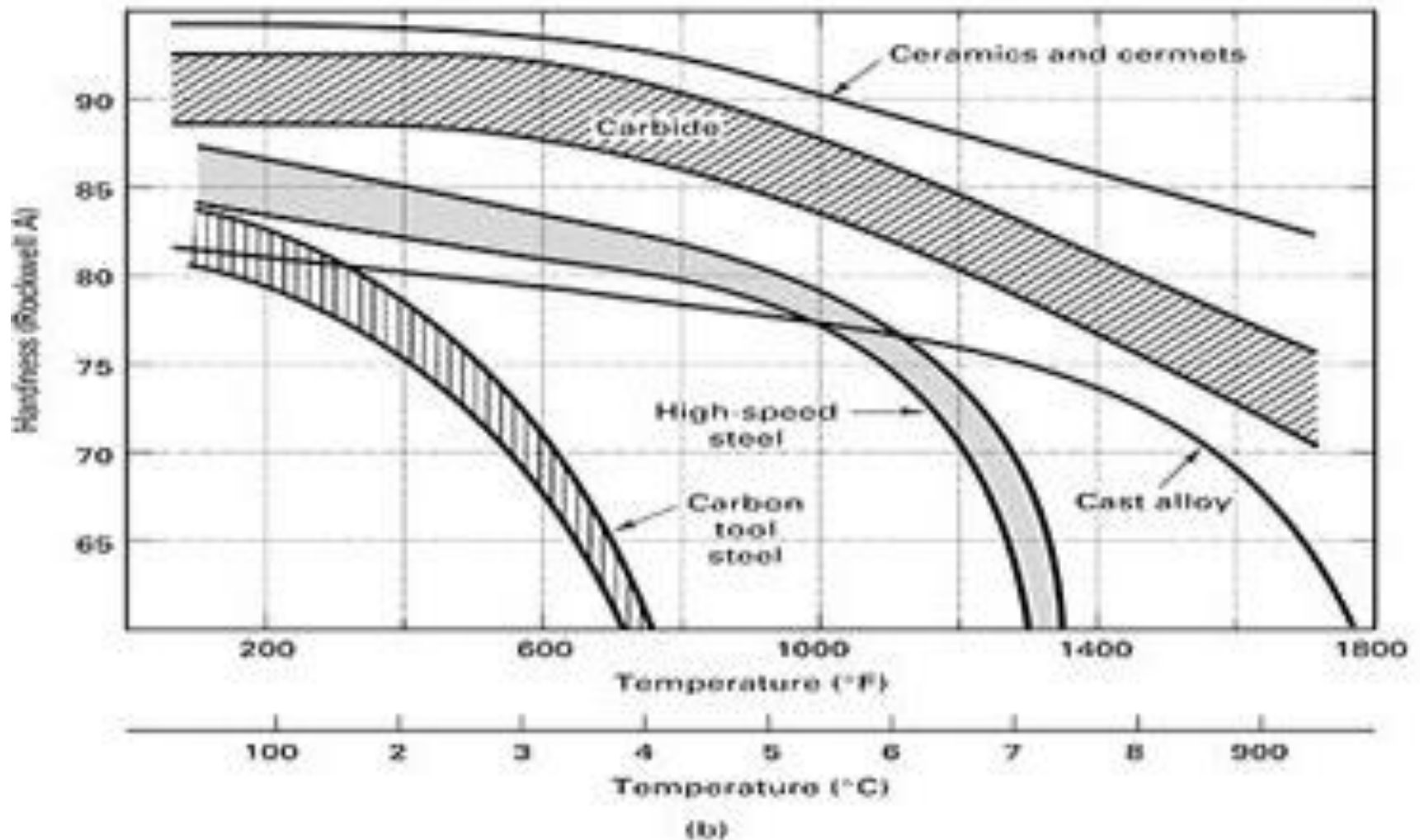
TOOL MATERIALS

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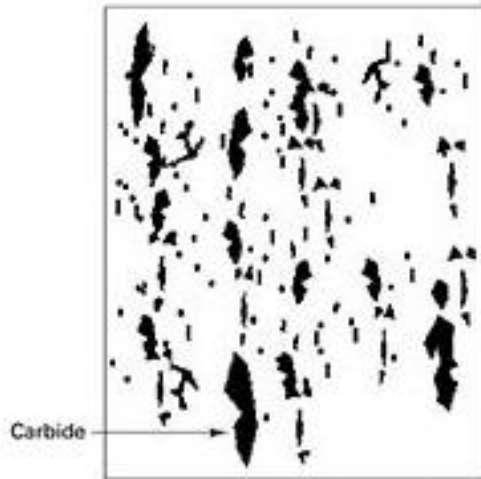
Desirable Tool Qualities

- High hardness
- High hardness temperature (hot hardness) – hardness decreases slowly with temperature
- Resistance to abrasion and wear due to severe sliding friction
- Resistance to chipping of the cutting edges
- High toughness (impact strength) – for interrupted cuts
- Strength to resist bulk deformation
