Hard Material Solutions

2022 EN

Carbide is a matter of confidence

CERATIZIT is a high-technology engineering group specialised in cutting tools and hard material solutions.

Tooling a Sustainable Future

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Welcome to Premium

Only the best in wear parts match up to your industry-leading processes. Your solution precisely – that's what you want. Do you need an expert able to transform your requirements into custom-made and standard products? CERATIZIT is your partner of choice, with leading tooling solutions as the final touch to your value chain.

Efficiency. Precision. Reliability.
Solutions are based on a consistently homogeneous and reproducible cemented carbide structure that guarantees extended tool performance, stability, and strength for the full working life. For example, CF carbide grades developed for toolmaking meet the most extreme requirements: corrosion-resistant, wear-resistant and optimally tailored to your needs. This solution has been found convincing by tooling experts all over the world.

Guaranteeing you a high-productivity result whatever the application, CERATIZIT is the partner who listens closely, thinks with you, and delivers personal service – with guidance on grade selection, mirroring your process chain and offering bespoke seminars. Trust in our leading expertise, which extends from raw materials and blanks to ready-to-use products. Years of experience help our experts create customer-focused ideas, using their outstanding know-how for maximum performance, to the benefit of your value chain.

More than just wear parts.
Deep knowledge in planning, design skills, and expertise in production engineering: three aspects that sum up exactly why the end result is just the solution you are looking for.
With new creations, innovations and milestones, CERATIZIT regularly shapes the future for tooling experts – helping you to sharpen your competitive edge with premium metal carbides. Today, tomorrow and the day after, one thing is constant: you are not just our customer but our partner.

Yours,
the CERATIZIT team

The CERATIZIT Group

For over 100 years, CERATIZIT

has been a **pioneer** developing exceptional hard material products for cutting tools and wear protection.

The privately owned company, based in Mamer, Luxembourg, develops and manufactures highly specialised carbide cutting tools, inserts and rods made of hard materials as well as wear parts.
The CERATIZIT Group is the **global market leader** in several wear part application areas, and successfully develops new types of cemented carbide, cermet and ceramic grades which are used for instance in the wood, metal and stone working industries.

Facts and figures

Headquarters

Mamer, **Luxembourg**

25 more than **production sites**

7 more than **000 employees**

80 more than **countries in which we are active**

1 more than **00 000 products**

1 more than **000 patents & utility models**

2 more than **00 R&D employees**

35 % of products **developped in the last 5 years**

15 more than **innovation awards**

Production sites

Four locations of the CERATIZIT Group focus on the development and the manufacture of products for wear protection.

Mamer (Luxembourg)
The CERATIZIT Group has its headquarters in Mamer in Luxembourg. Today the plant in Mamer has more than 1,150 employees and concentrates on industrial wear protection, wood and stone machining as well as inserts and tools.

Alserio (Italy)
CERATIZIT Como, formerly known under the name ‘Aldap’ has around 180 employees and is the centre of excellence for metal forming within the CERATIZIT Group. The product range of the Alserio plant ranges from high-performance cold forming tools to fastening and nail making tools.

Empfingen (Germany)
Around 400 employees at the Empfingen plant are responsible for the development, construction, production and sales of carbide products in the wear parts sector as well as for the tool and die industry.

Why cemented carbide?

Every year the requirements for tungsten carbide tools are growing. The reason for this is the competitive situation which we have to face and which is definitely not becoming easier through globalisation. An ever increasing number of competitors, some of them from low-wage countries push into the traditional markets putting traditional tool makers under pressure.

In order to face these difficulties it is necessary to respond with technically fully-fledged tools that offer both high-performance and high quality.

High-performance tools stand for long and predictable tool life. Actually it is possible to meet all these requirements with one tool material only, namely with high quality cemented carbide.

Carbide ensures long tool life, and the high quality level in manufacturing is absolutely necessary to guarantee consistent and homogeneous carbide quality which consequently results in predictable tool life.Suitable tool design combined with optimum tool material are the right answer to global competition. With the help of excellent partnerships with suppliers, every one of our customers will be optimally prepared for the market.

At CERATIZIT we look forward to being a partner for our customers in the field of materials at any time.

What is cemented carbide?

The term 'cemented carbide' generally describes a group of materials characterised by high hardness and metallic properties. The first carbides were developed in the year 1921. These were extremely simple carbides which were mainly applied in turning.

The metallic 'gloss' and the relatively good electric and thermal conductivity distinguish these materials decisively from non-metal hard materials which were used as abrasive materials long before the introduction of carbides.

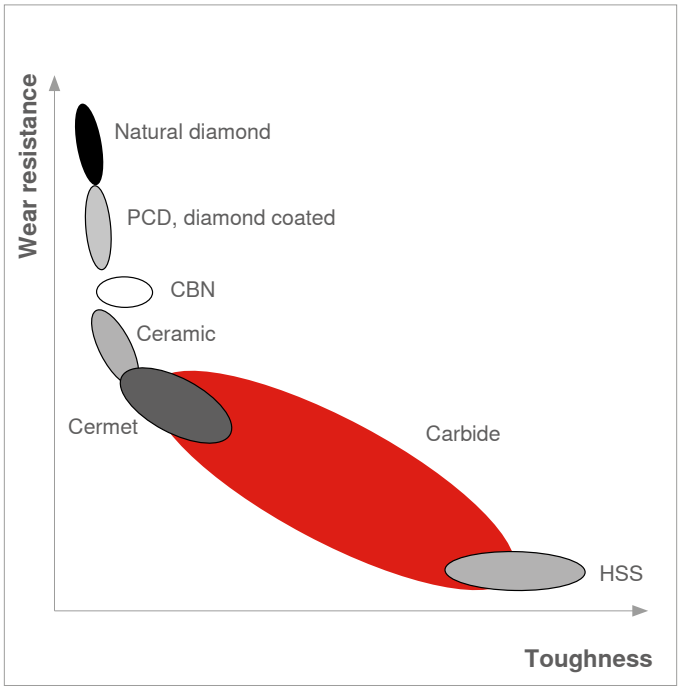
Cemented carbide is a powder-metallurgical two-phase material consisting of a hard material phase and a binder metal phase.

The hard material provides the necessary hardness (= wear resistance) and the binder metal guarantees appropriate toughness.

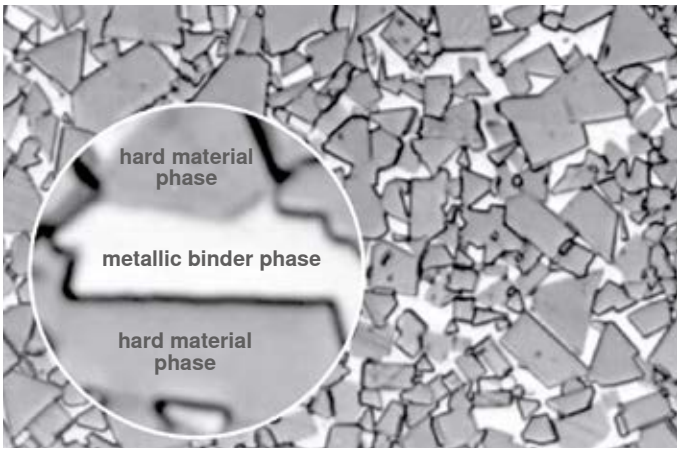
For the manifold possibilities of combining the metal binder content and the grain size, carbide covers a large range of applications, see also graphic below. The cemented carbides most commonly used in the tool and die industry are made of tungsten carbide (hard material) and cobalt (binder metal).
The reason for this is that applying this combination the best physical and mechanical properties can be obtained.

Criteria relevant for application

▲ Wear resistance, hardness
▲ Compressive strength
▲ Impact strength
▲ Transverse rupture strength
▲ Tribological properties
▲ Specific weight
▲ Magnetic properties
▲ Modulus of elasticity, rigidity
▲ Thermal properties
▲ Corrosion resistance, resistance to oxidation
▲ Toughness



Applications of various hard materials



Micrograph of WC-Co carbide

The hard material provides the necessary
▲ Hardness
▲ Wear resistance

The metallic binder provides
▲ Toughness

Examples of the various application fields

General metal forming

EDM block

Focusing tubes for water-jet nozzles

Rods & preforms

Silicon nitride

Hobs

Carbide production

The manufacturing process of the carbide has a notable effect on the quality of the final product. Carbide can only be produced applying powder metallurgy. In the numerous steps of the procedure all risks of impurity must be carefully eliminated.

Powder production

The manufacturing process of tungsten carbide starts with the mining of the tungsten ore. In the first separation and processing steps a very pure crystallised product, ammonium para-tungstate (APT) is produced.

Annealing in vacuum then results in the blue tungsten oxide W_2O_5, annealing in air produces the greenish yellow tungsten oxide WO_3.
At temperatures ranging between 800 and 1000 °C the tungsten oxide is reduced into pure tungsten powder. Tungsten carbide is produced through carburisation. For this purpose the tungsten powder is mixed with soot or graphite heating the mixture up to a temperature between 1,500 and 2,000 °C. The powder to be used further on consists of various carbide powders, binder metals and pressing additives as well as other additives which can be wet milled to the requested grain size in different periods of time; subsequently they are granulated through spray-drying.

Pre-forming

Pre-forming is carried out through various pressing procedures and forming procedures such as:

▲ **Direct pressing**
In this procedure a powder compaction die is used to press the powder into its final shape.

▲ **Wet-bag pressing with forming**
In this procedure rubber tubes in steel cages are filled with the powder and afterwards mounted in the cold isostatic press which then converts the powder into solid blanks. The following forming process then provides the final shape.

▲ **Extrusion pressing**
This procedure is applied to produce parts such as bars or strips; plastified powder is pressed through a die and then cut.

Die pressing

Isostatic pressing (cold)

Optional: machining of blanks

Sintering, HIP, sinter-HIP

The carbide grades receive their actual properties during the sintering process. In this process the material is heated to approx. 1,500 °C, cobalt becomes liquid.

The structure is densified by the cobalt 'enveloping' the tungsten carbide grains. The parts shrink by 20 to 25%, depending on the structure and the cobalt content.

This means that a lot of expertise is necessary for the production of the blanks so that the final products will have the correct dimensions.

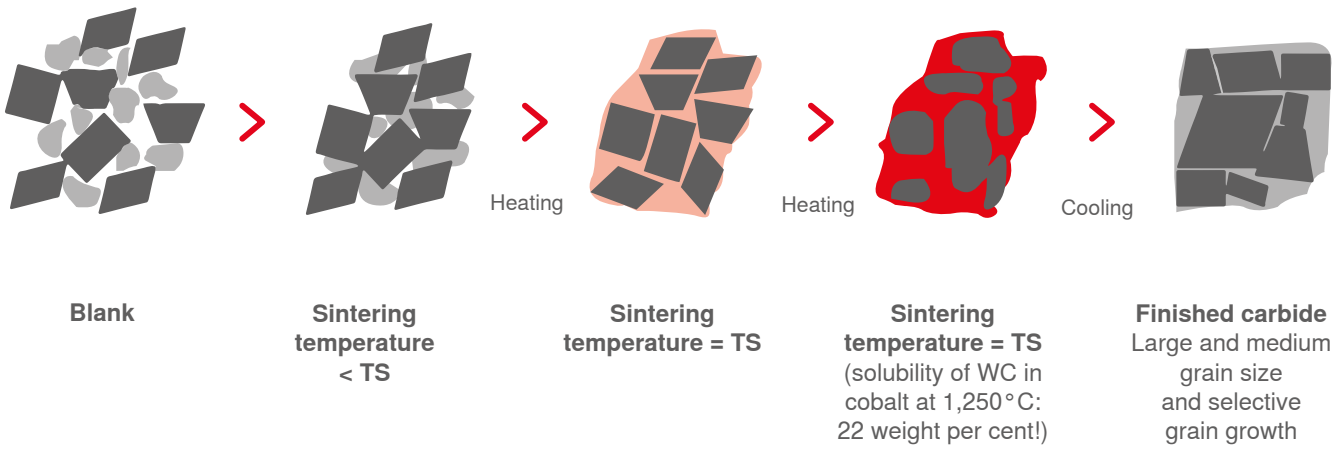
Despite all technical possibilities the sintering of carbide is a procedure which requires a lot of know-how and has great influence on the quality of the final product.

Despite carefully avoiding the risks of impurities in the numerous processing steps a certain residual porosity in the carbide cannot be totally excluded. This may have strong effects particularly in tool and die industry applications and is the case when pores occur in wire erosion or on the external/lateral surface of stamping punches. Applying the hot isostatic pressing (HIP) procedure it is possible to eliminate the residual porosity to a large degree. The carbide is again heated up to the sintering temperature and exposed to an inert gas pressure of 1,000 bar. This results in plastic deformation of the carbide that expands into the pores so that the pores are closed. The sinter HIP procedure is a combination of the sintering and the HIP procedure where the gas pressure treatment follows immediately after sintering. Sufficient densification is already reached at a pressure of 100 bar.

Furthermore the batch comes with test pieces which represent a powder batch combined with a sintering process. These test pieces are used for the following test procedures:

▲ Hardness test
▲ Density test
▲ Coercive force measurement
▲ Analysis of the structure and porosity

After detailed testing it is decided whether the tested piece meets the requirements of the specification and will therefore be released for delivery or not.



Sintering steps

Finishing

The most frequent procedures for the machining of sintered carbide parts are:

▲ **Grinding**
▲ **EDM**
▲ **EDM sinking**
▲ **Wire erosion**

These procedures will be dealt with in more detail from page 18 onwards.

