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TOOL MAKER'S TIP:

HSS cutting tools: the most versatile choice for machining steels!

Soft steels
< 550 Mpa

Include resulphurized and rephosphorized carbon steels containing less than 0.65% manganese, 0.60% silicon and 0.60% copper. Magnetic steels and leaded steels are also included.

- Uses: magnetic and electric devices and numerous other applications.
- Machinability: excellent.

Structural steels and plain carbon steels
< 850 Mpa

- Uses: buildings, bridges, shafts, axles, pins, bolts, nuts, rods, gears, track links, structural components, carburized parts and cold-headed products.
- Machinability: good.

Alloy steels

Contain percentages of manganese, silicon, nickel, chromium, molybdenum.

- Uses: bearings, machinery parts, axles, gears, pressure vessels, chains, hand tools, trucks and farm machinery.
- Machinability: generally good for alloy steels < 850 Mpa. More difficult when the strength increases.

TOOL MAKER'S TIP:

The sharp edges of HSS cutting tools help prevent work hardening of stainless steels

Free machining ferritic stainless steels

Have a ferritic structure sometimes with a matrix of chromium carbides.

No nickel content, low carbon content, not hardenable.

- Uses: electronics, automotive exhausts, material handling equipment, hot water tanks
- Machinability: low.

Austenitic stainless steels

Provide superior corrosion resistance. Most widely used stainless steels.

- Uses: electronics, pharmaceuticals, chemical industry, food processing equipment, architectural applications
- Machinability: difficult compared to ferritic and martensitic steels. Exhibit good high temperature strength, strong work-hardening tendencies and require greater power to machine. Low cutting speeds and heavy feeds are recommended.

Ferritic-austenitic, ferritic, martensitic, and precipitation hardening stainless steels

And highly alloyed stainless steels. Hybrid of ferritic and austenitic. Mechanical properties combine qualities of each component steel type. Duplex steels combine anti-corrosive and mechanical properties.

- Uses: marine applications, desalination plants, heat exchangers and petrochemical plants, structural parts.
- Machinability: good, for low carbon/ low chromium steels. Difficult for high carbon martensitic steels due to their abrasiveness.

TOOL MAKER'S TIP:

Use TiAlN-coated HSS cutting tools to machine cast iron and to avoid workpiece chipping when the tool goes out

Grey cast iron (lamellar graphite cast iron)

Basic low-cost cast iron.

- Uses: brake rotors and brake drums, head cylinders, cylinder blocks, valve bodies, machine tool frames.
- Machinability: excellent.

Nodular graphite cast iron

Exhibit the best strength, competing with structural steels in automotive applications.

- Uses: camshafts, crankshafts, etc.
- Machinability: good.

Hardened cast iron

- Uses: gears
- Machinability: poor

TOOL MAKER'S TIP:

Use HSS cutting tools to prevent built-up edges during machining of aluminium alloys and to produce thick chips in magnesium

Unalloyed aluminium

Pure aluminium (≥ 99% Al) exhibits excellent formability and resistance to corrosion.

- Uses: chemical processing, tanks, marine equipment, cooking ustensils, building frames and deep-drawing applications.
- Machinability: excellent but with continuous extra long chips and gumminess.

Aluminium alloys

High strength and good atmospheric corrosion resistance.

- Uses: aircraft structural applications, mobile equipment, pipes and fittings, high pressure hydraulic units, bikes and motorbikes.
- Machinability: good to excellent, depending on heat treatment. Easier with higher hardnesses.

Aluminium alloys 5% < Si <10%

Include the most widely used die-casting alloys.

- Uses: cylinder blocks, head cylinders, automotive and aeronautic casings, housings, structural frames, ornamental castings.
- Machinability: good.

Aluminium alloys >10% Si

Consist of forging and die-casting alloys.

- Uses: brake drums, pulleys, cylinder liners, forged pistons, complex castings.
- Machinability: only fair. Lower with higher Si content.

Magnesium

Lighter than aluminium.

- Uses: instrument housing, portable tools and automotive casing.
- Machinability: high but thick chips are needed to avoid fire hazard.

TOOL MAKER'S TIP:

Trust in the reliability of HSS cutting tools, for machining copper alloys

Pure copper

- Uses: EDM electrodes, electric components.
- Machinability: good, but gummy.