- Good chemical stability
- Adequate thermal properties
- High elastic modulus (stiffness)
- Correct geometry and surface finish

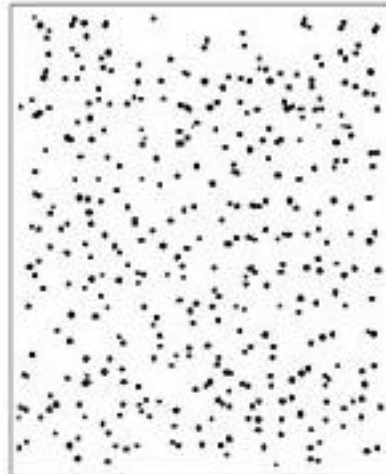
Hardness and Hot Hardness



Carbide Distribution



Conventional tool steel microstructure



P/M tool steels microstructure

Wear Resistance

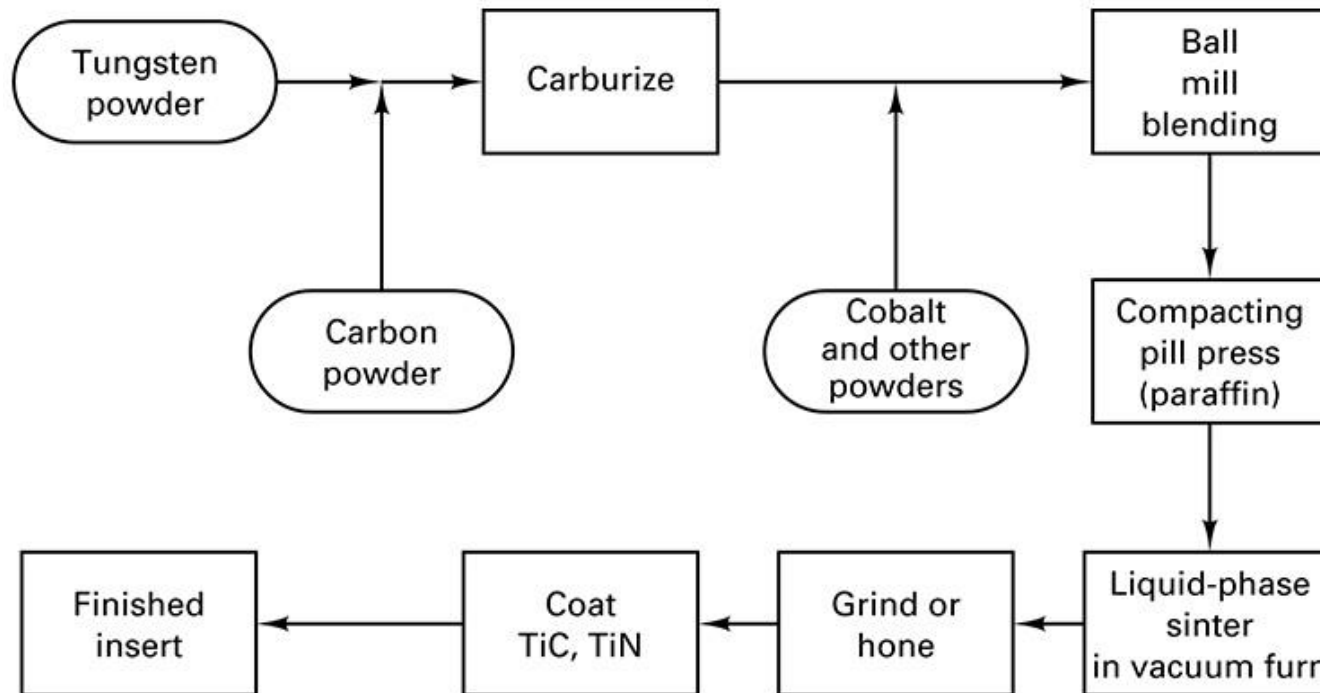
Alloy elements (Cr, V, W, Mo) form hard carbide particles in tool steel microstructures. Amount & type present influence wear resistance.