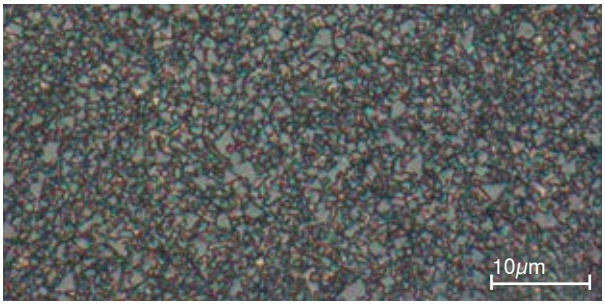
Grinding

Wire erosion

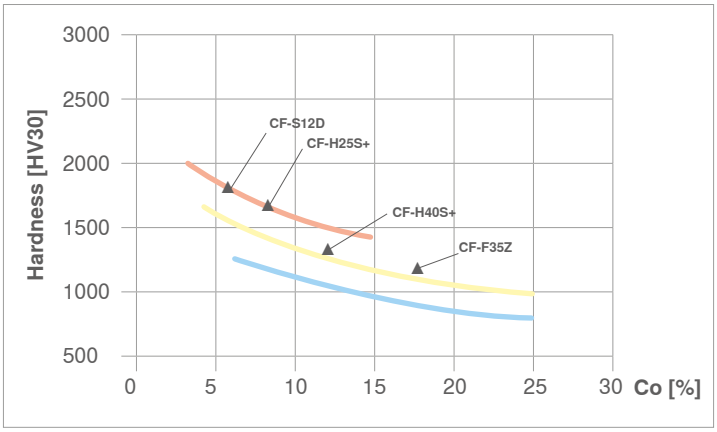
EDM sinking

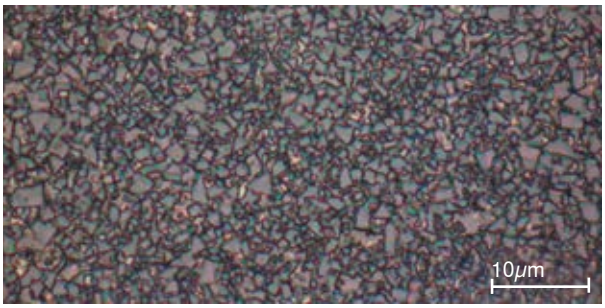
Finishing, most frequent procedures

Grade examples – properties

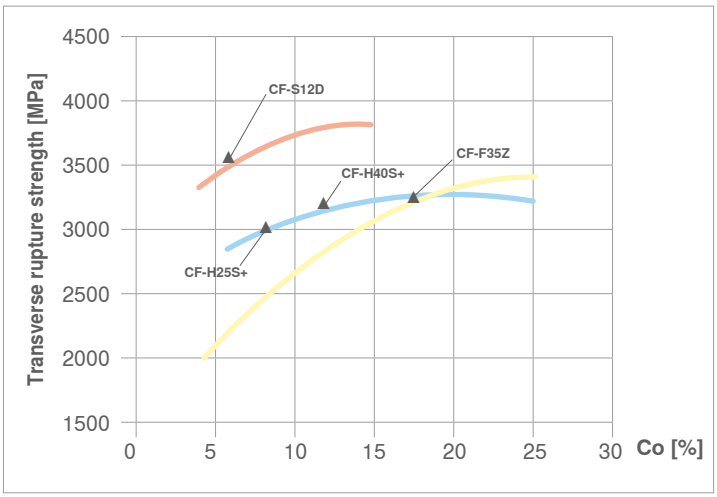


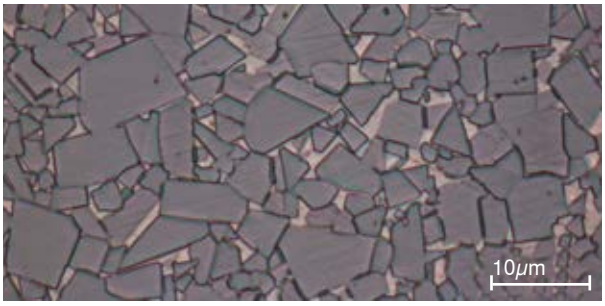
Submicron grain



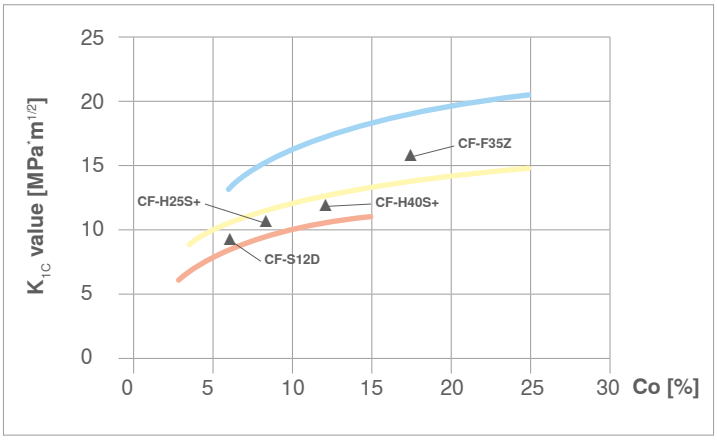


Fine / medium grain





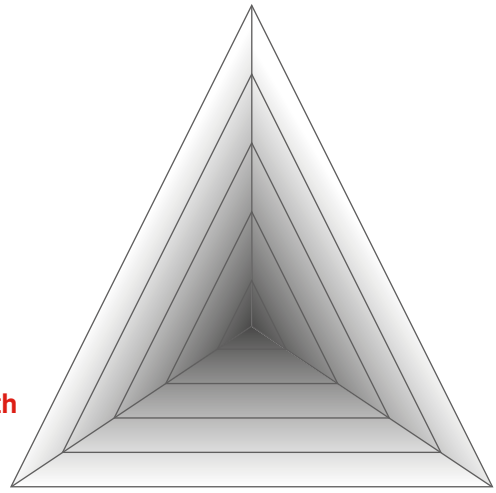
Coarse grain



Submicron grain
Fine / medium grain
Coarse grain

Carbide properties depending on the Co contents and WC grain size

Hardness
Cobalt content ▼
Grain size ▼



Transverse rupture strength
Cobalt content ▲
Grain size ▼

Toughness
Cobalt content ▲
Grain size ▲

Hardness (wear resistance)

Nozzles for water jet cutting
Type of stress
▲ Wear
▲ Corrosion

Carbide grade
▲ Very high hardness: 2650 HV_{30}
▲ Small grain size: < 0.5 µm
▲ Low Co content: 0.4%
▲ Corrosion resistance when adding Cr_3C_2

Transverse rupture strength

Micro-drills
Type of stress
▲ Wear
▲ Deflection

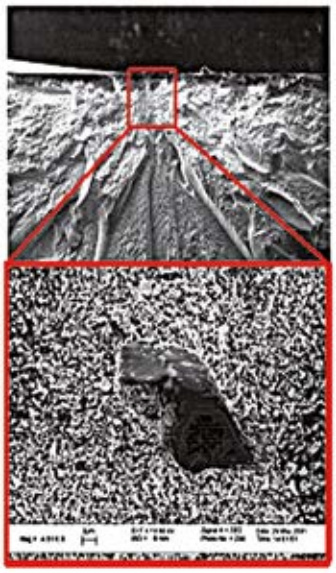
Carbide grade
▲ T.R.S.: > 4000 MPa
▲ Small grain size: < 0.5 µm + VC
▲ Low Co content ~ 8.5%
▲ High wear resistance: 1930 HV_{30}

Toughness

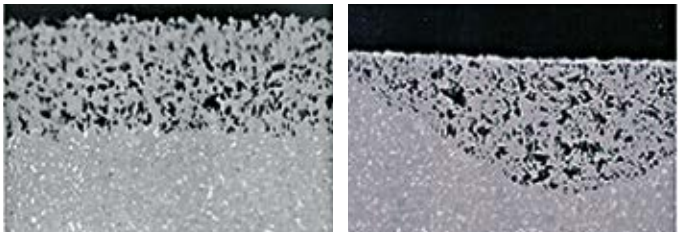
Hot rolling
Type of stress
▲ Wear due to abrasion
▲ Built-up edge
▲ Impact stress

Carbide grade
▲ Sufficient fracture toughness: Co content 20%
▲ Good wear resistance: 1030 HV_{30}
▲ Medium grain size coarse or extra-coarse

Due to brittleness and hardness the material's homogeneity is extremely important in terms of transverse rupture strength of the material and homogeneous wear.



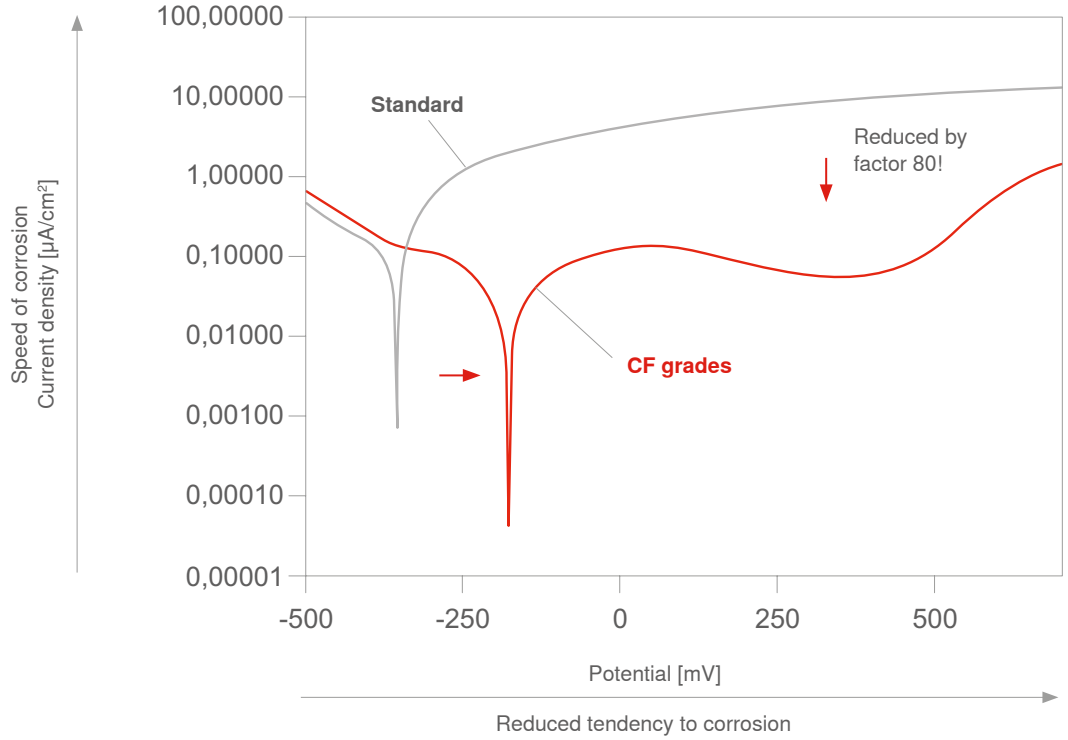
Example of a pore that causes fracture in a submicron carbide that did not undergo hot isostatic densification => T.R.S. 30% lower



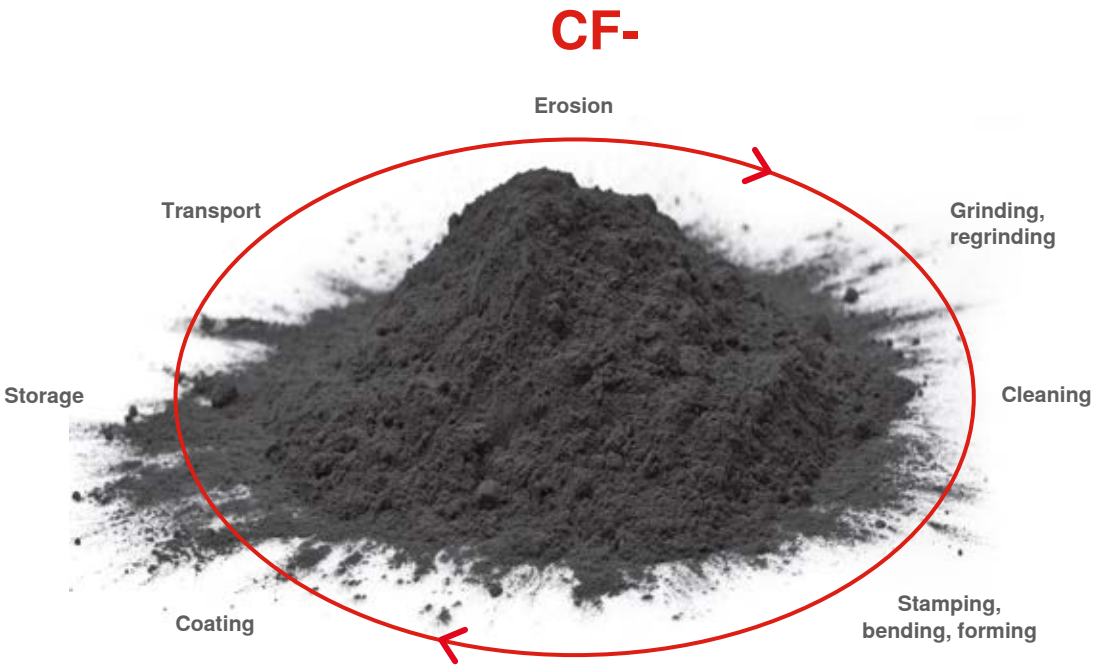
Example of cobalt depletion on the surface caused by corrosion

Corrosion resistance

Corrosion resistance is a property which should be taken into account particularly in applications for the tool and die sector. Due to the heterogeneous structure of the carbide in the case of corrosion the metal binder is removed from the structure. An extreme case of metal binder depletion can be seen in the following pictures. This can occur during machining (wire erosion in dielectric, grinding with emulsion), but also during the application process (corrosive lubricants).



