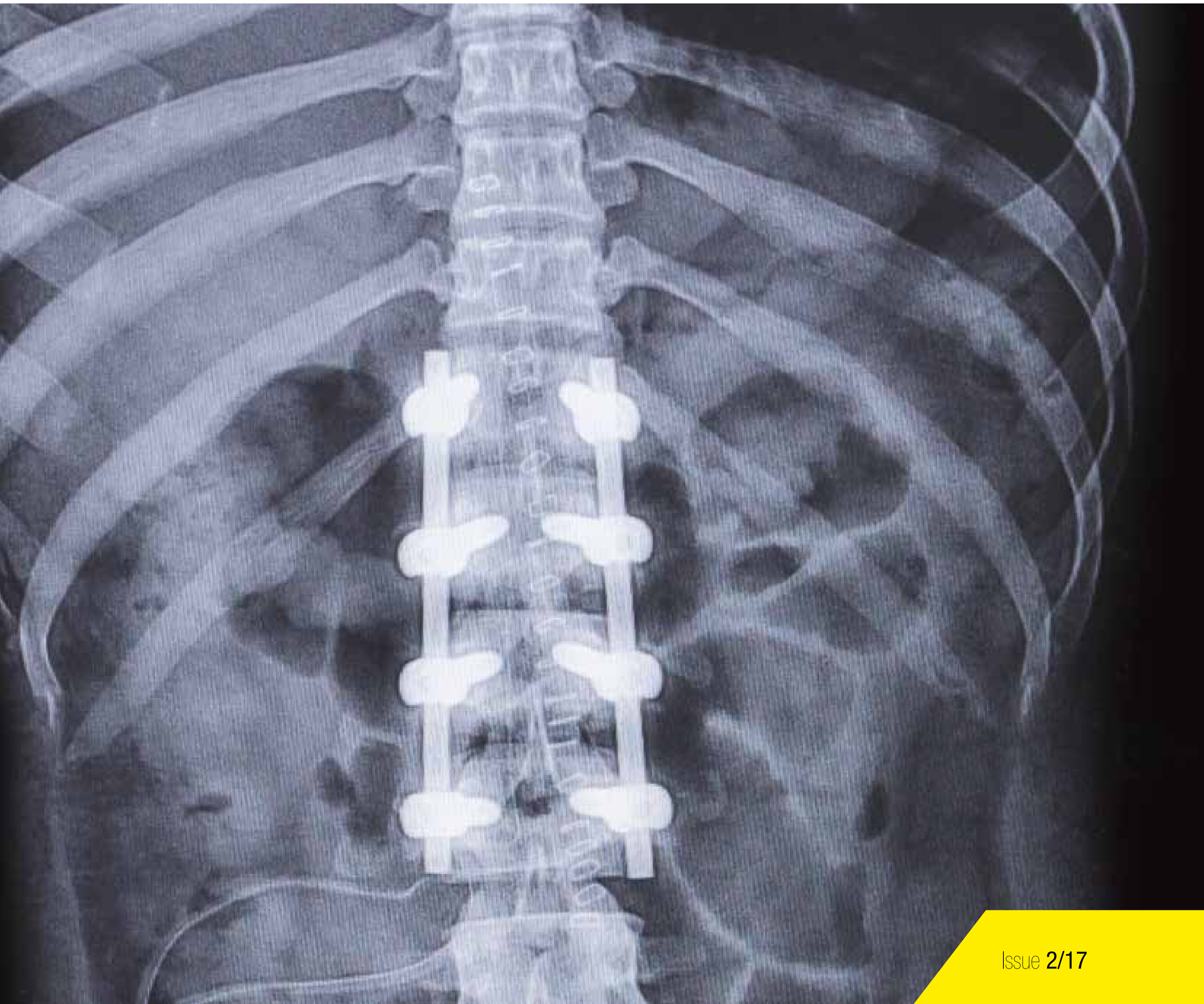
world of tools

TOPICS:

- Special feature: Medical technology
- Trade fair: EMO
- Special feature: Research projects
- Materials: Nickel-based alloys



Issue 2/17

EDITORIAL

Dear Readers,

The automotive industry is in a state of change, pursuing alternative propulsion concepts and autonomous driving – subjects that are on everyone's lips. While other industries tend to be less prominent in public discussions, in this issue we are looking at one of them. Medical technology now boasts state-of-the-art materials and is able to satisfy the very highest demands placed on quality, surface finish and process reliability. Every year, the industry reveals new horizons for treatment options – whether they are based on biological, technological or human factors. Machining plays a crucial role in the process, and we have some examples from real life to demonstrate this.

Innovations can develop in numerous ways – through our own research and development, through discussions between the customer and the sales department, from individuals or from team ideas, to name but a few possibilities. However, collaborations with research facilities and research groups can also lead to viable results. These are exactly the kinds of research projects we want to share with you. More specifically, in this issue we are looking at the GeWinDe project, which focuses on efficient manufacturing of threads by thread whirling using synchronous turning, and the SchwerSpan project, which tackles the issue of high-performance milling of materials that are difficult to machine.

We are also taking a look back at Technology Days 2017, which enjoyed a fantastic turnout – some 3,000 visitors from 35 countries. Based on the floods of positive feedback received from participants, we have decided to bring back HORN Technology Days in 2019. However, before we begin focusing on that event, we have another major occasion coming up: EMO 2017 in Hannover – the world's leading trade fair in our industry. We are looking forward to the event with much anticipation, as we have numerous new products and product enhancements to present this year.

I look forward to meeting you again at EMO in Hannover.

Lothar Horn
Managing Director
Hartmetall-Werkzeugfabrik Paul Horn GmbH
Tübingen

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world^of tools

MEDICAL TECHNOLOGY

MEDICAL TECHNOLOGY, A MARKET WITH A FUTURE

Technologies for patient welfare

Medical devices such as prosthetics, implants and dental prostheses are predominantly made of biocompatible materials such as stainless steel, titanium, plastic and ceramic. Machining these materials requires tools that satisfy the very highest standards.

Key facts about the medical technology industry

The German Federal Ministry of Health estimates that there around 400,000 different medical devices available. Devices for diagnostics, surgery, intensive care, implants, sterilisation, dressings and other aids, as well as materials used during operations, are not just important parts of healthcare provision itself – they also make a significant contribution to the country's economy.

In Germany, around 12,500 companies employing 210,000 people manufacture medical devices. 133,000 of these employees work in around 1,250 companies that have over 20 members of staff. 90 percent of medical technology companies employ fewer than 250 employees, demonstrating that the industry is composed predominantly of medium-sized businesses. Around 15 percent of employees work in research and development. The total turnover of manufacturing companies with over 20 employees was EUR 29.2 billion in 2016.

One of the leading German states working in this industry is Baden-Württemberg. According to its Federal Ministry for Economic Affairs and Energy, the district of Tuttlingen within the state represents the world's largest cluster for manufacturing surgical instruments.

Aid-giving, life-saving technologies

Medical devices improve quality of life, often even saving and preserving it. To achieve this, medical technology companies work in collaboration with users, doctors, scientists and engineers. In the process of developing technologies and putting them to use in production, digitisation is becoming an increasingly important factor at every stage of bringing a product to market. Other exciting approaches to production include miniaturisation and the use of new materials. There are now innovative operating tools made from fibre-reinforced plastics, for instance, and these have to be produced and machined entirely differently from their stainless steel or titanium counterparts.

A typical application in medical technology is whirling of bone screws.