Hardness of carbides:

- | | |
|---------------------------|-------------|
| • Hardened steel | • 60/65 HRC |
| • Chromium carbides | • 66/68 HRC |
| • Moly, tungsten carbides | • 72/77 HRC |
| • Vanadium carbides | • 82/84 HRC |

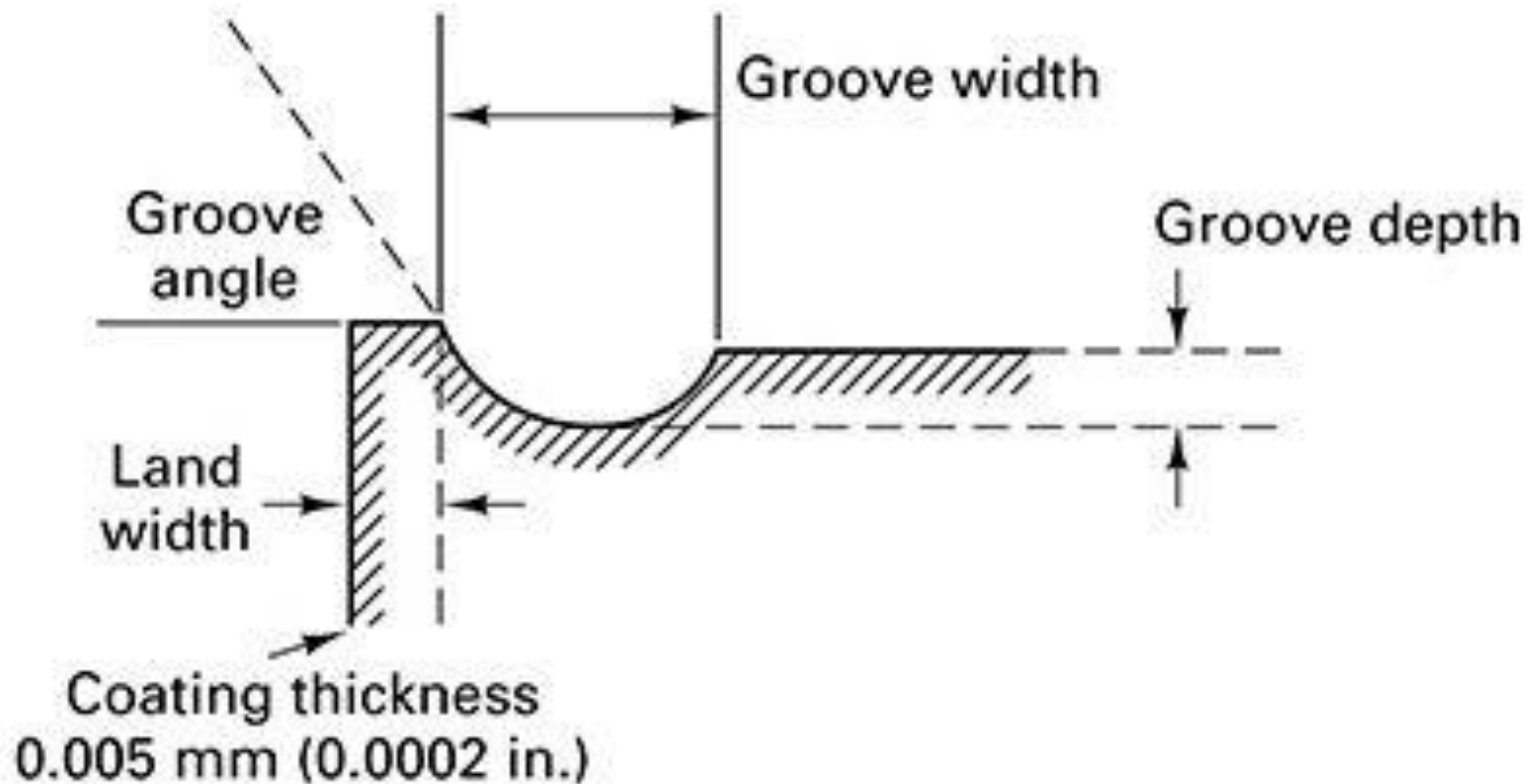
Microstructure of P/M tool steel versus conventional tool steels shows the fine carbide distribution, uniformly distributed.

