USEFUL
INFORMATION

SUMMARY

MACHINABILITY OF MATERIALS

WEAR, GLOSSARY, HARDNESS

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

- Uses: portable phones and computers, automotive parts, home appliances, building, packaging
- Machinability: excellent. HSS is the best choice !

Reinforced plastics

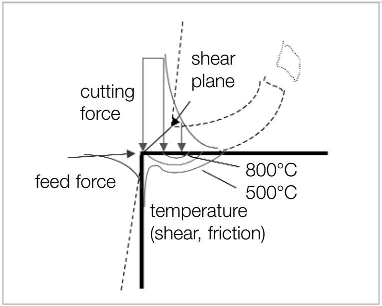
- Uses: motor vehicles, boat hulls, storage tanks, electrical components and pipe, sporting goods, aircraft, industrial machinery, computers
- Machinability: good. Sharp edges of HSS tools are efficient against delamination combined with coatings to resist abrasion. HSS-PM tools are recommended for the machining of multi-material components or for honeycomb parts.

Graphite

- Uses: crucibles, refractories, furnace hearths, rockets, nuclear power plants, motor brushes, electrodes
- Machinability: poor.

Wood

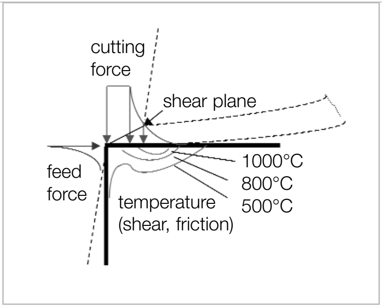
- Uses: furniture, construction, toys, musical instruments, kitchen ware
- Machinability: excellent.



Hard, brittle material

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

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

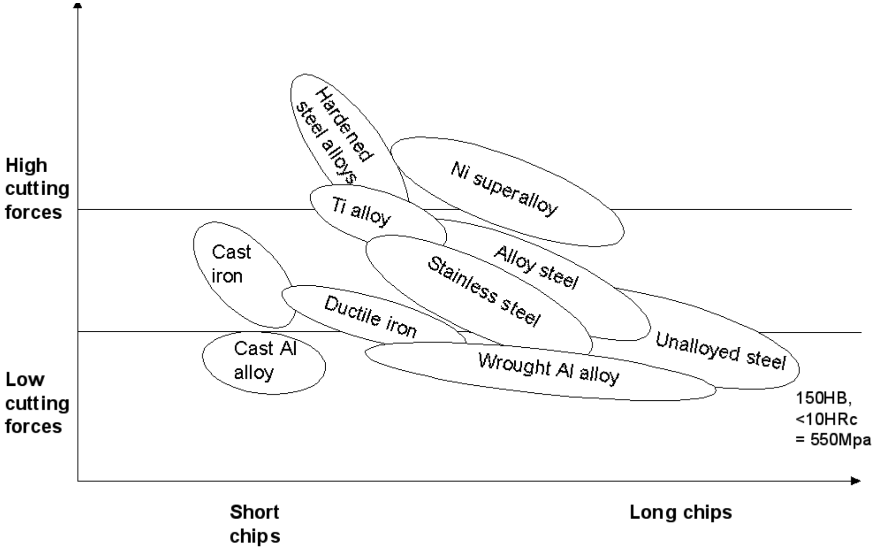


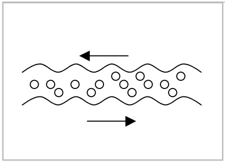
Soft, ductile material

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

Requirements :

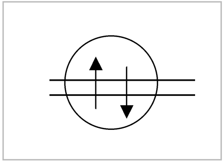
+ high chemical wear resistance
+ best adhesion of coating
+ no tendency for sticking


