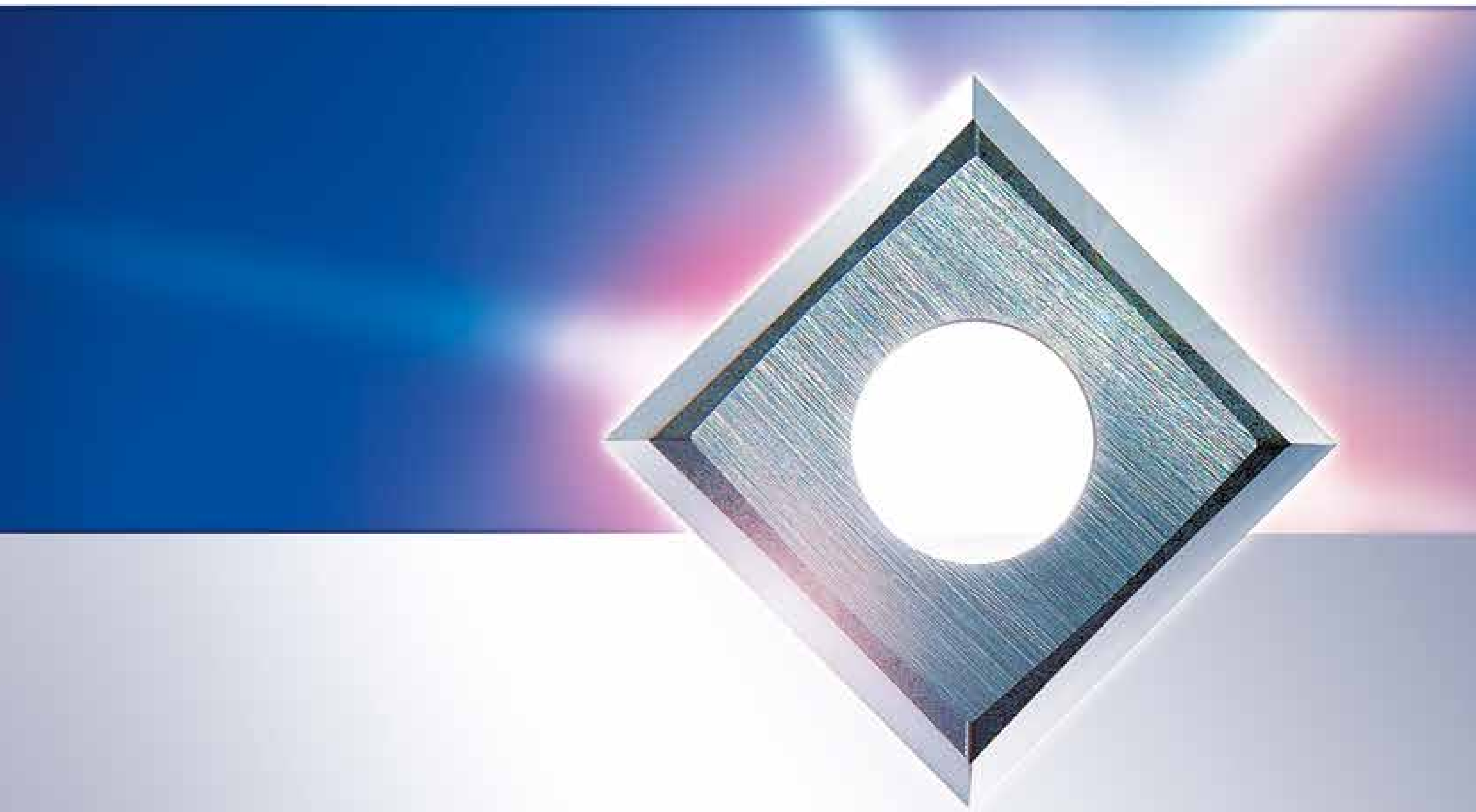
TOOLS CUT BETTER WITH TIGRA



TUNGSTEN CARBIDE
FOR WOODWORKING TOOLS

2016

Index

TOOLS CUT BETTER WITH TIGRA

1. INTRODUCTION

Processing of wood and wood composite materials has changed little at first glance in the last decades: sawing, milling, planing - everything looks rather unchanged.
However, exactly the opposite is the case: huge steps have been taken in the development of woodworking machines, drastically increasing feeds, speeds and rpm. In the area of cutting tools, completely different cutting angles and geometries are used.

And finally, there was a huge growth in the range of materials to be processed:
Always new panel materials, coatings and adhesives turn processing into a challenge, as well as the re-cycling market and the processing of frozen wood.

Since TIGRA started more than 30 years ago to develop different carbide grades for woodworking, cutting edge lifetime was multiplied. Every year new grades are developed and optimized, setting new standards in durability and surface finish. This diversity also leads to ever-increasing demands on the tool supplier. To facilitate the grade selection and carbide processing, we frequently test and characterize our products. Close R&D cooperations with technical universities in Germany and abroad as well as the partnership with our customers play a major role. We have put together the results of our tests here in this technical, practical guide.

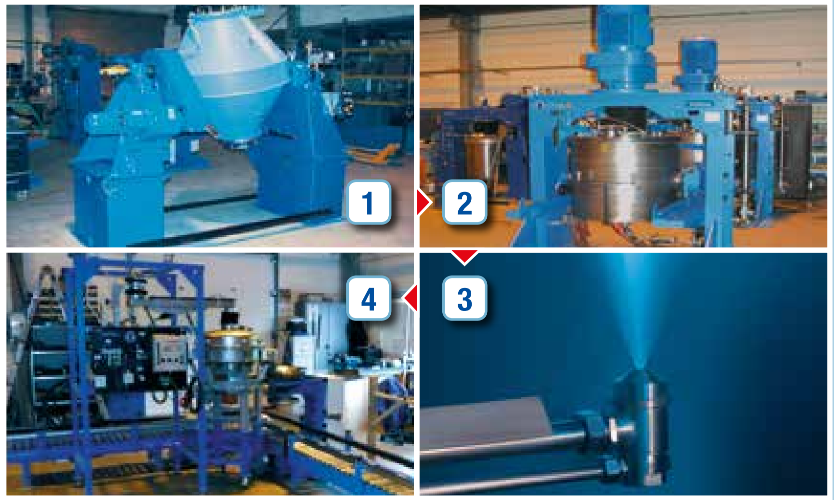
Fig. 1: View into the tungsten carbide manufacturing of TIGRA, Oberndorf, Germany

2. MANUFACTURING OF TUNGSTEN CARBIDE

Carbide woodworking consists of 80-98% of tungsten carbide and a binder,
usually cobalt. Additionally, corrosion resistant binders are getting more popular (see. p.10), where part of the cobalt is replaced by nickel, as well as complex binders with iron and molybdenum. The carbide raw materials are milled, mixed and spray dried. In spray drying, the mixed carbide powder is blown through a fine nozzle into a typically 6-8 meters (20-26 feet) high tower, where it receives its spherical shape, so important for pressing.
The finished powder or granulate is then compressed under several tons of pressure on a powder press in a mold to a solid with the consistency of chalk. It can as well be mixed with further materials and shaped by injection molding or by extrusion. This „green stage carbide“ can be processed either in the still soft state or immediately sintered at about 1400° C / 2550° F for several hours, then reaching its final shape, size and hardness. The metallurgical processes as a function of carbide powder, binder content, sintering temperature and time must be calculated accurately and executed and monitored closely. The final sintered product, if necessary, is then ground and cleaned. In this way, TIGRA manufactures hundreds of millions of parts. The aim is to achieve highest precision in dimensions and uniformity of the metallurgical and mechanical values to offer perfect usability and tool life. On pages 6-7 we have visualized the single steps of manufacturing.