Copper alloys

Brass (5-45% Zn)
and bronze (3-20% Sn)

- Uses: electric components, electronics, building equipment, lock parts, automotive valves, micromechanics
- Machinability: good

Aluminium bronze

- Uses: chemical industry, pumps and valve seats, marine applications (propellers), desalination plants
- Machinability: medium

TOOL MAKER'S TIP:

TiAlN coated HSS-PM cutting tools: an efficient choice for the machining of titanium and nickel alloys

Unalloyed titanium

(or pure titanium)

Show superior corrosion resistance

- Uses: chemical processing industry.
- Machinability: moderate work hardening tendency but require sharp tools, rigid set-ups, low cutting speeds, heavy feeds and high coolant flow.

Coatings also useful against seizing and galling tendencies.

Titanium alloys

(or alpha-beta titanium alloys)

Can be heat treated to very high strength levels.

- Uses: compressor blades, jet engine parts, air frame and space capsule components, pressure vessels, fasteners, helicopter rotor blades.
- Machinability: rigid set-ups, low cutting speeds and high coolant flow recommended.

Unalloyed nickel alloys

(or pure nickel)

Mechanical properties similar to those of carbon steels. Good to excellent corrosion resistance .

- Uses: chemicals, catalysts, batteries, coins
- Machinability: low speeds required due to high temperatures during machining. Coatings useful against galling and built-up edges.

Nickel alloys

Often contain chromium.

Exhibit high strength at high temperatures with resistance to oxidation and corrosion.

- Uses: turbine blades, power plant components, marine uses.
- Machinability: low. Require rigid set-ups and specially designed cutting tools, with TiAlN coatings.

TOOL MAKER'S TIP:

Coated HSS-PM cutting tools: the «four-wheel drive» solution to machining hard materials

Tool steels
> 45 HRC

Alloy steels with high carbon content.

- Uses: cutting and forming dies, punches, rolls, gages, cams and fixtures
- Machinability: poor

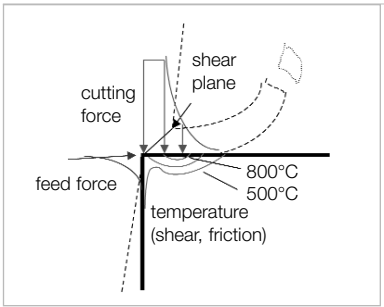
SUCCESS STORY

Wear resistant steel
600 HB

Operation
- Drilling of through holes Ø 18 mm, depth 25 mm with 5% emulsion on pilar-type drilling machines

Solution:
- HSS-PM 5% Co drill with TiAlN coating and special geometry
  Benefits compared with conventional HSS drills (carbide drills could not be used)
  - Longer tool life (30 holes)
  - Higher cutting data (v_c 15 m/min, f 0.14 mm/rev)

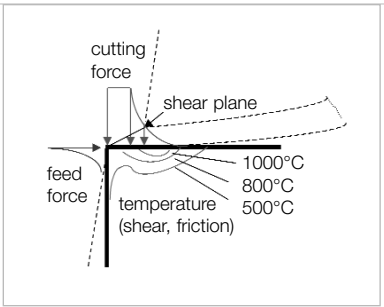
Plastics and thermosetting plastics	Reinforced plastics	Graphite	Wood
• Uses: portable phones and computers, automotive parts, home appliances, building, packaging • Machinability: excellent. HSS is the best choice !	• Uses: motor vehicles, boat hulls, storage tanks, electrical components and pipe, sporting goods, aircraft, industrial machinery, computers • Machinability: good. Sharp edges of HSS tools are efficient against delamination combined with coatings to resist abrasion. HSS-PM tools are recommended for the machining of multi-material components or for honeycomb parts.	• Uses: crucibles, refractories, furnace hearths, rockets, nuclear power plants, motor brushes, electrodes • Machinability: poor.	• Uses: furniture, construction, toys, musical instruments, kitchen ware • Machinability: excellent.



Hard, brittle material

- Short chips, moderate temperature
- High normal cutting and feed forces

Requirements: high abrasive wear resistance & compressive residual stress of coating

