Issue 2/12

HORN

# world of tools

## HORN´S CUSTOMER MAGAZINE

SPECIAL:

**OVERVIEW OF IMPORTANT FEATURES** AND PROCESSING OF ADVANCED MATERIALS

- HORN Academy
- Innovations at AMB and IMTS
- HORN in China

**Dear Readers,**

Globalisation: a blessing or a curse? Whatever the case, it is now a permanent part of our continuously changing and developing existence. That is certainly true for industry, technology and the environment. For us too, the international markets are of increasing importance. In some countries, we have our own local representatives, in others we work together with strong partners. With each customer and application, both in Germany and overseas, we collect experience, work on solutions and discuss future projects and topics. These flow into our new products and new special solutions, so that, together with you, we can find the perfect result. This knowledge has also flowed into our new products for AMB, in order to open up further new opportunities and to shift borders.

The materials, which are a central topic in this "world of tools" are market-independent. Each material has its own 'DNA', which makes it different from other materials. This influences the choice of tools, the coating and the application. What is behind the selected materials, what are the challenges involved, how does HORN tackle the task and what do things look like in practice – we will be answering these questions on the following pages.

I hope you find the HORN customer magazine both interesting and informative.

Lothar Horn
Managing Director,
Hartmetall-Werkzeugfabrik Paul Horn GmbH
Tübingen

# world of tools

HORN´S CUSTOMER MAGAZINE




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Those responsible for the HORN Academy (from left):
Patrick Wachendorfer, Hans-Jürgen Bender.

# HORN ACADEMY

## Training for beginners, practitioners and professionals

**Training courses for our customers and employees have always been important to us. As career requirements increase, this company policy has received increased emphasis through the foundation of the HORN Academy. The HORN Academy began work in May 2012. Its modular courses, with vertical and horizontal linking, permit the following core areas of learning: customer training courses, advanced training of employee groups, milling seminars, study courses and employee qualification. The numerous modules on offer were developed in conjunction with external organisations and are also part of state training courses and examinations. The study material is formulated by our specialists as well as speakers from colleges and specialist institutions.**

### The Academy at a glance:

**Customer training courses**

From the basics of cutting technology through to special applications. The seminars on the technologies of our machining solutions all contain a theoretical and a practical section.

**Training and advanced training**

– Special tuition for industrial technicians, also as preparation for courses of study
– Advanced training for machine and systems' operators. The two-year training course is run together with the German Federal Employment Agency (Agentur für Arbeit). Advanced courses in industrial mechanics.
– Advanced training as industrial specialist for cutting tools with German Chamber of Commerce (IHK) examination

**BSc/MSc studies in cutting tools**

This training course, together with the Duale Hochschule Horb DHBW (Duale Hochschule Baden-Württemberg) will commence in 2013 and, with the new field, offers a long-term study alternative.

**Employee qualification**

The core areas are further technical and commercial qualifications, languages and general knowledge.

**Competence Centre**

Together with the companies DMG, Castrol, Tyrolit, 3M Winterthur and the DHBW Stuttgart, Horb Campus, we have established the Cutting Tool Technology Competence Centre. It supports the training course to a level of industrial specialist for cutting tools and studies in cutting tools.

**HORN Academy, today and tomorrow**

Currently, the seminar rooms are located in company buildings. In the medium-term, the Academy will have its own premises in close proximity to our head office.

**www.horn-akademie.de**

# SPECIAL MATERIALS

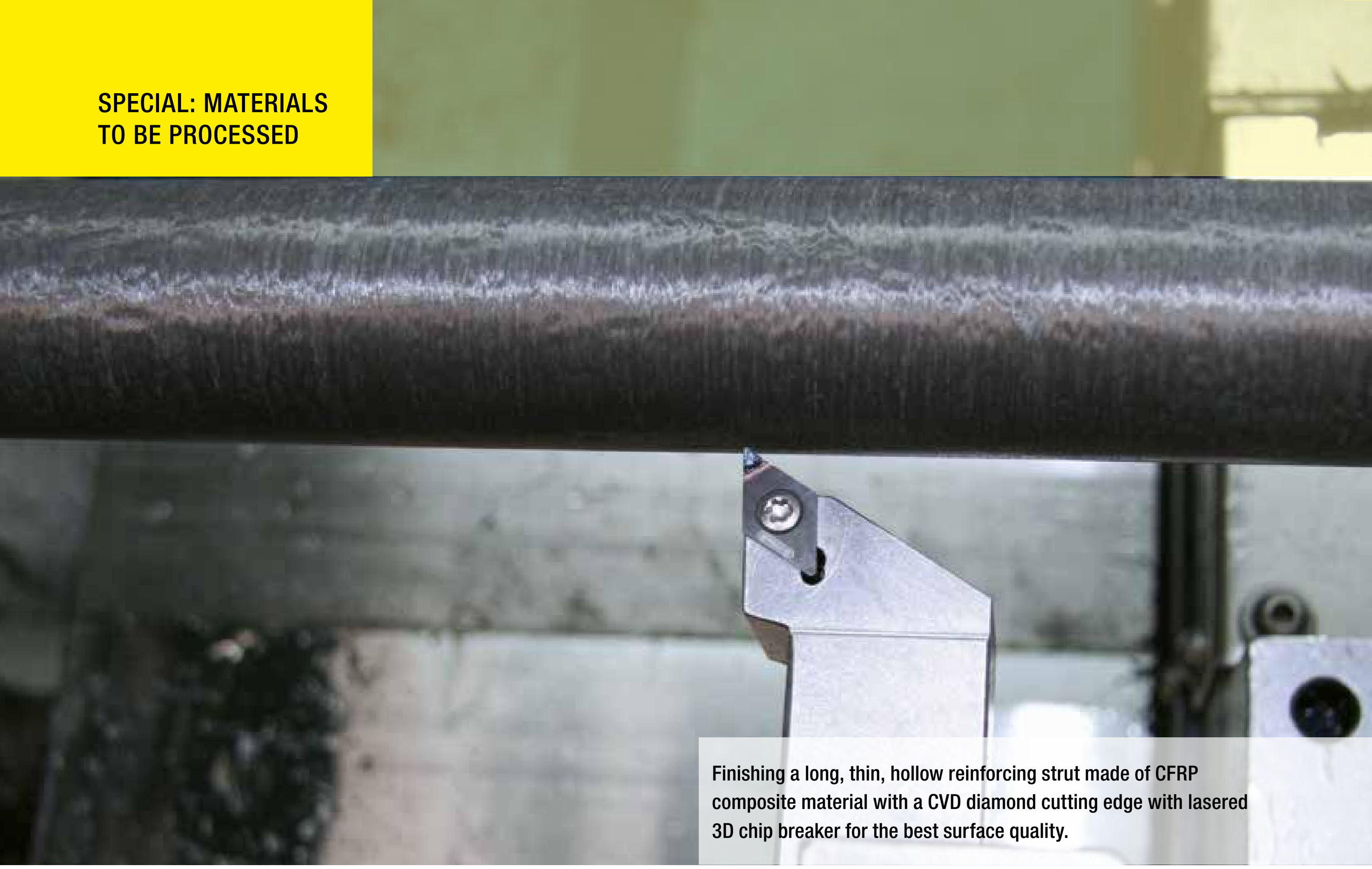
Composites

Highly heat-restistant steels

Titanium

Stainless steels

An overview of important features and processing of advanced materials



Finishing a long, thin, hollow reinforcing strut made of CFRP composite material with a CVD diamond cutting edge with lasered 3D chip breaker for the best surface quality.