Powder Metallurgy Process



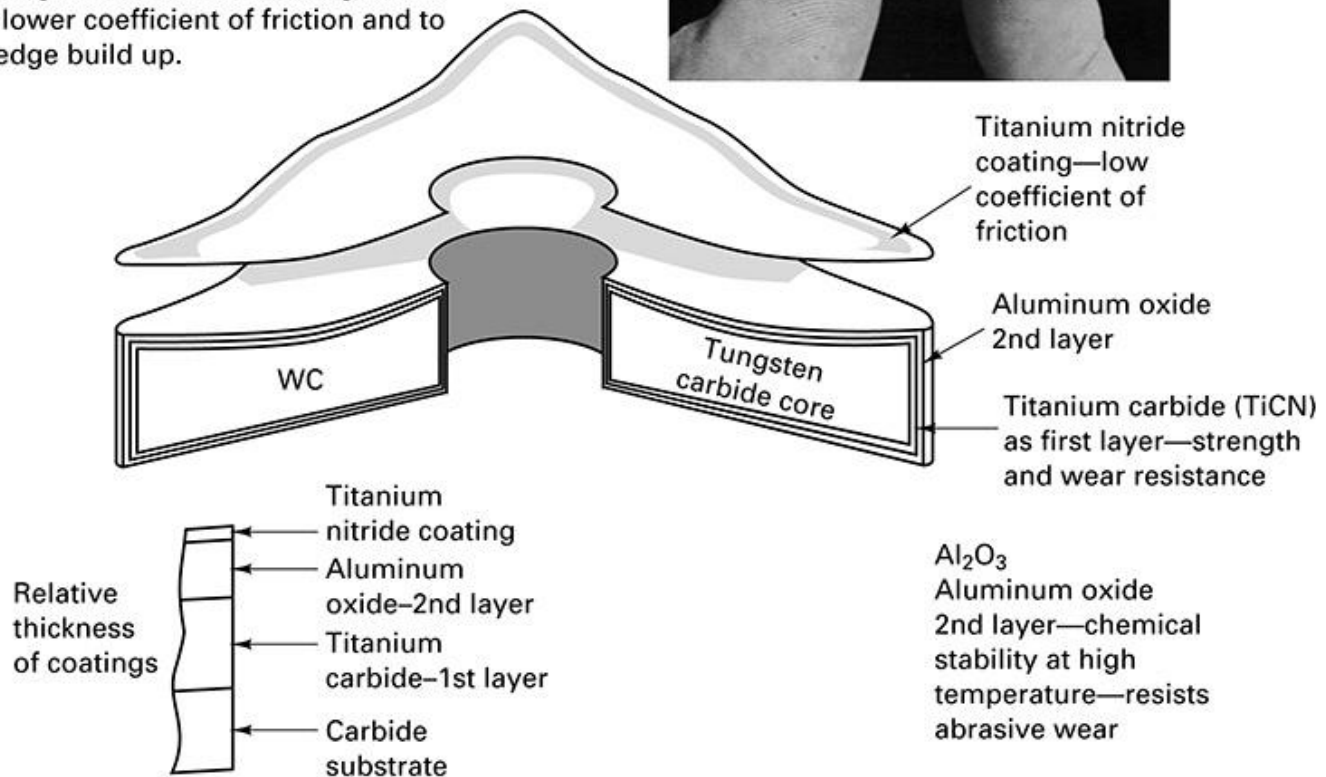
Tungsten is carburized in a high-temperature furnace, mixed with cobalt and blended in large ball mills. After ball milling, the powder is screened and dried. Paraffin is added to hold the mixture together for compacting. Carbide inserts are compacted using a pill press. The compacted powder is sintered in a high-temperature vacuum furnace. The solid cobalt dissolves some tungsten carbide, then melts and fills the space between adjacent tungsten carbide grains. As the mixture is cooled, most of the dissolved tungsten carbide precipitates onto the surface of existing grains. After cooling, inserts are finish ground and honed or used in the pressed condition.