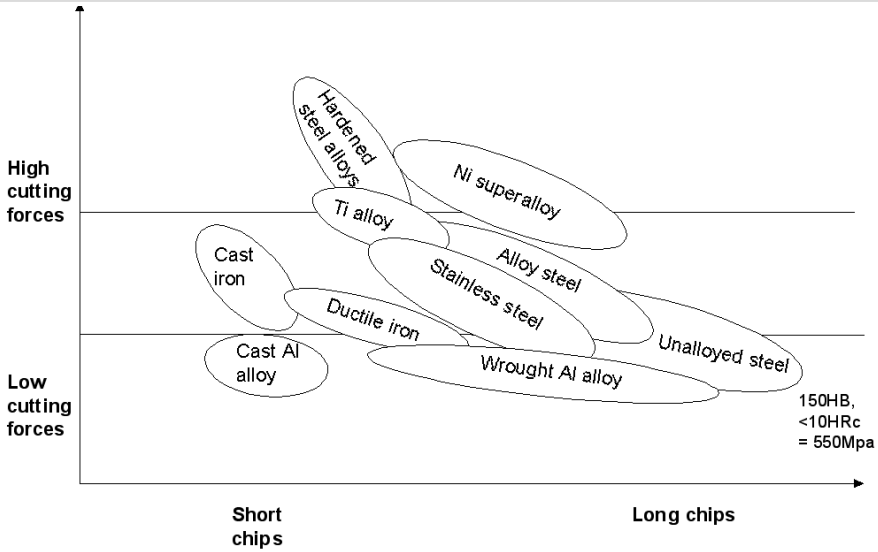


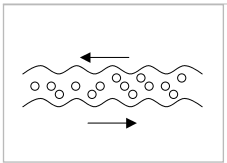
Soft, ductile material

- Long contact length and high temperature on rake face
- High surface shear forces
- Tendency for built-up edges

Requirements :

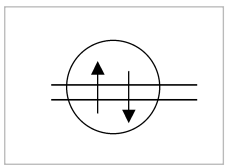
+ high chemical wear resistance
+ best adhesion of coating
+ no tendency for sticking


High cutting forces
Low cutting forces
Hardened steel alloys
Ni superalloy
Ti alloy
Alloy steel
Cast iron
Stainless steel
Ductile iron
Unalloyed steel
Cast Al alloy
Wrought Al alloy
150HB, <10HRc = 550Mpa
Short chips
Long chips



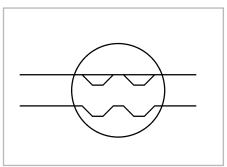
Abrasive wear

Mechanical wear due to friction between the piece and the tool



Chemical wear

Migration of atoms between the tool and the chip due to high temperature and pressure

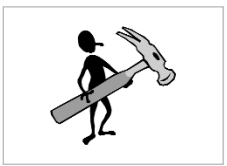


Adhesive wear

Combined thermal and chemical wear caused when chip removes tool material by «sticking»

Thermal stress

Stress due to high temperatures (400-750°C)



Mechanical stress

Stress due to vibrations, shocks, pressure

Flank wear

Friction between the workpiece and the flank face of the tool, due to abrasive wear

Crater wear

Wear mode producing a crater on the cutting face of the tool, due mainly to chemical wear and partly to abrasive wear

Built-up edge

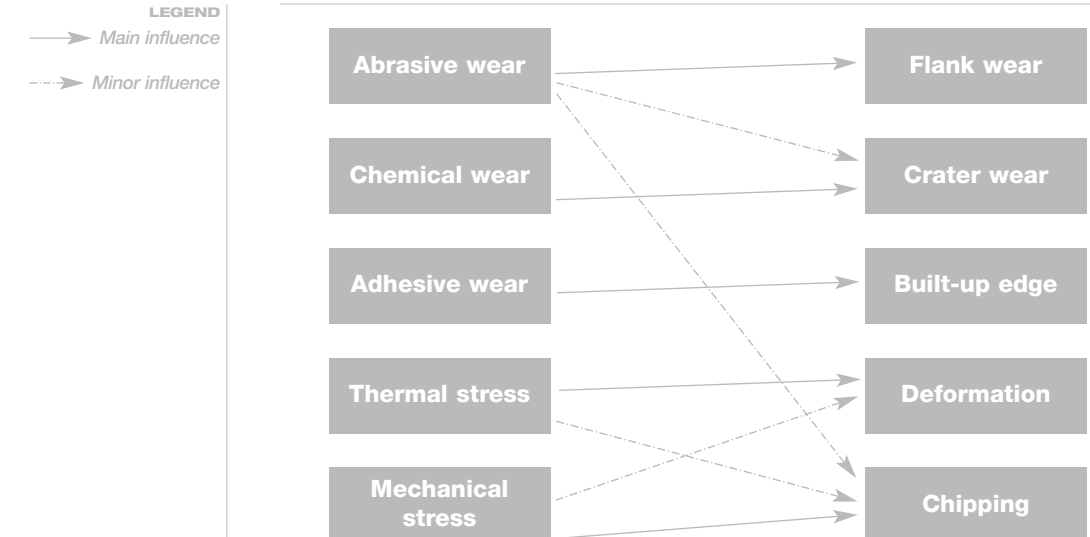
Wear mode where the workpiece material sticks on the tool edge, due to adhesive wear