Measured potential graphs of current density



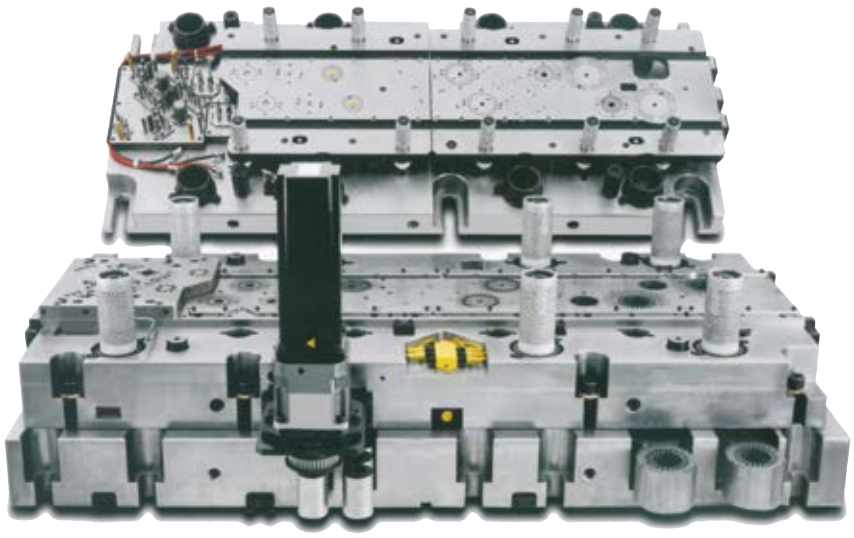
Graph: CF process chain

Edge stability

The cause of insufficient edge stability in a worn-out tool can almost only be interpreted by experts with longstanding experience in the sector. A carbide grade with high hardness may have insufficient rupture toughness so that edge chipping occurs due to the high dynamic stress on the cutting edges. When applying a carbide grade with insufficient hardness, cutting edge deformations may occur showing a similar picture of failure.
Inhomogenity in the carbide structure may also lead to local chipping in a suitable carbide grade.

Tendency to adhesion

In addition to the carbide grade, also the tendency to adhesion (tendency to stick) of the cutting material highly depends on the material to be cut, surface quality of the tool, cutting clearance and tool geometry and the lubricant applied.



A typical rotor/stator die

Machining of carbide

The machining of tungsten carbide has a high influence of the properties and the performance of finished tools, with the quality of each step during machining the tool life can be increased strongly if it is done the right way. In this chapter the following machining technologies are described:

▲ Grinding
▲ EDM machining
▲ WEDM
▲ EDM sinking
▲ Start holes
▲ Carbide milling
▲ Carbide turning
▲ Sandblasting
▲ Polishing
▲ Coating

Grinding of carbide

Definition of grinding according to DIN 8589: grinding is a machining method consisting of various cutting procedures. Grinding wheels as cutting tools are provided with cutting edges which are not defined geometrically.

The cutting edges are made of cutting materials which are harder than the materials to be ground.

Selection of grinding wheels

When selecting the grinding wheels, the grain size, type of connection and concentration has to be taken into account.

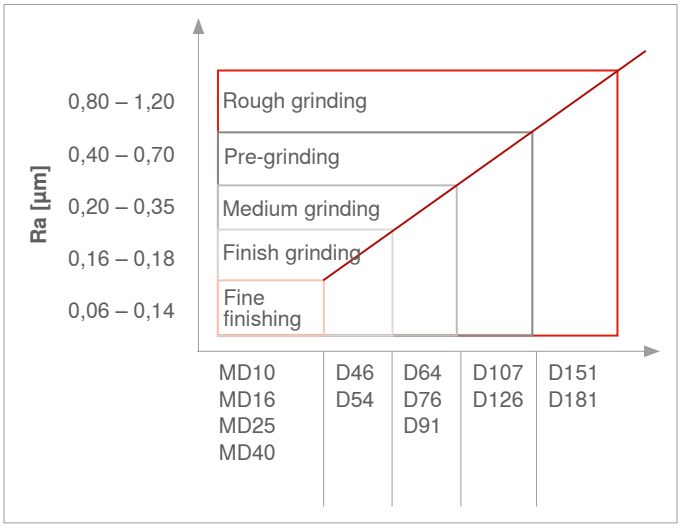
Grain size

The larger the abrasive grain:
▲ the higher the grinding forces
▲ the shorter the tool life of the grinding wheel
▲ the shorter the surface quality
▲ the higher the grinding temperature

Binder of grinding wheel

Basically the following distinction can be made: synthetic resin, metal sintering, ceramic and galvanic bonds.

The harder the bond:
▲ the higher the grinding forces
▲ the tool life of the grinding wheel is not affected
▲ the better the surface quality
▲ the higher the grinding temperature



Indicative values for the selection of grinding wheels (diamond grinding wheel on carbide)

Size of abrasive grains	CBN HSS 64 HRC	DIA Carbide K20
D301	R_a 2.10	–
D213	R_a 1.41	–
D181	R_a 1.12	R_a 0.53
D91	R_a 0.50	R_a 0.33
D54	R_a 0.33	R_a 0.16
MD20	–	R_a 0.05

Indicative values for the selection of grinding wheels (comparison of CBN wheel/steel with diamond wheel/carbide)

Concentration of cutting grains

The concentration of the cutting grains is a significant parameter for CBN and diamond grinding wheels and indicates the volume percentage of the CBN or diamond grains in the grinding wheel surface.

The higher the concentration:
▲ the higher the grinding forces
▲ the better the tool life of the grinding wheel
▲ the better the surface quality

Grinding of cemented carbide

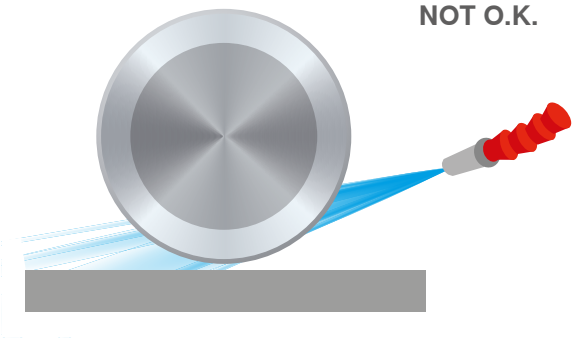
Coolant selection

From the point of view of the carbide producer, cooling during the grinding procedure is of maximum importance. A coolant should always be used in grinding operations.

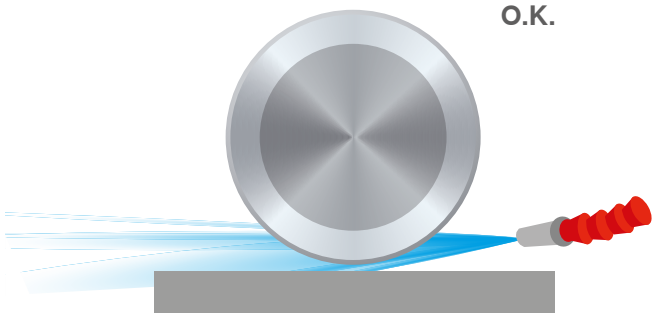
	Oil	Emulsion	Water
Cooling effect	medium	good	good
Lubricating effect	very good	medium	insufficient
Number of necessary control measures	low, when volume is high	high, continuous control	low
Number of cleaning procedures	high, special facilities	medium	low
Environmental impact	high	low	low
Cost	high	medium	low
Corrosion potenial	low	medium	high

Information on the selection of coolants

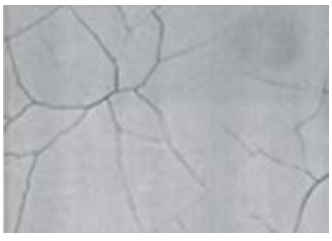
When it comes to lubrication, it is essential to ensure that the lubricant is actually applied at the most effective point, in order to result in optimal cooling. If this is not the case, the carbide may be damaged.

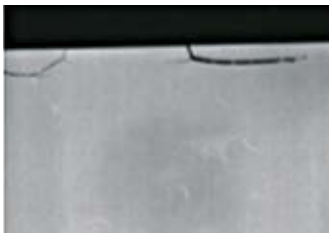


Incorrect application of cooling lubricants



Correct application of cooling lubricants

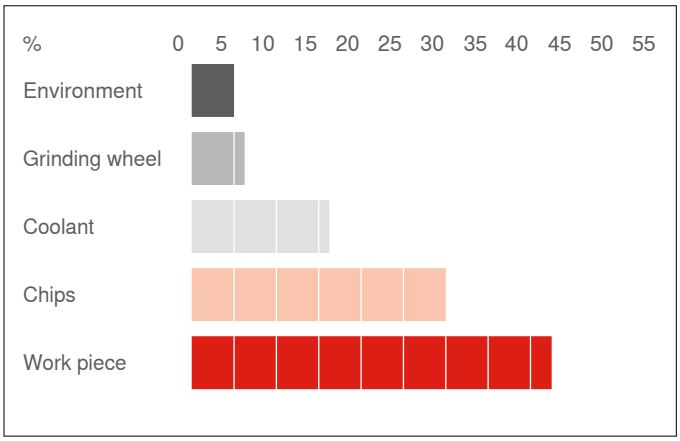




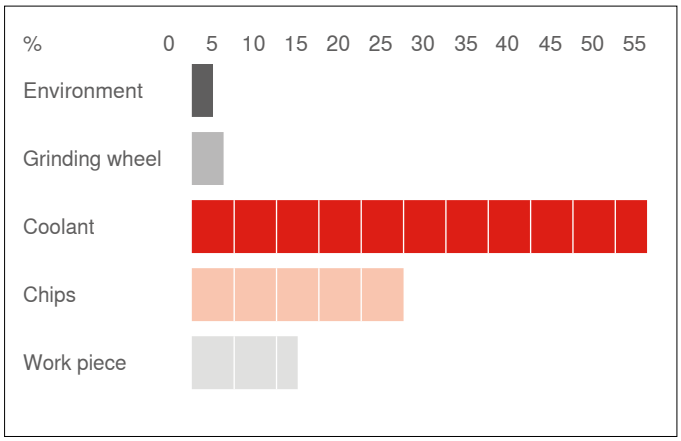
Possible effect of insufficient cooling

Optimum surface in the case of correct cooling

Heat consumption in the case of bad cooling

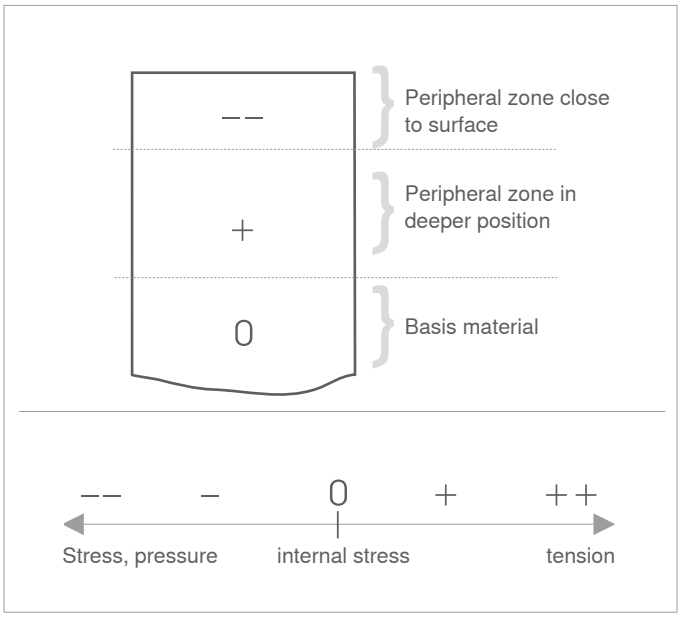


Heat consumption in the case of good cooling



Internal stress

When grinding carbide, internal stress occurs in the upper layers; this may considerably affect the transverse rupture strength, depending on the cross-section of the component.



Creation of stress during grinding of carbide components

Table of conversion

Diamond standard FEPA	US standard (US mesh)	DIA carbide K20
D301	50/60	300 – 250
D251	60/70	250 – 212
D213	70/80	212 – 180
D181	80/100	180 – 150
D151	100/120	150 – 125
D126	120/140	125 – 106
D107	140/170	109 – 90
D91	170/200	90 – 75
D76	200/230	75 – 63
D64	230/270	63 – 53
D54	270/325	53 – 45
D46	325/400	45 – 38
D35	400/500	40 – 32
D30	500/600	32 – 25
D25	–	30 – 20
D20	–	25 – 15

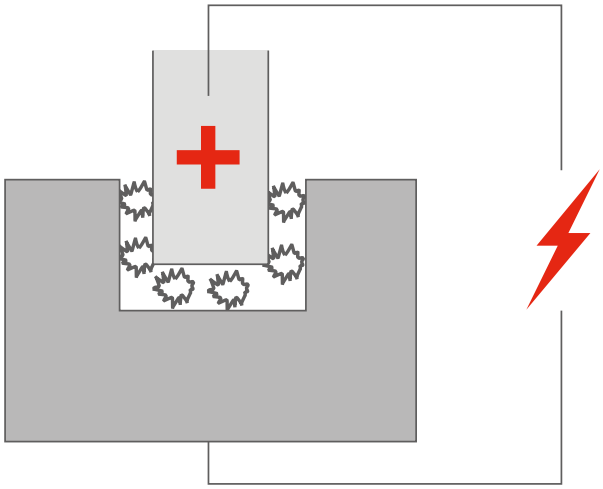
Conversion table for grain sizes

EDM machining

In the process of Electro Discharge Machining, conductive materials like tungsten carbide are machined in a dielectric (water or oil). The work piece and the forming tool each represent an electrode between which high-frequency discharge processes occur. These discharge processes are triggered by exceeding the electric disruptive voltage between work piece and forming tool, which is determined by the working distance and the insulation capacity of the dielectric. The picture on the right shows the principle of EDM machining.