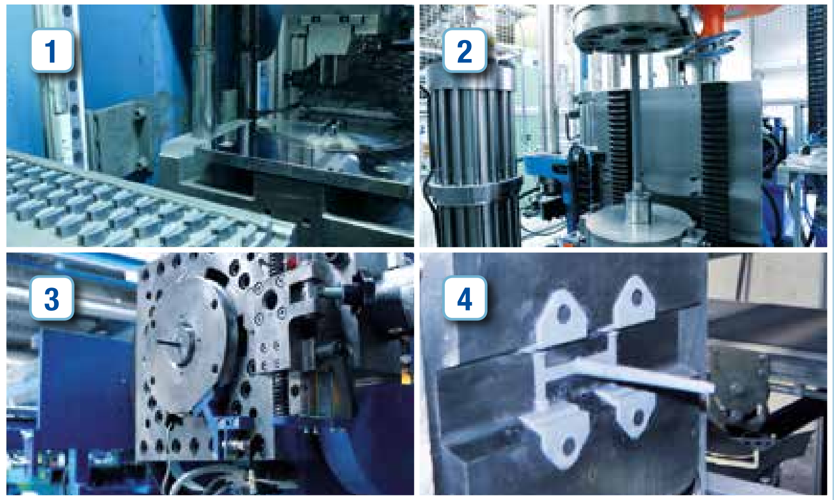
Fig. 2: Presses

3. THE SINGLE PRODUCTION STEPS



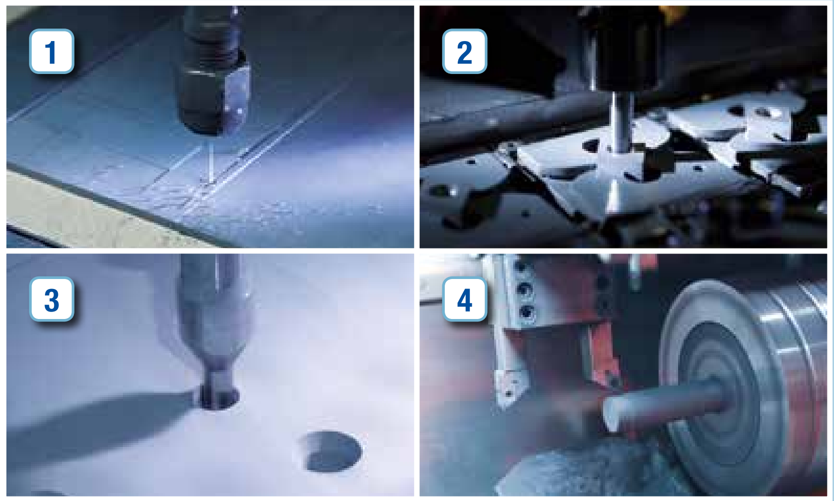
Powder manufacturing

1. Mixing → 2. Milling → 3. Spray drying → 4. Sieving



Pressing

1. Uniaxial pressing
2. Isostatic pressing
3. Extrusion pressing
4. Injection molding



Green carbide processing

1. Cutting
2. Drilling
3. Milling
4. Turning

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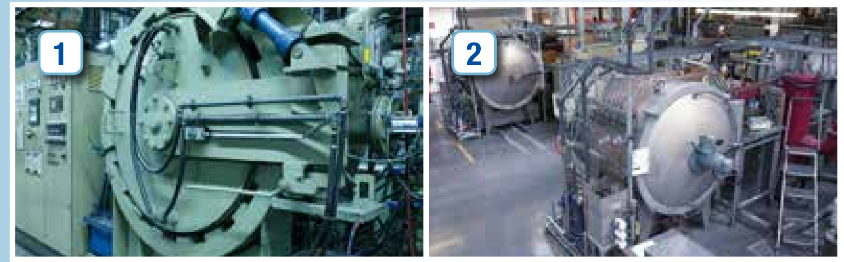
Sintering

1. Pressure sintering
2. Vacuum sintering

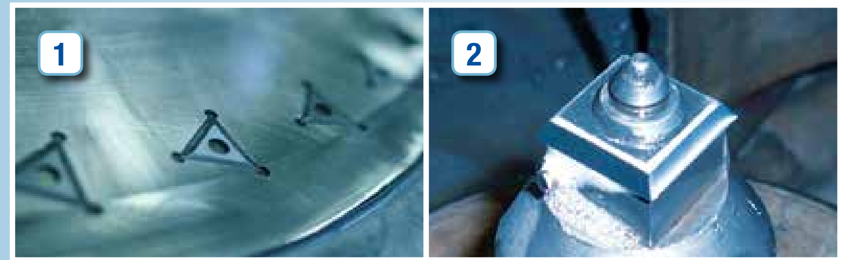


Surface treatment

1. Sand blasting
2. Coating

Grinding

1. Flat grinding
2. Edge grinding



Quality control

1. Analysis
2. Dimensional control

Packing and shipping

1. Packing
2. Shipping

4. BASIC TUNGSTEN CARBIDE PROPERTIES

Optimum results are achieved by a combination of four characteristics:

1. **Hardness**
2. **Bending strength**
3. **Wear resistence**
4. **Fracture toughness**

The hardness provides long lifetime, bending strength protects against breakage which can occur when working very hard coatings and/or at high cutting speeds and feed rates.
The toughness is a measure for the resistance against impact, important for example when cutting wood with knots, impurities in boards, or even nails.
Because of its high content of hard materials, tungsten carbide is much more wear resistant than other cutting materials (exception: diamond)

Hardness, bending strength and toughness mainly depend on 2 properties:

Grain size and binder content

In the modern tungsten carbide industry, grades are classified according to these properties.

Example: T03SMG describes a TIGRA carbide grade with 3% binder and extremely fine carbide grains (SMG = sub micro grain)

Additional name components can point to particularities (e.g. „-CR“, see p. 9).
At a closer look under the microscope, the various hard metals differ significantly (see fig 3: Photos of microstructures). As a result, they are more or less suited for different applications.

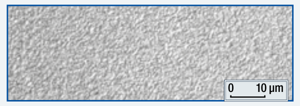
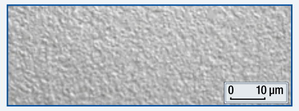
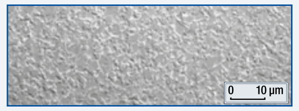
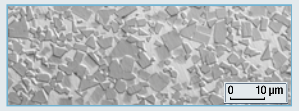
Grain size abbreviation	Explanation	Grain size (µm)	Microstructure	Example of TIGRA grades
UMG	Ultra Micro Grain	0.2 - 0.5		T02UMG, T05UMG
SMG	Sub Micro Grain	0.5 - 0.7		T02SMG, T03SMG, T12SMG
MG	Micro Grain	0.7 - 1.0		T03MG-CR, T04MG-CR, T06MG, T10MG, TL15, TL20
F	Fine Grain	1.0 - 1.4		T03F-CR, T04F-CR, T06F
MF	Medium Fine Grain	1.4 - 2.5		T07MF-CR
M	Medium Grain	2.5 - 4.0		T06M, T12M
C	Coarse Grain	4.0 - 10.0		T15C

Fig. 3: Abbreviations of grain sizes and microstructures of the different grades

The following illustrations show the most important dependencies of tungsten carbide properties from grain size and binder content.

There is a correlation between the tungsten carbide grain size, bending strength, and toughness which can be generalized as follows:
- The finer the grain size, the higher is the hardness (at same binder content).
- The finer the grain size, the higher is the bending strength (at same binder content and grain sizes of below 2.
- The higher the binder content, the higher the bending strength, but the lower the hardness and the wear resistance.
- The higher the binder content, the higher the toughness
- The larger the grain size, the higher the toughness (at same binder content)

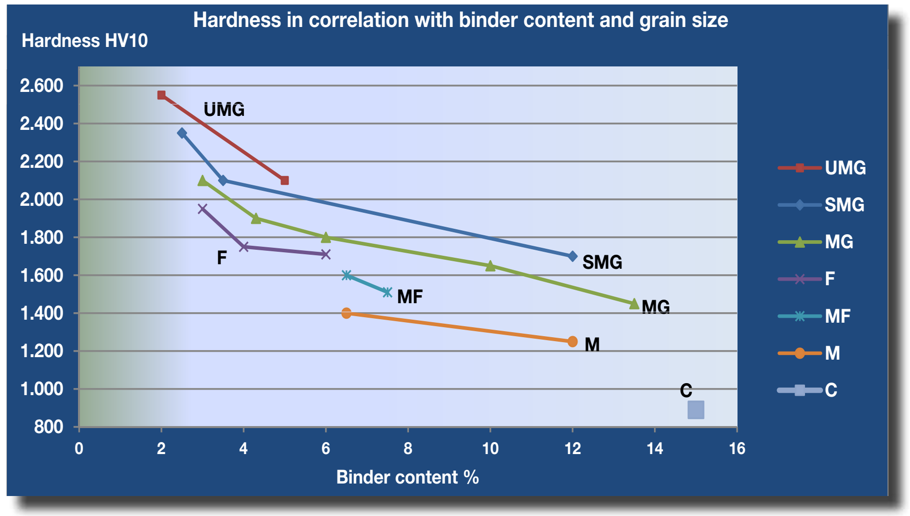


Fig. 4: Correlation of carbide grain size - binder content - hardness

Practical example:

TIGRA's carbide grades T02UMG and T02SMG with very low binder contents are setting standards when machining materials like MDF and HDF. The high hardness and wear resistance of the two grades is perfectly suited.