Tools for health

For many years now, HORN has been a much sought-after partner when it comes to machining materials for medical devices. With our expertise and the wide range of standard and specialist tools we offer, we have already been able to provide solutions for a large number of incredibly complex tasks. HORN's ability to execute all the tasks required for the production process – and achieve extremely short turnaround times as a result, particularly when it comes to special tools – are just some examples of the strengths that numerous medical technology manufacturers have harnessed for their production needs:

Products	Tools/work processes	Main customer benefits
Dental implants	Milling internal threads, whirling external threads	Highly precise, reliable production
Hip replacements	Ball socket and expandable socket milling	2.5 times longer tool life
Tweezers and surgical scissors	Groove, circular and face milling cutters	4 times longer tool life, improved process reliability
Gouge forceps	Groove circular milling cutters	2 times longer tool life, improved repeatability
Knee implants	Solid carbide milling cutters, micro end mills	Higher product quality, shorter runtimes
Bone and jaw screws	Thread whirling	60 percent shorter machining time, improved surfaces, higher level of precision

Research project: Synchronous rotary whirling

To date, thread whirling has involved the revolving whirling head cutting the thread with its inserts. This requires the tool to remove all the material between the raw material diameter and the core diameter of the thread. Now, a synchronous rotary whirling technique developed as part of a collaborative project is putting an end to this disadvantage (see page 30). In this process, the whirling tool only cuts the thread profile; the other material is removed by a turning tool positioned in front of the whirling tool – creating a precise, efficient and reliable solution.

(Source: BVMed – The German Medical Technology Association)

MEDICAL TECHNOLOGY

MILLING FOR HEALTH

New milling cutters facilitate the production of titanium implants

Medical subcontractors need tools to cope with significant demands posed by the wide range of workpiece shapes, dimensions and quantities they have to process, as well as the large number of materials that are difficult to machine. The new DS titanium milling system from HORN provides a custom, highly economical solution for mastering these tasks.

... Tolerances from + 0.02 mm (0.0008") and a surface roughness of $R_z \leq 4$ µm

A selection of the new DS titanium end mills for machining titanium.

Everyone involved is delighted with the results of the collaborative efforts that went into milling the implants (from left): Tibor Veres, Hymec Managing Director, Thomas Wassersleben, HORN Technical Consultant, and Thorsten Brüssow, Foreman at Hymec.

Manufacturing medical devices, implants and surgical instruments made of stainless steel or titanium is exceptionally challenging work. That is why the cutting tools used must be able to meet the highest standards of quality, precision, reliability and process efficiency. Tibor Veres, Managing Director at Hymec Fertigungstechnik (founded in 1972), faces these challenges every day. Following its establishment by his father, the company quickly acquired an outstanding reputation as a manufacturer that was able to accomplish high-precision tasks. It is now a top supplier of orthopaedic implants as well as the instruments associated with them. The company's global customer base benefits not only from the high quality turning, milling and spark erosion it carries out, but also from the numerous services that guide customers through the product development process – from technical advice on the design all the way through to quality certification.

A service provider testing the limits of machining

At the company's new site in Norderstedt, near Hamburg, eight employees are responsible for producing prototypes as well as small and large batches of products from aluminium and titanium alloys, titanium, implant steel and other stainless materials. State-of-the-art CNC lathes and machines centres enable turning work up to 250 mm (9.8425") diameter, and machining of prismatic workpieces up to 400 mm (15.7480") x 400 mm (15.7480") x 300 mm (11.8110"). Wire-cutting and die-sinking EDM machines, plus laser welding and labelling machines, provide yet more services. Not only that, but surface treatments, polishing and special labels are offered in cooperation with expert suppliers.

Tibor Veres' team boasts expertise in all things tool-related, thanks to the questions on the subject of cost-effective machining it answers every day. When it comes to machining titanium, however, there are always new facts to discover. This biocompatible material demonstrates high levels of wear and heat resistance that, in many cases, quickly become too much for tools to cope with. Tibor Veres is highly pragmatic in his approach to everything from acquiring knowledge to exploring potential for investment in machines and tools: “We provide top-quality products and are constantly pushing the limits of what is technically feasible. That's why we need suppliers with excellent products and excellent services. Not many companies can meet these demands, however, so our pool of suppliers is relatively small. When it comes to cutting tools, for example, we rely almost exclusively on HORN products.”

MEDICAL TECHNOLOGY

Made of Ti6Al4V, the implant is produced from a Ø 40 x 30 mm (1.5748" x 1.1811") billet in one hour and 40 minutes on a 5-axis machining centre.

Titanium implants for spinal disc pain relief

The company turned to HORN once again while it was considering options for machining spinal disc implants. This time the Managing Director contacted Thomas Wassersleben: a machining expert responsible for technical consultation, sales and application technology, he was able to make several suggestions and, as a result, prepare the ground for the difficult machining processes involved. In this case, the task was to produce a prototype from a Ø 40 mm (1.5748 ") x 30 mm (1.1811") Ti6Al4V billet in one clamping on a Hermle C12U 5-axis CNC machining centre. The company wanted recommendations for the machining strategy and for a comprehensive tooling concept, all with a view to series production of around 1,000 implants per year in the future.

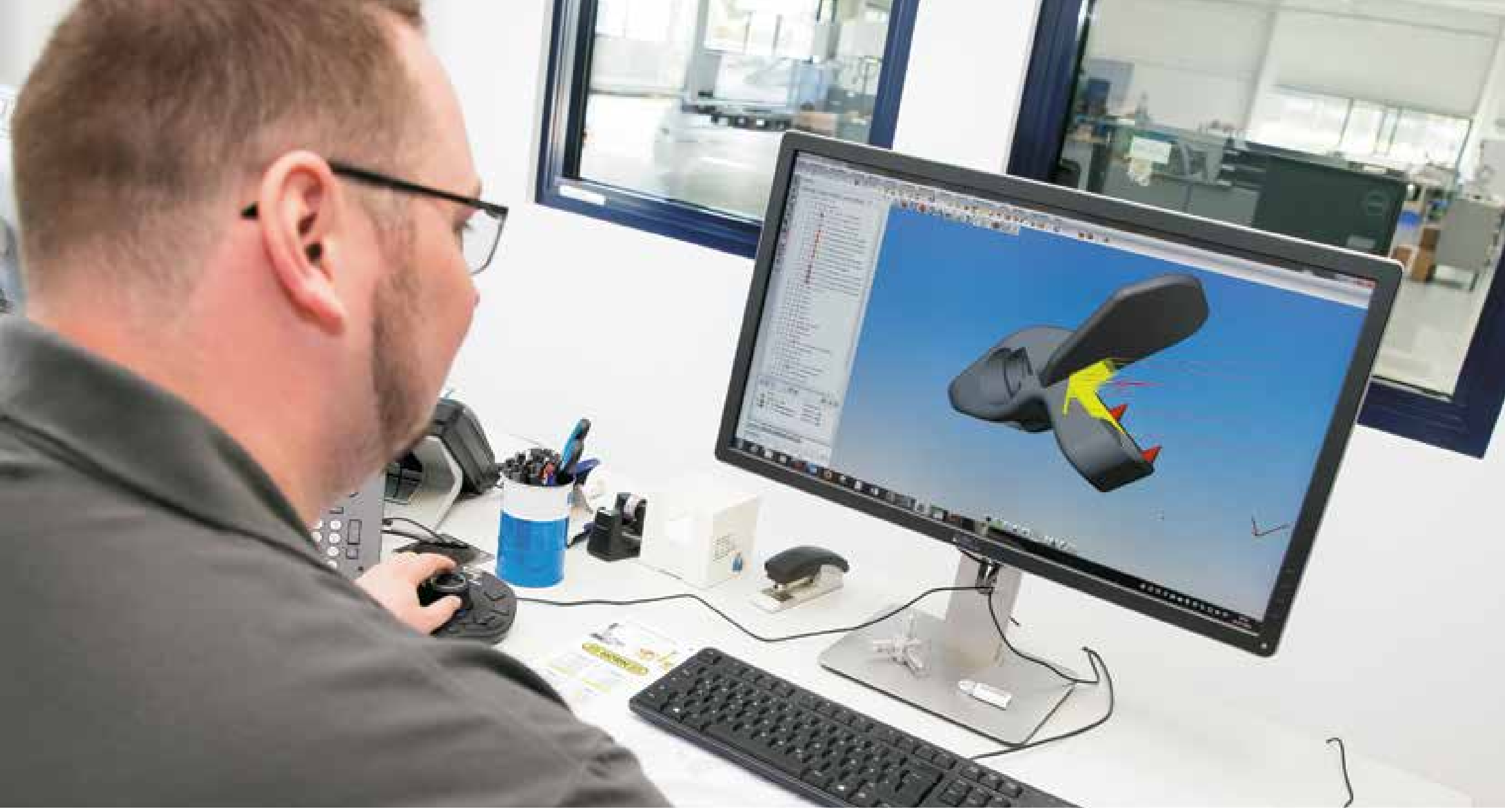
The CAM program for the implant, featuring numerous free-form surfaces, around 20 different radii and several concave fillets arranged at different angles, was programmed by Hymec in hyperMILL.