Generally there are two different methods:
▲ Wire EDM
▲ EDM sinking

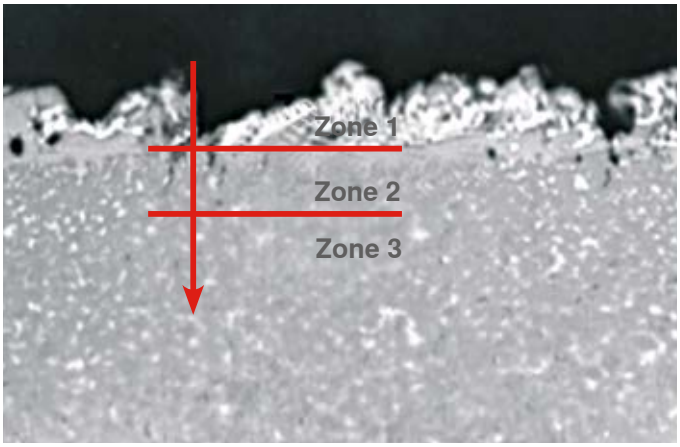
Both methods are described in the following paragraphs.



Principle of EDM machining

Problems and problem avoidance in WEDM

Surface damage
Generally, the examination of any WEDM roughed or precut, surface will display the following scenario:



Rough-cut carbide surface

Zone 1:
For rough cutting generally the highest electrical power and feed rates are used, so that a 'white zone' is created which comprises a mixture of residues of various materials. Most of the residue, or re-cast layer, comes from molten material from the work piece and the wire. This zone is approximately 3 – 5 (microns) µm deep.

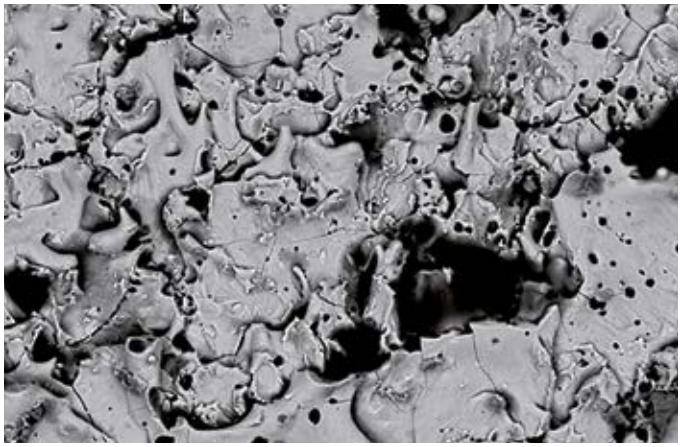
Zone 2:
The high performance and feed rate create another strongly affected zone which is located immediately beneath zone 1 and has a depth of 9 µm due to the temperature of approx. 15,000 °C. Numerous surface examinations however showed damage reaching considerably deeper. If zone 2 is not completely removed by a sufficient number of finish passes the result may be cobalt depletion with disastrous effects. We will cover this in greater detail later.

Zone 3:
This is the undamaged carbide area which must be reached through sufficient recutting if the tungsten carbide is to regain its important mechanical properties. It is absolutely essential that this zone be reached. Knowing how many passes are needed calls for WEDM eperience, but all employees involved should be fully aware of the (zone 1 and 2) condition and the need to remove it.
The picture on the left left clearly illustrates the situation described above.

Thermal impact, thermal cracks

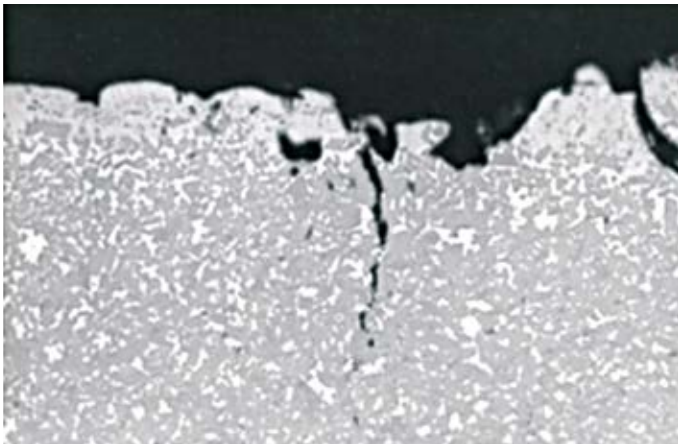
The high power of the generator can create very high temperatures which cannot be conducted away from the machining area by the surrounding carbide. Combined with the very high feed rate, this results in poor flushing conditions, the conductivity of the dielectric rises and both cracking and cobalt depletion will tend to result.
But we will go into this in more detail below. Such cracks are unacceptable for practical purposes, because immediately the tool comes to be used, they propagate and so lead to ruptures. All too often the quality of the carbide is blamed for this.

Good surface quality means longer tool life. But at the same time, good surface quality costs money!



Micrograph of a WC Co cemended carbide surface after the initial EDM cut in oil.[1]) (Ra= 1,3 µm)

10 µm
EHT = 20.00 kV
WD = 6.0 mm
Signal A = CZ BSD
Mag = 1.00 K X



Typical thermal cracks after rough cut

Micrograph of a WC Co cemented carbide surface after the ninth consecutive EDM cut in oil.[1]) (Ra= 0.06 µm)

10 µm
EHT = 20.00 kV
WD = 6.0 mm
Signal A = SE1
Mag = 1.00 K X

Surface created by a sufficient number of recuts

[1]) Klünsner 2016: fatigue life equality of polished and electrical discharge machined WC Co cemented carbide achieved solely by wet blasting

Start hole blasters

Spark erosion machines (also known as ‘start hole blasters‘) are frequently used to punch ('shoot‘) instant holes in carbide blocks. ‘Blasting‘ and ‘shooting‘ are commonly used words to describe this process in carbide. Ruptures and cracks up to a depth of 0.5 mm (0.02”) are the result of too much power, excessive feed rates and poor flushing. Judging by the number of failures we have seen, we recommend reduced power and an allowance of at least 0.3 mm between the start hole and a finished surface position.

Electro-chemical reaction (pitting / corrosion)

Pitting and corrosion have to be considered together, since these reactions occur simultaneously on both eroded and non-eroded surfaces. These effects are evident on the entire work piece (not only on the wire-cut surfaces). The spots, or small holes, that appear on the surfaces are called ‘pitting‘. Often it is not possible to see the pits (actually cobalt depletion) during the first stages. They only become evident in subsequent machining or polishing, or still worse, when the tool comes to be used.
The picture on the right shows typical pitting, which is visible to the unaided eye. As mentioned above, the pits will appear on non-machined surfaces as well. This is because the cemented carbide includes a component of cobalt as a binder, which is magnetic. The magnetic cobalt draws particles from the dielectric which results in

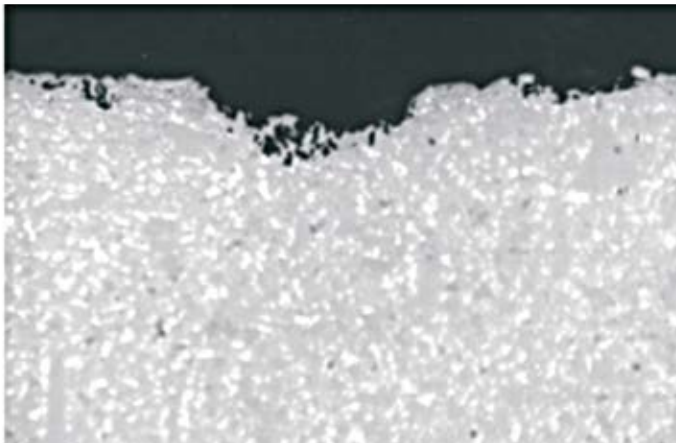
▲ more rapid corrosion,
▲ and local mechanical wear,

occasioned by vibration of the dirt particles on the surface.

Pitting

The picture below shows the effects of pitting in cross-section. The pitting of the binder is due to an electro-chemical process taking place in the dielectric, which affects the surfaces to a depth of approximately 20 µm.

The cause of this process is inadequate flushing of the cut, and in many cases too high conductivity of the dielectric.



Pitting in cross-section

Interestingly corrosion also occurs on non-eroded surfaces due to electrolysis. This is caused by poor control of the dielectric (very dirty) in combination with the electro-chemical process described above. The cobalt depletion is not visible without a microscope. The dielectric penetrating through microcracks dissolves the cobalt, the tungsten carbide on the surface lacks the support of a binder. Thus, the entire area affected has completely lost its stability, hardness, and toughness. It is essential that this surface be ground to remove the damage. Most die makers remove 0.3 mm to 0.5 mm.

Suggestions to avoid problems (EDM tips)

- The thermally affected zone has to be removed by a sufficient number of recuts.
- Be careful when start hole blasting, as the thermal effects can be enormous. When properly used, however, start hole drilling machines can be very useful tools.
- Carbide is magnetic:work pieces have to be demagnetised before EDM machining.
- Principle of minimal injection: instead of working according to the instructions, sometimes the same pressure is set on both the upper and lower nozzles. The result is that both water jets meet with equal force in the area where the material is cut, trapping particles (wire, metal and dirt) instead of flushing it away. Immediately, the electrical conductivity of the dielectric reaches unacceptable levels, so that corrosion occurs as described above. It is important that the pressure of the upper nozzle be significantly higher than the pressure of the lower nozzle, which is only responsible for flushing the wire guides.
- Working procedures:It is not advisable to finish one part and then start working on the next one. It is much safer to do the rough cut on all parts, then the first finishing cut on all parts, etc. Otherwise the first part cut (the component with the finished surface) will be exposed to water, and thus to the risk of corrosion, for a longer period. When the right procedure is observed, the risk of corrosion can be greatly reduced.
- Constantly watch the electrical conductivity of the dielectric < 5 µmS/cm. Do not start an operation if it is difficult to maintain this value.
- Conservation of work pieces after machining: clean the work piece with clear water, put the parts into an oven for 1 hour at 100 °C to evaporate all the water out of possibly remaining micro-cracks.
- NB: do not drain the water when work is completed, leaving the work piece in the tank. The water drops that remain on the work piece will have the highest concentration of corrosive materials. It is better to leave the piece submerged in a full tank.
- Keep the dielectric clean. Filters do not remove all cobalt particles completely.
- Water has to be checked regularly for pH value, conductivity, hardness, chlorides. The uncritical pH-range of cemented carbide is between 6.5. and 8.5, the ideal value to be achieved is 7.
- Only use high quality carbide that has been HIP treated. Carbide quality and stability greatly affect the surface finish and precision of the parts you produce.
- Face sides have to be ground after WEDM machining. A depth of approx. 0.3 mm is sufficient to remove any surface damage.
- Marking of work pieces: avoid using marker pens with solvents which may attack the cobalt.
- If an EDM machine is primarily used for the machining of steel, and only once in a while for the machining of cemented carbide, it is strongly recommended to clean the dielectric before starting the carbide machining operation. Otherwise, this may result in increased corrosion tendency. The ideal solution is to use the EDM machine exclusively for cemented carbide.

EDM cutting of mounted carbide

Carbide dies used in the cold forming of metal wire or sheets are often mounted in a steel casing with interference to compress the carbide. Thanks to the compression the carbide exhibits its best mechanical properties and the risk of cracking is reduced.

The interference introduces a state of compression in the carbide which is useful during the stamping/forging operations but which can be critical when cutting the carbide by EDM.

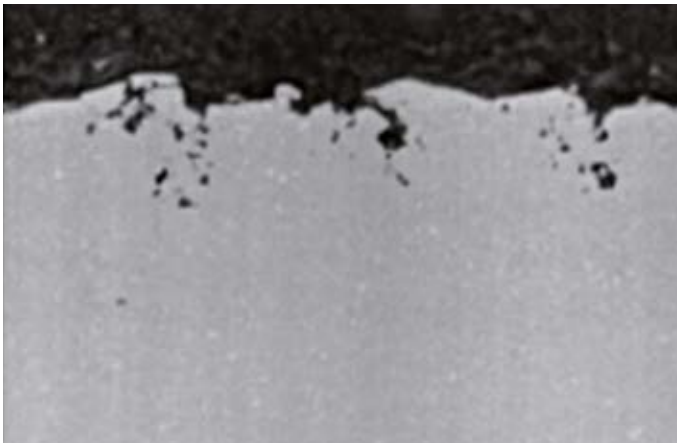
It is not recommended to cut a mounted carbide part removing a substantial amount of material (e.g. cutting a shape from only a starting hole) when it is mounted in a steel casing. This is because during EDM the compression stresses in the carbide are released in an uncontrollable way, bringing the risk of fracture.