# DIAMOND - THE CUTTING MATERIAL FOR COMPOSITES

**Developments in technology, in particular lightweight construction, in almost every sector, such as cars, aerospace and general mechanical engineering, all require the use of composite materials. A composite material is made up of multiple combined materials with various material properties. These composite materials are created according to the load or application situation. Sandwich structures made up of all kinds of materials permit highly complex constructions with a wide range of tailor-made application options.**

## Basic principles

In principle, composite materials are hybrid constructions. Copper layers for PCB functions or titanium layers for increased stability are just the simplest of examples. Machinability has to be evaluated differently with all composite materials, making the allocation to cutting classes, as is normal practice with steels, almost impossible.

In order to obtain an overview, composite materials can be roughly assigned to three main groups

– **Laminates** such as plywood panels
– **Particulate** composites such as chipboards
– **Fibre composites,** where a distinction is made between metal-matrix-composites MMC, fibre-plastic-composites FPC and ceramic-matrix-composites CMC.

The most important group is that of the FPC materials. This group includes the well-known carbon fibre reinforced plastics, CFRP, which is the most common area of application and is primarily used in aerospace construction.
In boat construction, FPC materials are used in the form of both glass fibre reinforced plastic (GFRP) and CFRP.
If components are needed with extremely high resistance and impact strength, then aramid or kevlar are used, in the form of aramid fibre reinforced plastic (AFRP).
High-performance composite materials are modern, lightweight construction materials with a high potential for innovation. Through the targeted combination of various fibre and matrix materials, as well as the use of special reinforcement architectures, tailor-made products can be created with the highest level of fitness for purpose for many different requirement profiles.

## Challenges in the machining of composite materials

When cutting composite materials, such as CFRP and GFRP, the machining situation is often unclear on account of the heterogeneous properties of the workpiece material.
Composite materials consist of a matrix, which is usually reinforced using glass or carbon fibres. Depending on the application, high-resistance fibres of every conceivable kind are used. The


A wealth of highly-innovative CirComp products made of high-performance composite materials with fibre or mesh matrices, surface-machined with CVD diamond cutting edges from HORN.

fibres are orientated according to the appropriate application of the end product. If these fibres are cut, then parallel or vertical fibre cutting takes place almost unchecked. Workpiece damage, such as jagged edges, delaminations and fibre breaks are the result. In particular, high-resistance fibres lead to strongly abrasive wear, which requires the use of high-hardness cutting materials.

The binding materials of the composites are not particularly temperature-stable and often set limits to cutting speed, in order to avoid thermal damage.

The combination of the composite materials can cause chemical reactions with the cutting material. Many criteria, such as the definition of component quality through the specification of surface qualities and guidelines for emission protection, are not defined.

The heterogeneous properties and difficult conditions involved when cutting composite materials require almost the complete spectrum of cutting materials. If sharp cutting edges are required to cut the fibres, then CVD diamond and PCD-equipped tools are used. However, shaping is limited using equipped tools, particularly in the case of complex workpiece contours. In some cases, even geometric requirements demand the use of carbides. In order to counteract abrasive wear, an appropriate diamond layer can be applied to carbides. There can be no generally valid standard solution for cutting composite materials.

## HORN tools offer solutions

For several months now, the composite material specialist CirComp GmbH in Kaiserslautern, Germany, has machined rotation-symmetrical components, such as pipes, struts, masts or slide bearings to diameter from high-performance composite materials using HORN CVD thick-film diamond cutting inserts. Previously, PVD cutting edges were the state of the art when machining fibre composites such as CFRP or GFRP. However, the superb properties of the CVD cutting edges are miles ahead of the cutting results of the PCD edges.

## Cutting fibres, not breaking them

Composite materials possess a range of fibre-matrix combinations. Seen microscopically, cutting fibres is akin to extremely

CVD-D tipped inserts with laser machined chip breaker.

interrupted cutting at intervals of microseconds with continually changing cutting angles through the high-resistance fibres: straight, transverse, diagonal, different in every layer. The new HORN cutting inserts, with their CVD thick-film diamond cutting edges soldered on using a special method, have increased tool life by 5 or 6 times, compared to the PCD cutting edges. There are several reasons for this: The CVD diamond cutting material is 99.9 % pure diamond made of homogeneous crystals of 20 (0.0079") to 25 µm (0.0098"). By comparison, PCD is a mixture of diamond and binder with a diamond component usually slightly over 80 %. This means that the CVD diamond is also considerably harder than PKD and is somewhat harder than a natural diamond. The cutting edge is precision-lasered with edge rounding and improved edge sharpness of 1 (0.0004") to 2 µm (0.0008"). During lasering, the individual crystals are cut and not broken out, as is the case with grinding. This means that CVD cutting edges are at least 10 times sharper than PCD cutting edges. The laser can be used to apply various chip breakers precisely to the cutting edge.

## High process reliability and tool life

The sharpness of the cutting edge, together with the increased hardness and toughness of the monolithic and finely crystalline CVD, is decisive for the long tool life and cutting performance of the CVD diamond cutting edges. As the sharp CVD cutting edge also cuts the fibres, instead of breaking them like PVD, there is logically also much less erosive wear. And when wear occurs on the CVD cutting edge, then it is often flank wear, which actually resharpens the cutting edge, with or without a chip breaker, up to a certain level. Diamond is also one of the best conductors of heat, meaning that individual areas of heat on the cutting edge are dissipated immediately, without overheating the blade.

The successful use of the highly-innovative CVD diamond cutting material has shown the basic fact that a positive cutting angle is the best universal solution for cutting fibre composites. It achieves the best results in combination with rough machining and finishing, particularly in the case of a high feed rate and changing chip thickness, for example during the first rough cut. Cutting with a 3D chip breaker also achieves the best surface qualities during finishing, as well as a long tool life.

Source: Institut für Werkzeugmaschinen Universität Stuttgart, Tagungsband 2011


Hans-Peter Fuchs, Production Manager at CirComp (from left) and Thomas Massinger from HORN are sure: "The CVD diamond cutting material will become the favourite for the machining of abrasive fibre composite components."

With a stable cutting point and high-performance HORN cutting inserts, four minutes were saved when grooving cooling ribs in stainless steel flanges, and the tool life more than doubled.

# SHORT CHIPS AND A LONG TOOL LIFE FOR STAINLESS STEEL

**The foundation stone for global use of corrosion-resistant stainless steel was laid 100 years ago. The patent for the "Manufacture of objects which require high resistance against corrosion" was issued on 18th October 1912. A quantum leap in materials' research, followed two months later by the patent for the "Manufacture of objects, which required high resistance against corrosion by acids and high strength".**

Heat-resistant, rustproof steels were marketed as "heat-resistant steels" and could be used at temperatures of up to 900 °C. Heat and acid-resistant stainless steels are described by the standard DIN EN 10020. In particular, it deals with steels with a high degree of purity and a sulphur and phosphorus content below 0.025 %.