Plastic deformation

Wear mode where the tool edge is deformed, mainly due to high temperatures and partly to high mechanical stresses

Chipping

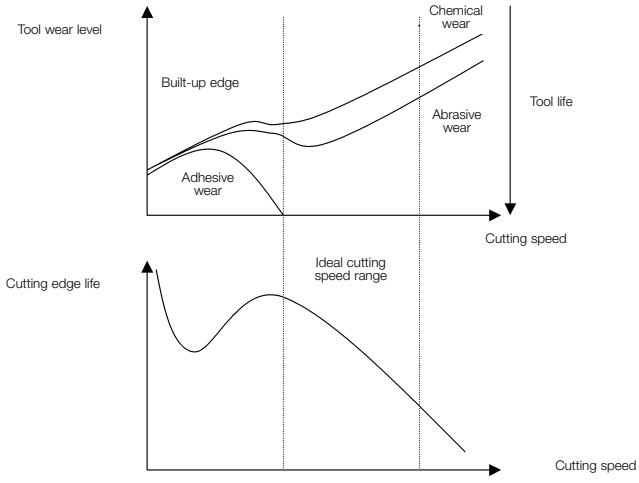
Breakage of small pieces of the tool edges, mainly due to mechanical stresses and partly due to thermal stress



FAILURE MODES AND TYPES OF WEAR

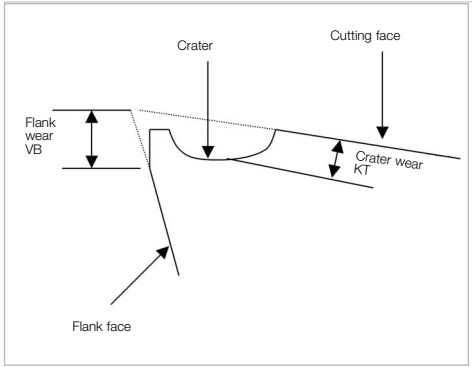
TOOL MAKER'S TIP:

In the ideal cutting speed range, abrasive wear must be predominant. Chemical and adhesive wear must remain at a low level.

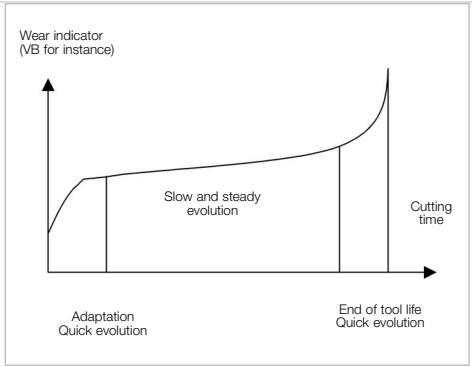


TOOL MAKER'S TIP:

Prefer abrasive wear for a long and predictable tool life.



Wear indicators (VB, KT)



Wear evolution

English	French	German	Italian	Spanish
Machining	**Usinage**	**Metallbearbeitung**	**Lavorazione**	**Mecanizado**
Machine tool	Machine-outil	Werkzeugmaschine	Macchina utensile	Máquina-herramienta
Workpiece	Pièce	Werkstück	Pezza	Pieza
Coolant	Fluide de coupe	Kühlemittel	Lubrificante	Fluido de corte
Wear	Usure	Abnutzung	Usura	Desgaste
Toollife	Durée de vie	Werkzeug-lebensdauer	Durata di vita	Vida útil
Chip	Copeau	Span	Truciolo	Viruta
Roughing	Ebauche	Schruppen	Sgrossatura	Desbaste
Finishing	Finition	Schlichten	Finitura	Acabado

Cutting tool	Outil de coupe	Werkzeug	Utensile	Herramienta de corte
High speed steel	Acier rapide	Schnellstahl	Acciai rapidi	Acero rápido
Coating	Revêtement	Beschichtung	Rivestimento	Revestimiento
Shank	Queue	Schaft	Coda	Mango
Cutting edge	Arête de coupe	Schneidkante	Spigolo di taglio	Arista de corte
Cutting tooth	Dent	Werkzeugzahn	Dente	Diente
Rake face	Face de coupe	Spanfläche	Faccia di taglio	Superficie de corte
Flank face	Face de dépouille	Freifläche	Fianco	Superficie de incidencia
Helix	Hélice	Spirale	Elica	Helice
Flute	Goujure	Spannut	Scanalatura	Ranura
Pitch	Pas	Teilung	Passo	Paso
Point	Pointe	Spitze	Punta	Punta