The correct sequence of operations is:

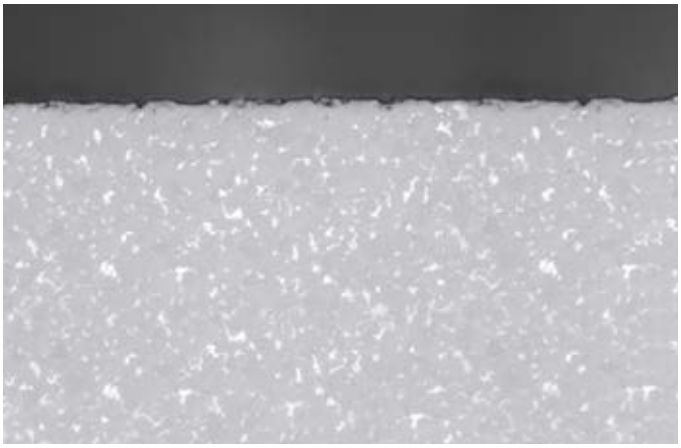
- Precut before mounting: The profile required is precut before the carbide is mounted in the steel casing. The profile should be precut with a tolerance of a few tenths of millimetres to allow for finishing.
- Mounting: After the precut the carbide can be mounted in the steel casing. Due to shrinkage, deformation of the internal profile can be expected.
- Finishing: After mounting, the profile can be finished to its final dimensions by wire EDM. Since the amount of material removed in this operation is limited, the risk of cracking is greatly reduced.

EDM sinking

In EDM sinking the tool is an electrode which has the negative shape of the final result of the operation. By using several axes complex shapes can be machined. Electrodes can be manufactured out of tungsten-copper, copper or graphite. For the dielectric oil is used, so the danger of corrosion is minimised. A very critical aspect in EDM sinking is that wrong settings may create thermal damage on large sections of the work piece surface.



Thermally influenced surface, cross-section



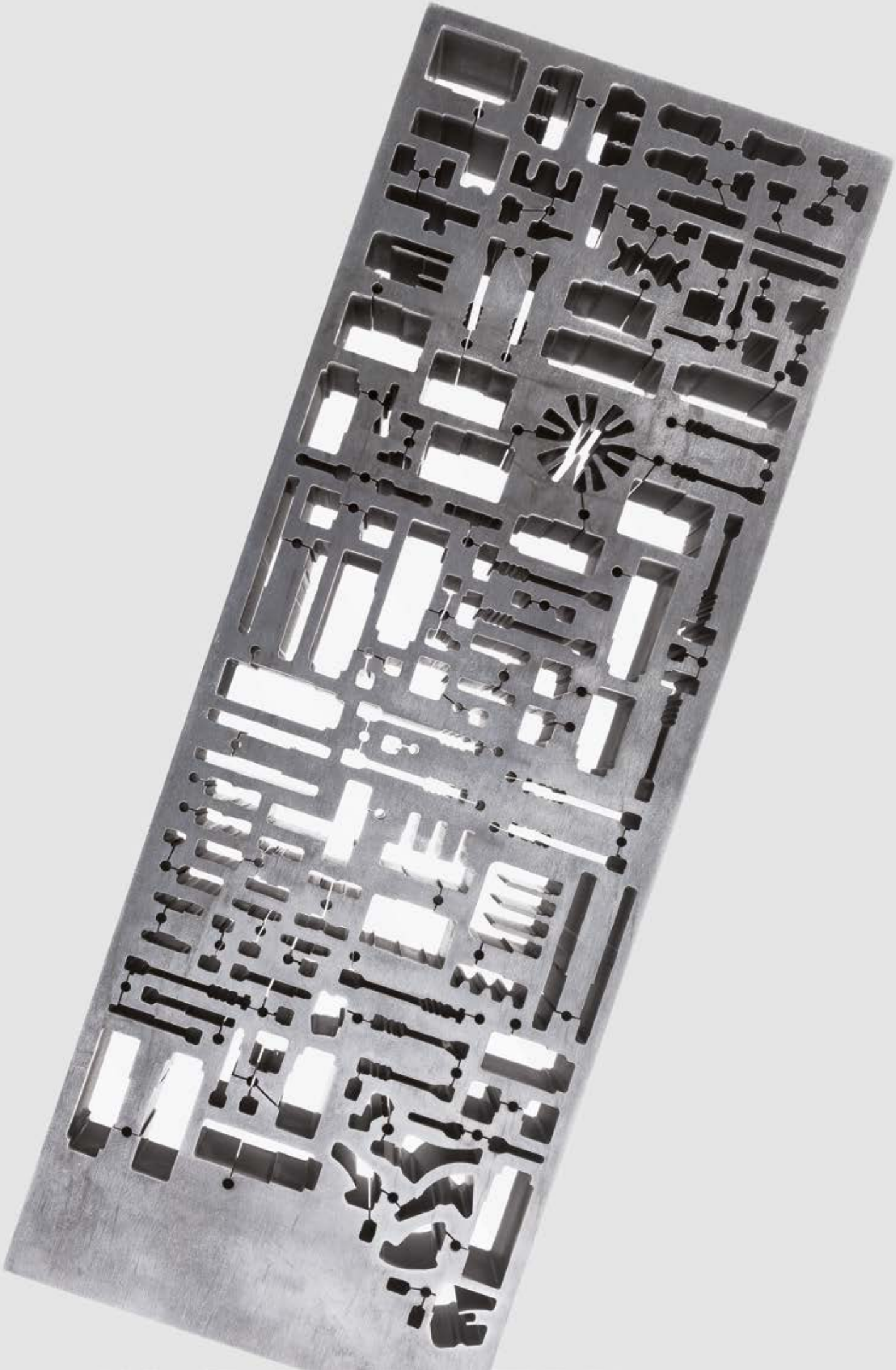
Surface with optimised settings

Electrode materials

Requirements on electrodes	Resulting necessary properties
High removal rate	High electrical conductivity
Low wear rates	High melting point. High thermal conductivity
High precision	Low thermal expansion Low internal stress High edge stability
Low machining cost	Good machinability
Reasonable price	High availability of raw materials

Surface quality

Machining steps	Roughing	Finishing	Fine finishing	Polishing
Removal rate [mm^3/min]	≥ 17	≥ 2.5	≥ 0.5	< 0.5
Specific removal rate [mm^3/(A-min)]	4.5 - 9.0	0.3 - 4.5	0.1 - 0.3	< 0.1
Roughness Ra [μm]	≥ 3	≥ 0.8	≥ 0.5	≥ 0.5



Carbide milling

Introduction

The milling of carbide is a new technology which has emerged in the last years and can bring advantages compared to other production technologies.

Advantages and limits of milling:

- ▲ Compared to other production technologies like die sinking EDM, milling reduces the processing time. This is possible thanks to the fact that the part is machined directly, electrode machining is eliminated and other lost time, like the waiting periods between the different operations, are reduced.
- ▲ Good surface finish: Ra values up to 0.05 can be obtained directly by milling, thus reducing the time needed for final polishing.
- ▲ Complex shapes can be produced. Shapes and profiles that could previously only be produced by die sinking EDM can be milled.
- ▲ A limit of the technology is that it is unsuitable for the removal of large amounts of material. Given the types of milling tools available for carbide, removing large amounts of material may be economically disadvantageous.
- ▲ Small negative radii can be difficult to machine. The radius on the machined part will be directly affected by the radius of the milling tool.

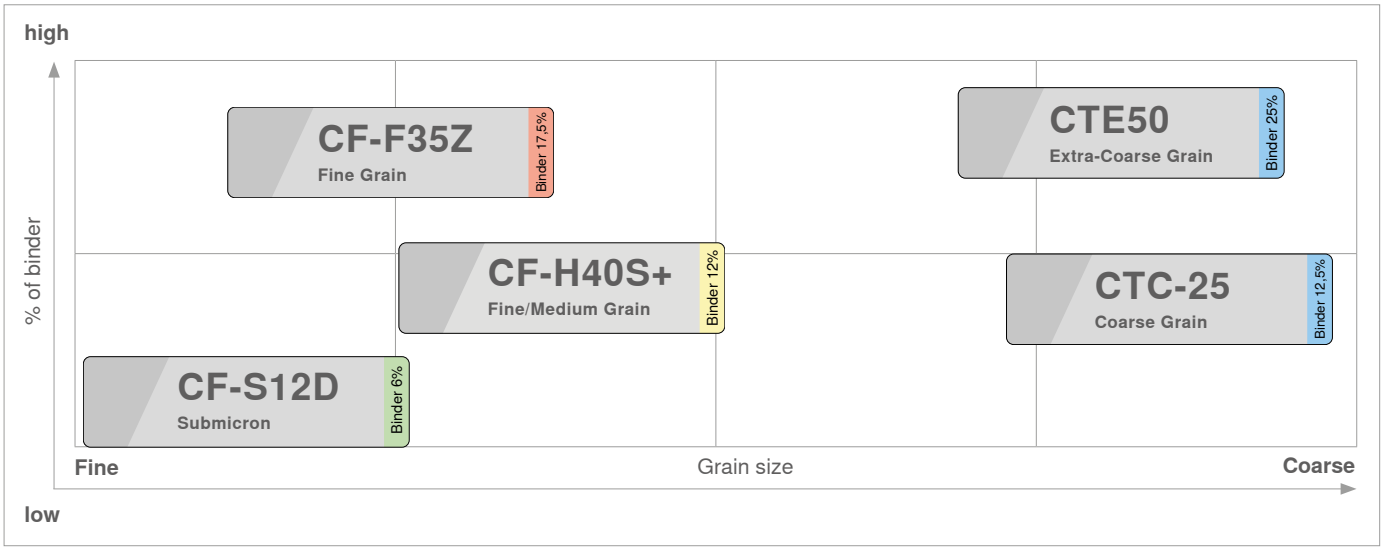
Milling tools for carbide (CVD diamond coatings, PCD)

To be able to cut, the tools need to be about four times harder than the material to be machined. Based on the mechanical properties and the hardness of the carbide grades (800-2,200 HV_{30}) only two materials are normally used for machining: PCD (polycrystalline diamond) or CVD (diamond coated) tools. Both these materials have a hardness around 8000-10,000 HV_{30} and are therefore suitable for machining carbide.

Milling of tungsten carbide [2])

[2]) Fraunhofer IPT

Carbide grades suitable for milling



Suitable carbide grade for milling

The properties of the carbide grade to be machined have a great influence on the milling process. The harder the carbide, the more difficult the milling operation will be. In the graphic the machinability of different carbide grades is illustrated as a function of the grain size and binder amount.

Hardness values around 1860 HV_{30} represent the limit of possibility for the materials to be milled.
The tool life of a milling tool is also influenced by the hardness of the material being machined. When milling a carbide grade with a hardness around 750 HV_{30} (25% binder and coarse grains), a milling tool can remove around 1000 mm^3 of material; when the hardness of the material increases, the tool life decreases.

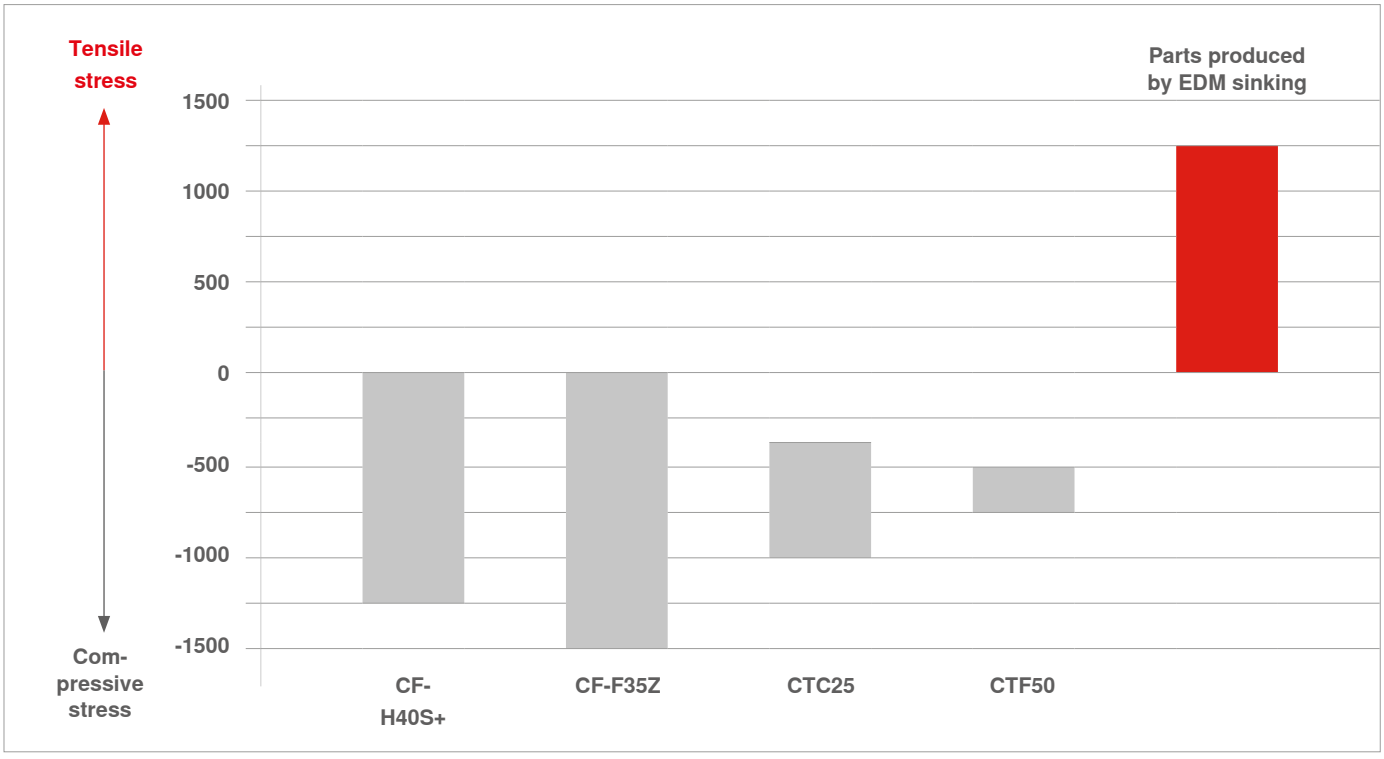
Tip: the milling of threads has become very economical. Another advantage is the considerably higher resistance of milled threads compared to threads produced by EDM.