## Basic principles

Simultaneous alloying using specific quantities of chromium and nickel, heat treatment and a reduction of the carbon content created the patented material V2A (austenitic steel). This material, called 1.4300, was the first, commercially-produced rustproof steel and, today, called 1.4301, makes up a third of the global stainless steel production. The then Krupp brand Nirosta - "nichtrostender Stahl" (rustproof steel) was created from these humble beginnings and patented in 1922. Slowly, the other members of the stainless steel family, ferritic and martensitic, as well as compound, were added to the austenitics.

Ammoniac synthesis (Haber-Bosch method), begun in 1913, could only be achieved through the use of austenitic steels, as developed by Krupp the year before. Thus, the parallel development of the steel and chemicals industry was no surprise, particularly in Germany.

Five HORN tools are involved in the decisive operations in the comprehensive machining of a workpiece made of rustproof stainless steel - one of them with a standard and special insert.

One of the radar level measuring systems from Endress+Hauser from the Micropilot series. Measurement accuracy: 0.1 mm (0.0039") across several metres.

The internal cone and the cooling ribs are the tricky operations on this component. Both were decisively improved using HORN tools.

Today, the deep grooves of the cooling ribs were rough-machined and finished using the same tool in one operation, using a HORN solution.

The main types are austenitic steels with approx. 18 % chromium, and make up approx. 70 % of the total, such as 1.4571, 1.4301 and 1.4401. Austenitic steels have the highest level of corrosion resistance and are usually not magnetic. In conjunction with carbon, the carbide former Cr forms the strongly abrasive chromium carbide.

## Challenges in the machining of rustproof steels

The strong tendency towards 'work hardening' during structural changes leads to major tool wear. Chromium and nickel reduce the heat conductivity to a great extent, meaning that the cutting tool must dissipate high cutting temperatures. The temperature is usually reduced by reducing the cutting speed vc [m/min](SFM), by approx. 50 % compared to structural steel. In addition, ferritic types, such as 1.4012 with approx. 17 % Cr, or martensitic varieties such as 1.4006 or 1.4021 with approx. 11 % Cr, are used. There are also compound steels and hardenable varieties, some with a chromium content of over 22 %.
Stainless steel is not necessarily rustproof steel. The exact material designation is required here in order to provide tool recommendations and cutting data.
Ferritic and martensitic rustproof steels have a relatively high carbon content and can thus be hardened. They have low to medium corrosion resistance. All the tools used for low-alloy steels can be used for these easily machinable rustproof steels.

## Difficult-to-cut austenites and compound steels

Austenitic rust-proof steels are considerably harder to cut. This material tends to stick and form build-up edges. The hardening of the material and the chips cause notching on the tool. Sharp cutting edges, positive geometries and heat-resistant hard metal types should be used with the tools.
Compound steels offer high corrosion resistance with high levels of strength. With them, chip breaking cannot be expected during turning work. High cutting forces create a lot of heat. High levels of crater wear and plastic deformation are the wear characteristics of these steels. Machinability can be considered as being considerably worse. Here too, heat-resistant metals, sharp cutting edges and positive geometries should be used.
The cutting data should be reduced according to the reduced machinability, both in the cutting speed and in the feed.

## HORN tools offer solutions

At Endress+Hauser in Maulburg, Germany, around 1,200 tonnes of rust-proof stainless steel are used every year to create hundreds of thousands of housings and other components for highest quality measuring equipment. 600 tonnes are turned into chips. The production of these stainless steel components is highly challenging, on account of the high requirements for dimensions, surface finish and economic viability. With its 82 different cutting solutions, HORN is one of the most important tool suppliers - and the favoured problem-solver on account of its knowledge and ability to react quickly.

## Doubly process-safe tool life – four minutes faster per part

When machining flange variants made from difficult-to-cut 1.4404 for a radar sensor, the greatest problem was the machining of the cooling ribs. The tool life of the cutting edges was only 6 to 7 parts and, despite pecking cycles, snarl chips prevented process safety - but there is an requirement for 100,000 similar parts per year.

Therefore, experiments were carried out with HORN inserts. Even without the previously standard pecking cycles, the "worst" insert in the trial achieved better results with acceptable chip breaking. The best solution, with regard to chip breaking and tool life, was an insert system Mini. Although the feed was increased from 0.09 mm/rev (0.0035 IPR) to 0.15 mm/rev (0.0059 IPR), with an average of 18 parts, this insert achieved more than double the standard quantity. The total time was also reduced to 14 minutes per part. The complete 4-minute time-saving could be put down to the RS108 grooving insert – as could the good chip breaking as well as the process safety, achieved for the first time on these parts.

Since then, the complete rib contour has been machined using the same insert. Firstly, pre-grooving to the rib diameter occurs, then each rib is pre-grooved on the toolpath using a cutting edge width of 4 mm (0.1575") to reduce the external diameter of 50 mm (1.9685") with 13 mm (0.5118") grooving depth to an internal diameter of 24 mm (0.9449"), in a single operation. Then the grooving of 5 mm (0.1969") is created by machining the left and the right flank - each with a slight finish milling allowance. In the finish milling cycle, the insert with its radius of 0.4 mm (0.0157"), creates the visually-required surface quality whilst maintaining the dimensions exactly.

A Capto cassette holder, with replaceable cassette, ensures easier changing of the insert, which also saves on downtime. The base of the standard insert S229 is coated with a 4 µm (0.0016")-thick nano-structured TiAlN layer.

A well-established team with almost 100 practical applications and 22 years of successful use of HORN tools. "Several large and small problems could be cut away with the right tool." V.l. Stefan Deiss, Group Manager in CNC production at Endress+Hauser in Maulburg, Dipl.-Ing. Armin Nüssle, Head of Mechanical Production, Karl Schonhardt, HORN and Thomas Herzog, responsible for production planning at E+H.

HORN circular mills worked best in a bow-shaped exact groove in a component made of Nimonic 90.

# HIGHLY HEAT-RESISTANT STEELS – BENCHMARK FOR TOOLS

**The DIN standard 17240 considers steels to be highly heat-resistant if they maintain good mechanical properties over a long period of time, including high time yield limits and creep strengths, as well as good relaxation resistances - at temperatures of up to approx. 800 degrees Celsius. For this, a minimum Cr component of 12 % as well as alloy additions, such as Mo, V, N or Nb, are necessary. They can be manufactured using either smelting or powder metallurgy processes.**

## Basic principles

With good resistance properties over the short and long-term, highly heat-resistant steels are particularly resistant to the effects of hot gases and combustion products at temperatures above 550 °C. The highest application temperatures in the air can be up to 1200 °C. This means that highly heat-resistant steels retain good mechanical properties at high temperatures. The evaluation criterion for resistance at high temperatures is the 1 % time yield limit Rp1/1000. It specifies the tension (in MPa), at which a permanent expansion of 1 % exists after 1000 hours.

A sufficiently high resistance to scaling is necessary for temperatures of 600 °C or higher. As carbon steel scales strongly, only high-alloy steels can be considered for these temperatures. Highly heat-resistant steels are also impervious to temperature changes, show a low tendency to embrittlement and are suitable for components with low mechanical loads (low heat resistance). Chromium is the most important alloy element, as it offers the best resistance to scaling. If, in addition, high resistance is required at high temperatures, then, besides high-alloy nickel steels with high contents of Cr, Mo, Nb, Ta and Tungsten, special heat-resistant non-steel alloys on a nickel-chromium basis - so-called "super alloys"- are available. Polycrystalline super alloys can sustain application temperatures of approx. 80 % of the melting point and monocrystalline alloys roughly 90 %.

