Issue 1/17

world of tools

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THE CUSTOMER MAGAZINE FROM HORN

TOPICS:

- Special feature on technology and sport
- Special feature on surface quality
- HORN Technology Days 2017
- HORN on course for the future

EDITORIAL

Dear Readers,

Higher, faster, further. This maxim doesn't just apply to sport, but to the manufacturing industry too. And if you take an in-depth look at the two fields, you are certain to come across many parallels and even interdependencies. Skis, table tennis tables, bicycle frames, moulds for the soles of trainers and many other items associated with sport undergo a machining process. To achieve success, athletes and sports equipment, and precision tools too, need to perform at their peak.

In addition to machining for sports equipment, the subject of surface quality provides the focal point of this issue of world of tools. This is crucial in many applications, especially those involving ultra-high precision processing, particularly when machining with monocrystalline diamond. The background to the applications, technical possibilities and collaboration with customers reflect this in the truest sense of the word.

In addition, I cordially invite you to the HORN Technology Days 2017. Again this year, we will be showing technology at the highest level – in the form of eight presentations as well as numerous live machine demonstrations.

As during previous events, you will once again have the opportunity to visit the production facilities of Paul Horn GmbH and Horn Hartstoffe GmbH. New this year is our additional production building that will be open to visitors under the motto “A glimpse into the future”.

I hope you find this issue an informative and entertaining read and look forward to welcoming you to our Technology Days in Tübingen between 10th and 12th May.

Lothar Horn
Managing Director
Hartmetall-Werkzeugfabrik Paul Horn GmbH
Tübingen

world of tools

THE CUSTOMER MAGAZINE FROM HORN

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Cycling – a popular sport with and without an electric motor.

SPORT UNITES. SO DOES TECHNOLOGY.

People and technology – Hand in hand

The Olympic Games and World Championships certainly capture the imagination. When it comes to such major events, millions of people get carried away on a wave of excitement either watching on TV or live at the stadium. They cheer, agonise, cry and celebrate in unison. Sport unites. So does technology.

High-tech materials are subjected to high loads during skiing.

Sport and technology complement each other in many ways. Sports equipment is developed by means of mechanical machining and many production plants also make sport a part of their daily routine. Playing sport after work is a way for colleagues and managers to get to know each other beyond the four walls of the company. Sport often forms part of team building activities, and speed and precision are frequently in demand in many disciplines and in technology.

Equipment plays a key role

Professional athletes often have tailor-made sports equipment that is manufactured as individual items or in very small batches. By contrast, sports equipment for the mass market is produced on a large scale. Football, cycling and skiing are popular pursuits at the amateur level. And the trend towards increased physical activity is providing strong momentum for these sports as well as other areas such as sport at work. A further interesting aspect relates to the materials that are used. The sports industry knows almost no bounds here – fibre-reinforced composites for skis and snowboards, aluminium and titanium for bikes, wood for skateboards, metal and leather for ice skates, celluloid for table tennis balls and polyethylene for kayaks. Even if not all of

these are machined, this cross-section clearly shows the variety of materials that are in widespread use in sport. Ultimately, it is always the individual circumstances that determine the right machining strategy.

Medical technology

Unfortunately, injuries in sport are all too common. A fall while running, a collision when skiing or a foul on the football pitch often have unpleasant consequences. In such cases, it is good to know that the appropriate, custom-produced, long-lasting prosthetic is available to fix your body thanks to the application of state-of-the-art precision tools. Whether bone screws for fractures, knee joints for wear and tear, or dental implants – the alternatives on offer are constantly expanding. Even the mould for producing a cannula for delivery or removal of body fluids undergoes a machining process.

New possibilities for peak performance

Congenital impairments and accidents can have detrimental effects – and not just in sport. Particularly when it comes to replacing limbs, technology has seen huge advances in recent years. This is in part due to the special materials that are used in prosthetics, for example, where lightweight construction is key. Sports wheelchairs also demonstrate that sport provides the opportunity to overcome obstacles. The first championships for wheelchair athletes took place in parallel with the Olympic Games in London back in 1948. Twelve years later, in 1960, the “International Stoke Mandeville Games for the Paralysed” marked the birth of the Paralympics. In 2016, Rio de Janeiro hosted the Summer Paralympics.

HORN pedal car

At HORN, sporting prowess is particularly in evidence among our trainees. The pedal car project has been capturing the imagination of young talent at HORN since 2011. The idea is to calculate the costings for, design and manufacture a pedal car – a sort of modern, pedal-driven soapbox cart. The project is open to second-year apprentices. The third series of the pedal car is currently in use. It is a hand-moulded CFRP design, has attachments made of aluminium and titanium and is completed with high-quality bicycle components. The aim is to make it to the annual race in the UK, where up to 70 teams take part.

The race begins with a Formula 1 start on a circuit. Teams consist of four drivers, one pusher and one mechanic, the winning team being the one that completes the most laps in two hours. Around 15,000 spectators come along to support the sporting event. So far, our best placing was achieved by the 2015 team of trainees, which came fourth behind professional cyclists, triathletes and a women's team bolstered by an Olympic champion and world champion cyclist. The project is proof that technology and sport bring people together.

The HORN CFRP pedal car is setting technical standards.

Diving is enjoying ever-increasing popularity. Safety therefore has to be the top priority.

FACE MILLING BOTH ENDS OF A CONNECTING ROD IN ONE CLAMPING

Side milling cutter makes it easier to machine connecting rods for breathing air compressors

For amateur and professional divers alike, breathing air is a vital part of their equipment. A compressor manufacturer therefore places particularly high requirements on its components and on the machining processes used. A HORN side milling cutter makes an important contribution to the "connecting rod supply" production line.

When media such as air, breathing air or gases are to be compressed, products from the BAUER GROUP are very often brought into play. With its high-pressure and screw compressors, the company has been building an excellent international reputation for compression systems with air supply volumes of 100 to 10,400 l/min at pressures of between 90 and 500 bar since 1946. Since 2002, UNICCOMP GmbH in Geretsried near Munich has been responsible for block and component manufacturing within the Group. At the site, around 250 employees produce high-pressure and medium-pressure piston blocks as well as blocks and compact modules for low-pressure screw compressors. For all of its products – from portable breathing air compressors for private use right through to professional system installations in diving centres – ensuring a reliable supply of clean breathing air is the top priority.

High manufacturing flexibility with fluctuating quantities

On behalf of the BAUER GROUP, the Geretsried plant manufactures all critical parts for the different compressors. Irrespective of the batch sizes, which can vary between one and thirty items, the employees in charge of production are always pursuing the same objective – the fastest possible delivery and the best possible quality. The resulting machining performance is proven by the processing of a connecting rod made from EN-GJS-600-3 for a piston compressor. The compressor is usually manufactured to order as an individual item. From experience, the sales department orders 35 connecting rods on average each quarter. Call-offs are made at irregular intervals. As a result, all resources from the machining centre and tooling to the workholding equipment must be available at short notice to enable the connecting rods to be delivered on schedule to the final assembly stage of the compressor blocks.

The connecting rods are machined in five stages. Machining starts on the right hand rod with the milling of the eye surfaces.

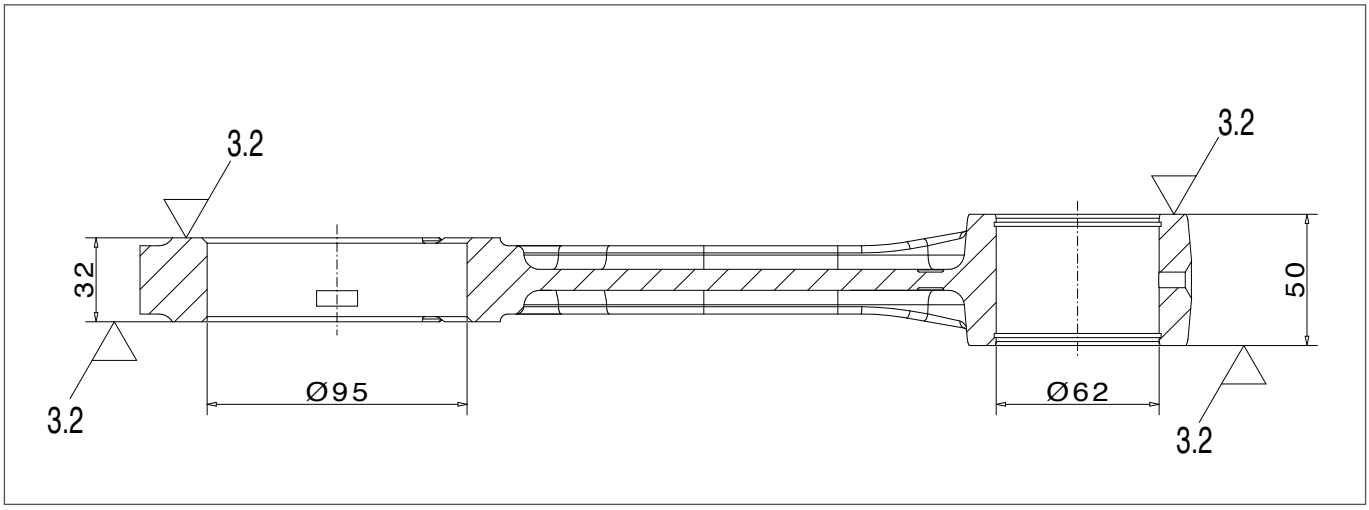
The 006 combination milling tool rough machines and finishes the connecting rod eyes on the top and bottom.