Milling parameters

▲ Cutting depths of 0.005 to 0.2 mm
▲ Steps from 0.005 to 0.4 mm
▲ Speeds from 20,000 to 48,000 rpm
▲ Feeds from 80 to 750 mm/min.
▲ Tool service life up to 400 minutes

Residual compressive stresses

A big advantage of the milling process is that during the milling process internal compressive tensions in the tungsten carbide occur. These internal compressive tensions lead to a better toughness of the machined parts and prevent crack growing.
Tests have shown that milling can improve the lifetime of active parts by a factor of 3.5. This is due, among other factors, to the residual compressive stress inside the part.



Internal stress after milling process

Hard turning

Another production technology that can be applied to carbide is turning. The term 'hard turning' is used when machining materials with a hardness higher than 80 HRA (58 HRC). Hard turning can be used for roughing with high metal removal rates and depths of cut, or for producing complex profiles with excellent surface finish and both low material removal and depth of cut.

To have a stable and repeatable process it is important to have the right machine for working carbide. For turning it is important that the machine be rigid.

Cutting tools for turning carbide

As in the case of carbide milling it is important that the tool used for machining carbide is harder than the carbide to be machined. The main materials used for the inserts for turning carbide are CBN (cubic boron nitride) and PCD (polycrystalline diamond).

CBN inserts are used for carbide grades with a hardness up to around 1100 HV_{30}. For these grades, it is possible to reach high metal removal rates and considerable depths of cut by using tools with the appropriate geometry.

For harder carbide grades, up to hardness values around 1600 HV_{30}, it is necessary to use PCD cutting tools. These cutting inserts are usually brazed to the steel body of the tool.

By hard turning, when using PCD tools, it is possible to reach surface roughness values of around Ra 0.1.

Carbide grades suitable for hard turning

As with carbide milling, the mechanical properties of the carbide have great influence on the machining process.

Grades with a hardness lower than 1100 HV_{30} – corresponding to a medium grain size and 15% binder – are relatively easy to machine. These grades can be machined with both CBN and PCD cutting tools. Turning can be used as a roughing operation with high metal removal rates and depths of cut up to a few tenth of a millimetre per pass.

Grades with a hardness between 1100 and 1600 HV_{30} are more critical when hard turning. For these materials, the operations that can be performed are more restricted and are usually limited to the execution of radii or profiles. Only PCD tools are suitable for these kinds of grades. The machining parameters are also more limited, with depths of cut as small as only a few hundredths of a millimetre. Harder carbide grades can theoretically also be subjected to hard turning. The limit is often not technical but rather economical, since performing one operation will be too expensive given the cost of the cutting tools.

Machining parameters for the hard turning of carbide

General recommendation for the turning parameters for three carbide grades, using PCD tools. To be adapted, based on the operation.

Carbide grade	PDC tool, roughing	PCD tool, finishing	
WC 12% Co	N/A	10 m/min	Cutting speed (m/min)
	N/A	0,01 – 0,02	Feed rate
WC 15% Co	10 m /min	20 m /min	Cutting speed (m/min)
	0,05 – 0,10	0,01 – 0,03	Feed rate
WC 25% Co	15 m/min	30 m/min	Cutting speed (m/min)
	0,05 – 0,10	0,01 – 0,03	Feed rate

Machining parameters

Turning of tungsten carbide

Sandblasting

Sandblasting can remove (in some cases completely) the thermally stressed zone created by the previous eroding process, as well as the white zone. In addition, tensile residual stress in the surfaces can be converted into compressive residual stress, and the outermost surface layer of the carbide compacted.

Any microcracks that may have arisen in the course of grinding can also be removed by sandblasting.

Particularly suitable for the finishing of carbide tools is microblasting followed by polishing of the blasted surfaces. A blasting material of fine-grained white Corundum can be used for this process.

Aerolapping and drag finishing are also excellent for the finish machining of carbide tools.

Sandblasting

Polishing

Polishing is usually the last operation to improve the surface finish of the part. This operation can be performed automatically, using machines, or manually.

With carbide this is generally done using diamond pastes of different grain sizes, depending on the initial roughness of the surface.

Automatic polishing

Several types of machines are available on the market for polishing operations.

Automatic polishing

Internal polishing
Machines for polishing internal profiles work by pushing a paste containing diamond particles through the part which needs to be polished (e.g. extrude-hone).

Advantages: repeatable process, possible to polish deep and small holes.

Disadvantage: hard to improve the surface finish significantly.

External polishing
External polishing is done with drag polishing machines in which the pieces are moved inside a container with media (diamond) and granules (e.g. Otec machines). With this approach, and using different kinds of media, it is also possible to carry out other operations such as deburring, edge preparation, etc.

Advantages: repeatable process, possible to automate, possible to work several pieces at once.

Disadvantages: rigid process, takes time to develop and adapt the polishing cycle/process to the product.

Manual polishing

Manual polishing of carbide is always done using diamond pastes which are applied to the parts to be worked with different wood or plastic supports.

The polishing of profiled shapes (both internal and external) is usually done with vibrating tools (e.g. Diprofil). Pieces with axial symmetry can be mounted on a spindle for polishing.

By using different diamond pastes it is possible to improve the surface finish. Depending on the initial surface roughness to be achieved by polishing, it is necessary to use different diamond grits.

Advantages: flexible process, possibility of working pieces with very different sizes and geometries; by using different media grain sizes, it is possible to make big improvements to the surface finish, values of Ra reachable down to around R_a 0.05.
Disadvantages: difficult to replicate the manual process exactly, depending on the skill of the operator; if rougher diamond pastes are used, profiles/radii may be distorted.

Manual polishing

Inital Ra	I polishing	II polishing	III polishing	Final Ra
0.8	D45	D15	D3	0.05
0.4	D15	D3		0.05
0.1		D3		0.05

Initial value	R_a 0.6-0.8
After polishing with D45	R_a 0.3
After polishing with D15	R_a 0.15
After polishing with D3	R_a 0.05

Residual compressive stresses

The polishing process can equalise tensile residual stress on the surface and/or convert it into compressive residual stress.

The white and thermally stressed zones resulting from the previous EDM process can as a rule not be completely removed by the polishing process.

Coatings

Wear-resistant coatings are being used more frequently nowadays to improve the tool life and the process quality in many applications.

Wear-resistant coatings are usually ceramic compounds with high hardness and wear resistance.

Examples of materials used for coatings: SiC, TiC, TiN, TiCN, BC, etc. The choice of coating is often difficult and good performance depends on many process parameters (worked material, lubricant, etc.).

These materials can be deposited on the carbide with different technologies, the most common being PVD (Physical Vapour Deposition) and CVD (Chemical Vapour Deposition).

PVD process

The physical vapour deposition technique is based on the vaporisation of the material so that it can be deposited as a thin film. The material in solid form is either heated until evaporation occurs (thermal evaporation) or sputtered by ions (sputtering).

Advantages:
▲ Low deposition temperature (200–500° C)
▲ Possible to coat steel parts without loss of hardness
▲ Possible to coat brazed tools
▲ Good dimensional control (smaller tolerances possible)

Disadvantages:
▲ Line of sight deposition:
  – Holes, complex geometries which are difficult to coat
  – Coating of holes limited to 1-1.5 x the diameter
▲ Limited adhesion with the substrate (compared to CVD coatings)
▲ Limited thickness (approx. 2 µm) compared to CVD coatings

CVD process

Chemical vapour deposition is based on a chemical reaction occurring at high temperature within a reacting atmosphere in which the parts to be coated are immersed. This chemical reaction takes place on all surfaces inside the reaction chamber, thus the parts are completely coated at the end of the process.

Advantages:
▲ High thickness – higher wear resistance
▲ Excellent adhesion to the substrate – chemical bonding with the substrate
▲ Uniform distribution of the coating – inside holes, complex geometries, etc.

Disadvantages:
▲ High deposition temperature
  – Possible formation of eta phase in the carbide
  – Carbide with <20% Co must be used to avoid deformation
  – Impossible to coat mounted tools (steel and carbide) due to loss of hardness of the steel
  – Impossible to coat brazed tools
▲ More complex structure (in the case of mounted parts)
▲ Need for larger tolerances (compared to uncoated or PVD-coated parts)

Coating process

Joining techniques

Most of the existing joining techniques can be applied for carbide, for example:

Material joints:
▲ brazing
▲ welding
▲ gluing

Power joints:
▲ shrinking

Shape joints:
▲ threads
▲ wedging
▲ casting

The design of a joint has to comply with the characteristics of carbide:

▲ Carbide is a brittle material
▲ Edges have to be protected (use radii, chamfers, …)
▲ Fits and guides need to be adapted to carbide (centring, angles, clearances, …)
▲ The combination of various materials may cause stress close to the joint depending on the thermal expansion and rigidity of the material)

Brazing

Definitions / explanations

Melting point, melting range, working temperature
Only pure metals and eutectic alloys have a defined melting point. The metal becomes liquid at temperatures above the melting point. Brazing metals usually have a melting range, the temperature range between the solidus and liquidus temperatures. Below the solidus temperature the brazing metal is solid; above the solidus temperature a liquid phase may occur.
The brazing metal is only completely molten above the liquidus temperature. The ideal working temperature at which wetting and complete spreading of the brazing metal occurs, is just below the liquidus temperature (in the upper melting range).

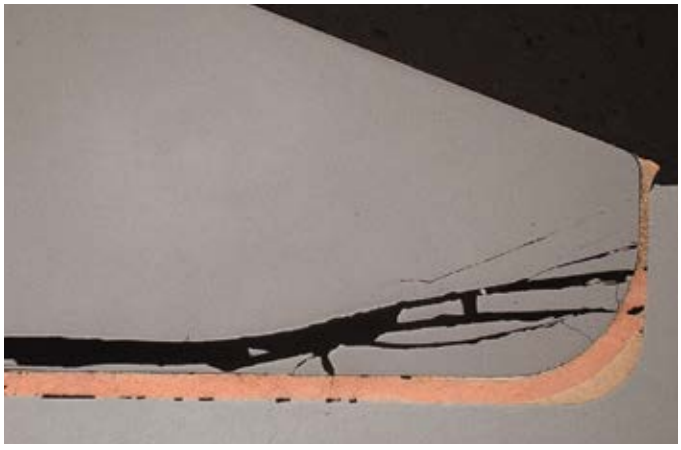
Soft brazing
▲ Working temperature <450 °C
▲ Advantages: large surface bonds are possible, minimum brazing stress
▲ Disadvantages: low mechanical stability
▲ Application: thin bending / distortion-sensitive carbide components (rulers, ...)

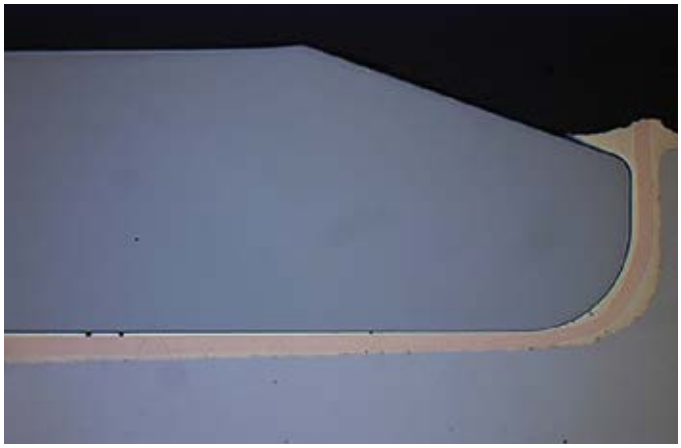
Hard brazing
▲ Working temperature >450 °C
▲ Advantages: high thermal and mechanical stability
▲ Disadvantages: due to brazing stress component dimensions are limited

Wettability, fluxing agents
Wetting is defined as the spreading of the liquid brazing metal on the substrate material and the flowing of the brazing metal into narrow gaps.

Fluxing agents
Fluxing agents facilitate the wetting process between cemented carbide and brazing metal by reducing the surface stress and providing protection against oxidation.

Brazing process
▲ Mechanical cleaning and degreasing of the brazing zone
▲ Fast charging of fluxing agent as protection against oxidation
▲ Positioning of the parts
▲ Fast and continuous heating, always on a large surface area and from the side of the substrate material
▲ The entire fluxing agent is now displaced by brazing metal
▲ Slow cooling to prevent internal stress, by placing work pieces in furnaces or preheated sand heaps ... NOT to be cooled by exposure to the open air, by means of compressed air or quenching with water, etc.

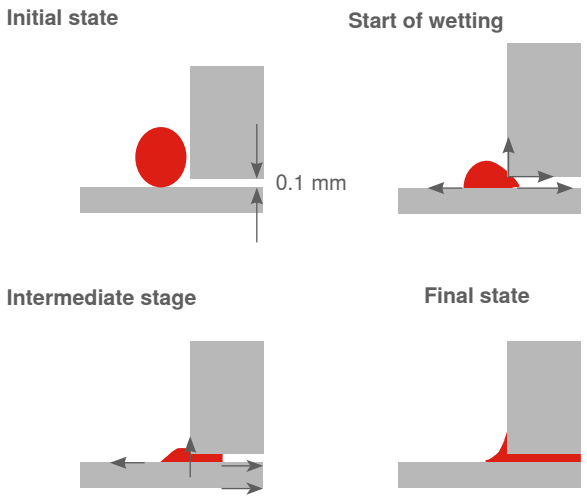




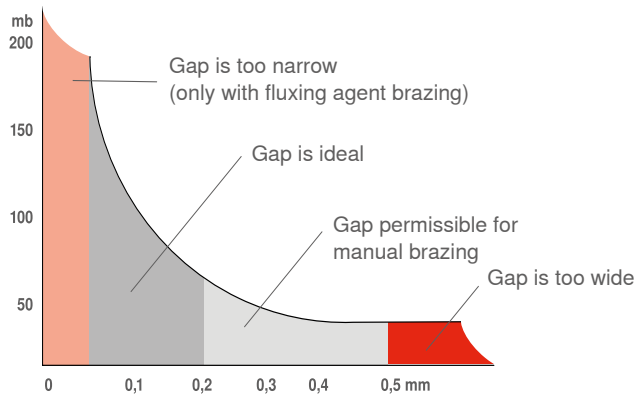
Brazing of cemented carbide

Brazing cemented carbide to steel requires temperatures >450 °C. Brazing bonds are characterised by high thermal and mechanical stability.