Carbide Insert Contours

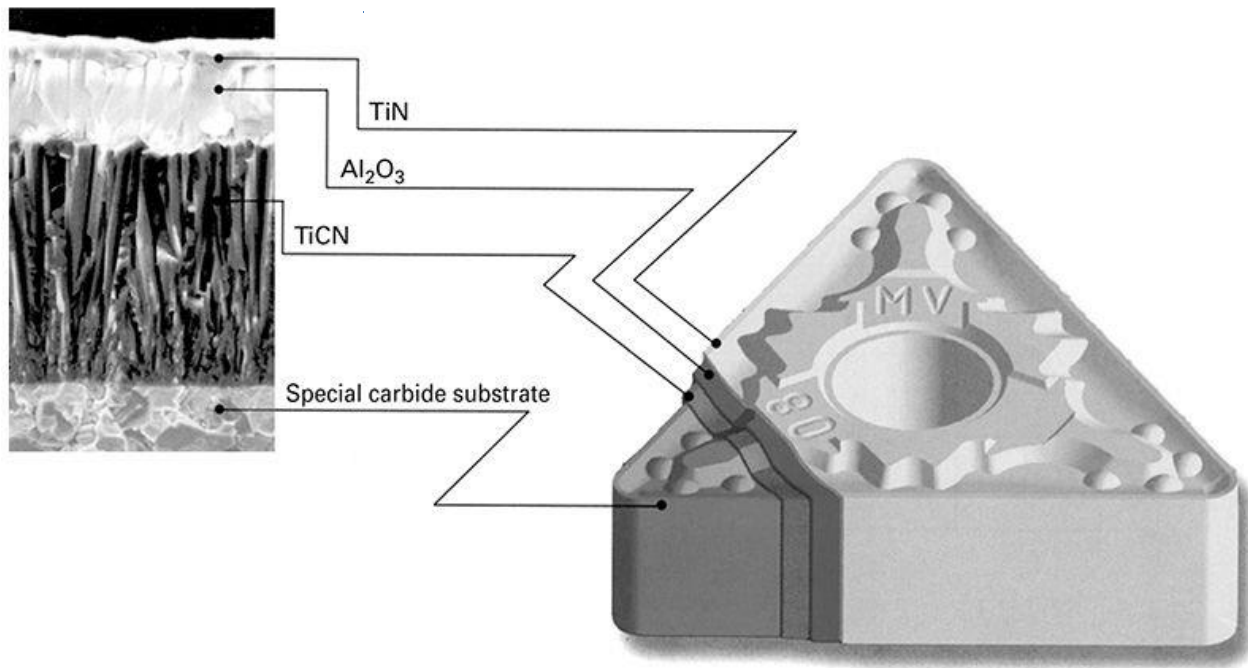


Coated Carbides

Titanium carbide remains as the basic material covering the substrate for strength and wear resistance. The second layer is aluminium oxide, which has proven chemical stability at high temperatures and resists abrasive wear. The third layer is a thin coating of titanium nitride to give the insert a lower coefficient of friction and to reduce edge build up.



Coated Carbide with Chip Groove



Cermets vs. other materials