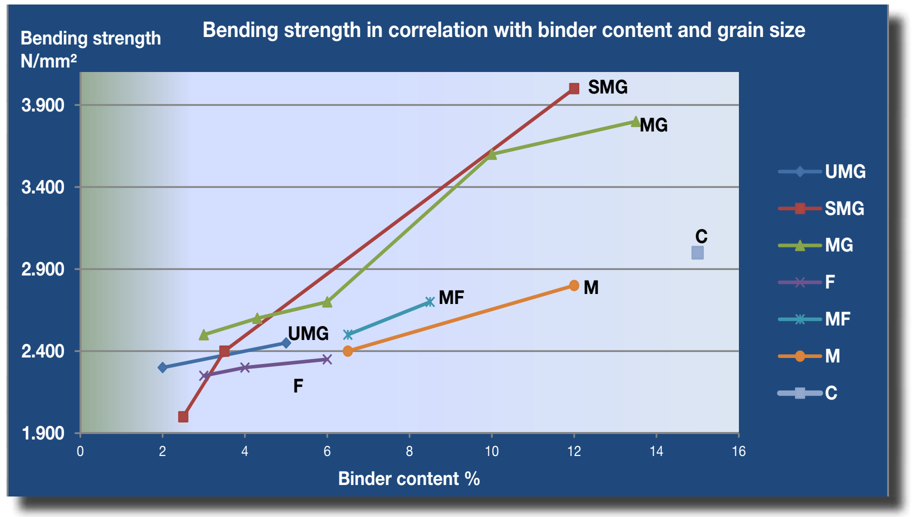


Fig. 5: Correlation of carbide grain size - binder content - bending strength

Practical example:

TIGRA's carbide grades T10MG and T12SMG with small grains and high binder content ensure high bending strength when machining soft woods.

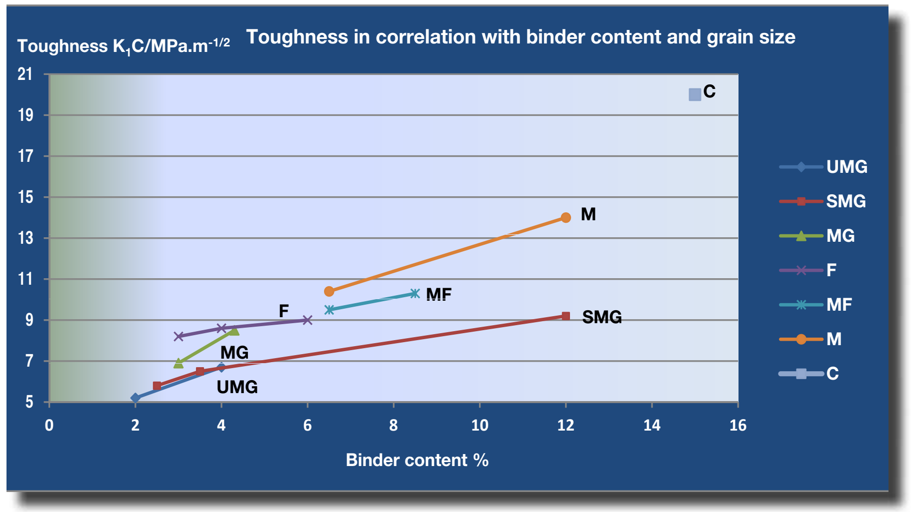


Fig. 6: Correlation of carbide grain size - binder content - toughness

Practical example:

TIGRA's carbide grade T12M is a rather large grain size grade with high binder content. The excellent toughness makes it a good choice for saw mills.

TIGRA TOOLS CUT BETTER WITH TIGRA

5. APPLICATION RECOMMENDATIONS OF THE TIGRA CARBIDE GRADES

TIGRA Grade	ISO	USA	Properties					Product groups					Recommendations								Annotation
			Hardness	Toughness	Bending strength	Braze-ablility	Grind-ability	Turnover knives	Blanks	Saw tips	Carbide for brazed cutters	Rods for solid carbide	Plastics	HDF	MDF	Chipboard	Hardwood	Softwood	Saw mills	Recycling	
T02UMG	K01	C4 +++	■■■■	□□□□	■□□□	□□□□	■■■■	■■■■	■■□□	□□□□	□□□□	□□□□	■■□□	■■■■	■■■■	■■□□	■■□□	■□□□	□□□□	□□□□	very brittle, preferably for hard, abrasive but homogeneous plastics and board materials
T02SMG	K01	C4 +++	■■■■	□□□□	□□□□	□□□□	■■■□	■■■■	■■□□	□□□□	□□□□	□□□□	■■□□	■■■■	■■■■	■■■■	■□□□	■□□□	□□□□	□□□□	rather brittle, preferably for hard, abrasive but rather homogeneous plastics and board materials
T03SMG	K01	C4 ++	■■■■	■□□□	■■□□	■□□□	■■□□	■■■■	■■■■	■■□□	□□□□	□□□□	■■■■	■■■■	■■■■	■■■■	■■□□	■□□□	□□□□	□□□□	all kinds of board materials, also CFK/GFK and very hard exotic woods without knots
T03MG-CR* (former: T05CR*)	K01	C4 ++	■■■■	■□□□	■■□□	■■□□	■■□□	□□□□	□□□□	■■■■	□□□□	■■□□	■■■■	■■■■	■■■■	■■■■	■■□□	■□□□	□□□□	□□□□	premium grade with high wear- and corrosion resistance for high end panel saws
T03F-CR* (former: T06CR*)	K01	C4 +	■■■□	■■□□	■□□□	■■□□	■■□□	□□□□	□□□□	■■■■	■■□□	■■■■	■■■■	■■□□	■■■□	■■■■	■■■□	■■□□	□□□□	□□□□	corrosion resistant grade for general use on panel and aluminum saws as well as solid carbide nesting tools
T04MG-CR* (former: T08CR*)	K01	C4 +	■■■□	■■□□	■■□□	■■□□	■■□□	■■■■	■■■■	□□□□	■■□□	□□□□	■■■□	■■□□	■■■□	■■■□	■■■□	■■□□	□□□□	□□□□	harder corrosion resistant universal grade for board materials and hard woods
T04F-CR*	K05	C4	■■□□	■■□□	■■□□	■■□□	■■■□	□□□□	■■■■	■■■■	■■■■	□□□□	■■■□	■□□□	■■□□	■■■□	■■■□	■■■□	■□□□	□□□□	universal, corrosion resistant standard grade for almost all wood and board materials
T05UMG	K01-K10	C3 ++	■■■□	■□□□	■■□□	■■□□	■■□□	■■□□	■■□□	□□□□	□□□□	□□□□	■■■□	■■■□	■■□□	■■□□	■■■■	■■■□	□□□□	□□□□	for hard and exotic woods as well as hard glue lines.
T06MG	K01-K20	C3 ++	■■■□	■■□□	■■■□	■■□□	■■□□	□□□□	□□□□	□□□□	■■□□	■■■■	■■■□	■■□□	■■□□	■■■□	■■■□	■■□□	□□□□	□□□□	wear resistant grade for solid carbide tools
T06F	K10	C3	■■□□	■■□□	■■□□	■■■□	■■■□	□□□□	□□□□	■■■■	■■□□	□□□□	■■□□	■□□□	■■□□	■■□□	■■■□	■■■□	■□□□	□□□□	universal grade for standard sawblades
T06M	K20	C3 -	■□□□	■■■□	■■□□	■■■□	■■■■	□□□□	□□□□	□□□□	■■■□	□□□□	■□□□	□□□□	■□□□	■□□□	■■□□	■■■□	■■■□	■■□□	for brazed cutters which need to be brazed and resharpened under simple conditions
T06MF	K20	C2	■□□□	■■□□	■■□□	■■■□	■■■■	□□□□	□□□□	■■■□	■■■■	□□□□	■□□□	□□□□	■□□□	■□□□	■■■□	■■■□	■■■□	■□□□	standard K20/C3 grade for brazed cutters, to be replaced by T07MF-CR
T07MF-CR*	K20-K30	C2-C3	■□□□	■■■□	■■■□	■■■■	■■■■	■□□□	□□□□	■■■■	■■■■	□□□□	■□□□	□□□□	■□□□	■■□□	■■■□	■■■■	■■■□	■■□□	new, corrosion resistant standard grade for brazed cutters, combines the properties of T06MF and T08MF
T08MF	K30	C2	■□□□	■■■□	■■■□	■■■■	■■■■	■□□□	□□□□	■■■□	■■■□	□□□□	■□□□	□□□□	□□□□	□□□□	■■□□	■■■■	■■■□	■■□□	standard K30/C2 grade for brazed cutters, to be replaced by T07MF-CR
T08M	K30-K40	C1-C2	■□□□	■■■■	■■■□	■■■■	■■■■	□□□□	□□□□	■■■■	■■□□	□□□□	□□□□	□□□□	□□□□	■□□□	■■□□	■■□□	■■■■	■■■□	tough grade for circular saw blades in saw mills
T10MG	K10-K40	C3 +	■■□□	■■□□	■■■■	■■■■	■■■□	■■■■	■■■■	■■■■	■■■■	■■■■	■■□□	■■□□	■■□□	■■□□	■■■□	■■■■	□□□□	□□□□	solid wood working with brazed and insert cutters; universal grade for solid carbide tools
T12SMG		C1 ++	■■□□	■■□□	■■■■	■■■□	■■□□	□□□□	□□□□	□□□□	□□□□	■■■■	■■□□	■■□□	■■□□	■■■□	■■■□	■■■■	□□□□	□□□□	high bending strength for high speed cutting in solid carbide tools
T12M	> K40	C1	□□□□	■■■■	■■■□	■■■■	■■■■	□□□□	□□□□	■■■■	■■■■	□□□□	□□□□	■□□□	■□□□	■□□□	■■□□	■■□□	■■■■	■■■□	saw mill and recycling applications, frozen lumber, easy to use
T15C	> K40	Nail Cut	□□□□	■■■■	■■■□	■■■■	■■■■	□□□□	□□□□	■■■■	■■□□	□□□□	□□□□	□□□□	□□□□	□□□□	■□□□	■□□□	■■□□	■■■■	extremely high fracture toughness for the recycling industry
TL15*	K10-K40	C3 +	■□□□	■■■□	■■■■	■■■■	■■■□	■■■■	■■■■	□□□□	■■■■	□□□□									softwood and window tooling, clearance angles of more than 40° possible
TL20*	K10-K40	C2 +	■□□□	■■■□	■■■■	■■■□	■■□□	□□□□	■■■■	□□□□	■■■■	□□□□									highly complex binder grade for excellent results in soft wood with knots