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



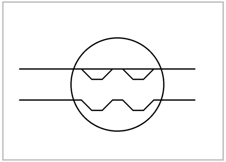
Abrasive wear

Mechanical wear due to friction between the piece and the tool



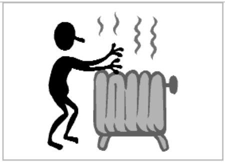
Chemical wear

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



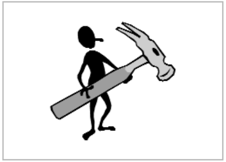
Adhesive wear

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



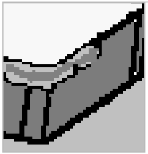
Thermal stress

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



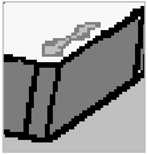
Mechanical stress

Stress due to vibrations, shocks, pressure



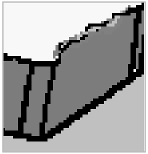
Flank wear

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



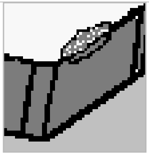
Crater wear

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



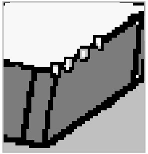
Built-up edge

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



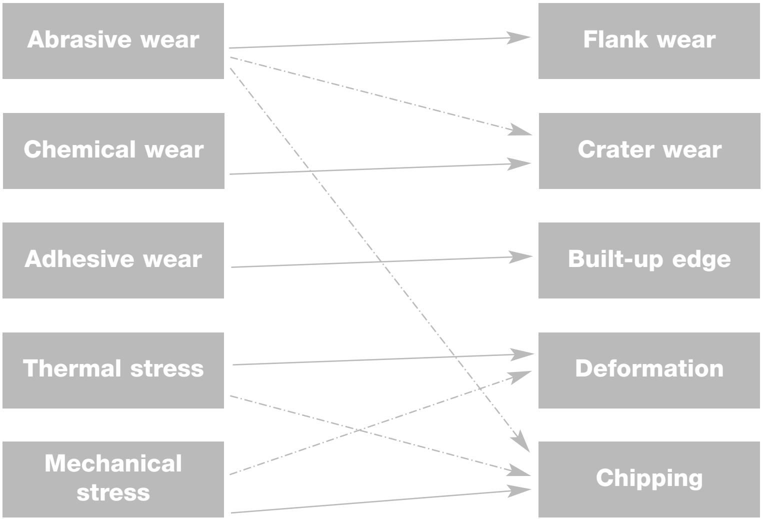
Chipping

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

LEGEND

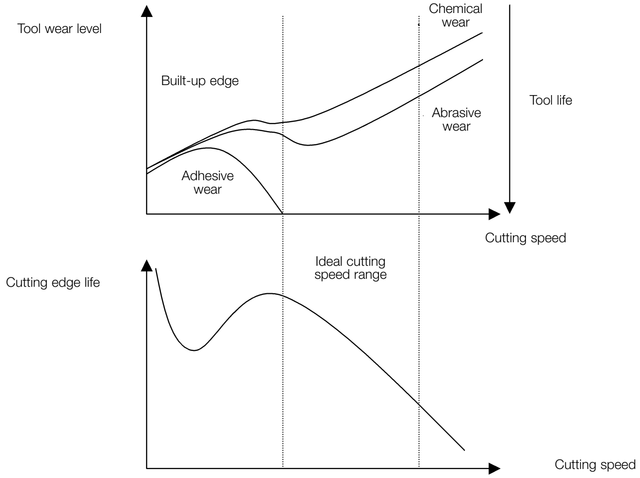
Main influence

Minor influence



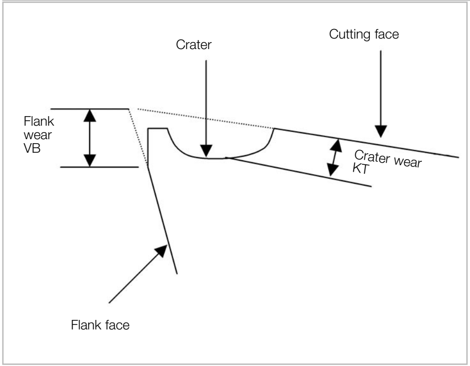
TOOL MAKER'S TIP:

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

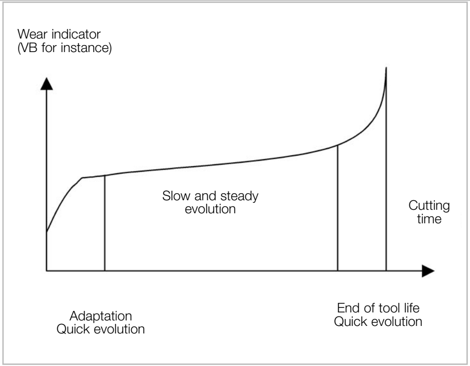


TOOL MAKER'S TIP:

Prefer abrasive wear for a long and predictable tool life.



Wear indicators (VB, KT)



Wear evolution