These yellow boxes contained the decisive solution for the machining of thousands of workpieces made of Nimonic 90.

A basic distinction is made between ferritic and austenitic steels. In ferritic steels, the main alloy element is chromium, whereby additional Al (CrAl type) or Si content (CrSi type) are beneficial. Ferritic steels possess a non-convertible ferritic structure. Their resistance to shock loads is relatively low. Above 900 °C, they suffer from coarse grain formation, which is connected to brittleness. It is difficult to reshape them in a cold state. The steels are impervious to sulphurous gases.
By adding over 9 % nickel, austentic steels possess a non-convertible austenitic structure (e.g. CrNiSi and CrNiTi steels). Their high level of resistance makes them impervious to shock loads and sudden temperature changes. Additional properties include no susceptibility to coarse grain formation at high temperatures; considerably higher resistance to heath and creep strengths compared to ferritic steels; good shaping using any method; and resistance to sulphurous gases.

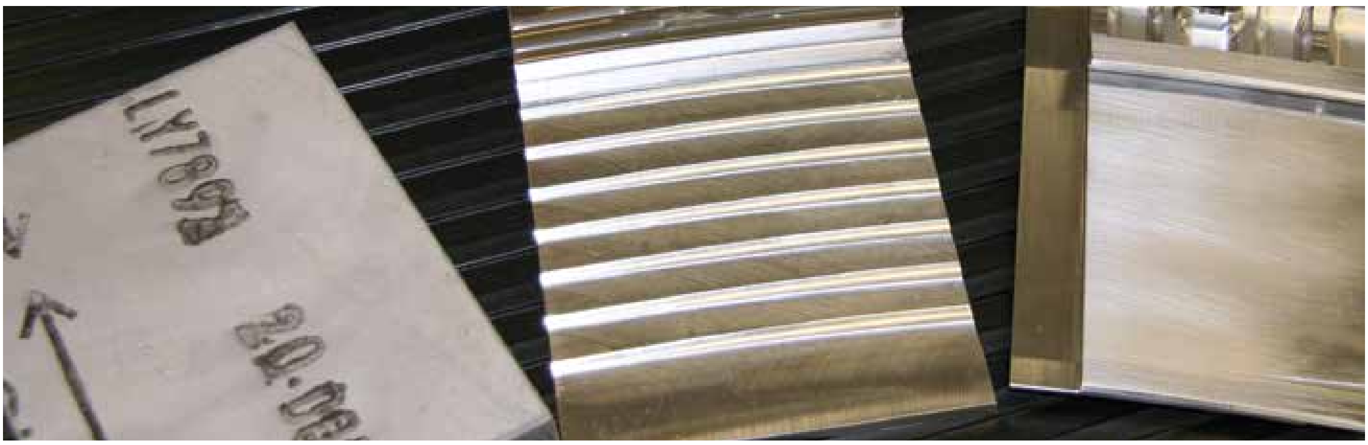
## Cutting tool requirements

If special requirements are placed on the thermal, mechanical and chemical properties of the workpiece material, then nickel-based alloys are generally used. Compared to steel materials, they have particularly low heat conductivity and, during cutting, tend strongly to the formation of built-up edges and hardening. Intermetallic phases in the nickel-based alloys have a very high melting point and abrasive effect. As a result, nickel-based alloys can be cut with coated carbide and relatively low cutting speeds of approx. vc = 30 - 60 m/min.

To achieve higher cutting speeds, tools equipped with polycrystalline boron nitride or whisker-reinforced ceramics can be used. However, due to the manufacturing process, the shaping of the cutting edge is very restricted.

A HORN circular mill, Type 628, roughly machines the groove, its twin brother finishes it and a further circular mill creates exact edge rounding.

The 6 mm (0.2362")-deep groove is rough machined to a depth of 5.9 mm (0.2323") in a single pass.



45 tools and up to 12 hours are required for the journey from the raw part to the finished sealing plate with 150 x 120 x 30 mm (5.9055" x 4.7244" x 1.1811").

## HORN tools offer solutions

Highly heat-resistant materials such as Inconel, Nimonic, Hastelloy, Waspaloy and other nickel-based alloys should be machined with the sharpest-possible cutting edges. Coatings tend to compromise the necessary cutting edge sharpness. In its milling tools, HORN uses a TiAlN nano-structured thin layer with low cutting edge rounding and excellent tool life results. The precision of the milling tools make a significant contribution to true running through the even load placed on the individual cutting edges. These are the primary reasons for the considerable increasing in cutting power of HORN milling tools on highly heat-resistance materials. Indexable inserts can also be manufactured using this carbide for grooving in turning, although finely-grained types are often used to machining the end contour. Despite lower cutting values with this uncoated version, the tool life result is perfectly acceptable.

## High geometric quality, process reliability and tool life

At Ottmar Buchberger near Nuremberg, Germany, a specialist for the machining of high-resistance materials for turbines, major benefits on cycle time and tool life have been achieved by using HORN milling tools.

A sealing plate of forged Nimonic 90 with the dimensions 150 x 120 x 30 mm (5.9055" x 4.7244" x 1.1811") is machined in several clampings. Due to the large amount of released stress, many measuring cycles have to be enabled and the zero point frequently redetermined between the 45 machining steps. The workpiece exerts pressure and, through the friction, generates a high level of workpiece wear, particularly on the free areas.
The machining of a bow-shaped groove with the radius of the appropriate compressor disc is the trickiest operation on this component. This 6 mm (0.2362")-deep and 3.6 mm (0.1417")-wide groove fixes the sealing plate exactly to the compressor disc, which turns at a high speed. This groove is machined using a Type 628 circular groove milling tool from HORN. The mill, with a diameter of 28 mm (1.1024"), a width of 3.34 mm (0.1315") and a radius of 1.67 mm (0.0657"), roughly machines the groove to the full depth in a single pass. A second identical groove miller is used to finish the top and bottom flanks with a feed of 0.1 mm (0.0039") to the dimension 3.6 x 6.0 ± 0.05 mm (0.1417" x 0.2362" ± 0.0020"). This operation has to be spread across two millers due to the required surface quality. The highly-loaded roughing mill is replaced after 21 parts and the less worn finishing mill after 36 parts.

The exact internal/top radius of the suspension groove is created by a miller of type 613, with a diameter of 21.7 mm (0.8543") and a convex radius of 1.25 mm (0.0492"). The finely-grained substrate of all three millers is coated with a thin layer of TH35. This nano-structured thin layer of TiAlN provides excellent shielding against high surface temperatures and, despite the necessary slight cutting edge rounding, ensures a sharp cut.
The results have been impressive the Type 628 miller is three times faster, with a tool life four times longer, than the previous best results. The Type 613 miller is four times faster with a doubled tool life.

From left: Peter Rümpelein from HORN and Michael Buchberger: "Highly-resistant materials soon sort out good tools from the best tools and good solutions from the ideal ones."

The rear side of a titanium housing lid for a motor-racing application after rough machining.

