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General Cutting Tool Material

Characteristics of tool material is the major factor to influence the surface quality after machining, efficiency, and tool life. It affords the direct cutting work during machining.Mostly the cutting performance depends on the materials of cutting edge, the geometric parameters and the choice of the tool structure and design.The productivity, tool life, tool consumption, processing costs, machining accuracy, and surface quality,..etc., almost depends on the choice of tool materials.

The necessary properties of cutter materials:

1, Higher hardness and wear resistance
2, Sufficient strength and toughness
3, Better heat resistance
4, Excellent technology and economy

Popular tool materials:

carbon tool steel:

Nice steel with higher content of carbon (carbon content of 0.7% to 1.2%,such as T10A), higher hardness after quenching, low cost, but poor heat resistance.

alloy tool steel:

Adding a small amount of Cr, W, Mn, Si and other elements in carbon tool steel to formed carbon tool steel formation (such as 9SiCr.)It may reduce heat deformation and increase heat resistance. It's used to produce some hand tools which cutting speed isn't high, such as File, saw blade, reamer, and less used in the manufacture of other tool.

High-speed steel materials:

It is kind of alloy tool steel containing more alloy elements like W, Cr, and V. General high-speed steel: like W18Cr4V, widely used for the manufacture of various cutters with more complex shapes, such as twist drills, milling cutters, broaches, gear cutters and other forming tool, and so on.

Tungsten carbide material:

Carbide is made of difficult-to-fuse metal carbides (eg. WC, TiC, TaC, NbC, etc.) and the metal binder (eg. Co, Ni, etc.) powder by metallurgy method. It is with high hardness, good wear resistance, high heat resistance, and allowing higher cutting speed, several times higher than high-speed steel, but its strength and toughness are lower than high-speed steel, the craft is not as high-speed steel, so it is often made of various types of blades,welding or mechanical clamping on the turning tools, planer, end mill shank (cutter body).

Ceramic or metal cermet materials:

Al2O3 base, and Si3N4-base two types, a kind of cutting tool material is based of aluminum oxide or silicon nitride matrix and adds tiny metal, then sintered under high temperatures, which with high hardness and wear resistance. The hardness may reach 91 ~ 95 HRC at room temperature; and with high heat resistance, the hardness is 80HRC under high temperature of 1200 ℃; And bending strength and the toughness decreases is very few under high temperature conditions; High chemical stability, low affinity for ceramic and metal, good oxidation resistance under high temperature, no interaction with steel even in the melting temperature. Thus less tool bonding, diffusion, and oxidation wear; low coefficient of friction, which the chip is not easy to stick and difficult to produce a built-up edge.

Super-hard tool materials:

There are three kinds, natural diamond, polycrystalline diamond and polycrystalline cubic boron nitride.
Natural diamond: the hardest material in the world, its hardness range during HK8 000 ~ 12 000 (HK The Knoop hardness, unit: kgf/mm2), the heat resistance is around 700 ~ 800 ℃. Natural diamond has excellent abrasion resistance but very expensive, mainly used for precise parts with strict standard of the machining accuracy and surface roughness, such as processing a floppy disk, laser reflectors, drum, and muti-mirror. The main drawback is the affinity of ferrous materials, not proper for machining steel and cast iron.

Polycrystalline diamond (PCD):

Allotrope of carbon, transformed from graphite under high temperature and pressure, which is the hardest artificial material. High hardness, good wear resistance and cutting sharp edge, sharp blade, low surface friction coefficient ,difficult to bond or BUE, it can replace the natural diamond in most places, which can be produced various turning, boring,cutters and other blades.

Cubic boron nitride (CBN):

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Cubic Boron Nitride (CBN) is a new synthetic cutting tool material, it is transformed from hexagonal boron nitride by adding a catalyst under high temperature and pressure. High hardness and wear resistance, good thermal stability, chemical inertness, not easy to have chemical reaction with ferrous metals at 1300 ℃, good thermal conductivity, low coefficient of friction.

Comparison Table of cutting tool materials

切削刀具材料比較表									
材質material 屬性properties		Mono Diamond	CO PCD	si PCD	PCBN	Si3N4	SiC	WC	Steel
Density 密度	g/cm3	3.52	3.8~4.10	3.4	4~4.20	3.2	3	15	7.8
Knoop Hadrness 諾氏硬度	kg/mm2	6000~9000	5000~8000	5000	2700~3200	1800	2200	1500	560
Toughuess 韌性	Mpam-2	3.4	6.1~8.9	6.9	4.1~7.2	6.4	4	11	46
Compression Strength 壓縮強度	Mpa	2000	7700	4200	3800	6800	7000	5400	1850
Tensile strength 拉伸強度	Mpa	2600	1300	600	500	470	400	1100	1760
Thermal Expansion 熱膨脹係數	10-6/℃	0.8~4.8	1.5~3.8	3.8	3.5~4.2	3.5	3.8	4.3~5.6	11.2~14.3
Thermal Conductivity 導熱係數	w/mk	600~1200	560	120	150	30	40	80	50
Friction 摩擦係數		0.05~0.10	0.1	0.1	0.1	0.2	0.2	0.2	0.8