The aim of this task is to improve the rough machining and finishing of the lateral surfaces of the two ends of the connecting rods. The results achieved previously by an international tool manufacturer, which involved two side milling cutters with a cutting edge diameter of 50 and 63 mm (1,968" and 2,480"), failed to make the grade, particularly in terms of tool life and surface quality, due to their low cutting depth and tendency to vibrate. During their search for alternatives, the production team contacted HORN application engineer Korbinian Niedermeier. He was charged with proposing a future-proof solution for this operation that would offer significantly improved tool life and process reliability.

M310 side milling cutter with cylindrical shank

With respect to tool planning, the application defined the following key parameters: milling of the lateral surfaces of the big and small end of the connecting rod in one clamping on a Heller CP6000 milling/turning centre with HSK 100 tool holders. Internal diameter of the small end 62 mm (2.440"), surface quality $R_z \leq 3.2$ µm (0.001260"), parallelism of the surfaces 0.01 mm (0.0003"), required tool life three times longer than before.

The horizontal clamping position of the cast part and the small end diameter of 62 mm (2.440") dictated a maximum diameter of 60 mm (2.362") for the tool. This dimension enabled the tool to plunge into the small end and also machine it from underneath. For the connecting rod used in a UNICCOMP compressor block – whose special feature is its consistent zero point for all modules – Korbinian Niedermeier recommended the following machining



Sectional view of a connecting rod with the data relevant for milling.

cycle: rough machining and finishing of the big end initially from above and then from below, followed by the same sequence for the small end using a 006 combination milling tool. Its key components are the DIN 1835 A-25 cylindrical shank with a 25h6 fit at a length of 56 mm (2.204") and the M310 slotting cutter screwed into place on the face side with a cutting edge diameter of 60 mm (2.362"). The main body of the tool of the side milling cutter holds three 3-edged indexable inserts of type S310 on both sides in right-hand and left-hand versions with a cutting width of 2.2 mm (0.086").

From standard to special versions

In the standard version, the slotting cutters from the M310 series are available with a cutting width of 3 mm (0.118") and cutting diameters of 80/100/125 and 160 mm (3.149"/3.937"/4.921" and 6.299"). In the side milling cutter version, they are designed for milling depths of 18 to 50 mm (0.709" to 1.968"). Grooves with depths between 25 and 44 mm (0.984" and 1.732") can be milled with the arbour cutter version. Depending on the cutting diameter, 8 to 20 type S310 indexable inserts are bolted to the main body. The three-edged inserts are available in right-hand and left-hand versions with coatings of various carbide grades. They are impressive for machining all materials due to a good chip load distribution and excellent chip removal. For the application at UNICCOMP, standard S310 indexable inserts in right-hand and left-hand versions are used, each of which has three effective cutting teeth in carbide grade TN35. Only the milling shank was designed as a special version due to the overhang of 110 mm (4.330") and the machining conditions of the connecting rod material.

New concept with five times the tool life

The combination milling tool lived up to expectations right from the first time it was used. For rough machining the four connecting rod eyes and with a radial width of cut of a_e = 16 mm (0.629"), the machining specialists selected a cutting speed of v_c = 150 m/min (5905.511"/min), a feed rate/tooth of f_z = 0.1 mm (0.003"), a rotational speed of n = 796 rpm and a cutting depth of a_p = 5 mm (0.196"). The workpiece made from spheroidal graphite cast iron was rough machined in a single pass to leave an allowance of 0.3 mm (0.011"), firstly on the top and then on the bottom. Finishing was carried out using the same cutting data.

With these parameters, the milling cutter achieved a tool life of 60 minutes – five times better than the competitor's tool. A further advantage is the higher surface quality achieved, including the parallelism of the surfaces of the connecting rods, which is critical to their function. As the machining cycles for the various, geometrically similar connecting rods run extremely reliably, flexibility can now also be significantly enhanced thanks to the Heller rack-type magazine that can hold 265 tools. And in the event that new indexable inserts are required at short notice, HORN's flexibility guarantees fast delivery for both standard and special tools.

MAXIMUM MOBILITY FOR SPORTING SUCCESS

Teamwork, precision and sport. Swabian-based PRO ACTIV Reha-Technik GmbH brings all of this together in its sports wheelchairs and handcycles. Added to this is the sporting success of its in-house team. In order to manufacture the individual components, the company from Dotternhausen has for some time been placing its trust in precision tools from Paul Horn GmbH.

Low centre of gravity and lightweight construction. Handcyclists in training on the track.

Machining from one side and a long overhang requires the milling shank to be able to absorb vibrations well.

Following the accident of a friend who then found himself confined to a wheelchair, brothers Andreas and Jörg Sättele came up with the idea of manufacturing accessories for wheelchairs. From this idea, and after three years working as subcontractors, they founded what is now known as PRO ACTIV Reha-Technik GmbH in 1992. Today, they have 70 employees and are regarded as a specialist in the development and manufacture of active wheelchairs, sports wheelchairs, folding wheelchairs, handcycles and electric wheelchair attachments. “Our aim is to develop and produce products of first-class quality to guarantee our customers maximum mobility in their everyday lives,” explains Andreas Sättele, Managing Director of PRO ACTIV.

Delivery within one week

The company produces around 2,500 wheelchairs, handcycles and attachments each year. All wheelchairs produced by PRO ACTIV are tailored to the user, manufactured within one week and delivered to the customer. In order to achieve this, Andreas Sättele developed a parametric program in a CAD system for entering the wheelchair dimensions. The system automatically calculates the dimensions of the individual components, generates the CNC program and sends this to the machine over the DNC server. All machining centres are linked via an automated storage system. This means that up to 450 different parts can be produced each night during unmanned shifts.

To enable the wheelchair to be steered and manoeuvred, the two front wheels can be rotated through 360 degrees. These caster wheels are connected to the wheelchair's tubular frame by means of a bearing block. To manufacture these, a Heller H2000 with a pallet changer is used. The machine is directly connected to the automated storage system which houses pallets with pre-fixtured workpieces to enable rapid transfer to the machine. To minimise idle times, 24 bearing blocks are clamped on each pallet, which the system automatically delivers to the machine when required.

The initial process for manufacturing the bearing seats of the AlCuMg1 bearing block required some improvement. Previously, the bearing seats were milled from two sides using a solid carbide end mill. The rectangular pocket between the two bearing seats was machined using an HSS T-slot cutter. Reclamping the workpiece led to problems with the concentricity of the close-tolerance bearing seats. In addition, the tool had to be changed in order to machine the rectangular pocket. To reduce machining times and idle times, and to manufacture multiple parts in one clamping, it was necessary to rethink the machining strategy.