* Special binder; CR = corrosion resistant

APPLICATION RECOMMENDATIONS OF THE TIGRALLOY PLUS GRADES

TIGRA Grade		Hardness	Toughness	Bending strength	Braze-ablility	Grind-ability	Turnover knives	Blanks	Saw tips	Carbide for brazed cutters	Rods for solid carbide	Plastics	HDF	MDF	Chipboard	Hardwood	Softwood	Saw mills	Recycling	Annotation
TL48	TIGRAlloy	□□□□	■■■■	■■■■	■■■■	■■■□	□□□□	□□□□	■■■■	□□□□	□□□□	□□□□	□□□□	□□□□	□□□□	■■■■	■■■■	■■■■	■■■□	tips for band saws and circular sawblades in saw mills, recycling
TL60	TIGRAlloy	□□□□	■■■■	■■■■	■■■■	■■■□	■■■■	■■■■	□□□□	■■■■	□□□□	□□□□	□□□□	□□□□	□□□□	■■■■	■■■■	■□□□	■■□□	planing, edging and profiling of several kinds of hard- and softwood. Very high surface quality and amazing lifetimes

Technical Data:

TIGRA grade			Binder	Hardness		Bending strength		Toughness
	ISO	USA	%	HV 10	(HRA)	(N/mm²)	psi	$K_IC/MPa.m^{-1/2}$
T02UMG	K01	C4 +++	2.0	2500	> 95.5	2300	334.000	5.4
T02SMG	K01	C4 +++	2.5	2350	95.3	2000	290.000	5.7
T03SMG	K01	C4 ++	3.5	2100	94.6	2400	348.000	6.4
T03MG-CR* former: T05CR*	K01	C4 ++	3.0	2100	94.6	2500	363.000	6.9
T03F-CR* former: T06CR*	K01	C4 +	3.0	1950	94.1	2300	334.000	8.2
T04MG-CR* former: T08CR*	K01	C4 +	4.3	1900	93.8	2350	341.000	8.5
T04F-CR*	K05	C4	4.2	1800	93.3	2350	341.000	8.7
T05UMG	K01-K10	C3 ++	5.0	2050	94.5	2450	355.000	6.9
T06MG	K01-K20	C3 ++	6.0	1800	93.3	2700	392.000	8.2
T06F	K10	C3	6.0	1740	92.9	2350	341.000	9.0
T06M	K20	C3 -	6.5	1400	90.3	2400	348.000	10.4
T06MF	K20	C3	6.5	1600	92.0	2500	363.000	9.5
T07MF-CR*	K20-K30	C2-C3	7.5	1580	91.8	2600	377.000	10.1
T08MF	K30	C2	8.5	1510	91.3	2700	392.000	10.3
T08M	K30-K40	C1-C2	8.5	1350	89.8	2700	392.000	12.0
T10MG	K10-K40	C3 +	10.0	1650	92.3	3600	522.000	9.4
T12SMG		C1 ++	12.0	1700	92.7	4000	580.000	9.2
T12M	> K40	C1	12.0	1250	88.8	2800	406.000	14.0
T15C	> K40	Nail Cut	15.0	890	84.5	3000	435.000	> 20
TL15*	K10-K40	C3 +	13.5	1450	90.8	3800	551.000	10.5
TL20*	K10-K40	C2 +	20.0	1230	88.6	3800	551.000	12.0

* Special binder; CR = corrosion resistant

Fig. 7: Technical data of the TIGRA carbide grades

Changes and adaptations reserved!

6. CORROSION RESISTANT („CR“) TUNGSTEN CARBIDE

Green lumber and wood with high resin content, just like several glues and adhesives often contain acids. Depending on the pH-Value, these acids can cause negative reactions on the carbide cutting edge: the cobalt-binder is getting leached out of the tungsten carbide. This can result in a shorter lifetime. For this reason, the modern carbide industry is more and more offering grades which are less sensitive to acids. This corrosion resistance („CR“) is reached by substituting the cobalt binder by a mixed binder which consists of cobalt and nickel. Besides the positive effect, this mixed binder (cobalt+nickel) also slightly increases the fragility of tungsten carbide. That's why additional modifications had to be made to create the ideal grade for every application. Fig. 8 and 9 examplarily show how the former standard grade „T04F“ and the corrosion resistant grade „T04MG-CR“ have been melted into the new universal standard grade T04F-CR.