# EVERYTHING'S EASIER WITH TITANIUM

**Titanium was discovered by the English vicar William Gregor in 1791. Pure titanium was created for the first time in 1910 by Matthew A. Hunter (Amercian metallurgist). In 1940, William Justin Kroll was able, to create titanium for commercial applications using the Kroll process which relies on reduction of titanium tetrachloride with magnesium.**

## Basic principles

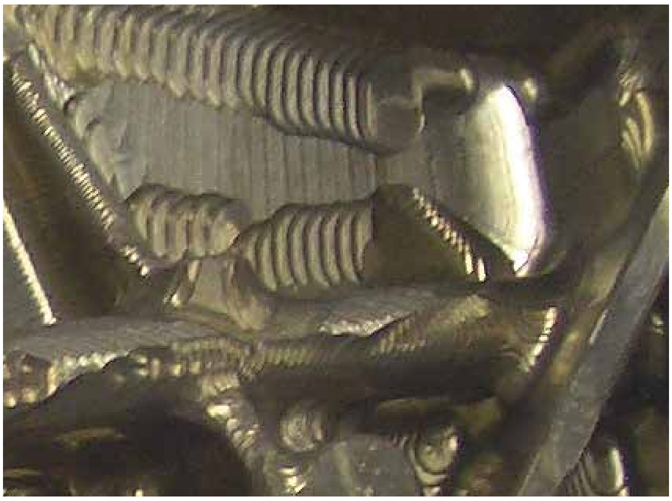
In the earth's crust, titanium is only found in oxides as a compound with oxygen. It is not a rare metal. With a content of 0.565 %, it is the 9th most abundant element in the continental earth's crust. It is most commonly found in the minerals rutenite ($TiO_2$), ilmenite ($FeTiO_3$) and $CaTiSiO_5$.

Since the discovery of the Kroll process, the refining process has remained almost unchanged. It is very complex and expensive. Starting mostly with ilmenite or rutenite, enriched titanium dioxide is heated and mixed with chloride and carbon to form titanium (IV) chloride and carbon monoxide. In the next step, reduction using liquid magnesium creates a titanium sponge. To create machinable alloys, this titanium sponge must be remelted in a vacuum arc furnace. Titanium is as hard as steel and twice as hard as aluminium. However, it is around 45 % lighter than steel and 60 % heavier than aluminium. Titanium and titanium alloys are used in aeronautical construction, in medical technologies, as construction parts, for outdoor and sports articles, and in electronics.

When exposed to air, titanium forms an extremely resistant oxidised protective layer, which makes it resistant to corrosion in many different media. Resistance properties diminish rapidly above temperatures of 400 °C. Titanium becomes super-conductive at temperatures below 0.4 K. Below 880 °C, Titan is found in a hexagonal system with a close packing of spheres. Above 880 °C, a body-centred cubic grid structure. High-purity titanium is ductile. At higher temperatures, it quickly becomes brittle through taking on oxygen, nitrogen and hydrogen.

Titanium has a high reactivity with many media at increased temperatures or increased pressure, if the passive layer cannot withstand the chemical reaction. Here, the reaction speed may increase up to an explosion.

Three HORN high feed milling cutters with extreme tool lives in titanium: one for volume, one for the contours and one for undercutting.



Cut-out of the front side of the housing lid after rough machining with the spherical cutter. The rest of the part is secret.

High feed milling with system DAH for geometrically complex components made of Titanium.

The mechanical properties and the corrosive behaviour can be improved considerably by small alloying additions of aluminium, vanadium, manganese, molybdenum, palladium, copper, zirconium and tin. Titanium is used both in its pure form and as an alloy. It has different properties, depending on the alloy content. The most common forms are pure titanium (high corrosion resistance), alpha titanium alloys (high resistance), alpha-beta titanium alloys (high hardness with high brittleness) and beta titanium alloys (for high-resistance connection elements).

## Cutting tool requirements

During cutting, the exceptional properties of titanium, in particular the low conduction of heat and high level of heat resistance, lead to great loads being place on the tools and thus cause major levels of wear. In particular, the high-resistance forms of titanium retain their hardness up to their maximum application temperature of roughly 880 °C. Due to the low heat conduction of the material, the greatest proportion of cutting heat is dissipated via the tool. The characteristic behaviour when cutting titanium materials is a high-frequency whistle created by microvibrations, which can be reduced by positive cutting. Countless investigations have shown that, during cutting, heat is dissipated better by negative cutting than by positive cutting. The challenge is to create a cutting edge geometry in which the best possible heat dissipation is guaranteed during soft cutting. When cutting titanium, thermal and abrasive wear is to be expected and the tool is subjected to heavy mechanical shattering.

## HORN tools offer a solution

Titanium's properties place special requirements on the tools. High concentricity and true running accuracy are required, e.g. for millers. In addition, the tools should have high static and dynamic stiffness against microvibrations. An uneven pitch and angle of twist can have a positive impact on circumferential milling. Tools with indexable inserts usually work with screwed-on cutting inserts. For positive cutting, we recommend the HORN geometry .40. for grooving, and it is also used successfully in turning. As a hard metal, we recommend the HORN TA45, a finely-grained hard metal with TiAlN coating, which does not tend to notching.

For plunge and groove milling, all the tools from the HORN product range can be used, according to the application, even with slight modifications. Various tools are available for milling.

## High process reliability and tool life

High feed milling using the HORN DAH system represents a model of success in this field. This tool can be used for, amongst other things, machining titanium housing lids for motor racing applications. The dimensions of the raw part are 300 x 200 x 100 mm (11.8110" x 7.7840" x 3.9370"). During cutting, over 90 % of the volume is turned into chips. What remains is a geometrically-challenging, structured housing lid with thin walls and ribs, with wall thicknesses of up to 1.2 mm (0.0472"). The component is machined in two variants, one small and one large. And although 10 pairs of each part are manufactured, each is considered to be unique.

Firstly, volume is removed using a high feed milling cutter of the DAHM series with a diameter of 32 mm (1.2598"), and then a spherical cutter of type DM with a diameter of 10 mm (0.3937") is used for rough machining of the finer contours. After hardening, the same spherical cutter performs the final machining and then a special milling cutter is used to make scale copies.

In a deep, round cavity, a HORN groove cutter of type 636 now mills multiple undercuts. Tool life: ten parts, each with multiple undercuts.

A HORN milling cutter of type 636 performs undercutting in a deep cavity. The complete machining task with all the operations takes approximately 80 hours for each of the smaller parts and no less than 120 hours for the larger, more complex part. 20 hours of this are spent on the volume cutting with the high feed milling cutter and in rough machining with the spherical cutter.

The high feed milling cutter used possesses an HSK-A63 mounting, its milling head is securely connected to the shaft using a screw-in mounting with M 16 thread and supported by the diameter. The 32 mm (1.2598") milling head has four precision-ground, three-edged inserts, DAH 37.022 M08.SA4B. The finely-grained basic material of the inserts is coated with a PVD multilayer coating.

With an advance of 0,5 mm (0.0197"), a feed speed of 1,800 mm/min (70.8661 IPM) and a feed per tooth of 0.83 mm (0.0327"), the milling heads mill well away from the limit area. This is not the aim, as, in the case of any operation on these valuable parts, it is process safety which is paramount. Internal air cooling cools the edges and the workpiece and blows the chips out of the cutting zone. A tool life of four hours for each of the cutting edges ensures safe and economical machining. The process safety of the millers is so high that the machines then work unattended overnight.