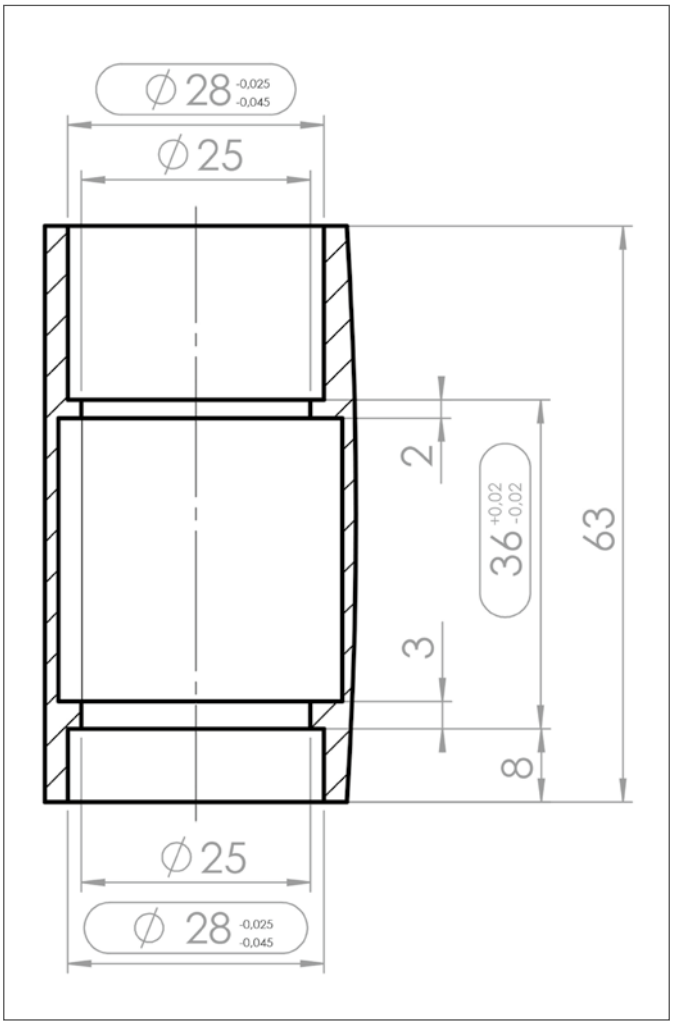
The solution came in the form of HORN's carbide inserts for milling by circular interpolation (type 313). The cutting insert mills the two bearing seats and the rectangular pocket in one clamping. The workpieces are machined from one side only. The cylindricity and concentricity of the bearing seats with one

another is ensured thanks to this machining strategy. The tool mills the seats using a helical motion with a 1 mm (0.039") pitch. The vibrations generated by the long overhang of the tool are absorbed by the mass of the internally cooled carbide shank. The required surface quality of the bearing seats is therefore achieved and shows no chatter marks.

Wide range of applications

The HORN circular milling system offers users a host of process advantages: it is fast, reliable and achieves good surface quality. During the process, the tool is helically interpolated to ramp into the material either vertically or at an angle. This means that threads, for example, can be manufactured to a high level of quality and reproducibility. When compared to machining using indexable insert cutters of larger diameter or solid carbide milling cutters with smaller diameter, circular milling is generally more economical. Circular milling cutters have a wide range of applications: they are able to machine steel, special steels, titanium and special alloys. These precision tools are especially suited to groove milling, circular interpolation milling, thread milling, T-slot milling and profile milling. However, they also produce impressive results in special applications, such as milling sealing grooves or machining connecting rods.

Cooperation between the two companies has been ongoing since 1992. “We value the comprehensive selection of products and the technical advice that HORN offers,” states Sättele. In addition to the circular milling tools, other products – of the Supermini and Mini types – are also used by PRO ACTIV.



Sectional view of the bearing block.

Excellent teamwork. Rainer Saile, HORN field sales, in conversation with Andreas Sättele and machine operator Tobias Exner. (From left to right)

In 2001, PRO ACTIV founded the PRO ACTIV Handbike team in collaboration with Tübingen’s Rollstuhl und Kulturverein e.V. association. Today, the team is made up of 15 active and enthusiastic athletes. The primary focus is the handcycle team; however, sportspeople from wheelchair basketball, wheelchair racing and athletes from the Nordic combined discipline also count among its members. The sporting successes of the team are plain to see. Gold medals at the Paralympics, World Championships and World Cup victories are just some of their achievements. Nevertheless, the team does not feel under pressure to perform. “The focus is on enjoying being active and on team spirit,” states Sättele.

Lothar Horn, Managing Director of Paul Horn GmbH.

Innovations for today and tomorrow – Three questions, three answers

HORN isn't just growing in terms of its employees, buildings and the numbers of orders it receives – it is also expanding its product portfolio. Where is this development headed?

HORN is known as a specialist in machining between two flanks – the ultimate discipline in this field. This is where we have established ourselves and are continuing to develop our portfolio. Take for example our new 64T grooving insert and our new Supermini boring tools. Additions have supplemented the existing portfolio and new products have enhanced it even further, meaning that today we regard ourselves as a provider of precision tools for machining tasks and solutions that present a technical challenge. When it comes to ISO turning and ISO milling, we have been very busy since the AMB and IMTS 2016 trade shows. The development of our products is geared towards current and future customer needs.

In this context, how does HORN approach the trend towards special tools?

This trend is ideal for us. Special tools already make up around 50 per cent of the orders we receive. The decision to opt for a special tool is usually made once the customer has taken advice from the HORN field sales team. Tools with special cutting widths, profiles or combined applications, for example, are then developed following the consultation. A specific example is the M279 gear milling cutter, to which cutting inserts from our 409 tangential milling system have been added alongside the gear cutting inserts that were previously used. As a result, Cyclo-Palloid gears based on the Klingelnberg design are produced. The system is 20 per cent faster than existing methods involving solid carbide tools.

Is there "one" key product innovation for you?

Yes and no. Naturally, we prioritise our product innovations and expansions through internal discussion as well as for marketing and communication. In addition, there are products that have more market potential than others. Which products are ultimately important is decided by the customer. The advantage that we have is that we carry out our development in close consultation with the market. Extensive trials enable us to assess how effective the product innovation or expansion is well in advance. A new product ultimately has to be better than what is already out there. It has to offer added value to the user.

Supermini® and Mini with diamond cutting edges

Diamond-tipped Supermini® and Mini tools are a welcome addition to the product range that HORN offers for boring. These tools are not only used for boring but also, copying and grooving of aluminium, sintered carbide, ceramics or plastics. They are also used for machining non-ferrous materials which are either very abrasive due to their high silicon content or have a tendency to exhibit chipping problems and form built-up edges. The chip breaker geometry, which has been specially developed for this purpose, solves virtually all process problems caused by uncontrolled stringy swarf.

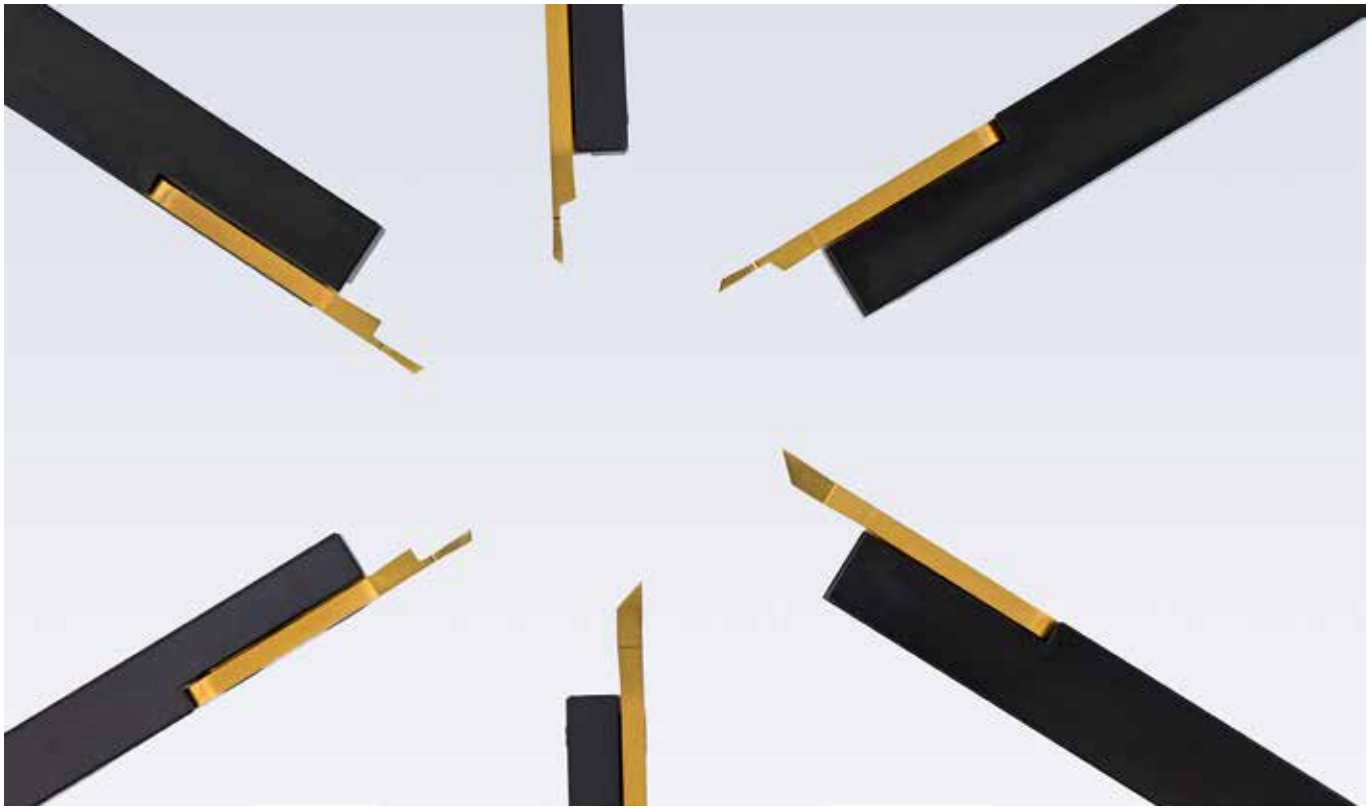
The CVD-D-tipped or PCD-tipped Supermini and Mini ranges from HORN boast a number of impressive USPs in the market segment for diamond tools, including active chip breaker geometries and internal cooling directly to the cutting edge. With the expansion of the diamond range, HORN is responding to the increasing requirements of customers experiencing machining problems.