Milling cutters for titanium extend the DS end mill range

Thomas Wassersleben opted for the new DS titanium milling cutter system and for a machining strategy that involved roughing all contours with dimensions of 0.1 (0.0039") to 0.05 mm (0.0020"), followed by finishing. The new milling cutters are available with four or five and flutes in 2 x D and 3 x D versions and in diameters from 2 mm (0.0787") to 20 mm (0.7874").

The most important features of the tools are their extremely sharp cutting edges, positive rake angles, large clearance angles, polished cutting edges and the TSTK grade, which offers a high level of temperature resistance and low transmission of heat into the substrate. Various helix angles and pitches produce a smooth cut and prevent vibrations.

DS titanium milling cutters were developed based on the tried-and-tested DS solid carbide milling cutter system, which for years has been used to machine soft and hardened steels, chromium-nickel steels, titanium and superalloys as well as copper, aluminium, plastics and fibre-reinforced plastics. With cutting diameters from 0.1 mm (0.0039") to 20 mm (0.7874"), the end, torus, full-radius, double-radius, multi-flute and roughing milling cutters are used for boring as well as profile milling, shoulder milling, groove milling, face milling, pocket milling and chamfering.



Foreman Thorsten Brüssow was in charge of creating the implant, from programming at the CAM station to production on a machining centre.

The new milling cutter range provides a complete machining solution

For rough machining purposes, Thomas Wassersleben looked to the DS titanium series of solid carbide end mills, selecting a cutter with a diameter of 10 mm (0.3937") and a corner radius of 0.2 mm (0.0079"), as well as a cutter with a 6 mm (0.2362") diameter and a 0.5 mm (0.0197") corner radius. Where finishing was concerned, he opted for an end mill with a diameter of 1 mm (0.0394"). When it came to the other processes being carried out on the implants, additional DS milling cutters with 10/6/4/2 and 0.6 mm (0.0236") diameters came into play, as did a ball nose end mill with a 2 mm (0.0787") diameter and a thread milling cutter with a DCG profile featuring three flutes in carbide grade AN25. This mills the M 3.5 x 0.5 through-hole thread, which is 8 mm (0.3150") deep and inclined at 35°, in one operation. Previously, a milling cutter had been used to drill a core hole with a diameter of 3 mm (0.1181"). The process of milling two studs proved to be very challenging.

The 43° taper is around 2 mm (0.0787") in height and must end in a geometrically perfect apex. The DSTM micro end mill met these requirements during the roughing and finishing passes, offering speeds of n = 3,000 rpm to n = 18,000 rpm and feed per tooth of f_z = 0.02 (0.0008") to f_z = 0.04 mm (0.0016").

Close collaboration leads to success

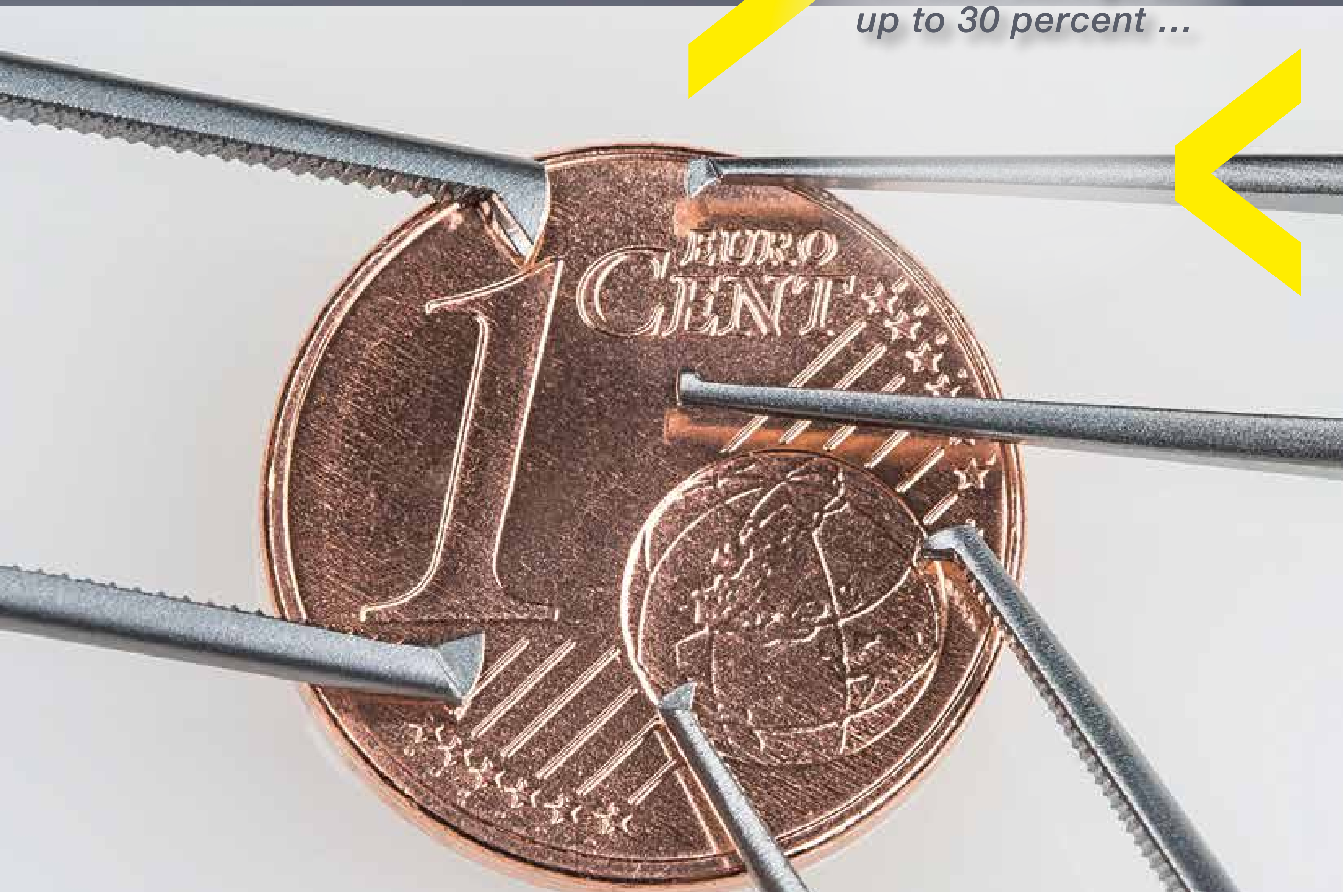
Evaluating the results produced by the DS titanium milling cutter, Managing Director Tibor Veres says: "With these tools, we were able to produce implants with tolerances of + 0.02 mm (0.0008") and a surface roughness of $R_z \leq 4$ µm in a cycle time of one hour and 40 minutes. This outstanding result provides us with a solid foundation for making additional calculations, which is essential as these implants need to be produced in both left-hand and right-hand versions, as well as in various sizes. We were also particularly thrilled with the reliability and tool life of the milling cutters." Looking to future developments, the Managing Director recognises that it is becoming increasingly important for these tools to offer a combination of substrate, geometry and coating that is ideally suited to the application and for machining parameters to be perfectly tuned. With HORN constantly enhancing its expertise through research, development and trials, he can rest safe in the knowledge that he will continue receiving suggestions for economical, reliable solutions to the problems of handling materials that are difficult to machine – and that it will be possible to apply these solutions to products quickly, thanks to in-house production. For HORN, the milling results achieved at Hymec attest to the capabilities of its new DS titanium solid carbide milling cutters. It enabled the market launch at the AMB trade fair in Stuttgart, which took place in autumn 2016, to be backed up by reliable data.