Pages 9 - 17 Sources: W. Seidel, F. Hahn: Werkstofftechnik, Hanser Verlag 2012, 9th edition, K. Weinert, D. Biermann: Spanende Fertigung, Vulkan Verlag 2009, 5th edition, Harry H. Binder: Lexikon der chemischen Elemente, S. Hirzel Verlag, Stuttgart 1999

From left to right: Georg Kloos, Programmer at Böhm + Wiedemann in Cologne, Siegfried Schäfer from HORN in Tübingen, Guido Gabriel, Head of Operations and Sven Griese, Head of Machining: Three of the four have long-term experience in motor racing - at least in the context of machining components for it.

# AMB AND IMTS 2012

## AMB, 18th – 22nd September 2012, Stuttgart

Hall 1, Booth 16

**"In those years when there is no EMO exhibition, we regard the AMB as the leading trade fair for the machining industry within Europe. It provides us with an opportunity to meet customers and interested parties from all the sectors that are important to us. That is why we use the AMB to present numerous innovations and developments – including solutions for machining applications that lie outside the core business for which we are known." explained Lothar Horn.**

Beside the company's own stand, technology from Paul Horn GmbH features on the DMG/MORI SEIKI stand, the "Lathe operater of the year", "Special show for young people", "THINK ING." and "Art meets technology".
More than 1,350 exhibitors from over 30 countries will show their products at AMB 2012 on over 105,000 m$^2$ of exhibition space. Special attention is being given to, amongst others, composites, wind energy, energy efficiency and BlueCompetence.
The VDMA sustainability initiative known as BlueCompetence aims at emphasizing the additional benefits that certain tools and machining technologies bring for mankind and the environment. The issue of innovation is particularly important in this regard. Whether we are talking about lightweight construction, composite machining, environmentally friendly lubricants or other applications – German tool manufacturers and our customers are leading the way internationally.
**We look forward to meeting you and would like to thank you for your interest in the AMB and/or the IMTS – and the innovative technologies available from HORN.**


## IMTS, 10. – 15 September 2012, Chicago, Illinois, USA

**At IMTS in Chicago, the largest and most important trade fair for machine and tool manufacturing in North America, we will be hosting an exhibition area of 250 square meters. The latest innovations and developments being exhibited are largely identical to the product news at the AMB.**

At IMTS in Chicago, the largest and most important trade fair for machine and tool manufacturing in North America, we will be hosting an exhibition area of 250 square meters. The latest innovations and developments being exhibited are largely identical to the product news at the AMB.

In 2010 there were over 82,000 visitors from 119 countries to the largest trade fair for machine tools and machinery on the South and North American continent. In the exhibition halls at McCormick Place 1728 exhibitors showed their products and services. This year the organizers expect, despite the tense economic situation on the American continent, similar numbers of exhibitors and visitors with a slightly increasing trend. These expectations are based amongst others on a major IMTS-theme: bringing back jobs to the USA.

Hall W, Booth 1722

# Tool cooling with nitrogen

**Test of tools for cryogenic cutting**

One of the EMO highlights last year was cryogenic cutting. Cooling with nitrogen allows improved cutting parameters and permits longer tool life, particularly in the case of titanium and nickel alloys or compound steels – materials in which the high thermal load on the cutting edge leads to high tool wear.

As countless customers are expecting statements on the practical application of the new cooling alternative to conventional cooling lubricants, tests are currently being carried out in our own demonstration centre and by partners. The core items are tangential rotation and grooving with indexable inserts and tool holders, adapted to the special application conditions. Of particular interest is the transition of the coolant from a liquid to a gaseous state, its impact on tool design and the design of a detensioning chamber.


Indexable insert and holder for cryogenic cutting.

# S100 cutting insert with internal cooling

S100 cutting insert with internal cooling.

**Cutting zone cooled effectively**

Thanks to provision of an internal coolant supply duct, the latest development of the HORN S100 range expands the versatility available with this series of inserts. Available on an insert width of 4 mm (0.1575"), the integrated coolant jet works directly at the cutting edge, ensuring the best cutting conditions in the cutting zone. The funnel-shaped nozzle creates a coolant jet which generates specific chip forming, and thus reduces the chance of chip build-up. In addition, the formation of a build-up edge and the risk of break-outs on the cutting edge are considerably reduced. Compared to standard cooling systems, higher cutting parameters are possible and better tool lives are achieved.

With hard-to-cut materials, the carbide version AS45 and the EN geometry shape with chip former also permits good chip flow with long tool lives and process-safe work, even with long engagement times and at high temperatures.

The holders with inner cooling are available in clockwise and anticlockwise versions. Screw clamping or self-clamping permit simple insert replacement with high repeat accuracy.

# Fine-boring head with digital display

**Tools for pre-drilling, finish boring, axial reduction and reaming pre-machining**

When grooving holes of Ø 0.2 mm (0.0079") or more, our Supermini® system is able to produce topquality results. These system benefits are now also available in the digital fine-boring head DB05. In conjunction with the Supermini® tool holders and inserts, types 105 and 110, holes of Ø 0.2 – 14 mm (0.0079" – 0.5512") can be finish-bored. With carbide and steel shafts, as well as ISO indexable inserts, working ranges of between 5.8 – 40 mm (0.2283" – 1.5748") hole diameter are possible.
Fine boring heads equipped with cartridges and ISO inserts can be used for fine boring applications from 20 mm (0.7874") to 88 mm (3.4646") diameter.
The precision of the fine-boring heads DB05, which have internal coolant supply, comes primarily from the simple balancing. With mechanical balancing for speeds of up to 20,000 1/rpm, every tool holder/cutter combination can be set to a fine adjustment of 2 μm (0.0008"). This operation is now simplified by the DAZ display unit, with its digital display of the adjustment travel. The device – which is simply clipped onto the head of the spindle tool using a magnetic plug – shows the adjustment travel of the tool edge on the display with μm-accuracy. The balancing compensation is achieved by simple adjustment of the compensation rings. With heads that have an integrated balancing mechanism, this occurs automatically.


Fine-boring head  with digital display of the adjustment travel.

# Mini 106 cutting insert

Mini 106 cutting insert for grooving and boring out holes from Ø 6 mm (0.2362").

**Grooving from Ø 6 mm (0.2362")**

With the new 106 cutting insert, the Mini system can now be used for hole diameters from 6 mm (0.2362"). Compared to the previous working range of ≥ 7 with Mini 107 mm (4.2126"), this offers additional possibilities for use in internal grooving and boring out.

The cutting inserts are available from stock with ground geometries for machining steel and cast iron. They can be used for grooving from a hole diameter of 6.5 mm (0.2559") or greater with widths of 0.7 (0.0276") to 1.5 (0.0591") mm for a groove depth of up to 0.8 mm (0.0315"). Cutting inserts with corner radii of 0.2 (0.0079") and 0.4 mm (0.0157") are available for grooving out of diameters of 6 mm (0.2362") or more.

Like all Mini system cutting inserts, the new inserts are also bolted on the face side to the vibration-damping carbide shank with brazed steel head. The hardened insert seat (patented) guarantees a high-precision location and secure connection. Shanks with internal coolant supply are available in different lengths and the steel head is replaceable if worn or broken.