Over 100 different versions of standard diamond-tipped Supermini and Mini tool system are held in stock.

Supermini tools with CVD-D or PCD cutting edges are available with diameters from 1.5 mm (0.059") and in three different geometry versions, depending on the application. The H0 geometry with a rake angle of 0 degrees is used to machine hard and brittle materials such as carbides, pre-sintered ceramics, graphite and short-chipping brass. The H5 geometry with a rake angle of 5 degrees is for machining abrasive and soft materials. These include aluminium alloys with a high silicon content, fibre-reinforced plastics and other plastics with abrasive content.

Diamond is also used without chipping problems for cutting precious metals and non-ferrous heavy metals such as platinum, iridium, gold, tantalum and titanium, as well as sintered metals such as tungsten copper. The HF geometry is used for long-chipping non-ferrous metals such as all aluminium wrought alloys as well as copper and its alloys – bronze, for example, and both lead-free and low-lead (long-chipping) brass. Due to controlled chip breaking, the geometry is able to effectively prevent process problems caused by stringy swarf.

Active chip geometries and internal cooling at the cutting edge. The diamond range from HORN.



Optimised for use in Swiss-type lathes. Precision and indexability through ground contact surfaces.

262 tool system for machining precision parts

With the 262 system, HORN is fulfilling customers' demanding requirements for sharp-edged tools for free-cutting and pinpoint precision in the µm range. Two screws ensure that the indexable insert is clamped securely. Ground, sintered contact surfaces, enable the inserts to be replaced without having to readjust the tool, reducing set-up time and downtime.

The lateral insert seat offers maximum freedom when designing the cutting edge. In combination with cutting edges with large overhangs, the tools can also be used without readjustment on Swiss-type lathes with the holders at 45°.

The precision ground cutting edges are available in 21 different versions as standard as well as to suit special customer specifications. Maximum grooving depths of up to 7.5 mm (0.295") can be achieved with groove widths of 2 mm (0.078"). The sharp abrasive indexable inserts are ideal for producing the smallest of components requiring high precision, such as watch parts or tiny screws for a hearing aid. With its high degree of hardness and layer adhesion, the new EG35 carbide substrate boasts optimal properties for machining steel, stainless steel and non-ferrous heavy metals. A gold-coloured top layer makes it easy to detect wear.

The tool holders are ground on the contact surfaces, resulting in high precision indexing. The hard-milled insert seat for retaining the insert ensures precision and prevents wear arising from frequently indexing and exchanging it. The holders are available in the cross-sections 6 x 6 mm (0.236" x 0.236"), 7 x 7 mm (0.275" x 0.275") and 8 x 8 mm (0.314" x 0.314").

Extension for the 960 modular grooving system

HORN is extending the modular systems for the 845 interface by adding new grooving cartridges to hold the S229 cutting insert. The double-edged insert for grooving and parting off, as well as for longitudinal and contour turning, is available ex stock with various chip breaker geometries and substrates. The maximum grooving depth of the cartridge is 25 mm (0.984") with a maximum machining diameter of 68 mm (2.677"). Groove widths between 3 mm and 6 mm (0.118" and 0.236") are available. All grooving cartridges are fitted with an internal coolant supply. Cooling takes place via the clamping finger and support.

The modular system has a selection of basic holders for turrets with BMT connections, based on standard machine types. Alternatively, VDI holders are available in various sizes, as are holders for turning and milling centres. The matching grooving tool holders with integrated coolant supply allow the cartridge height to be adjusted and mounting in either a normal or inverted position on the left or on the right. The combination of different projection lengths and grooving depths covers all parting-off requirements in the machine.

New grooving cartridge for the modular system with S229 cutting inserts.

T-slot type cutters for the 406 and 409 systems

Cutting widths of between 11 mm and 22 mm (0.433" and 0.866"). HORN is extending its tangential milling system to include T-slot type cutters with indexable inserts.

Growth for the patented tangential milling range. The T-slot type cutters with type 406 or 409 rhombic indexable inserts have shanks compliant with DIN 1835 B. Thanks to the design optimised for machining T-slots, the cutter bodies are extremely stable and have an internal coolant supply with radial exit which provides efficient cooling and optimises chip evacuation. Thanks to its hardness and strength, the specially treated milling cutter body boasts long-term protection against abrasion from chips.

The precision-ground 406 and 409 inserts achieve premium surface quality at the base of the groove and on the flanks. Positive geometries as well as a free-form chamfer provide a stable wedge angle and a particularly smooth milling process. The bodies are available for cutting widths of between 11 mm and 22 mm (0.433" and 0.866") depending on the diameter, which varies from 25 mm to 50 mm (0.984" and 1.968"). The milling cutters are designed with two or three rows of inserts. This ensures the optimum distribution of the cutting forces as well as smooth machining.

New DA62 milling system

HORN has developed the new DA62 milling system for corner, face and plunge milling. The system from the precision tool manufacturer uses a new six-edged indexable insert. Both sides of the insert can be used and it has three axial and radial cutting edges on each side. The precision-ground, trigonal insert boasts a large core cross-section and maximum cutting length. The design of the cutting edges produces a positive cutting geometry despite the negative insert angle. The six cutting edges on each indexable insert provide excellent value for money for each edge.

The DA62 system can also be used for roughing and finishing. During trials, the milling system resulted in excellent surface finishes. Selecting the axial and radial angles has enabled a lower torsional moment and lower transverse loading of the spindle to be achieved compared with previous systems. This allows the DA62 to be used on less powerful machines. A further advantage of the selected axial angle is its excellent ability to remove chips, particularly in the case of helical plunge milling.

The cutting edge shape generates a precise 90° corner angle with a maximum cutting depth of 4.5 mm (0.177"). The inserts are currently available with corner radii of 0.4 mm and 0.8 mm (0.015" and 0.031"). They use the tough, tried-and-tested carbide substrate SA4B, which is a useful all-rounder for milling steel, stainless steel, cast iron and aluminium. The inserts are also available in SD6A, which is especially well suited to machining cast iron. Both carbide grades are held in stock.

The milling bodies are available in diameters of 20, 25 and 32 mm (0.787", 0.984" and 1.259"), with a Weldon toolholder (DIN 1835 B) or as a screw-in milling cutter. In these variants, the milling tools are equipped with two, three and four inserts. The tools are available as arbour milling cutters (DIN 8030 A) with cutting edges of 40, 50, 63 and 80 mm (1.574", 1.968", 2.480" and 3.149"), equipped with five, six, eight or ten inserts. All bodies have internal cooling directed at the point of cutting.

The DA62 milling system ensures process reliability for a broad range of applications, maximum performance and economic benefit for the customer.

Large core cross-section and maximum cutting length. The six-edged DA62 cutting insert.

Innovative milling system for gear milling

High cutting depths as individual cutting edges overlap. The M279 system from HORN makes it possible to produce convex and concave tooth flanks in five-axis simultaneous operation.