Good wetting between the brazing metal and the carbide is necessary in order to completely fill the narrow joining gaps (capillary forces) between the steel and the cemented carbide. It must also be ensured that sufficient brazing metal flows into the joining gap.



Brazing of cemented carbide



Capillary effect as function of gap width

The wettability of carbide with the brazing metal (usually with a copper and silver base) depends very much on the cobalt and/or nickel binder content. Coating the carbide with cobalt, nickel or copper improves the wetting behaviour.

Fluxing agents are used for brazing in oxidising atmospheres. These agents dissolve oxide layers on the carbide surface and improve wettability. In general, carbide and steel surfaces should be clean and free of oil and grease in order to ensure optimum wettability of the brazing metal.

Internal stress

In all processes with large differences in temperature, the various heat expansion coefficients (HEC) cause bond stress and internal stress.
In hard brazing of cemented carbide and the substrate material (generally steel), temperatures >450 °C occur. Due to the different HECs, internal stress can cause warping or fractures.

- Steel: 12.0–14.0* 10–6 1/K.
- Cemented carbide: 4.7 (low cobalt content) – 7.3 (high cobalt content)* 10–6 1/K.

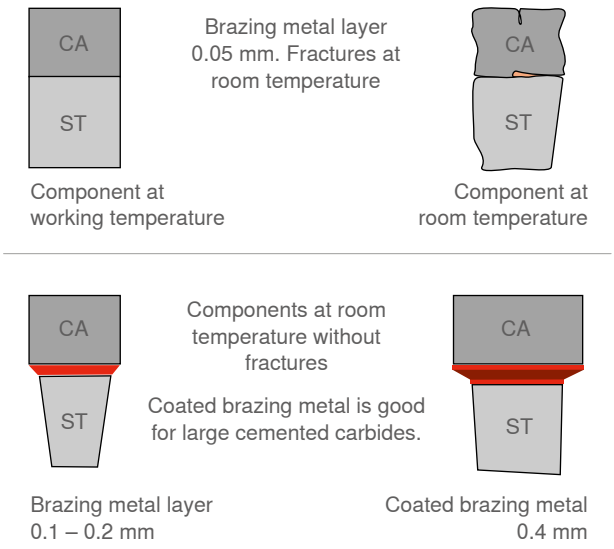
Size and distribution of the internal stress depends on:

- Difference in the HEC (see above)
- Melting temperature of the brazing metal
- Ductility of the brazing metal
- Thickness of the brazing layer
- Component geometry / dimension
- Mechanical properties (elasticity module, strength, fracture toughness) of the cemented carbide and of the substrate material / steel.

Reduction of brazing metal stress

Internal stress after brazing can be partially reduced by plastic deformation of the brazing joint. Therefore, the following should be used:

- Brazing metals with a low melting temperature
- Thick brazing metal layers
- Coated brazing metal (copper layer, nickel network) especially with a joining surface of 100 mm² or larger.



Use of coated brazing metal

Troubleshooting

▲ The brazing gap between the carbide and the steel is too narrow:
Causes: uneven heating, insufficient brazing metal, mistakes in profile / geometry
Effect: fractures in the carbide

▲ Poor wetting of carbide and steel:
Causes: contamination of the surface, insufficient brazing temperature, incorrect amount of fluxing agent.
Effect: no adhesion between brazing metal and bonding part

▲ Fractures / pores in the brazing zone:
Cause: excessive brazing temperature, insufficient brazing metal
Effect: pores and shrink holes, possibly fractures in carbide

▲ Occlusions in the brazing zone:
Cause: too much fluxing agent used
Effect: fractures / cracks in the brazing metal

Even heating is important when brazing:

▲ Heat the entire work surface
▲ Apply brazing metal to joining gap
▲ Maintain working temperature until fluxing agent and brazing metal emerge from the gap
▲ Do not overheat bond! Excessive working temperatures will damage the brazing metal and the work piece

Also, to prevent internal stress, the bond / component should be allowed to cool slowly. In this way, any internal stress will be reduced by plastic deformations in the brazing metal. The brazed component should therefore not be cooled by air under undefined conditions, but rather as follows:

▲ In a furnace, at a temperature of 350 to 400 °C
▲ In a powder / sand heap
▲ In warm air

Connections with screws

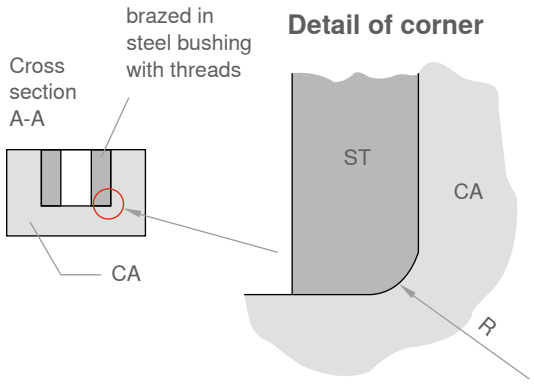
Through holes in the carbide for screws present no problem.

Threads in the carbide

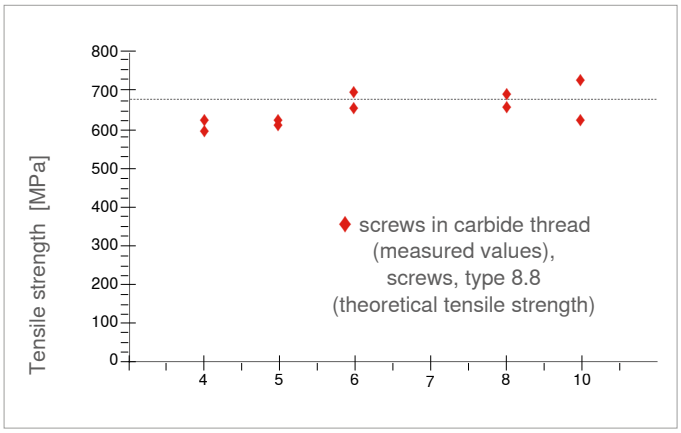
Moulded / ground / spark-eroded solid carbide threads are very expensive to manufacture.

Internal threads (solid carbide)
CERATIZIT studies have shown that the maximum tensile load of screws in cemented carbide internal threads (M4 to M10) is limited by the tensile strength of the screw material.

Internal thread (steel bushing in carbide)



Internal thread brazed into steel bushing



Results of the pull-out tests

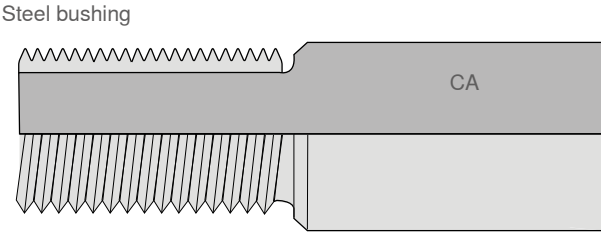
External threads (solid carbide)

External threads made of solid carbide are notch sensitive and can break off at high torsional loads with excessive torque.

Threads with steel bushings / screws

It is recommended to use threaded bushings made of steel that are brazed or bonded adhesively to the carbide.

External threads(steel bushing on carbide)



External thread (steel bushing on carbide)

Preformed thread as sintered

Thread	Max. length
M4	16
M5	20
M6	20
M8	30
M10	30

Adhesive bonding

Adhesive bonding is an uncomplicated, fast and inexpensive process. Industrial adhesive bonding should not be confused with handicrafts!

The surface treatment is crucial for the quality of the bond and its stability under load.
▲ Surfaces must be clean, dry and free of oil and grease
▲ 'Normal' surface roughness is preferable

There are different types of adhesives.
▲ One and two-component adhesives
▲ Cold and warm-hardening adhesives

Adhesive bonds can be used with a fracture resistance of <25–35 MPa and operating temperatures of <150–250 °C.

Adhesives are subject to ageing and therefore can be used only for a limited period of time.

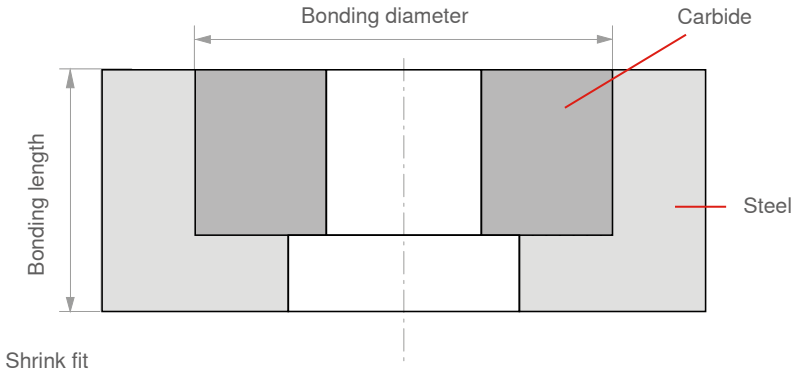
The bonded joint must be protected from cleaning agents and thinning agents. Liquids can wash out the adhesive, i.e. the bonded joint must be protected.

Design guidelines for adhesives must be observed. These may deviate from design guidelines for joints (example: butt joint adhesive bond).

Shrink fit

Shrink fit is another method for inserting a carbide die into a steel part. The carbide core is clamped by shrinking and hot or cold pressing with the steel fitting. Any internal pressure operating forces that occur can thus be compensated to a certain degree without the occurrence of tensile stress. In this bonding method, the carbide part is manufactured larger than the internal bore diameter of the steel part. After shrinking into the heated steel casing, the oversize allowance produces a clamping force, together with the cooling of the steel. It is important that the maximum bonding temperature not be exceeded during heating, in order not to adversely affect the hardness properties of the steel. However, the temperature must be high enough so that the inner diameter of the steel fitting expands by the amount of the oversize allowance.
Hot pressing is a combination of shrink fit and pressing. The steel casing is heated only moderately and the carbide is pressed in by means of additional pressing force. The steel retains its hardness properties for the most part.
If retaining the properties of the steel is the most important criterion, however, cold pressing must be used instead.

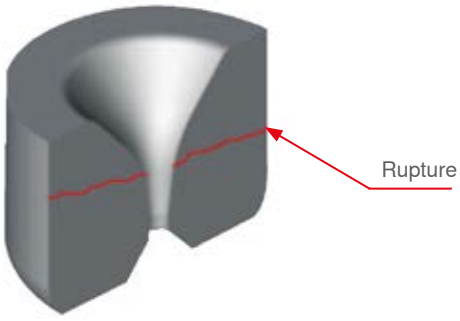
In addition to a high surface quality (through honing) of the bonding surfaces, the ratio of the bonding diameter of the steel and carbide, the so-called shrinkage ratio, is the decisive factor. This shrinkage ratio determines the exact bonding pressure and therefore the subsequent clamping force prior to assembly.



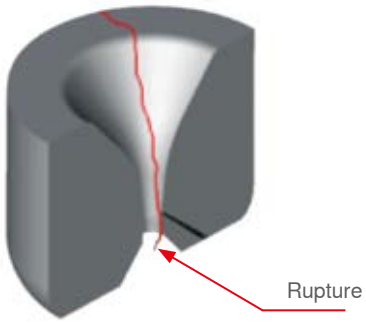
The surface quality of the contact surfaces should be the best possible and the fit should be tapered. Cold pressing can be conducted only with a tapered bonding diameter.

Overload fractures can occur if the clamping force does not sufficiently compensate the operating forces.

Effective solutions include:
▲ Increased clamping force
▲ Optimisation of shrink fit diameter



Rupture path due to excessive shrink tension



Rupture path due to insufficient shrink tension

Selecting carbide grades

For the successful use of carbide tools the following prerequisites are absolutely necessary:

▲ Correct machining / handling of the carbide
▲ Suitable die design
▲ Die stability
▲ Press stability

Grade selection criteria – example for the tool & die industry

Once the above prerequisites for the application of carbide are fulfilled, it is necessary to find the 'right' carbide grade for the specific application.

This selection process is affected by several factors:

Type of die
▲ Rotor / stator dies
▲ Connector / electronic dies
▲ Micropunching dies
▲ Fine blanking dies

Operation
▲ Stamping operation
▲ Bending operation
▲ Coining operation

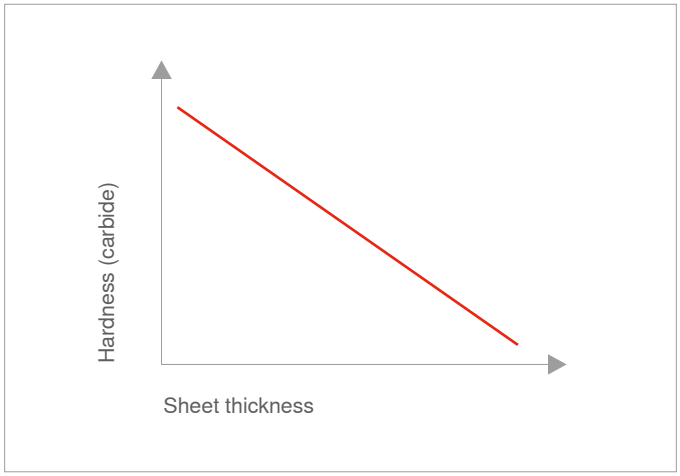
Stamping material
▲ Magnetic steel sheets
▲ Non-ferrous metal sheets
▲ ...