MEDICAL TECHNOLOGY

FINISH MILLING WITHOUT REWORKING

Aesculap AG in Tuttlingen, a global leader in the field of surgical instruments and sterile technology, produces around 1,000 different types of tweezers alone, in a range of sizes and designed for a variety of tasks. However, one type – its surgical tweezers – is different from the others because of the highly precise so-called mouse tooth geometry it features on the grippers. Machining this implement is not easy – but special milling cutters from HORN provided exactly what the company was looking for and now ensure precise, reliable and cost-effective production.

... cost savings of up to 30 percent ...



Approximately 50 varieties of surgical tweezers are produced in three different sizes with mouse tooth profiles on the grippers ranging from 0.7 mm (0.0276") to 4 mm (0.1575").

Cutting the female mouse tooth geometry. The flank angle of the profile is 25°, 30° or 35°, depending on the profile height.

Tweezers are an everyday item that we are all familiar with. Stamp collectors use them, engineers use them to separate small components, and everyone likes having a pair to hand when they need to get a splinter out of their finger quickly. Quite simply, they are a universal tool. The medical industry uses a whole range of different types: anatomical tweezers with a straight gripper end, surgical tweezers with one or more mouse teeth for securely gripping and separating even the tiniest of tissue samples, gentle atraumatic tweezers, micro-tweezers and splinter tweezers.

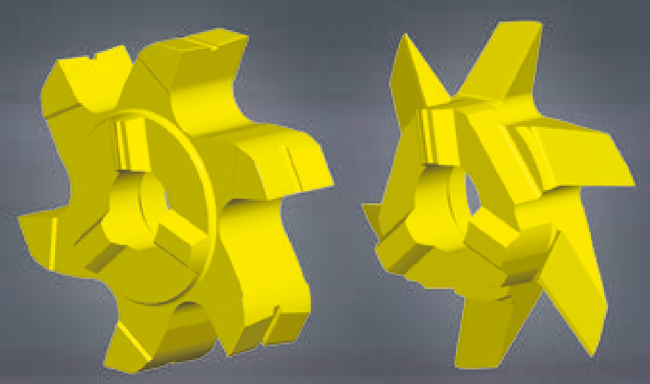
More than 1,000 types of tweezers

Aesculap offers more than 1,000 different types of tweezers. The top seller among its surgical tweezers can achieve over 20,000 unit sales per month, while demand for some of its specialist tweezers is only 50 units per year. Almost all tweezers have one thing in common: the materials most commonly used to make them. For surgical instruments, these are 1.4021 and 1.4024 in quality grades X20Cr13 or X15Cr13. Stainless steels having good machinability (class 5), they are tough, work hardening, burr-forming and have a tendency to cause built-up edges during turning.

Aesculap's range offers around 50 types of surgical tweezers with mouse teeth grip geometry. Its internal standard distinguishes between three types, according to the width and height of the mouse tooth profile – with profile heights ranging from 0.7 mm (0.0276") to 4 mm (0.1575"). The geometries borrow from older designs that have proven themselves in practice and have been used in these classic instruments for generations. The three types of mouse teeth differ according to the tooth angle: 25°, 30° or 35°. The angle used depends on the size of the tweezers. Both the machining and clamping processes present significant challenges due to the strict requirements for the mouse tooth geometry, the need for a precise fit between the male and female geometries, the tight tolerances of the tip and base angles, and the instability of the narrow tweezer ends.

In the past, conventional milling machines produced the mouse teeth in several operations, based on the geometric requirements of the tweezers. Reworking was also necessary; done by hand, it was time-consuming, expensive and required years of industry experience – making it almost akin to the work of a watchmaker. The problem posed by the process was achieving repeatable results, particularly when it came to the tiny mouse tooth dimensions of 0.7 mm (0.0276").

MEDICAL TECHNOLOGY



To avoid confusion over the flank angles, a male and a female milling cutter are assigned as a pair to each profile height. The three different diameters of the milling cutters with six inserts – types 613, 628 and 632 – help to make the distinction.

Milling the male mouse tooth geometry using a 5-axis process with undercutting. The base angle of the tooth geometry is limited to a maximum of 0.03 mm.

Intricate design

Nowadays, the tweezers are held in machinable soft jaws and the mouse tooth geometry is finish milled on a 5-axis machine. However, it is not the machine that makes this kind of work difficult. In this case, deciding on how the clamping would be arranged, as well as the tools, required a more extensive period of process development. The tweezer tips undergoing machining are unstable parts, sensitive to vibrations and unsuitable for even low levels of cutting pressure. This made it necessary to produce special vice jaws for every one of the 50 or so tweezer varieties featuring mouse tooth geometries. The next stage was to develop pairs of tools for machining the male and female tweezer arms. Since the three mouse tooth sizes have different tooth and opposing tooth angles (25°, 30° and 35°), the decision was made to design them with three different diameters in order to prevent the tools from being mixed up. Working on the basis of the mouse tooth size and the associated angle, male and female varieties of HORN milling cutters with six inserts – types 613, 628 and 632 – were paired with corresponding diameters of 21.7 mm (0.8543"), 27.7 mm (1.0906") and 31.7 mm (1.2480").

Extremely strict specifications

The extremely tight specifications for producing the rounded base contour of the male mouse tooth, measuring no more than 0.03 mm and 0.05 mm, to match the female contour posed a real challenge for HORN's tool grinders, especially because the need to consider the coating thickness made these requirements even more exacting when grinding the main body. Not only that, but it was also necessary to achieve an extremely sharp cutting edge contour to ensure geometric precision, long tool life and excellent reliability when machining 1.4021 and 1.4024 materials. This was no mean feat, particularly as the moderately positive rakes required a very sharp design in order to minimise cutting pressure and burr formation. As a result of optimisations, the mouse tooth geometries are now milled in the direction of the tweezer tip, the small amount of unavoidable burring being removed during the subsequent rounding of the tweezer tip. The process of optimising the machining, the clamping and the tool design took a total of six months, three of which involved the Tuttlingen company working closely with the Tübingen machining experts. This built on the successful partnership that the two companies had already been enjoying for decades. As a result, there was a broad base of experience available resulting from determining requirements for machining a wide range of Aesculap's instruments and other products.