Paul Horn GmbH has developed a new milling tool for manufacturing Cyclo-Palloid gears based on the Klingelnberg design. The M279 milling system is intended for producing small batches and individual parts. The cut distribution of the twelve-edged tool enables a high chip volume to be achieved with a low cutting pressure.

A system was required that would save time and be at least 20 per cent faster than existing methods involving solid carbide tools. A robust tool with indexable inserts for taking full cuts on milling and turning machines while also being suitable for simultaneous 5-axis milling using DMG MORI gearMILL®. These were the requirements specified by DMG MORI, the world's leading manufacturer of metal cutting machine tools.

Targeted symbiosis

HORN met this challenge with the development of a new and innovative concept. Four S279 indexable inserts with a corner radius of 2 mm (0.078") screwed into place on the face and eight tangentially secured 409 inserts produce a targeted symbiosis with stable insert seats. The fact that the rows of edges overlap enables the system to achieve high depths of cut. HORN designed the main body of the tool with targeted internal cooling as an arbour milling cutter in accordance with DIN 8030 A with a diameter of 100 mm (3.937").

Thanks to test runs at DMG MORI's Pfronten site and modifications to the cutting data, convex and concave machining of tooth flanks can be achieved with the milling tool in 5-axis simultaneous operation. The module can be more or less freely selected. A crown wheel made from 17CrNiMo6 with module 7.6 was used as a trial workpiece. The Klingelnberg Cyclo-Palloid gear was produced with v_c = 250 m/min (9842.519"/min) and v_f = 650 mm/min (25.590"/min) with full cutter engagement and the tooth flanks with v_f = 2000 mm/min (78.740"/min).

Precision and time savings

The principle of the M279 milling system provides the design framework for further module sizes to enhance the tool system. The innovative milling tool excels due to its proven S279 and R/L 409 cutting inserts and their stable seats. It also makes the grade thanks to its high degree of precision and, in particular, the amount of time it saves when producing individual parts and small batches.

With the development of the M279 milling cutter, HORN is extending its portfolio for the manufacture of gears in the 0.5 to 30 module range. In addition to the DS solid carbide milling cutters and the DG exchangeable head system for finishing tooth flanks, HORN offers solutions for rough machining in the form of the DAH high-feed milling cutter system. What's more, tool solutions for broaching internal and external gear teeth can be brought into play, subject to the application.

Brilliant-finish machining even with plastics.

THE SURFACE IS THE KEY

Milling and turning in the µm range

The surface quality of workpieces depends on the requirements that are placed on them and can therefore vary greatly. Accordingly, the required surface quality should be attained using the optimum production method. Discrepancies between the specified surface finish and the ideal geometric form influence subsequent functional behaviour and the service life of a machine part, for example.

The surface of a PET blow mould is perfectly reproduced on the finished bottle.

Surface quality determines wear rate, frictional properties, lubricity, fatigue strength, fit, susceptibility to corrosion, paint adhesion and reflective properties to name but a few. This quality is defined as “roughness” during surface inspection. Measures of this are, firstly, the roughness average R_a, which is an arithmetic value of the deviations from the centre line in µm, secondly, the peak-to-valley height R_z, which is the roughness average of the measured peak-to-valley values in µm, and thirdly, the maximum peak-to-valley R_{max} or R_t, which is also given in µm. In addition, the maximum profile peak height designated R_p is the distance between the highest point of the profile and the mean line within the evaluation length, and the mean line at which the deviations above and below cancel each other out is defined by D_m. The percentage material ratio Mr defines the quality of the contact surface, for example on sliding surfaces. Profiling devices such as perthometers are used to measure these values.

Surface quality depends on the method

The best average values (R_a) that can be achieved with conventional machining methods vary depending on the method: precision boring (1.2 µm) (0.00005"), milling (0.5 µm) (0.00002"), face turning (0.3 µm) (0.000012"), longitudinal turning (0.2 µm) (0.000008"),

reaming (0.1 µm) (0.000004") and for operations with a geometrically undefined cutting edge such as grinding (0.012 µm) (0.000005") as well as honing and lapping (0.006 µm) (0.0000002"). Polishing methods achieve even smoother surfaces up to mirror finish; however, these compromise the geometric surface quality.

When it comes to the surface quality to be achieved, tools from HORN fall within the premium category. With ground cutting edges, specifically developed grades and coatings as well as a special cutting edge preparation, they achieve top marks across all material grades for milling, turning, grooving, slotting, thread cutting, reaming and other special machining processes.

Three examples of outstanding surfaces

Specifically for machining precision parts in the watchmaking industry, for instance, the S274 system from HORN comprises inserts for turning, grooving and parting off. Each insert with the high-precision "µ-Finish" design is magnified 200 times and inspected. They are suitable for machining watch materials such as 20AP and 4C27A, stainless steels and brass.

A HORN 117 monocrystalline diamond (MCD) milling cutter produces geometrically precise parabolic mirrors made from aluminium offering a maximum reflection coefficient for short-wave terahertz beams. These mirrors are used in astrophysics.

A manufacturer of premium bathroom fittings uses MCD cutters with a large radius to produce geometrically precise brilliant-finish surfaces on components made from brass. The costly polishing process that was previously necessary prior to plating is now a thing of the past, increasing cost-effectiveness and the value of the product.

Premium class cutting

The last two examples certainly fall within the premium class of machining. High quality MCD inserts and many years of experience play a decisive role in this. In addition to the high level of hardness demonstrated by monocrystalline diamonds, the amorphous structure in particular is a basic requirement for ultra-precision and brilliant-finish machining with geometrically defined cutting edges. The extremely sharp and flawless inserts allow for surface accuracies of < R_z 0.02 µm (0.000001"). The quality of the cutting edge perfectly reflects the surface quality that can be achieved. When it comes to manufacturing tools, particular attention is paid to the crystal-system-based, direction-dependent hardness values of monocrystalline diamonds. This is the only way of ensuring that maximum tool life is achieved. The geometric design of the cutting edge is optimised for the materials to be machined. MCD tools are ideally suited to finishing processes for non-ferrous metals and their alloys, precious metals such as gold and platinum as well as transparent plastics such as PMMA and PC.

With respect to turning, HORN offers a whole host of MCD cutting inserts, such as types CCGW, VCGW and S117, with a full complement of different cutting geometries. When using the cutting material MCD for milling, it is recommended to use cutters such as the DSK.MD micro endmill, DSFF.MD chamfer milling cutter and milling cutters with the S117 cutting insert, for which a broad selection of cutting geometries are available.

Premium threads place high requirements on the tool and surface quality.

TEAMWORK THAT SHINES THROUGH

Mirror finish over the entire surface. HORN and DMG MORI use the sine wave to demonstrate their expertise in brilliant-finish machining.

Dazzling beauty, lustrous curves and high-carat stones. Not a scene from the red carpet at a film awards ceremony, but a shining example from the tool and mould-making industry. In order to produce reflective surfaces and flatness in the nanometre range, HORN offers a wide range of solutions with its diamond tools portfolio and expertise. Working together with DMG MORI, the tool manufacturer has, in conjunction with a high-precision machine, been able to prove the performance of monocrystalline diamond tools.

Generating brilliant-finish surfaces requires precise MCD tools.

A huge challenge

The sine wave is a well-known term in mathematics and physics. It is represented in two dimensions on a piece of paper or in moving waves on an electronic measuring instrument. Milling a sine wave three-dimensionally from solid material using current CAD-CAM technology does not present a challenge to experienced users. But to grind the surface so that you can see your face in it requires an extra degree of expertise. Therefore, the application engineers from DMG MORI took advantage of the support offered by HORN when they had the idea of manufacturing a brilliant-finish sine wave as a demo workpiece at the company's in-house exhibition. “We wanted to demonstrate the high surface quality with long-term accuracy achievable using diamond milling cutters from HORN, and therefore to highlight our unique machine and cooling concept,” explains Marcus Krüger, head of the application department at DECKEL MAHO in the German town of Seebach, a subsidiary of the DMG MORI Group.