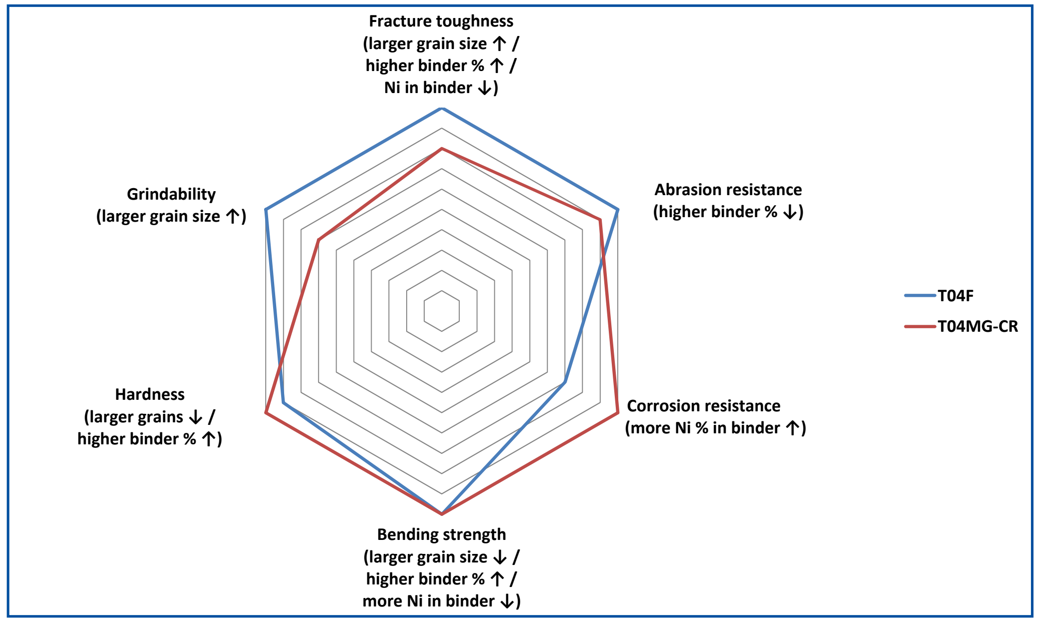


Fig. 8: Former carbide grades and their properties

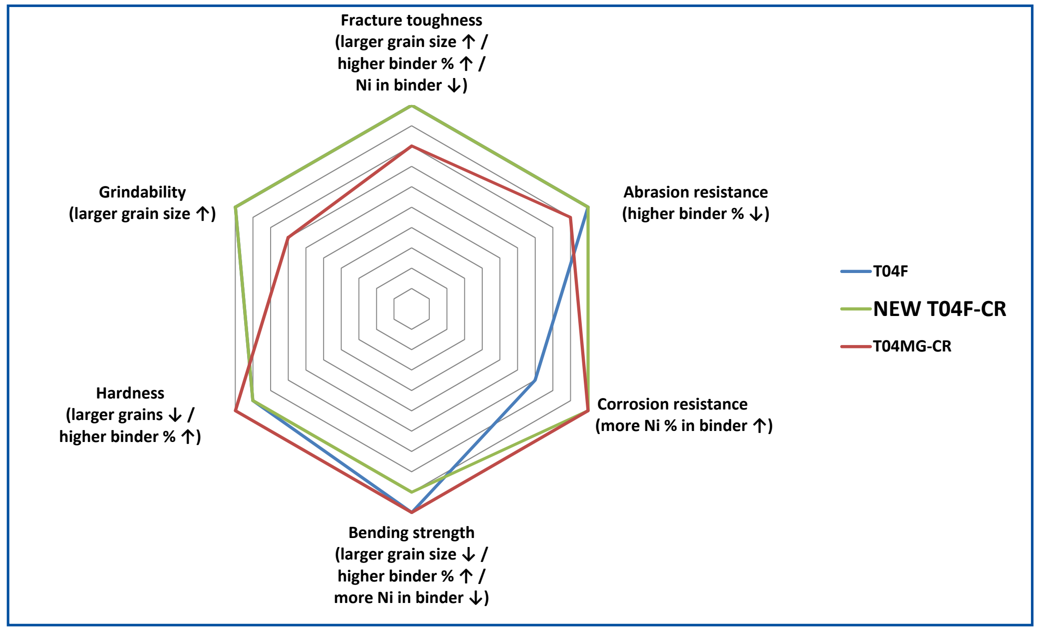


Fig. 9: Properties of the new carbide grade T04F-CR (geen color)

A large variety of further corrosion resistant grades rounds up the range:

T03MG-CR: Premium grade for panel saws and solid carbide tools for machining composites
T03F-CR: Standard grade for panel and aluminum saws as well as for solid carbide nesting tools
T03MG-CR: Harder universal grade for board materials and hard woods in knives and blanks
T04F-CR: Universal standard grade for all board and solid wood materials in knives and blanks
T07MF-CR: Symbiosis of K20+K30+CR (C2+C3+CR), perfect for many brazed tools

7. TIGRALLOY PLUS - A COBALT-CHROMIUM-TUNGSTEN ALLOY FOR SOLID WOOD

TIGRAlloy Plus, an alloy which mainly consists of cobalt, chromium and tungsten, takes a special position within the cutting materials being neither tungsten carbide nor HSS.
Even though its hardness is rather low, TIGRAlloy Plus can achieve multiple lifetimes of tungsten carbide in many applications because its wear pattern is completely different. In addition, TIGAlloy Plus is extremely corrosion resistant, tough and heat resistant up to around 800°C / 1500°F. The high bending strength and material composition allow steep angles and very sharp cutting edges which reduces cutting pressure and can achieve excellent surface qualities.
TIGRAlloy Plus is made by powder metallurgy and thus, compared to similar, cast materials 100% void-free (see Fig. 10).

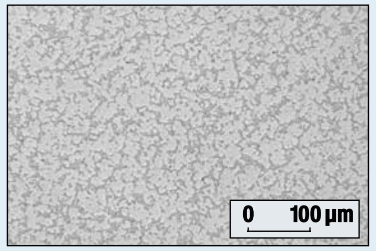
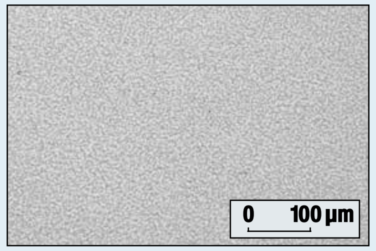
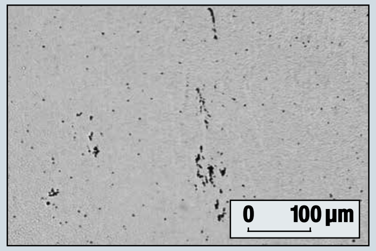
	TL48 Powder metallurgy	TL60 Powder metallurgy	Cast product (competitor)
100x			

Fig. 10: Homogeneous, void-free TIGRAlloy Plus made by powder metallurgy compared to a similarly alloyed but cast product.

2 grades are offered:
TL48 (hardness 48 HRC), especially as saw tips for processing green lumber. Here, the high toughness is used to make TL48 the ideal cutting material for circular, band- and gangsaws for the saw mill industry. Available in shapes of triangles, rectangles and typical saw tip shapes.

TL60 for indexable inserts, blanks for profiling, planer knives, back corrugated knives and STBs for brazed tools: perfect surface qualities and excellent lifetime in the described types of wood (without gluelines), compare to page 11. In addition, weight of the blades is reduced by around 40%.

Processing:

- **Use borazon grinding wheels only!**
- **Triangles and squares are usually welded, other tips and STBs are brazed.**

Application:

- **At fixed rpm, increase feed rates by 10-20%.**
- **At changeable rpm, reduce this by around 10%.**

TIGRA TOOLS CUT BETTER WITH TIGRA

Application recommendations for both TIGRAlloy Plus grades:

TL48 - for circular saw blades and band saws

recommended:	not recommended:
nearly all kinds of raw woods	Board materials
frozen wood	Glued-up wood
recycling of wood with impurities (e.g. pellets)	Extremely abrasive woods

TL60 - for planers, indexable and brazed profiling tools

recommended:

Abachi	
Afromosia	
Afzelia	min. 12% humidity
Alder	
Ash	
Avodiré	
Beech	min. 12% humidity
Birch	European
Cedar	Western Red
Cedar	
Cherry	
Chestnut	cultivated
Elm	
Fir	
Framiré	
Hemlock	
Incense cedar	
Larch	
Limba	
Mahogany	American red
Makoré	
Maple	European
Mengkulang	
Meranti	
Oak	American Red
Oak	European
Oak	Japanese
Okan	
Okoumé	
Oregon pine	
Parana pine	
Pear	
Pine	
Plane	
Poplar	
Ramin	
Redwood	
Sapele	
Sipo	
Sugar pine	
Tasmanian Oak	
Tola branca	
Walnut	
Willow	

not recommended:

Board materials	
Glued-up wood	
Extremely abrasive woods	
Afzelia	dry
Azobé	
Balau	
Beech	dry
Boxwood	
Bubinga	
Hickory	
Hornbeam	
Keruing	
Lignum vitae	
Maple	American
Merbau	
Movingui	
Mukulungu	
Muninga	
Oak	American white
Ogea	
Padouk	
Panga Panga	
Purpleheart	
Red kabbes	
Rosewood	Rio
Saligna gum	
Tali	
Teak	
Wengé	

8. BRAZING OF TUNGSTEN CARBIDE

Brazing is an important component in the manufacturing of carbide tools for woodworking. The higher the binder content of a tungsten carbide – cobalt alloy the easier the brazing process (the adherence of the solder on the hardmetal surface). Low binder content results in reduced adherence which is combined with a higher brittleness or a lower bending strength. Therefore large pieces of carbide with low binder content are especially difficult to braze without adherence or cracking problems. Larger tips for brazing should have at least a content of 6% cobalt. Uncoated, sand blasted tips are susceptible to grease which causes adherence problems during brazing. Sandblasted tips should be handled only with gloves.

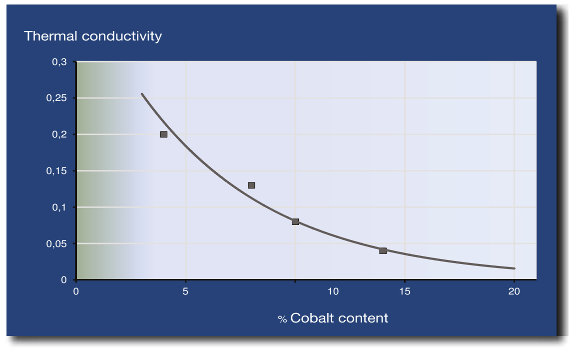


Fig. 11: Thermal conductivity with different cobalt contents

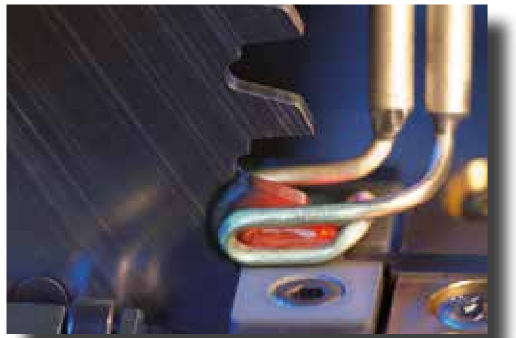


Fig. 12: Brazing of saw tips to a steel saw body

Coatings with nickel or cobalt improve the protection against surface contamination, while providing protection against oxidation and improve the solder flow. For larger cutters, coatings are not necessary - sandblasting or grinding of the carbide surface provide the best results. For router bits and saw tips, coating improves the brazeability significantly. In automatic brazers, coatings are mandatory.

The coefficient of thermal expansion or contraction during the cooling process is a very important point in the brazing process since it changes the severeness of heat-inducted tensions. The thermal expansion of tungsten carbide is reduced with increasing cobalt content (see Fig. 11).