Step by step towards a solution

The first stage in the tool design process involved establishing the tool system, the milling cutter type and the number of

(from left) Daniel Abert, Machine Supervisor at Aesculap; Gisbert Voss, HORN's field sales representative for this case; and Heiko Martinic, who is responsible for R&D production at Aesculap, often meet three times per week in order to drive progress forwards.

inserts. The second step consisted of developing the ideal cutting geometry and deciding on superfine grain as the substrate. Finally, when selecting the most suitable coating, it was possible to call upon a pool of experience gained from machining 1.4021 materials. Taking the exceptionally fine contours of the inserts into consideration, a highly smooth and relatively thin coating was selected. This facilitates chip formation and chip flow, as well as delivering very low frictional resistance. Low friction produces less heat, which minimises its transfer to the tool. This results in longer tool life and minimises cutting pressure. The grade chosen, Ti25 featuring a TiCN coating, is also a perfect choice for machining martensitic stainless steels.

Cost savings of up to 30 percent

Heiko Martinic, who is responsible for machining and process development with a view to achieving worldwide standards at Aesculap, says: "The entire process, which we developed in close collaboration with HORN – starting from CAD/CAM and including the decision to use the DMG Mori MILLTAP 700 turret-type milling machine, as well as the choice of clamps, tools and coolant – needs to be completely and reliably transparent in our production facilities both at home and abroad. For this reason, we also reworked our entire range of tweezer products by determining 20 geometry values using a parameter-based process. Our investment in developing standardised mouse tooth machining is now coming to fruition in the cost savings of up to 30 percent that we are achieving. The process of milling the mouse tooth profile of a new set of tweezers – which includes changing the workpiece and tool – now only takes a little over one minute. One pair of milling cutters is able to machine 1,400 male and female halves of a pair of tweezers reliably. So it was all worth it. And that's why we are already working on our next project – developing a machining strategy for multiple mouse tooth geometries."

The story doesn't end there, however: "I would like to add one more thing. Collaboration between two partners needs values that go beyond simply the technology itself. Throughout our long-standing, successful partnership with HORN and its field sales representative Gisbert Voss, who acts as our consultant as often as three times per week, we have already been able to complete numerous projects and solve a wide range of problems. So there's a good reason why we use countless numbers of tools from almost all of the systems that HORN offers. We really value HORN's outstanding consultation skills and short delivery times. For our special tools and requests involving order quantities under 50 units, we have been able to benefit from the extra-fast delivery that the HORN Greenline service offers – allowing us to reduce and simplify our response times and storage periods in a cost-effective manner."

ABOUT US

HORN TECHNOLOGY DAYS 2017

A glimpse into the future

HORN Technology Days took place for the sixth time between 10th and 12th May 2017 in Tübingen. The motto this time around was "A glimpse into the future". Eight presentations and associated practical demonstrations provided the centrepiece for the event. The two plants of Paul Horn GmbH, plus the Horn Hartstoffe GmbH plant, also opened their doors to visitors. Rounding off HORN Technology Days were various exhibitions from an exceptionally wide range of customer industries as well as around 40 partner companies attending as co-exhibitors. The event saw more than 3,000 visitors in attendance.

Lothar Horn, Managing Director of Paul Horn GmbH, said: "We don't see our Technology Days as a promotional event. We want to engage in dialogue with our customers in order to advance technology and innovations, and pool our knowledge. This is also why the presentations are application-specific rather than product-specific."

Most of the specialist HORN presentations – which numbered eight in total – were coupled with corresponding practical demonstrations. The presentations were available in up to five languages: German, English, French, Italian and Turkish.

The automotive sector was one of several industry focus points.

The dialogue we are able to have with visitors is a key component of the event.

The presentation topics at a glance:

- High-feed milling cutters for cost-effective titanium machining
- Turbo whirling and rotary whirling – Thread cutting redefined
- Perfect gear teeth
- Trends in grooving and parting off
- Micromachining on lathes – Achieving success with precision
- Powerful milling systems
- Coatings
- Solid carbide cutting inserts with raw sintered precision interface

The company Tyrolit delivered an additional presentation, entitled "Dressing of grinding wheels".

Current tool trends attracted a high level of interest.

"HORN Technology Days 2017 represented the most successful Technology Days event yet. The feedback we received from customers, partners and representatives exceeded all our expectations, which is why we can already confirm that HORN Technology Days will take place in Tübingen again in 2019."
Lothar Horn

ABOUT US

EMO HANNOVER 2017

The world's leading trade fair for metalworking

German President Frank-Walter Steinmeier will be ceremonially opening EMO Hannover 2017 in September. “We are absolutely delighted that our head of state will be giving EMO Hannover this honour and thus highlighting the real significance of the industry it represents in Germany,” said Carl Martin Welcker, General Commissioner of EMO Hannover, at the EMO Preview 2017.

After a four-year hiatus, this world-leading trade fair for metalworking will once again be opening its doors in the city of Hannover from 18th to 23rd September 2017. With “Connecting systems for intelligent production” serving as the motto for the event, the topics of digitisation and networking for production will be at the forefront of the discussion.

HORN will be presenting numerous new products and product enhancements on Stand A54 in Hall 5. Lothar Horn, Managing Director of Paul Horn GmbH, said: “The key areas of focus for our innovations are gear skiving, substrates and coatings. Our ever-present goal is to achieve the best possible results for our customers' applications and, of course, to create something better than existing solutions offer.”

Intelligent production in a network of possibilities

As the EMO motto indicates, digitisation and networking are hot topics in international production technology. The EMO organisers believe that this event will provide significant momentum for the advancement of the much-debated concept of Industry 4.0 or the Internet of Things (IoT).

“Digitisation has been a component of machine tools for a long time,” says Welcker. “Digital images such as those used for simulations have also been a possibility for quite some while.” What Industry 4.0 now means to this sector is networking the entire process chain and every stage in the value-added chain. A consistently networked production line enables flexible production with optimised processes, allowing even short-notice orders to be fulfilled in small batch sizes. Complete networking of the entire production line with real-time communication and control provides companies with the greatest added value when it achieves horizontal communication from the incoming order all the way to delivery. Within the value-added chain, it is also important to network logistics partners and customers in addition to suppliers in order to achieve as much productivity, flexibility and efficiency as possible. Putting it in a

The new design for the HORN trade fair stand at EMO 2017.

nutshell, EMO General Commissioner Welcker says: “If you can succeed in this, the result is a quantum leap in productivity – catapulting you to the top of global competition”. As an innovation forum and trendsetter, EMO Hannover 2017 will also present a wide-ranging fringe programme addressing economic and technical subjects. The watchwords here will include Industry 4.0, future production, additive production processes, machining in the aviation and aerospace industry, machine tool safety, the development of the US, Mexican and Indian markets, start-ups for intelligent production, and how to attract young professionals.

EMO Hannover 2017 – the world's leading trade fair for metalworking

International manufacturers of production technology will be presenting at EMO Hannover 2017 from 18th to 23rd September 2017, under the motto “Connecting systems for intelligent production”. The world's leading trade fair for metalworking will showcase a comprehensive range of today's technologies – which form the beating heart of all industrial production. On show will be state-of-the-art machines and efficient technical solutions, product-related services, sustainable production solutions and much more besides. The focus of EMO Hannover will be machine tools for metalcutting and forming, as well as production systems, precision tools, automated material flows, computer technology, industrial electronics and accessories. EMO draws specialists from every key sector of industry, including mechanical engineering and plant construction, the automotive industry and its suppliers, aviation and aerospace technology, precision engineering and optics, shipbuilding, medical technology, tool-making and mould-making, plus steel and lightweight construction. It represents the world's most important international gathering point in the field of production technology. EMO Hannover 2013 drew over 2,130 exhibitors as well as around 143,000 specialist visitors from over 100 countries. EMO is a registered trademark of CECIMO, the European Association of the Machine Tool Industries.