# Size 109 addition to Supermini® series

**Processing variety from 0.2 mm (0.0079") bore hole diameter**

With a grooving and boring out range of ≥ 6 mm (0.2362") bore hole diameter, the new 109 series adds to the previous 110 and 105 series. Type 110 can be used for bore holes ≥ 7 mm (0.2756") and type series 105 for bore holes ≥ 0.2 mm (0.0079"). Cutting inserts are now available with the intermediate 109 size, which, depending on the bore hole diameter, offer additional alternatives for efficient working in the upper working area of the 105 series and the lower of the 110 series.

The Supermini® tool system is used for boring out, grooving, chamfering, threading, axial grooving, finish boring, surface tuning and broaching of small and precision diameters. For bore hole diameters of 0.2 mm (0.0079") or more, its more than 1,000 variants (cutting inserts) can solve very complex tasks in many areas when machining steels, cast iron, non-ferrous materials and exotic materials very successfully. Coated and uncoated carbide cutting inserts are available for this, as well as cutting inserts with CBN and PCD equipment.

The clamping of these delicate tools is particularly user-friendly: only one standard tool holder is required for clamping all inserts of a model series. These holders are available with and without internal cooling and with various left and right handed machine interfaces.

Supermini® 109 cutting insert.

# Square shank holder with internal cooling

Clamping holder with internal coolant supply.

**Direct cutting edge cooling**

Standard holders for the grooving systems S229, S224 and S100 are now also available with an internal coolant supply. Depending on the holder design, coolant is delivered either directly through the holder (VDI) or via an external coolant line, screwed to the side of the holder. In the case of the VDI holders, the coolant jet comes out of the clamping finger and hits the chip directly behind the cutting edge. Particularly in the case of groove widths of 3 (0.1181") to 5 mm (0.1969") as well as for greater groove depths, the internal coolant feed guarantees controlled chip removal and improved cutting edge cooling.

# Axial grooving system 25A

**Grooving from a diameter of 15 mm (0.5512")**

With introduction of the new axial grooving System 25A, we are expanding the wide range of application options of our grooving systems for general steel machining. The two-edged indexable insert (TH35 carbide type) is available for groove widths of 2 (0.0787") and 3 mm (0.1181")and for groove depths up to 15 mm (0.5512"). Its .10. geometric shape also ensures safe chip flow, even with large groove depths. As with other systems, the cutting insert is positioned precisely using the tried-and-trusted screw clamp with the standard holders 12x12, 16x16 and 20x20 mm.

| Groove width in mm (") | Maximum depth of cut in mm on outer groove diameter (") | | |
|---|---|---|---|
| | 15 – 20 mm 0.5906" – 0.7874" | 20 – 25 mm 0.7874" – 0.9843" | 25 – 30 mm 0.9843" – 1.1811" |
| 2 (0.0787") | 12 (0.4724") | 12 (0.4724") | 13 (0.5118") |
| 3 (0.1181") | 13 (0.5118") | 14 (0.5512") | 15 (0.5512") |

Axial grooving system 25A with two-edged indexable insert.

# Cassettes with internal cooling

Internally-cooled cassette with 220 interface on our PSC basic holder.

**Modular interface 220 for various holder designs**

We have developed the standardised 220 interface to connect our holders with square, round, PSC and KM mountings to the various cassette designs. Besides its modular structure, its key feature is the high stability of the cassette/holder combination. Cassettes are available with an internal coolant supply, in which the coolant is supplied via the clamping finger. The groove depth is dependent on the holder used.

Depending on the cassette type, the coolant is transferred via the contact surface. In addition to the jet of coolant coming out of the clamping finger, the cutting zone is also cooled by an adjustable cooling nozzle screwed onto the holder.

# DAH system

#### High feed machining

We have expanded the areas of application of the DAH high feed miller with four new clip-on cutter heads. Their cutting edge diameters of 63 (2.4803"), 80 (3.1946"), 100 (3.9370") and 125 mm (4.9213"), each equipped with 4, 5, 6 and 7 indexable inserts, offer the best possible conditions for economical machining during rough work with high feeds and cutting depths. A key element is the new indexable inserts with 2 x 3 cutting edges, as well as the newly-developed SC6A coating, which really proves its worth when milling steel, cast materials and aluminium. The coating is applied using the CVD method.

The very large radius on the main cutters ensures a particularly soft cut and even distribution of the chipping forces. On the inner side, a smaller cutting edge radius supports easy, quick plunging. Depending on the machine, feed rates up to 3 mm/tooth (0,1181 IPT) can be achieved for a maximum cutting depth of 2 mm (0.0787"). When machining steel, one of our customers was able to achieve a tool life which was three times longer than comparable competitive products.
The current indexable inserts which are SA4B coated have performed as "all-rounders" during milling applications in materials such as Steel, Cast Iron and Aluminium. The shank and indexable head versions of System DAH are available in 4 dimensions: Ø 20mm (0.7874") with 2 inserts, Ø 25 mm (0.9843") with 3, Ø 32 mm (1.2598") with 4 and Ø 40 mm (1.5748") with 5 indexable inserts. Additional milling cutters with the cutting diameters of 40 (1.5748"), 50 (1.9685"), 63 (2.4803") and 80 mm (3.1496") with 5,6,7 and 8 indexable inserts complete the range. All cutters are equipped with through coolant and the cutter bodies are TiN coated.
As a result of our experience in the high feed milling area we are also developing a variety of tools for high feed turning operations. As an additional highlight we will also offer indexable inserts and toolholders for high feed turning.

DAH clip-on cutter head with six-edged insert.


Tool holder with indexable insert for high feed turning.

# VDI holder with internal cooling


VDI holder with internal cooling.

#### Chip forming process influenced positively

We can now supply matching VDI holders for clamping holders with integrated coolant supply. The coolant can be supplied via the turret or via an external highpressure pump. In the case of external high-pressure cooling, close off the turret to prevent flow back. In addition to directing coolant through the clamping fingers, the coolant can also be supplied via a specially-designed nozzle on the VDI holder. Various nozzles are available for high-pressure and flood cooling.


China – a country with huge economic potential.

# HORN IN CHINA

## HORN China (Shanghai) Trading Co. Ltd. founded

**We have been active with our own employees in the People's Republic of China since February this year. The centre of our market activities is the branch office in Shanghai, which will commence its activities on 1st October 2012.**

With all its different aspects, China is difficult to categorize. The regional and social developments in the 23 provinces are wildly different. However, two key factors are likely to influence the future: China will probably overtake the USA this year to become the world's largest trading nation.

In 2011 China was the largest machinery producer with an approximate total of € 560 billion. China now plans to reduce its dependence on foreign technology and significantly increase it's share on the world wide machine tool market from a reported 27 % in 2010. The general strategy of China over the coming years is to eliminate the label of "low cost producer" to that of leaders in state of the art technology.

Around 650 million people – around half the population - live in the countryside. Over half are dependent on agriculture, which only produces around 10 % of the gross national product. A key task of Chinese economic policy is therefore the maintenance of social stability, as the rural population, along with Western, North-Eastern and Central China, have seen little economic growth.

### A local presence is expected

The high level of economic growth and the fact that ever more of our customers are not only located in the People's Republic, but also produce goods there, influenced our decision to become more active in China. Our past sales arrangements were not always able to fulfil the expectations of many of our customers.

Our Chinese colleagues during intensive training days in Tübingen.


Entrance of the skyscraper which houses the offices of HORN China.

The new offices are now ready for occupation.

They did not want to be without the "HORN unique features", which Germany and Europe enjoy. Guaranteed high product quality was a natural requirement, along with very high levels of advisory competence and extremely short delivery times, particularly in the case of special tools.