Also, a lower tungsten carbide grain size reduces the thermal conductivity. Like this, fine- and micrograin carbides with increased cobalt binder content show a 10-20% increased heat tension. These tensions are partially equalized by the higher bending strength, but the increase risk of cracks in grinding remains. During the heating prozess in brazing, the steel body and the carbide part must reach brazing temperature at the same time. When induction brazing, the steel body heats up faster than the carbide. Also, holding time at maximum temperature must be long enough for a good solder flow. Measuring temperature during brazing is a clear advantage.

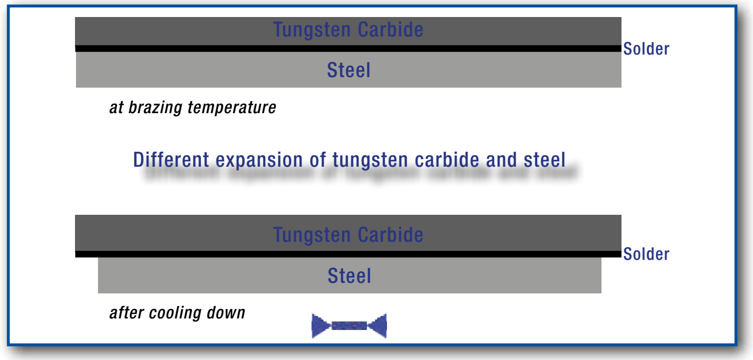


Fig. 13: Different expansion and contraction of tungsten carbide and steel when brazing and cooling down causes stress

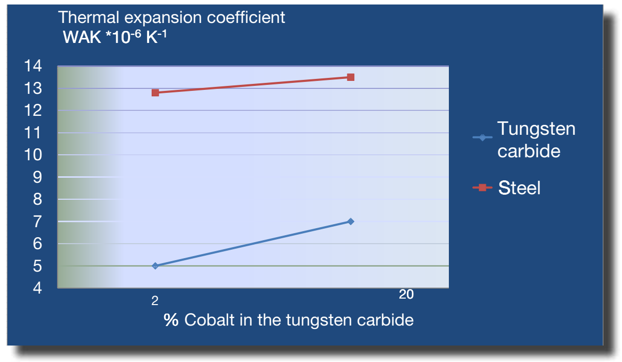


Fig. 14: Comparison of the thermal expansion of tungsten carbide and steel

Thermal expansion and contraction play a major role in brazing since the heat expansion coefficient of steel is around twice as high as of carbide (higher with high cobalt content, see Fig. 14). When cooling down, the steel body contracts further than the tungsten carbide (Fig. 13), leading to a convex deformation once the solder has solidified. This creates tensile stress on the carbide starting at its surface.

The crack starts vertically and then turns 90° converting into a horizontal crack when reaching the neutral zone. The horizontal part of the crack expands almost parallel to the carbide surface (Fig. 15). In many cases, this crack occures also when grinding the rake face. This risk can be reduced by cooling down slowly when below 450°C / 840° F, by e.g. cooling in a furnace or putting the tool in sand or pellets.

In critical cases, the use of trimet solder (silver - copper - silver) is benefitial. Also, the use of preprofiled carbide for brazing reduces tension and thus the risk of cracks.

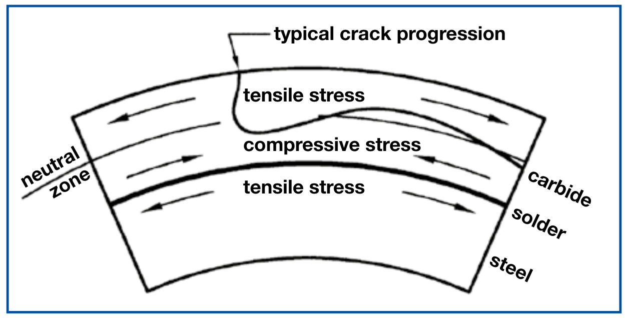


Fig. 15: Formation of a temperature stress caused crack

TIGRA TOOLS CUT BETTER WITH TIGRA

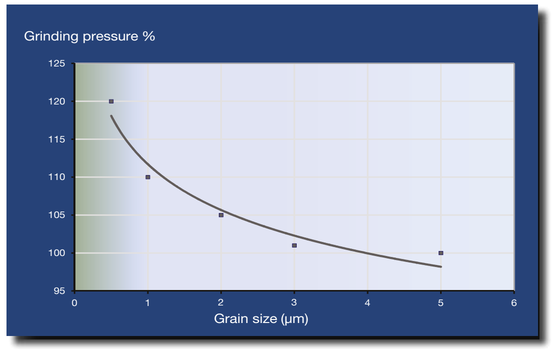


Fig. 16: Grinding pressure in relation to the grain size

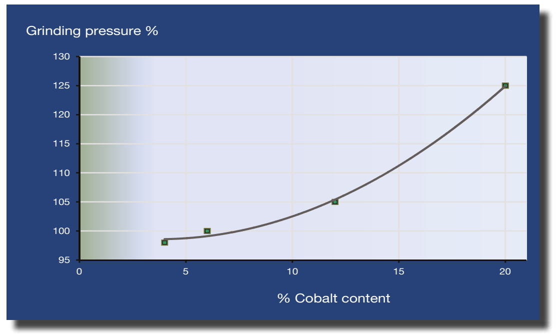


Fig 17: Grinding pressure in relation to the binder content

9. GRINDING OF TUNGSTEN CARBIDE

Thermal conductivity:

The most important factor is the decrease of the thermal conductivity with rising cobalt content (as shown in Fig. 11, page 12) and decreasing grain size. Carbides with less thermal conductivity need better cooling.

Diamond grain size of the grinding wheel:

- The lower the grain size of the carbide (see figure 3, page 4) the more fine should be the diamond grain size of the grinding wheel.
- The lower the cooling capacity, the lower should be the rpm of the grinding wheel.
- The thermal conductivity of the carbide decreases with increased cobalt content and smaller grain size.
- Carbide grades with less thermal conductivity and finer grains need a slower feed rate, lower RPM and good cooling with a lot of pressure.
- The pressure of the lubricants on oil base must be higher than that of the lubricants on water base.
- Grinding wheels with harder bindings are to be avoided. The diamond grain should always cut free.
- The grinding pressure is decisive for the amount of heat created in the grinding area. At high grinding pressures it is very important to have a powerful cooling (Fig. 16+17).

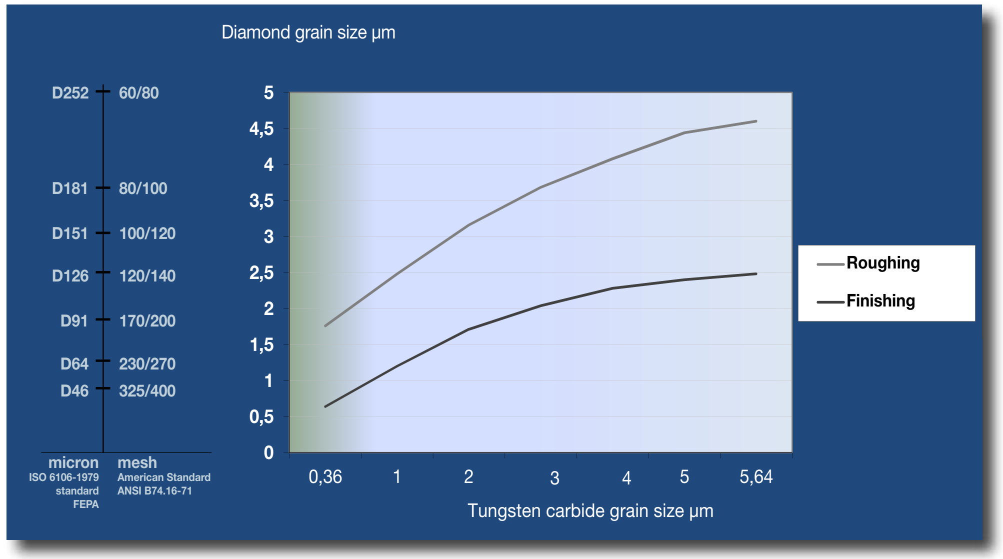


Fig. 18: Recommended grinding wheels per tungsten cabide grain size

Our grinding recommendations:

Tungsten carbide grain size	Grinding recommendation (based on water)
SMG	**Reduce grinding speed by 20%** **Roughing: D91 or D64 (170/200 or 230/270 mesh)/ Finishing: D64 or D46 (230/270 or 325/400 mesh)** **Coolant: min. 6 bar (87 psi)**
MG, TL15, TL20	**Reduce grinding speed by 10%** **Roughing: D91 or D64 (170/200 or 230/270 mesh)/ Finishing: D64 or D46 (230/270 or 325/400 mesh)** **Coolant: min. 6 bar (87 psi)**
F, MF, M	**Easy to grind** **Roughing: D151, D126 or D91 (100/120, 120/140 or 170/200 mesh)/ Finishing: D64 (230/270)**

Fig. 19: Grinding recommendations for the different grain sizes

Grinding recommendation (Formation and avoidance of grinding cracks)
Grinding cracks when grinding the tool face on brazed tools occur by increasing the tension which was built up during the brazing process in the carbide surface. When grinding the cutting edge of inserts and brazed tools, grinding cracks are caused by an insufficient cooling.To avoid cracks and reducing brazing heat tensions, the cooling process after brazing should be very slow. When grinding the cutting edge, a „“heat front““ is near the grinding wheel along the cutting edge. First, the cutting edge is heated highly by the grinding process itself, then it is cooled from the surface by the coolant fluid. This creates tensile stress which leads to cracks once the stress is higher than the tensile strength of the carbide.