Of vital importance is a good symbiosis between tool, machine, and the environmental conditions. Machining involved three tools equipped with monocrystalline diamonds (MCD): one face milling cutter for the faces and one peripheral milling cutter for the flanks. Both tools had a diameter of 12 mm (0.472"). For the convex surfaces, a ballnose end mill with a 10 mm (0.393") diameter was used. On account of the requirement for extreme precision in terms of concentricity and axial run-out, all tools for brilliant-finish machining are designed with single edges. To produce surface qualities of less than R_z 0.1, the quality of the insert edge plays a decisive role. This is polished by hand and is absolutely flawless at 200x magnification.

Apart from the MCD tools, the machine deployed has to be a match for the high requirements placed on it with respect to precision, thermal growth and spindle quality. DMG MORI's application engineers opted for the HSC 70 linear. Thanks to the thermosymmetrical gantry construction with active cooling, this machine ensures the necessary precision with very low thermal movement. In addition, the spindle is fitted with shaft cooling, allowing tool expansion to be reduced by 70 per cent. Developed for the tool and mould-making industry, the machine satisfies the demanding requirements of brilliant-finish machining.

Mirror finish without polishing

It took three weeks to progress from the idea to the implementation. During this time, application engineers from HORN and DMG MORI honed the cutting parameters, CAD data, CAM strategies and further optimisations. The finishing strategy is as follows: the aluminium sine wave with dimensions of 500 x 220 x 120 mm (19.685" x 8.661" x 4.724") is pre-finished after rough machining with an equidistant allowance of 0.05 mm (0.0019"). Finish machining with MCD tools starts with the concave radii and involves a machining time of approximately six hours. The tool profiled the contour in two axes. This was followed by machining

The thermosymmetrical construction of the HSC 70 linear ensures high precision brilliant-finish machining.

Purposeful collaboration. Marcus Krüger (l) in conversation with HORN technical consultant Max Zankl (r).

of the faces, which took 46 minutes, and of the flanks for another 33 minutes. The total time of around 7.5 hours sounds a long time but the surfaces produced with MCD tools do not require any subsequent polishing.

The range of applications for brilliant-finish milling is huge. In the tool and mould-making industry in particular, the method saves on polishing work, while also increasing the quality of the surface and degree of flatness. It is therefore used in applications where the surface of the mould is reflected in the parts being produced. These include PET blow moulds and chocolate moulds. In addition to brilliant-finish milling, HORN includes solutions for brilliant-finish turning with MCD tools.

An expert partner

Collaboration between the application engineers and product specialists at HORN and the engineers at DMG MORI in Seebach was conducted in a purposeful and productive manner and pursued the joint ambition of ultimate performance. “With HORN and its field sales team, we have a highly skilled partner at our side who is always ready to offer assistance, and who has so far been able to help us in even the most difficult of situations,” states Krüger. HORN's representatives are also delighted with the collaboration and the brilliant-finish machining of the sine wave has once again enabled them to put their expertise to the test.

The process data at a glance

Machining	Tool	n rpm	v_c m (inch)/min	f_z mm (inch)/z	v_f mm (inch)/min	a_p mm (inch)	a_e mm (inch)
Convex surfaces	Ball nose end mill diameter 10 mm (0.393")	22,000	691 (27,204.7")	0.033 (0.0012")	720 (28,346")	0.15 (0.005")	0.05 (0.0019")
Faces	Face milling cutter diameter 12 mm (0.472")	24,000	904 (35,590.6")	0.030 (0.0011")	720 (28,346")	4 (0.157")	0.05 (0.0019")
Flanks	Peripheral milling cutter diameter 12 mm (0.472")	24,000	904 (35,590.6")	0.035 (0.0013")	840 (33,070")	1 (0.039")	0.05 (0.0019")

Grinding MCD tools is a master craft.

STEPPING INTO THE FUTURE TOGETHER

HORN and H10 combine their strengths

Ultra-precision machining with monocrystalline diamonds is one of the main disciplines in the field of machining with geometrically defined cutting edges. The close working relationship between Paul Horn GmbH and H10 technische Diamanten GmbH started eight years ago. The solid carbide tool manufacturer from Tübingen and the specialists in industrial diamonds from Pforzheim have been combining their shared strengths ever since and deploying them to tap into new markets.

Over 40 years' experience in diamond machining. René Kraus (l) and Roland Gemp (r), the H10 team.

"Thanks to the excellent working relationship with HORN, we are in a position to quickly deliver high-precision diamond-tipped tool systems," explains René Kraus, Managing Director of H10. A few things have changed for the small diamond tool producer from Germany's Black Forest since the two companies started working together. HSS or tool steel was previously used for the tools. However, the different thermal expansion coefficient compromised precision and cutting times on the machine. Today, the specialists from Pforzheim are able to call on the broad tool portfolio from HORN. "This makes it much easier to design the tool," adds Roland Gemp, member of the management board at H10. Numerous precision tools from HORN can be tipped with MCD, where the advantage is that they are easy to deploy on the machine tool, without having to develop special solutions. Lothar Horn, Managing Director of Paul Horn GmbH, takes a highly positive view of the collaboration: "We work hand in hand, develop ideas and technologies jointly and solve the machining problems of our customers together."

Our customer base has also been expanded thanks to the collaboration. For example, in the past, customers of H10 were almost exclusively renowned manufacturers of jewellery, high-end stationery and other luxury items that use diamond tools to produce brilliant-finish surfaces. Yet since they have been working

Absolutely vital: the visual inspection of a ground MCD cutting insert.

A “perfect” cutting edge is essential to producing flawless surfaces.

together, both companies have tapped into additional markets. One key area of application for MCD tools is the manufacture of precision mirrors used in such fields as laser technology and research. The excellent collaboration has enabled the two companies to establish themselves in additional niche markets – including those where surfaces of less than R_z 0.1 and flatness in the nanometre range are required. The tools are used for machining non-ferrous metals and plastics.

A look at the future

Polishing a diamond insert so that a flawless surface can be produced with the precision tool is a piece of craftsmanship. The H10 team receives support from HORN with respect to peripheral equipment. This means that the two companies use the same measuring technology and equipment. As visual inspection of the diamond cutting edge is indispensable, a microscope with 200x magnification is employed. What's more, air-bearing and vibration-damping grinding tables made from solid granite provide optimum grinding conditions. One joint development relates to a machine with which MCD-tipped ball nose end mills and end mills can reliably be ground to a diameter of 0.2 mm (0.007").

In a further step towards the future, a HORN employee has been working in Pforzheim twice a week for the past year to learn the art of diamond cutting. “For us, passing on our knowledge is a very positive and important aspect,” states Kraus. Two grinding tables for polishing the diamond edges are now installed at HORN in Tübingen and the employee is already putting what he has learnt into practice. However, it will take several years for him to really become a master of the craft.

With over 40 years of professional experience, the H10 team is one of the leading manufacturers of diamond tools. Through the collaboration with HORN, they have been able to consolidate their position in the market and develop it further. As a result, both parties are looking to the future with confidence, as they prepare to work together to offer their customers new technologies and innovative solutions.

www.h10-diamanten.de

WELCOME TO THE HORN
TECHNOLOGY **DAYS**

HORN TECHNOLOGY DAYS 2017

A GLIMPSE INTO THE FUTURE

The HORN Technology Days will take place for the sixth time from 10th to 12th May 2017. Eight presentations and associated practical demonstrations provide the centrepiece for the event. In addition, the two plants of Paul Horn GmbH and the Horn Hartstoffe GmbH plant will be open to visitors. Various exhibitions from an exceptionally wide range of customer industries as well as around 30 partner companies attending as co-exhibitors complete the HORN Technology Days. A further focal point is the opportunity for everyone present to share their ideas and experiences.

The presentations at a glance

High-feed milling cutters for cost-effective titanium machining
The milling of titanium presents significant challenges. Among other things, the presentation will illustrate the results of the "Heavy Metal" joint project, which implemented user-oriented solutions to create a novel tool design.

Huge interest in the HORN Technology Days 2015.

Visitors are also expected to attend in large numbers in 2017.

Turbo-whirling and rotary whirling – Thread cutting redefined
The increasing economic importance of thread whirling means that it is necessary to rethink the process that has been in use since 1942. Turbo-whirling and rotary whirling are two new processes which bring about a significant increase in performance in the production of threads.

Perfect gear teeth
Gear teeth can now be produced with a number of different processes. The optimal machining process is determined based on the module, the batch size and other factors.

Trends in grooving and parting off
The tool plays a major role in the machining process. This presentation will focus on new systems for grooving and parting off. Participants will learn how to use the latest technology for versatile, high performance production.