Hall 5, Stand A54

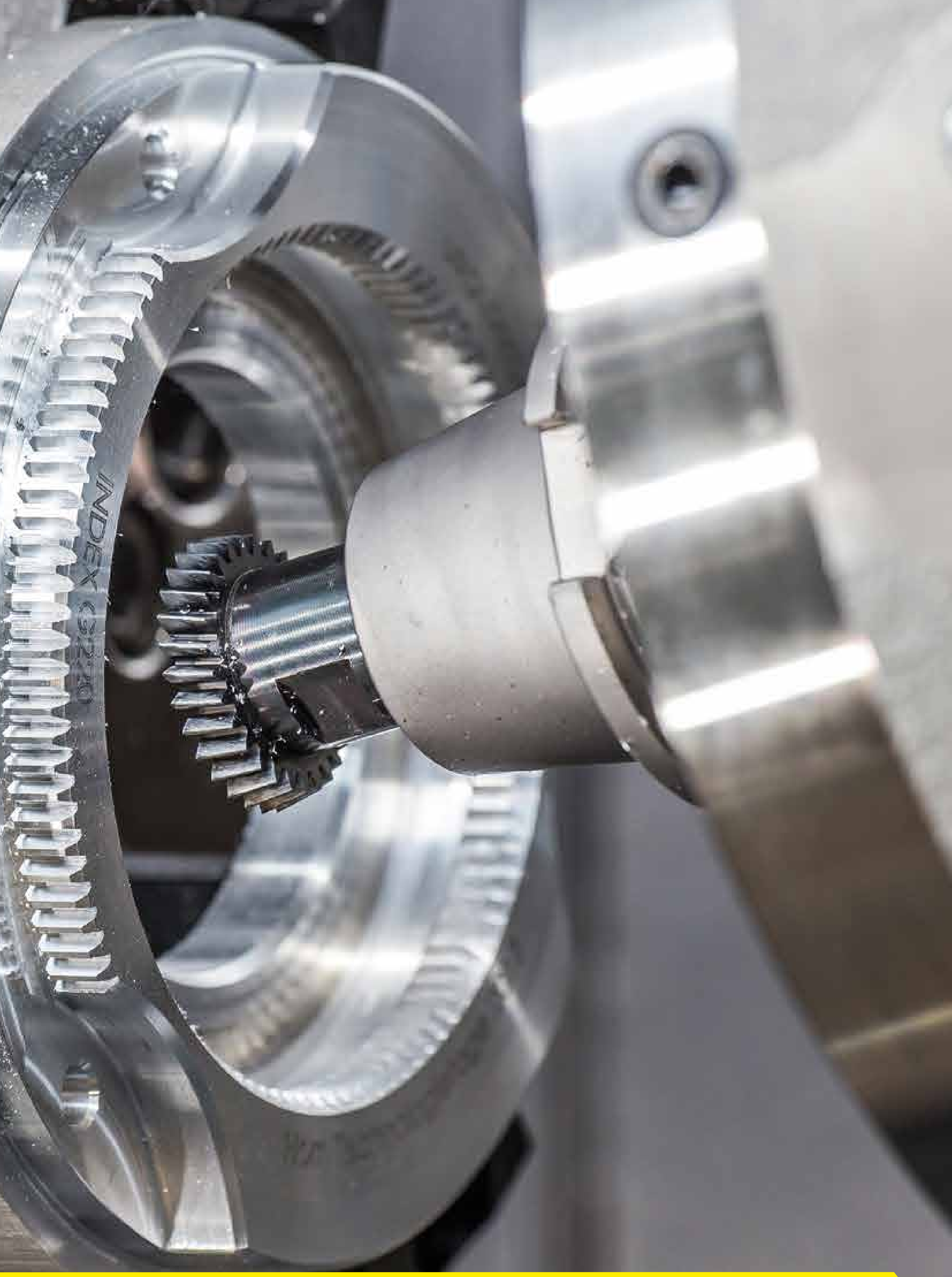
EMO Hannover 18-23·9·2017

Gear skiving: Fast and productive

New tools for gear cutting

HORN's product portfolio comprises a wide range of tools for the production of various gear tooth geometries of module 0.5 to 30. Whether this involves gear cutting for spur gears, shaft/hub connections, worm shafts, bevel gears, pinions or customised profiles, all these tooth profiles can be manufactured extremely cost-effectively with milling or broaching tools. Now, the new skiving tool range is yet more testament to the company's gear cutting expertise. It is a process that has been in use for over a century – but has only been incorporated into a wider range of applications since machining centres and universal machines with fully synchronised spindles and process-optimised software have been able to accommodate its highly complex technology. HORN will be introducing some of the tools that this process requires at EMO in Hannover.

Type SX gear skiving tool being used in a turning/milling centre.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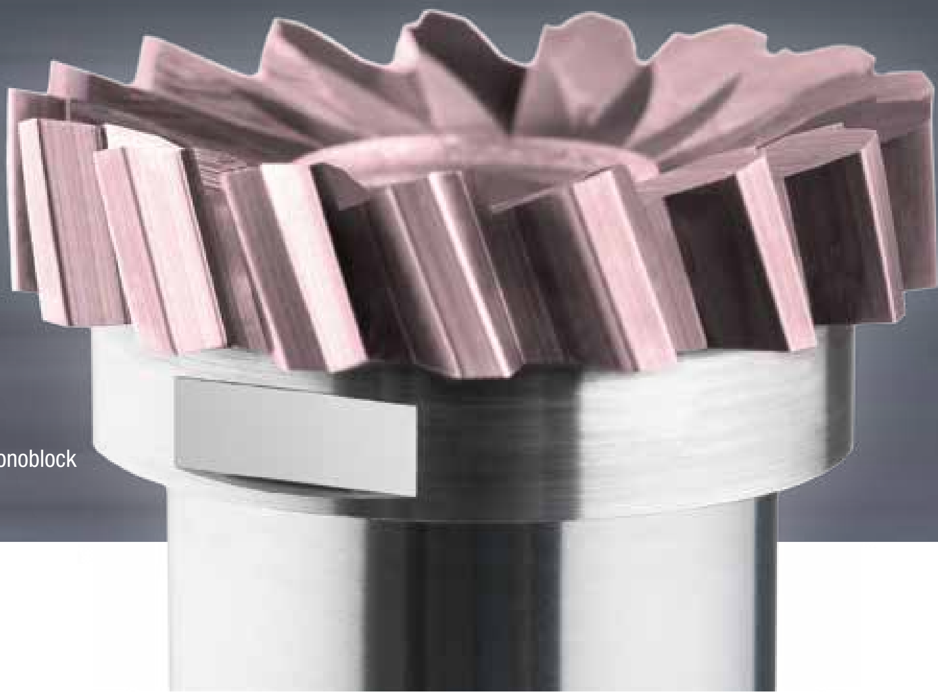
PRODUCTS

NEW



Skiving tool in monoblock design.

Productive and cost-effective

The new range consists of tools for high-yield manufacturing of internal gear teeth, splines and other internal profiles as well as external gear teeth with interferance. In these applications, the key advantages that skiving offers are significantly shorter process times in comparison to broaching, the ability to use the technique on optimised turning and milling centres, turning and gear cutting takes place in one set-up, the absence of undercuts at the end of the teeth, a manufacturing process that is generally more productive and cost-effective compared with gear shaping and broaching, and cycle times that are four to fives times shorter than those found in broaching processes.