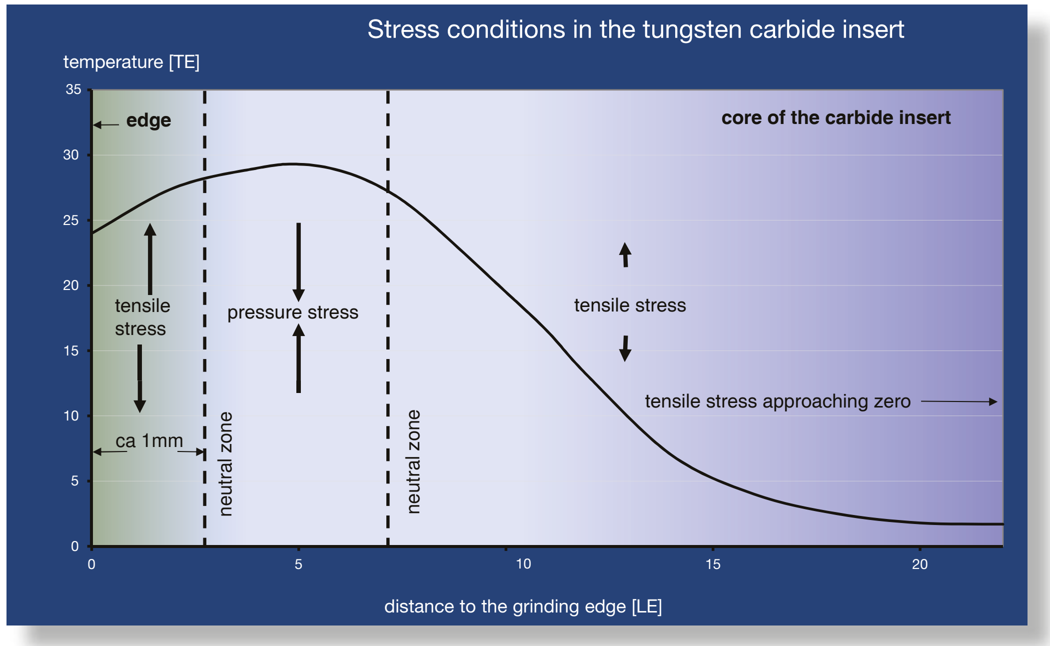


Fig. 20: Stress conditions in the carbide insert after a time t

The path of this tension is illustrated in Fig. 20. In the outer zone which is influenced by tensile stress, the strength of the carbide is surpassed and the carbide cracks from the outside since the tensile force is increasing from the neutral zone to the outer edge. The crack progresses towards the neutral zone where compressive force stands against the progress of the crack. This causes the typical shape of the grinding crack, starting diagonally from the edge towards the center, then rather parallel to the edge.This parallel line is always around 0.5-1 mm (.02“-.04“) away from the cutting edge (see fig. 21). The reason why this crack doesn‘t progress straight along the neutral zone, but always with an angle of around 60° can be explained as follows: The grinding wheel advances with a heat spot ahead of it, so the highest temperature is not vertical from the cutting edge, but has a directional component to the grinding wheel position from the outer point to a time t1. It was found that these grinding cracks reach an angle of around 60° in the direction of the wheel advancement until reaching the neutral zone and then progress rather parallel to the edge. Due to the crack the tension goes to zero and increases again when the wheel advances further. Then a new crack is formed having the same shape as the first crack. In studies up to 10 cracks with the same look and progresss have been found in almost always the same distance.

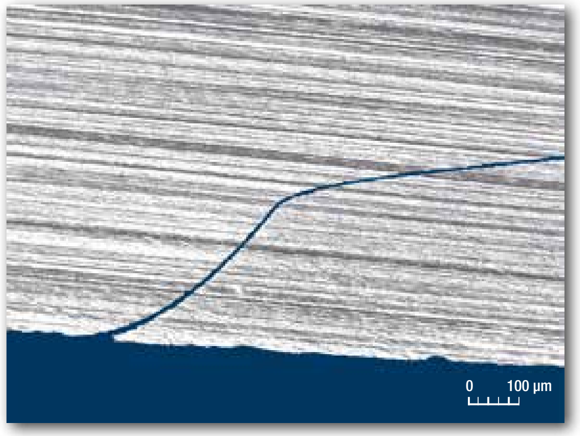


Fig. 21: Stress crack in edge grinding

These cracks mainly occur when coolant is insufficient and / or the grinding wheel is clogged. The pressure and the resulting speed of the cooling liquid is too low or the coolant doesn‘t reach the right spot of the grinding area. Furthermore, the correct diamond grain size and binder has to be chosen for the grinding wheel and the wheel must be cleaned regularly. Finally, feed rates and rpm have to be chosen correctly. Since these depend on machine and tool types, you find only indicative recommendations on p. 13, fig. 19.

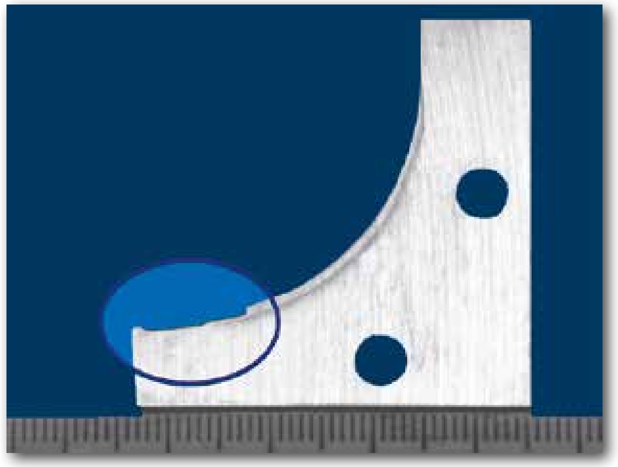


Fig. 22: Chip at the left side caused by heat, proven by the temper colors in the middle part of the profile.

10. TOOL GEOMETRIES

The angles on the cutting edge of the tools always play a decisive role in the performance of inserts and tools. Minor changes in the combination of angles can deliver critical results.

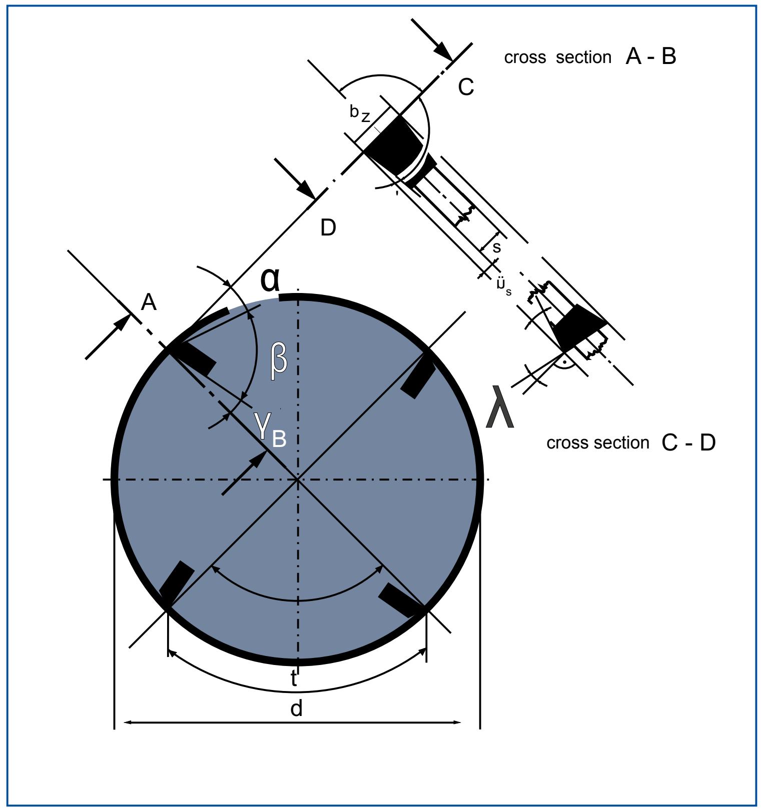


Fig. 23: Geometries on a peripheral milling cutter

Definitionen:

- α = clearance angle
- β = wedge angle
- γ = rake (hook) angle
- λ = cutting edge inclination (shear)

For clearance angle, wedge angle and hook angle, the correlation is:

$$\alpha + \beta + \gamma = 90°$$

The clearance angle (α):
A top clearance angle is required to avoid the contact between the clearance face of the tool and the wood surface. This clearance also helps prevent chips and wood dust, and glue and resin particles from creating pressure, heat and defects on the new wood surface.
The most common clearance angle is 15°, however this can vary depending on the wood.