Micromachining on lathes – Achieving success with precision
Micromachining on lathes places exacting demands on tools, machines and operators. Low feed rates and depths of cut plus high surface quality require well-conceived tooling solutions. The presentation will illustrate how the quality standards for microturning can be fulfilled by combining precise cutting edges, micrograin hard metals and innovative coatings.

Powerful milling systems
Manufacturers involved in one-off and series production today place high demands on milling tools. A large number of prerequisites need to be fulfilled to ensure that powerful milling systems can be used long term and with stability guaranteed. This presentation will look at the conceptual design of milling systems and their fields of application.

Coatings
When it comes to designing a tool, selecting the right coating is crucial. Depending on the application, a host of requirements come into play in relation to the machining process, including the high-performance coating of the tool. HORN will provide an insight into today's complex coating technologies. The coating equipment will be open so that visitors can take a look around.

Solid carbide cutting inserts with sintered precision interface
Taking the HORN interface with 120° gear teeth as an example, the presentation will take a look at the indexability of solid carbide cutting inserts with a sintered precision interface. The high frequency of indexing inserts demanded by customers leads to specific requirements regarding the form and dimensional tolerances of the solid carbide insert in general, and with respect to the interface between insert and tool holder in particular.

Technology partners at a glance

- BIG Kaiser GmbH, Vöhringen
- Boehlerit GmbH & Co. KG, Kapfenberg (Austria)
- Carl Benzinger GmbH, Pforzheim
- Chiron Werke GmbH & Co. KG, Tuttlingen
- Citizen Machinery Europe GmbH, Esslingen
- DMG MORI, Stuttgart
- DP Technology Germany GmbH, Bamberg
- Dugar + Schuster GmbH & Co. KG, Langenfeld
- Eugen Fahrion GmbH & Co. KG, Kaiserbach
- Ernst Graf GmbH, Dietingen-Böhringen
- Georg Noll Werkzeugmaschinen GmbH & Co. KG, Freiburg
- H10 technische Diamanten GmbH, Engelsbrand
- Haimer GmbH, Hollenbach
- HPM Technologie GmbH, Münsingen
- Index-Werke GmbH & Co. KG, Esslingen am Neckar
- LT Ultra Precision Technology GmbH, Herdwangen-Schönach
- MK Tools GmbH, Hauzenberg
- OPEN MIND Technologies AG, Wessling
- RENISHAW GmbH, Pliezhausen
- RIEGGER Diamantwerkzeuge GmbH, Affalterbach
- SCHUNK GmbH & Co. KG, Lauffen/Neckar
- Solidpro GmbH, Vöhringen
- Timatech GmbH, Nalbach
- Tornos Technologies Deutschland GmbH, Pforzheim
- Tyrolit Schleifmittelwerke Swarovski K.G., Schwaz (Austria)
- W&F Werkzeugtechnik GmbH, Großbettlingen
- WF Fottner GmbH, Mössingen
- Winterthur Schleiftechnik AG, Winterthur (Switzerland)

Over 40 years at HORN: Hans Schäfer.
The head of the technical office in conversation with Bettina Theil.

THE HORN STORY FIRST HAND

Hans Schäfer discusses his many years of service at HORN

Mr Schäfer, you have been at HORN for 40 years. What has spurred you on over all these years?

When I started at HORN, there were around 20 members of staff in the entire company. With such a compact team, we all took on a wide variety of duties – ranging from drafting and preparing quotations right the way up to providing customer support on the telephone and even generating production orders when deputising for other colleagues. The insights that we gained into the different areas meant that the work was always interesting and varied. Today, we have a very broad product range, so our duties are more specialised and our expertise is constantly being developed.

As the head of the technical office, you are in charge of products including combination and special tools. What advantages does such a tool offer the customer compared with a standard tool?

A standard tool is usually held in stock, the customer can select it from the catalogue and knows how it can be used. Special tools are employed in non-standard machining applications. In recurring batch or large-scale production, a special tool improves quality and saves time, as various processes can be completed with one tool. It always depends on the individual case.

How important is coordination with the sales department?

We receive customer enquiries from sales – both for orders and regarding the preparation of quotations. If it is a more complex job, we consult with the field sales team or, in special cases, directly with the customer.

So the field sales team is the key point of contact between the customer and HORN?

Absolutely. The field sales team is the direct link between the customer and tool manufacturer. It showcases the company to the customer. For the field sales representatives, this means that they constantly have to be available and be establishing and cultivating contact with customers. This allows them to improve existing areas and find solutions to new problems. This is absolutely essential.

HORN introduced the Greenline system some time ago. What does this involve?

Greenline is a production system that we have introduced to speed up order processing even further. As a result, customers receive cutting inserts within one week and tool holders within two weeks once they have approved the drawing. The technical office makes all the necessary details available – the model, the drawing, the work plan – and establishes the basis for the Greenline system.

How have the HORN products evolved over the years?

The first HORN product was an upright three-edged grooving insert, which, in its advanced version, is now known as the type 312. That was the first product that HORN developed as a grooving tool. The product range then evolved based on market requirements and was supplemented by the two-edged inserts for internal and external machining, the Mini and Supermini system, and the 117 inserts, to name just a few examples. It is important that the requirements of the market are taken on board by field sales and passed on to development and the technical office, as we can only sell what the market needs.

What have been the main challenges that you have faced so far in the company?

A major challenge was certainly the switch from 2D to 3D design. This involved a change in the design requirements, old models could no longer be used and the procedure had to be adapted accordingly.

What does the future hold and what will the coming years bring for HORN in the technical department?

I believe there is still a lot of potential in automation. The aim, of course, is always to shorten lead-times while also improving the quality of the drawings. Human creativity will not become redundant – the process will be enhanced by it. At present, we are already able to model certain requirements. This means that in sales, drawings can be generated by inputting parameters. I think that the modelling of recurring or similar parts can be improved but the designer will continue to have a determining influence when it comes to more complex tasks. The technical office has gone through many changes in the past and will continue to do so in the future. I'm looking forward to finding out what's around the corner.

The new Factory II at Paul Horn GmbH in Tübingen.

HORN ON COURSE FOR THE FUTURE

Commitment to Tübingen

Tübingen-based Paul Horn GmbH ended the year by moving into two new buildings housing its production and administration doubling the precision tool manufacturer's manufacturing capacity. It makes a clear commitment both to the city of Tübingen and to production in Germany. The total amount invested in the two buildings, including production equipment, amounts to more than EUR 70 million. Lothar Horn, Managing Director at HORN: "We are investing in our future. This will be especially beneficial for our customers as we continue to focus on speed of response to orders, top quality and precision. These values apply to our employees, to our infrastructure with its buildings, machines and equipment, processes and organisation, to our products and to our commitment to technology, innovation and production in Germany."

Covering an area of 3,500 m² across six floors, the new administrative block houses not only offices but also seminar rooms for customer training – something that is gaining in importance all the time – and internal development of employees. A clear architectural design and bright rooms offer space for the 120 employees who moved into the building in December 2016. The vacated space in the existing administrative building will provide opportunities to restructure and merge departments that were previously accommodated in a variety of rooms and buildings due to lack of space. The old entrance area now houses a modern in-house restaurant with a convivial outdoor space. The new build and restructuring of the existing building represents a total investment of EUR 16.5 million.

Impressive dimensions

171 metres long, 50 metres wide and 18 metres high. These are the dimensions of the new building adjacent to the existing production facility. Covering a total area of 20,000 m², of which 12,000 m² are dedicated to production, HORN is doubling its production space to approximately 25,000 m². Completed and occupied during the summer of 2016, the two-storey structure is now the biggest industrial building in Tübingen. With annual recruitment drives for new staff, Paul Horn GmbH intends to create even more jobs for the region in the future. "We are planning tangible growth over the coming years," Lothar Horn points out. The new production building houses tool holder production, the tool coating department and logistics. The building cost EUR 30 million to construct, with an additional EUR 25 million spent on new machinery and equipment.

An active supporter of BlueCompetence, the sustainability initiative of the German Mechanical Engineering Industry Association (VDMA), HORN is integrating modern systems for saving and recovering energy into the new production building. To protect the environment, a combined heat and power plant has been installed to use waste heat for cooling in summer and heating in winter. The CHP facility also supports power generation from gas at an efficiency of 90 per cent. Furthermore, energy-saving LED technology has been used for all of the lighting in the building. A sustainable approach to using resources, including the acquisition of raw materials, thus continues to be a part of HORN's corporate philosophy.