## Launch in the economic metropolis of Shanghai

The company name, HORN (Shanghai) Trading Co. Ltd., shows the location of our branch office. Shanghai is the most important industrial city in China with its roughly 23 million inhabitants. Currently, ten Chinese employees work in the office in the Putuo district, charged with the sale of our products in China. In the first phase, we will make use of the infrastructure created by our long-term European partner, Urma. We also share a sales office on the island of Taiwan with a sales' partner.
The organisational concept of the office and sales in Shanghai – a wide range of standard tools is kept in stock – follows Chinese business models. The language of business is English, although one of the Chinese employees speaks fluent German. Most of them have already been to Tübingen, in order to attend product and sales training courses and to discover more about our corporate philosophy. This overlaps to a great extent with the attitude of many Chinese people: partnerships require shared interests and mutual trust. For us in Germany, it was important to get to grips with the cultural differences and the different purchasing attitudes.

## Step-by-step launch

During the early phase, our Chinese partners are concentrating on existing customers from the car, energy and aerospace industries, as well as their suppliers. There are no limitations to the range of products and services for these customers. Despite the long distance between Shanghai and Tübingen, we can still show our strength in short delivery times in the Far East, especially in the field of special tools. This means that we are considerably faster than other companies producing goods in China, and we do not see having our own production facility in China as being a decisive issue for our market success there. In this case, we also act according to the following principle: think globally, act locally.

Hans-Jürgen Bender informs his Asiatic colleagues on product details.

Tony Hui, (left) National Sales Manager of HORN China, with colleagues.

# CHINA – ALREADY A MARKET OF THE FUTURE

## Andreas Vollmer comments on the foundation of HORN China.

**Mr Vollmer, China is the centre of the global market. Is that one of the reasons for the foun-dation of HORN China?**

China's developments in our sector were the reason we took this step. Previously, we did our homework on the domestic, European and North American markets.

**What expectations do you have of the Chinese cutting tools market?**

By 2030, China is expected to account for 40 % of the world cutting tools market. That is why we must achieve healthy long-term growth there – as in other locations – in order to establish China as an additional pillar in our sales structure.

**Do local conditions place new requirements on the HORN product range?**

We are always open for new ideas and requirements. Thus, we can be sure that there will be further launch pads for our product range, which is currently the world's largest in the fields of grooving, parting off and groove milling by circular interpolation.

**Is it sufficient to be solely represented in China by Sales?**

We consider growth with the protection of our interests to have priority. This is why we reckon that we can by-pass technology transfers through production shifts. We already have to deal with plagiarism and the theft of ideas on the German market.

**How are the HORN philosophy, customer service, quality and speed established locally?**

Comprehensive product knowledge and a wide range of back-ground knowledge are a basic requirement for our Chinese colleagues. Our IT structure allows us to respond to customer enquiries very quickly, shipments are made via the local warehouse and HORN Shanghai is also able to benefit from the very short production times in Tübingen.

**You have been at HORN for over 20 years. Is China suitable for the company?**

Yes, because we now have the resources to deal with the expected volume and to position our products successfully, taking the Chinese culture and philosophy into account. Before, it was more important to deal with "issues at home".

**Is it all about China? Or how would you evaluate the global situation in the field of cutting tools?**

We still have to wait to see what the consequences are from shifting the centre of the cutting tool industry to China. With the right forward-looking investments, Germany will be able to remain competitive in the future, without needing to follow the impetus to lower prices and shift production. However, with all the hype around China, we must not forget the other BRIC states: Russia, Brazil and India.

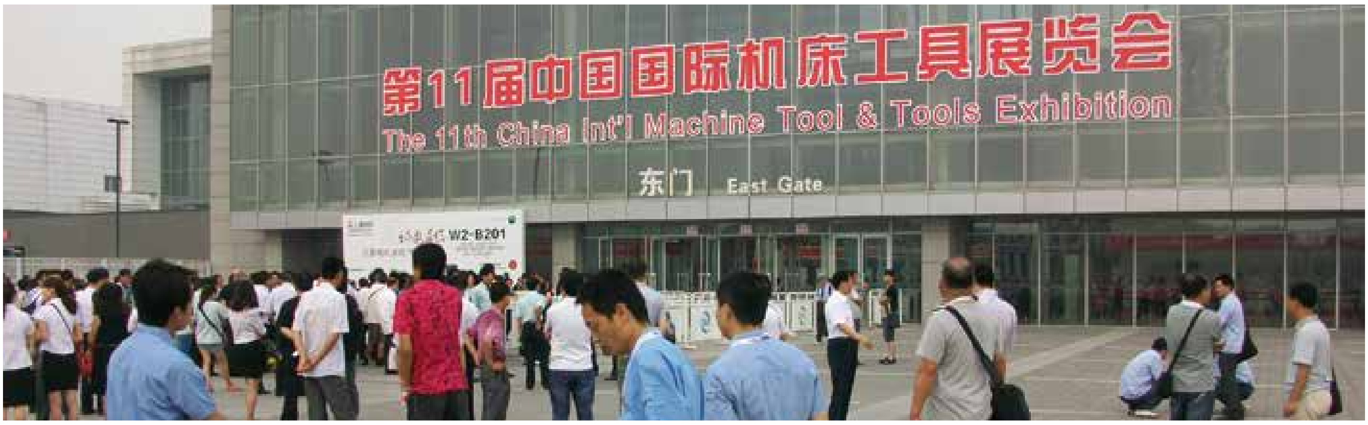
**How do you evaluate the activities of Chinese companies on the German market?**

The more technology that is transferred, the more likely it is that similar technologies will come back to the domestic market at lower prices. Think of the first years with Japanese trade fair visitors, with their camera and notebooks. China will also do what Japan did - as-sume technologies and develop them further.

Andreas Vollmer, 44, Dipl.- Ing. (FH), has worked for the company since 1992. He became Head of Exports in 1994. He has been a member of the Board of Paul Horn GmbH since 1999. He became the global Head of Sales in 2008.

**You're active in 70 countries and have your own companies in France, the USA, the UK, Hungary and now China - what's next?**

China is a long-term project. Based on our corporate policies and the implemented and planned investments at our main factory, we will then make strategic decisions to maintain HORN's position as one of the world's leading companies in the field of cutting tools.




CIMES is becoming one of the most important communications' platforms in China.

# CIMES 2012, 12th-16th June 2012, Beijing

BEIJING • CHINA June 12-16.2012

**CIMES – the China International Machine Tool & Tools Exhibition is one of the most important trade fairs for machine tool technology and tools in China. Since 2000, the exhibition has grown nearly six-fold to the current 120,000 m². This development also reflects the growth of the Chinese market.**

For the first time, we presented our company at CIMES, exhibiting a cross-section of our product range. The fair evaluation confirmed that we had met the expectations of the visitors with our selection of products. Discussions were held with around 90 companies, leading to promising post-fair contacts. Over half of the stand visitors represented end users from various sectors, whilst the remainder came in approximately equal shares from the automotive, aircraft, medical equipment and machine tool sectors. This is a considerable success for the branch office we are currently setting up, which, in turn confirms that our strategy for the Chinese market is the right one.


HORN China presented itself at CIMES with a stand of 60 m².

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## HORN is at home in over 70 countries across the world

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