The wedge angle (β):
A large wedge angle increases the breakage resistance of the wedge, but also increases the rounding during wear, which results in higher cutting forces.

The rake angle (γ):
A lower rake angle creates higher cutting forces and more severe deformations, crushing and destruction of the wood fibers, when machining softwood, creating a poor quality surface. A large rake angle results in a good surface when machining soft wood, and allows a higher feed speed.

The shear angle (λ):
The cutting edge inclination (shear angle) leads to a reduction of the cutting force and wear. Tools with helical or inclined cutting edges produce less noise and create a much better wood surface.

11. ACKNOWLEDGEMENTS

This compilation of technical information and experiences is in no way exhaustive. Rather, this work should act as an aid and reference booklet, assisting the operator in the everyday use of the products. We hope that this reference guidebook has been of assistance. We would like to thank the following companies and institutes for their support by providing professional pictures:

Fraunhofer-Institut
for Manufacturing Engineering and Automation IPA

(Title picture: Fraunhofer IPA, Rainer Bez)

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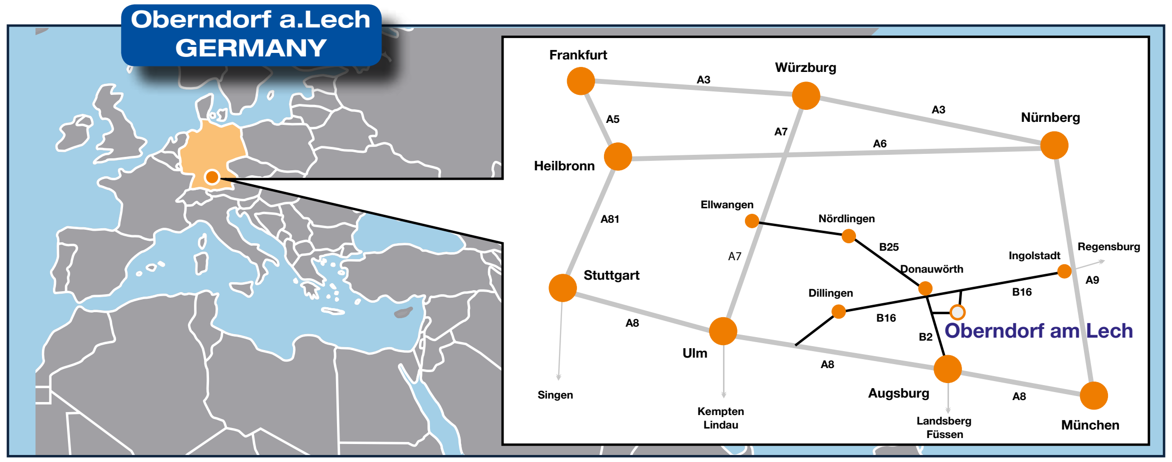

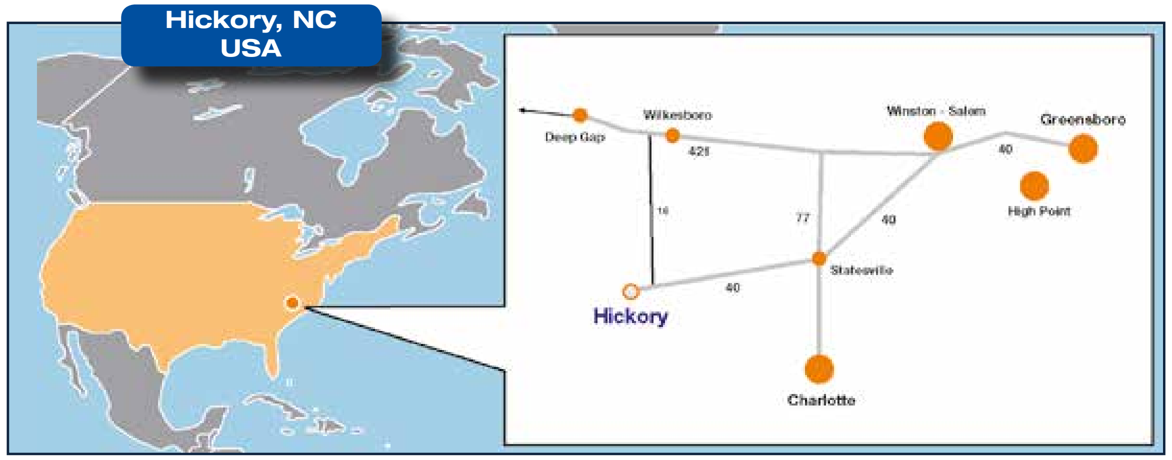

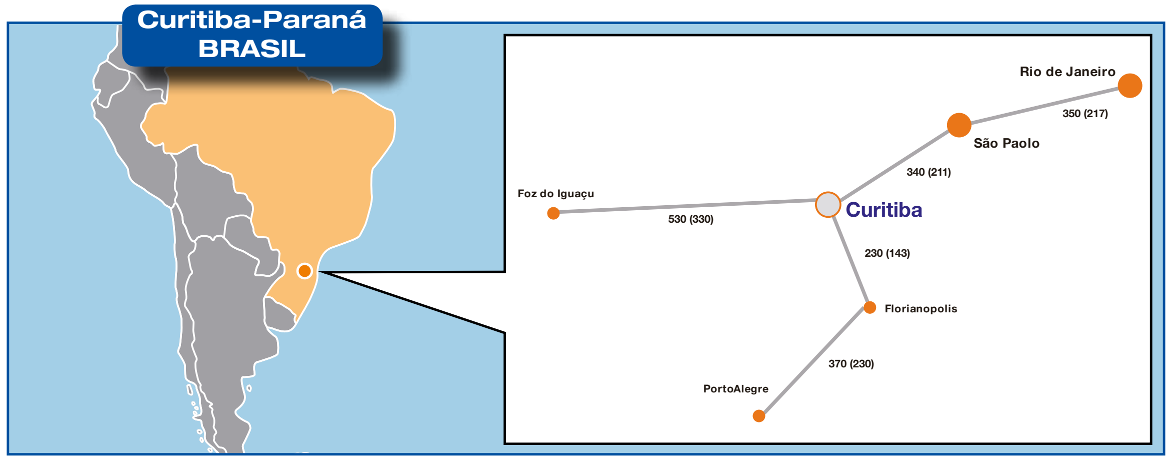

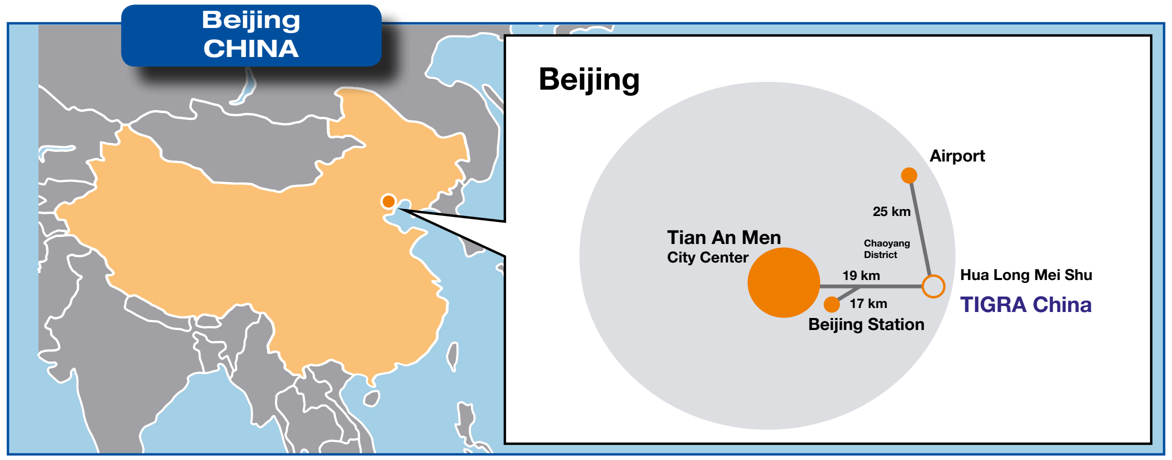

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