Fully automated movement

Approximately 60 percent of the total production area is given over to mechanical production. HORN has 75 milling centres, turning machines and other machinery to produce all of its tool holders in addition to equipment required in-house. Driverless autonomous transport systems are to be introduced in spring 2017 to transport materials, production orders and tools around the site. This is a sign of a gradual move towards Industry 4.0. With its capacity trebled, the new logistics centre is able to process customer orders quickly and deliver tools even faster. The fully automated shuttle system in the finished goods warehouse enables orders to be received and despatched quickly. The new warehousing system for high-speed storage and retrieval of products is exactly what is needed to process the annual throughput of approximately 96,000 production orders. The portfolio currently includes more than 20,000 line items standard tools. In addition, more than 120,000 custom-made tool solutions are available.

Coating doubled

The new production building has 1,100 m^2 of space dedicated to the coating department, twice as much as before. To supplement the eight coating stations it already had in place, HORN has invested in three new stations featuring HiPIMS technology. This is used to manufacture more complex coatings, to generate coloured layers and cover layers and to speed up coating rates.

The department also has five wet blasting machines, two fully automated cleaning units and manual workstations for loading operations.

Stunning architecture covering an area of 3,500 m^2. The new administrative building at Paul Horn GmbH in Tübingen.

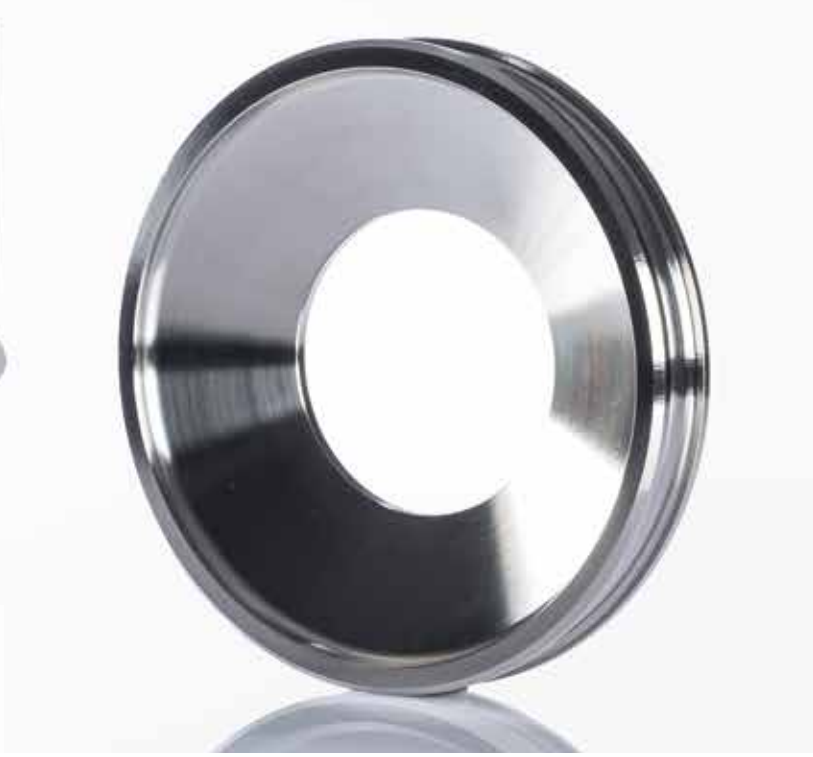
HORN was founded in 1969 in Waiblingen, with production sites in Gomaringen and Nehren. In 1981, the company moved its headquarters and production activities to Steinlachwasen in Tübingen. A new building at Unter dem Holz was purchased in 1991 and subsidiary Horn Hartstoffe GmbH commenced production in the same year. 1999 and 2008 saw HORN double its capacity from an original 2,800 m^2 first to 6,100 m^2 and then to 11,500 m^2. In 2011, HORN invested more than EUR 30 million in Horn Hartstoffe GmbH, acquiring 5,000 m^2 of production space. The company produces carbide green compacts and wear parts. In the last four years, two new sales companies have started operating in Mexico and China. To date, HORN has invested more than EUR 70 million in a new additional production building and a new additional administrative centre.

The new finished goods warehouse. High-speed shuttles facilitate the rapid storage and retrieval of products.

The new logistics centre is making even faster delivery times a reality.

The space inside the new production hall is modern and roomy.

The machinery on the ground floor of the new factory.



Aerospace components made from titanium.

TITANIUM – A CHALLENGING MATERIAL

The right strategy to ensure success

Almost as light as aluminium but stronger than steel, these are the properties we associate with titanium. The material is expensive – around 30 times more than high quality steel alloys and 200 times the price of crude steel. Originally used almost exclusively in high-tech applications, titanium is now employed in increasingly broad fields such as aerospace, as a biocompatible material in medicine and implantology, in power plant engineering, water desalination plants, environmental technology, racing and extreme sports. But titanium has some drawbacks when it comes to machining.

It is not a rare metal and is one of the ten most common elements in the earth's crust. Yet strong oxide bonds with iron, calcium, sulphur and barium mean that complex processes are required to produce pure titanium. This is what makes it so expensive. The metal's melting point is 1,677 °C and its boiling point 3,262 °C. It exhibits two crystal structures: the hexagonal close-packed α-Ti becomes the body-centred cubic β-Ti at 882 °C. Titanium is anti-magnetic, a good conductor of electrical current, but a very poor conductor of heat with low thermal expansion. Its strength is in the range of quenched and tempered steels, which is maintained up to temperatures between 200 and 635 °C. Depending on the alloy, titanium materials possess tensile strengths of between 300 and 1,150 N/mm^2. Certain titanium materials can be strengthened even further by forging. An oxide layer passivates titanium in normal ambient air and at room temperature and provides it with a high degree of corrosion resistance to aggressive media such as gases containing chlorine, salt water, lyes, alcohol and cold acids.

A fivefold increase in 20 years

20 years ago, around 60,000 tonnes of titanium were processed worldwide, 10 years ago the figure was 143,000 tonnes, and today, estimates put the consumption rate at almost 300,000 tonnes. Driving forces in the use of titanium are Western Europe and above all China, which record annual growth rates of five and ten per cent respectively.

The drawbacks of machining

Compared with steel, certain aspects are different when it comes to machining titanium. With respect to chip removal, such as when milling or turning titanium, its susceptibility to strain hardening can have a detrimental effect. If, for example, friction on the cutting edge is too great, the onset of strain hardening can cause the tool to quickly become blunt. When milling and turning titanium, sharp tools, the right cutting parameters and optimum chip formation are key parameters. The hardness of the tools

and the heat resistance of their coatings must be suitable for the hardness of the material. The combination of its properties such as elasticity (ductility) and tensile strength also complicate the machining of titanium.

Solutions from HORN

In order to machine titanium materials such as Ti6Al4V, which is in widespread use in the aerospace industry, HORN has developed an impressive portfolio of special tools that are able to overcome the main problems associated with processing titanium thanks to sharp cutting edges, a positive rake angle, a large relief angle and polished cutting edges. For the specific purpose of machining titanium in the aerospace and medical technology sectors, HORN has developed the cutting material grade TSTK for its solid carbide milling cutters, which boasts good tribological properties, high temperature resistance and low discharge of heat into the substrate – therefore providing a sort of heat shield. Another important aspect that had to be taken into account in the development of solid carbide end mills was to endow them with different helix angles and a different pitch. This results in a soft, low-noise cut and prevents vibrations. The titanium range from HORN comprises a completely new series of solid carbide milling cutters with diameters from 2 mm to 20 mm (0.078" to 0.787"), four or five cutting edges and 2 x D and 3 x D versions.

For titanium, the high feed rate milling cutters of the DAH 25, 37 and 62 system is suitable for large structural parts. In the case of forged titanium components, arbour milling cutters from the DAH system have proved successful and are also well suited to machining other aerospace materials such as Hastelloy, Inconel and Astroloy.

When turning titanium, HORN recommends the tool solutions it developed for machining stainless steels, which are highly temperature resistant, sharp, available in grades EG3 and HP6, and feature excellent tribological properties. A substantial and targeted supply of coolant is essential for all types of machining.

A comprehensive choice for titanium machining.

HORN is at home in more than 70 countries in the world

GROOVING • PARTING OFF • GROOVE MILLING • BROACHING • PROFILE MILLING • REAMING

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