English	French	German	Italian	Spanish
Steel	Acier	Stahl	Acciai	Acero
Stainless steel	Acier inoxydable	Rostfreier Stahl	Acciai inossidabili	Acero inoxidable
Tool steel	Acier à outil	Werkzeugstahl	Acciai per utensili	Acero de herramientas
Cast iron	Fonte	Eisenguss	Ghise	Fundición
Aluminium	Aluminium	Aluminium	Alluminio	Aluminio
Magnesium	Magnésium	Magnesium	Magnese	Magnesio
Copper	Cuivre	Kupfer	Rame	Cobre
Brass	Laiton	Messing	Ottone	Latón
Bronze	Bronze	Bronze	Bronzo	Bronce
Titanium	Titane	Titan	Titanio	Titanio
Nickel	Nickel	Nickel	Nichel	Niquel
Zinc	Zinc	Zink	Zinco	Zinc
Plastics	Plastiques	Kunstoffe	Plastiche	Plásticos
Fiber reinforced plastics	Plastiques renforcés	Faserverstärkte Kunststoffe	Plastiche rinforzati con fibre	Plásticos reforzados con fibras
Graphite	Graphite	Graphit	Graffito	Grafito
Wood	Bois	Holz	Legno	Madera

Symbol	English	French	German	Italian	Spanish
V_c	Cutting speed	Vitesse de coupe	Schnittgeschwindigkeit	Velocitá di taglio	Velocidad de corte
n	Revolution per minute	Vitesse de rotation	Drehzahl	Velocitá di rotazione giri	Número de revoluciones por minuto
V_f	Feed speed	Vitesse d'avance	Voschubgeschwindigkeit	Velocitá di avanzamento	Velocidad de avance
f	Feed per revolution	Avance par tour	Vorschub pro Umdrehung	Avanzamento per giro	Avance per revolución
f_z	Feed per tooth	Avance par dent	Vorshub pro Zahn	Avanzamento per dente	Avance per diente
d	Diameter	Diamètre	Durchmesser	Diametro	Diametro
z	Number of teeth	Nombre de dents	Zahnezahl	Numero di denti	Número de dientes
Q	Chip removal rate	Débit de copeaux	Zeitspanungsvolumen	Volume truciulo per unitá di tiempo	Caudal de viruta
h	Chip thickness	Epaisseur du copeau	Spandicke	Spessore truciolo	Espesor de viruta
a_e	Radial depth of cut	Largeur de passe radiale	Radiale Zustellung	Larghezza radiale di passata	Anchura de corte radial
a_p	Axial depth of cut	Profondeur de passe axiale	Axiale Zustellung	Profonditá assiale di passata	Profundidad de corte axial

Brinell	Vickers	Rockwell C
	1200	71.5
	1100	70.4
	1050	69.8
	1000	69.1
	970	68.6
	940	68
	920	67.5
	900	67
767	800	66.4
757	860	65.9
745	840	65.3
733	820	64.7
722	800	64
712	782	63.5
710	780	63.3
698	760	62.5
684	740	61.8
682	737	61.7
670	720	61
656	700	60.1
653	697	60
647	690	59.7
638	680	59.2
630	670	58.8
627	667	58.7
601	640	57.3

Brinell	Vickers	Rockwell C
578	615	56
565	591	54.7
534	569	53.5
514	547	52.1
495	528	51
477	508	49.6
461	491	48.5
444	472	47.1
429	455	45.7
415	440	44.5
401	425	43.1
388	410	41.8
375	396	40.4
363	383	39.1
352	372	37.9
341	360	36.6
331	350	35.5
321	339	34.3
311	328	33.1
302	319	32.1
293	309	30.9
285	301	29.9
277	292	28.8
269	284	27.6
262	276	26.6
255	269	25.4

Brinell	Vickers	Rockwell C	Rockwell B
248	261	24.2	
241	253	22.8	100
235	247	21.7	99
229	241	20.5	98.2
223	234		97.3
217	228		96.4
212	222		95.5
207	218		94.6
201	212		93.8
197	207		92.8
192	202		91.9
187	196		90.7
183	192		90
179	188		89
174	182		87.8
170	178		86.8
167	175		86
163	171		85
156	163		82.9
149	156		80.8
143	150		78.7
137	143		76.4
131	137		74
126	132		72
121	127		69.8
116	122		67.6
111	117		65.7