Sheet thickness

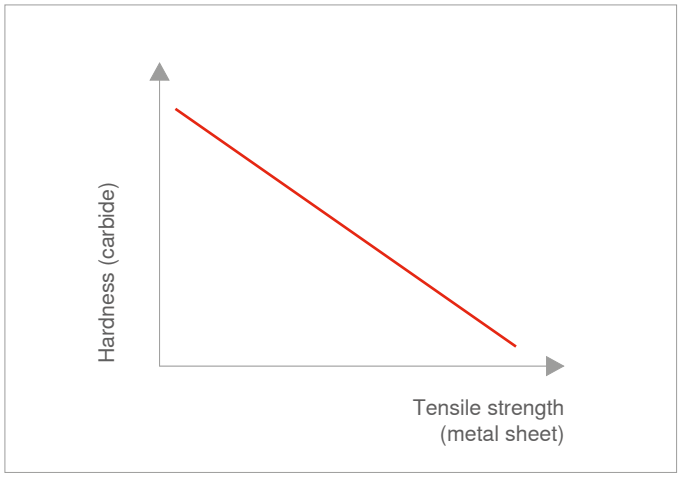
Tensile strength

The structural conditions of the stamping material (primarily the sheet thickness and tensile strength) provide the first general indication of the grade to be used. The other operations will help to narrow down the selection.

The relationship between sheet thickness and tensile strength in selecting a grade is graphically displayed below:



Sheet thickness



Tensile strength

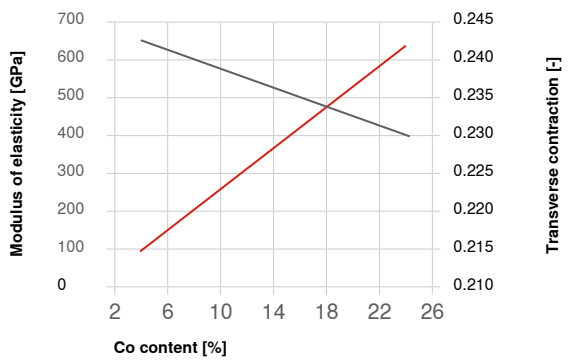
Carbide grades

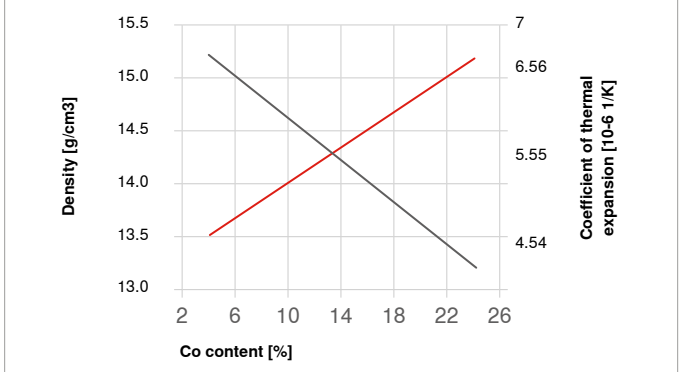
Fundamental guidelines for selecting the right carbide grade

Grain size	Impact strength	Stress caused by notch tensions	Tension and bending stress (with good surface quality!)	Resistance to adhesion (against metal)
Coarse/medium	++	+	o	o
Fine	+	o	o	+
Submicron	o	-	+	++
Ultrafine	-	--	++	++

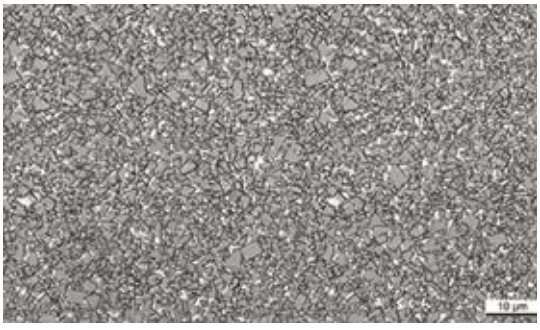
Within the grain size categories the following applies: with decreasing Co content (= increasing hardness) wear resistance and compressive strength rise, while toughness decreases considerably.

Modulus of elasticity, transverse contraction, density and coefficient of thermal expansion





Micrographs



WC Co carbide

Silicon nitride

Composition and properties

Corrosion-resistant grades

	CERATIZIT grade code	ISO code	U.S. code	Binder [m %]	Hardness HV10	Hardness HRA	Transverse rupture strength [MPa]	Transverse rupture strength [P.S.I]	Fracture toughness [MPa*m$^{1/2}$]
	Submicron grain								
	CF-S12D			6.0	1860	93.2	3600	522,000	9.0
	Fine / medium grain								
	CF-H25S+	K20-K30		8,5	1680	92,1	3600	435.000	10,3
	CF-H40S+	K40	C11/C12	12.0	1400	90.3	3200	464,000	12.5
	CF-F35Z			17.5	1200	88.2	3300	479,000	15.6

Other grades available upon request.

Classification of the WC grain size

Average grain size [µm]	Classification	CERATIZIT-Code
< 0.2	nano	N
0.2 – < 0.5	ultrafine	U
0.5 – < 0.8	submicron	S
0.8 – < 1.3	fine	F
1.3 – < 2.5	medium	M
2.5 – < 6.0	coarse	C
> 6.0	extra-coarse	E

The classification of carbides according to grain size corresponds to the recommendations of the Powder Metallurgy Association.

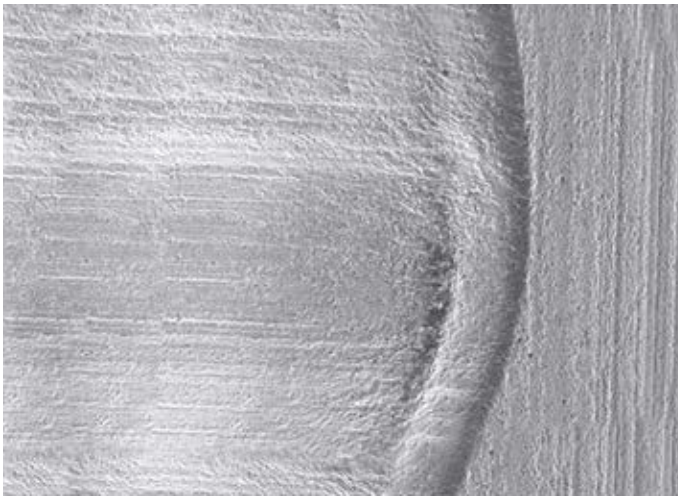
Comment:
1. The data in this table are typical material parameters. We reserve the right to modify the data due to technical progress or due to further development within our company.

2. K_{1C}*: The measured critical tension intensity factors (K1C) depend to a high degree on the sample geometry and sample preparation. A direct comparison with parameters which have been determined by means of a different method is therefore not admissible.

Application examples

In the following we will describe the selection of grades based on some examples.
If the selected grade is too hard for the application, the cutting edge will have the following appearance:

Cutting edge chipping



Shell wear

Consequently, a grade with a higher fracture toughness must be selected; however, it should not contain too much cobalt, since this can cause shell wear.

As a general rule, the following applies to the selection of the ideal grade:
As little cobalt as possible (to reduce adhesion and corrosion) and as large a grain as possible (in order to increase fracture strength and to stabilise the cutting edges).

The tables on the following pages is intended as a guideline to show you which grades have been applied successfully in the various forming processes. It should, however, be taken into consideration that in addition to the correct grade selection, a consistently high metallurgical quality is a precondition for long tool life.

Benefit from the know-how and the experience of your contact person at CERATIZIT to optimise tool life using the right carbide grade.

Application matrix

The following table offers a good basis for choosing the right grade. Further influencing factors such as the composition of the strip material, cutting gap, lubrication, geometry of the active parts and the structure of the tools should be taken into account in order to select the optimal grade.

Requirements regarding the surface quality

	Tensile strength (N/mm²)				
Strip thickness	< 500	500–900	900–1400	1400–2000	> 2000
< 0,2	CF-S12D CF-H25S+	CF-S12D CF-H25S+	CF-H25S+	CF-H25S+ CF-H40S+	CF-F35Z
0,2–0,5	CF-S12D CF-H25S+	CF-S12D CF-H25S+	CF-H25S+	CF-H40S+ CF-F35Z	CF-F35Z
0,5–0,8	CF-H25S+	CF-H25S+ CF-H40S+	CF-H25S+ CF-H40S+	CF-F35Z	○
0,8–1,2	CF-H25S+ CF-H40S+	CF-H40S+	CF-H40S+	CF-F35Z	○
1,2–1,5	CF-H40S+	CF-H40S+	CF-H40S+ CF-F35Z	CF-F35Z	○
1,5–2	CF-H40S+	CF-H40S+ CF-F35Z	CF-F35Z	○	○
2–3	CF-H40S+	CF-H40S+ CF-F35Z	CF-F35Z	○	○
3–6	CF-H40S+ CF-F35Z	CF-F35Z	○	○	○
6–10	CF-F35Z	○	○	○	○
> 10	○	○	○	–	–

○ Insufficient data. Test can be carried out upon request.
– Minimal damage due to machining operation (formation of thermal cracks, white zone, ...) and low roughness values. Adhesion due to strip material requires the best possible surface quality.

Hard Material Solutions

Hard cases are our speciality

We are your ideal partner when it comes to high-quality hard materials for production processes, tool manufacturing and wear protection.

From standard products to tailor-made solutions, from massive components to minute parts, from the blank to the fully finished product – a product that meets the highest standards of precision, surface treatment, and user-friendly assembly – our carbide and ceramic solutions ensure improved efficiency and outstanding total cost of ownership. This is the case in a variety of application fields and industrial sectors. Even when subjected to extreme stress, our cemented carbides are notable for the high flexibility they offer in numerous industries. Our products are specially designed for extreme working conditions, making our Hard Material Solutions impressive tools for optimising your processes and increasing wear resistance.

Product portfolio

▲ Blanks and semi-finished products

▲ Water-jet cutting

▲ Hob milling

▲ Drawing tools & drawing nibs

Solutions for:

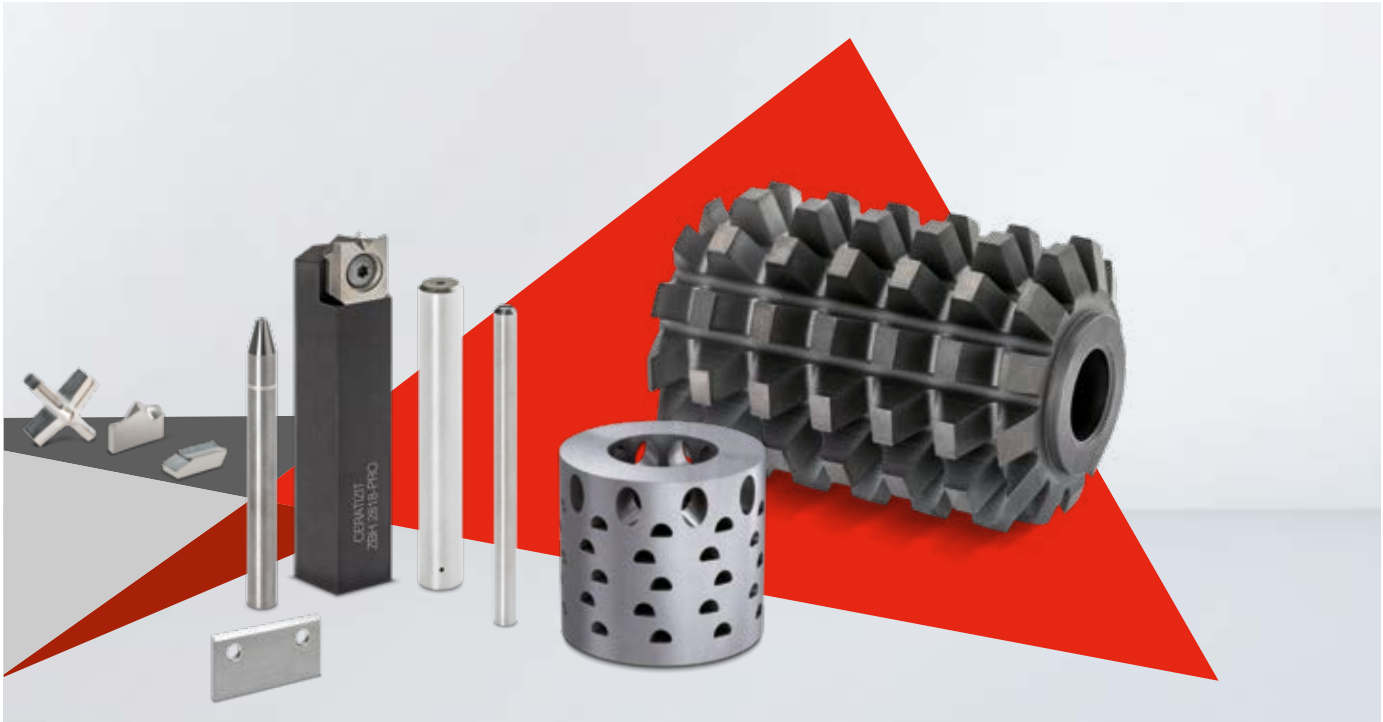
▲ Tool & die

▲ Fastening industry

▲ Injection technology

▲ Health industry

▲ Plastics industry



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We reserve the right to make technical changes for improvement of the product.

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