Skiving tools are designed for gear cutting in medium to large batches. Each tool is individually adapted to the application and to the material being machined, with the various tool interfaces based on the number of teeth and the module size.

Tools made of solid carbide or with an exchangeable head

The range comprises tools in cylindrical or conical form for modules from 0.5 mm (0.0197") to 2 mm (0.0787"). The solid carbide tools are available with diameters of ≤ 20 mm (0.7874") and in a compact design. These are used for small modules as well as small components, primarily in applications that require a narrow shank due to the risk of collision. Cutting materials and coatings matched to the application achieve excellent surface qualities on the workpiece.

Designed for gear cutting in medium to large batches.

Gear skiving tools with an exchangeable head system are used for diameters of ≥ 20 mm (0.7874"). The highly precise interface enables the cutting head to be replaced easily in the machine without the need to remove the holder. The solid carbide holder ensures a high level of rigidity, wear resistance and precision.

HORN tool systems for milling, broaching and gear skiving using standard and customised tooth profiles

Machining process	HORN tool system	Cutting edge Ø D_s (mm) (")	For module
Milling	6-insert (or 3-insert) of type 606–636	11.7 - 35.7 (0.4606-1.4055)	1 - 1.5
	Cutter head/side milling cutter, in one-row and two-row versions, M274	≥ 63 (2.4803)	≤ 4
	Cutter head/side milling cutter, in one-row and two-row versions, M279	≥ 100 (3.9370)	≤ 4
	M121 milling system	≥ 63 (2.4803)	≤ 6
	Special tools	≥ 100 (3.9370)	≤ 30
Broaching on turning and milling centres	Supermini 105	6 (0.2362)	0.2
	Supermini 110	8 (0.3150)	0.2
	S117 inserts	14 (0.5512)	0.3
Skiving	**Skiving tool VHM**	**≤ 20 (0.7874)**	**0.45 - 1**
	Skiving tool SX	**≥ 20 (0.7874)**	**0.45 - 2**

PRODUCTS

NEW

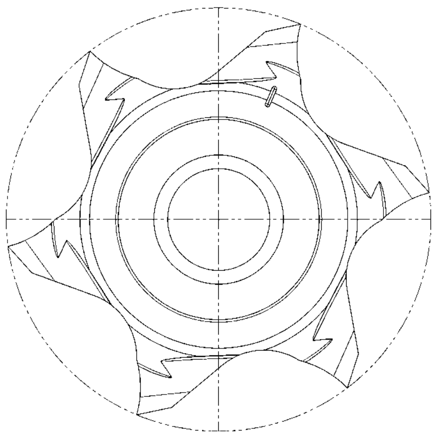
S64T precision-sintered insert

S64T system with chipbreaker geometry.

Chipbreaker geometry and coating open up new areas of application

The S64T insert with chipbreaker geometry is an evolution of the S64T insert that was unveiled at AMB 2016. In addition to the more extensive working range it offers, this precision tool with six cutting edges features a range of chipbreaker geometries and the new EG5 coating. Thanks to this coating, as well as the carbide substrate, the new insert is able to machine any kind of steel.

The new series of precision-sintered six-edged tools with ground inserts comprises a number of variants with different cutting widths. The S64T type enables groove depths of up to 5.5 mm (0.2165").



Four tools with the .1A geometry are designed for grooving and parting off, while four with the .DL geometry are designed for grooving, parting off and simple longitudinal turning operations. The excellent chip control demonstrated by the chipbreaker geometries ensures outstanding surface quality on the groove flanks and the straight main cutting edge creates a clean groove base. Designed as neutral inserts, they can be clamped on either a left or a right hand square holder with internal cooling. Holder dimensions of 16 mm (0.6299") x 16 mm (0.6299"), 20 mm (0.7874") x 20 mm (0.7874") and 25 mm (0.9843") x 25 mm (0.9843") are available. A single clamping screw fastens the insert precisely and securely in place in the central pocket.

PRODUCTS

NEW

DD solid carbide drills

New in the range: Solid carbide drills in various designs.

DD solid carbide tools for steel and stainless steel drilling applications

HORN will introduce a range of solid carbide drills at EMO in Hannover. Two geometry variants with diameters from 4.0 mm (0.1575") to 18.0 mm (0.7087") are available.

The tools feature the excellent standard of precision that customers have come to expect from HORN. They are produced with particular attention paid to the surface quality, the precision of the ground geometry and the cutting edge preparation. Together with the various coating options, these aspects ensure that customers using the tools will achieve excellent, consistent results.

DDP type tools for 3 x D, 5 x D and 8 x D hole depths have been designed for a universal range of applications. The materials they are most suited to are unalloyed steels, cast steel and alloyed steels with a tensile strength of up to 1,000 N/mm^2. All the tools feature internal cooling, although a variant without internal cooling is also available. Solid carbide drills with a conical ground surface are designed with double lands from 5 x D, which results in a higher standard of hole quality.

The DDM type's geometry variant with four ground facets is intended for machining stainless and acid-resistant steels, titanium alloys and nickel alloys. In order to achieve excellent results during use, the drills are designed with internal cooling and are available for hole depths of 3 x D and 5 x D. In combination with new coatings, this geometry ensures a longer tool life.

The entire range of tools available with both geometry variants can be obtained with taper shanks in HA and HE designs, conforming to DIN 6535. The outstanding performance of these tools is sure to impress and users also benefit from the flexible service and technical support that HORN provides.

NEW

DA32 insert with diamond tip

Diamond-tipped DA32 cutting insert.

New standard of performance for milling

At the EMO trade fair, HORN's proven DA32 milling system will be on show with diamond-tipped inserts for the first time. This feature allows the tools to achieve outstanding results during shoulder milling, face milling, plunge milling and circular milling.

The highly positive geometry of the inserts ensures a particularly smooth cut. This keeps the stress exerted on the workpiece and the tool to a minimum. As a result, a long tool life and virtually burr-free machining are guaranteed – particularly when it comes to long-chipping materials. The wide finishing radius creates the very best standards of surface quality, even at high feed rates. The coolant supply reliably ensures targeted cooling of the cutting edges as well as safe removal of the chips away from the working zone.

Thanks to the special geometry for fibre-reinforced plastics, combined with the hardness and wear resistance of the CVD thick-film diamond cutting material, outstanding levels of performance are achieved. Tried-and-tested HORN diamond substrates guarantee that the cutting edges – produced using state-of-the-art laser technology – are able to work efficiently.

All this, combined with the exceptional rigidity of the quenched and tempered steel as well as the wear-resistant TiN coating of the various tool holders, is what really makes the benefits of the DA system come into their own. The cutter head, screwed shank milling cutter and the end mill in the DA32 system are available in cutting edge diameters from 20 mm (0.7874") to 63 mm (2.4803") and with between two and six DA32 inserts.

PRODUCTS

NEW

EG3/EG5 for Supermini, Mini and 312

› Tool life increases of as much as 100 percent can be achieved with the new coatings.

New coatings improve tool life

Materials that are extremely difficult to machine can pose a significant manufacturing and financial challenge to cutting tools – particularly when it comes to small and miniature parts. To address the needs of these applications – in which tools from the Supermini product series machine holes with diameters from 0.2 mm (0.0079") – HORN has developed the EG3 and EG5 coatings.

The distinction between the two types rests in their substrates and layer thickness and they make it possible to achieve an extremely smooth layer – reducing the amount of heat that is transferred to the tool, and the cutting edge in particular, thanks to significantly lower friction. A golden wear layer provides a coating for improved wear detection.

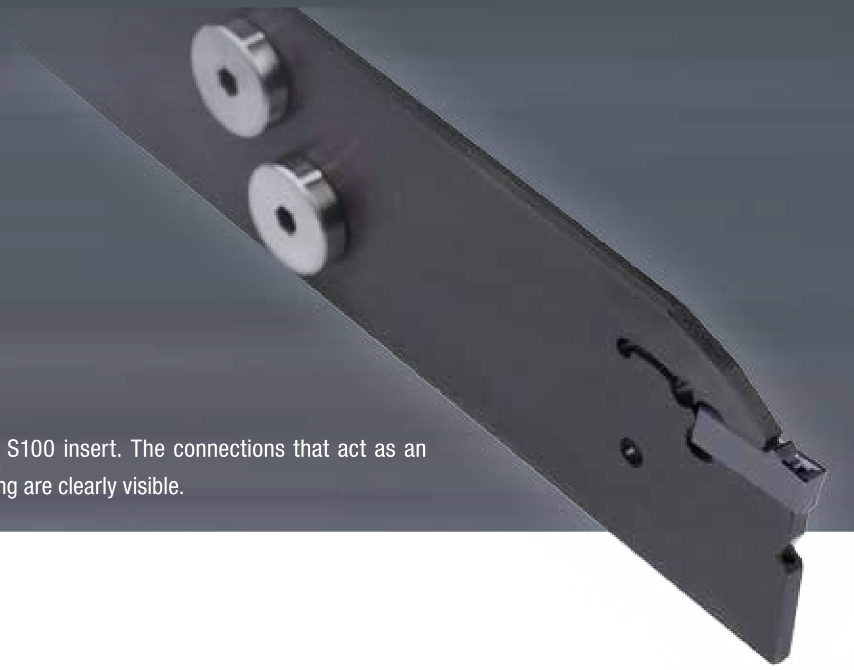
Numerous tests, plus experience that customers have gained in practice from highly precise, reliable procedures, have confirmed the excellent performance that the new EG3 and EG5 coatings are able to achieve. In comparison to previous coatings, they achieved increases in tool life of as much as 100 percent, depending on the material.

The new coatings have been developed for the Supermini, Mini and 312 tool systems. Supermini is primarily used for boring and grooving of hole diameters ≥ 0.2 mm (0.0079"). The Mini tool system comes into play in similar processes, but for hole diameters starting from 6.0 mm (0.2362"). The triple-edged inserts of the 312 system are also used for grooving and parting off, as well as for external machining and similar machining processes involving hole diameters from 46 mm (1.8110").

PRODUCTS

NEW

Grooving blade with internal cooling



Grooving blade with S100 insert. The connections that act as an interface for internal cooling are clearly visible.

Grooving and parting off depths of up to 55 mm (2.1654").

The new grooving blades are designed for universal use when producing small batch sizes. Six blades with cutting widths of 2.5/3 mm (0.0984"/0.1181") and 4 mm (0.1575") are available for these applications, with each pair of three blades measuring 26 mm (1.0236") and 32 mm (1.2598") high. Their projection length is universally adjustable.

The grooving blades hold two cutting inserts arranged in mirror symmetry. The self-clamping insert seat enables replacement that is straightforward and yet still highly precise. It is opened with a chuck key so that the cutting insert can be easily removed and a new one inserted. A prism in the insert and the groove blade ensures a secure connection. The inserts are available in all cutting widths with chipbreaker geometry.

The coolant is transferred to the blade from the base of the holder, which is specific to the machine being used. Two coolant connections act as the interface; as a result, the grooving blade can be switched from left to right with ease using a conventional spanner. The coolant is able to reach the flank of the S100 insert whatever the groove depth – and if an S100 insert with internal cooling is used, it will hit the point of cutting directly. The nozzle creates a coolant jet that flushes chips out of the working area, reducing the chance of chip accumulation. In addition, the formation of a built-up edge and the risk of breakouts on the cutting edge are considerably reduced. This means that higher cutting parameters are possible and longer tool life can be achieved in comparison to standard cooling systems.

PRODUCTS

NEW

Extension to range of face milling cutters and shoulder mills

ZETATec 90N roughing arbour milling cutter. Can also be used for helical or linear plunging despite the negative geometry.

ETATec 45P multifunction arbour milling cutter (with a round insert in the image) for face milling and profile milling.

Arbour milling cutters for long-chipping or short-chipping materials

At the EMO trade fair, HORN's milling tools sales portfolio – based on Boehlerit tools – will be expanded to include the ETAtec 45P face milling cutter and the ZETAtec 90N rough milling cutter.

The ETAtec 45P arbour milling cutters, featuring diameters of 50 mm (1.9685") to 160 mm (6.2992"), come equipped with between five and ten 7-edged inserts. The tools not only offer a 45° angle of attack and positive geometry, but also generate low cutting forces, all of which ensures a smooth machining process accompanied by high levels of productivity – an important user benefit, particularly in cases where less powerful machines and unstable clamping setups are being used. Thanks to the multifunctional concept – involving one tool holder for two different insert versions – the inserts designed for face milling can easily be swapped with round cutting inserts if profile milling needs to be carried out, for example. Where the new arbour milling cutters really show their strengths are in applications involving machining long-chipping materials such as stainless steels, titanium or nickel-based alloys. For these materials, inserts with or without chipbreaker geometry and in various steel grades are available. The ZETAtec 90N arbour milling cutters, featuring diameters of 50 mm (1.9685") to 160 mm (6.2992"), are equipped with five to ten inserts, each of which has six cutting edges. The excellent standards of reliability they achieve during rough machining are thanks to their negative geometry – while the positive rake angle ensures a smooth cut. What's more, the milling cutters also prove a real asset for customers performing helical or linear plunging, despite the negative geometry. The benefits of the cutting insert's properties truly come to the fore in cases where short-chipping materials are being machined – when milling anything from simple steels to cast materials, for example. To ensure that the correct cutting insert can be selected for the task at hand, two substrates and geometries are available: one steel grade for stainless steels and one for cast and non-ferrous metals.

INTERVIEW

UNDERSTANDING ISSUES AND PROCESSES

Dr Matthias Luik has been at HORN since 2004. He has headed up the Research and Development department since 2010.

As the Head of Research and Development, the subject of research is a key element of your job description. What are the differences between research and development?

Generally speaking, research refers to acquiring fundamental knowledge. We aim to use this knowledge in order to understand issues and processes. The knowledge is then applied during development and, where necessary, combined with innovation strategies. The aim of development, meanwhile, is to create a complete product or a new process.

How does a research project come about?

We distinguish between two types of research project – internal and external ones. The internal projects usually relate to questions we are trying to answer when we are faced with new challenges that our tools have to overcome – so we have to acquire the knowledge we need to do this. However, if the issue is on a universal scale, we involve our external partners. In these cases, it is important to ensure that we both gain a basic understanding of the situation, so that we can then begin the development process. First and foremost, the aim is to create a demo tool that can be put into practice as an actual product further down the line. We often collaborate with universities and research facilities at this stage.

In many cases, projects involve a number of partners. How does this collaboration take shape?

Since we define our joint goals at the beginning of projects like these, every partner is assigned their own tasks to complete. We have never seen a negative outcome as a result of this – quite the opposite is true, in fact. In many cases, partners come together again in the future to work on new projects. It is only when a group becomes too large that you start to run into difficulties – from an administrative perspective.

What is the main focus of the GeWinDe project and what challenges did you have to overcome?

The GeWinDe project is funded by the German Federal Ministry of Education and Research. Its main focus is on thread whirling with a parallel turning process. The biggest challenge in this case was synchronising the turning with the whirling: as the necessary cutting speed generates a much higher component rotation speed during the process, it is not possible to use a conventional whirling tool alongside it.

What was the aim of the research project?

There were two aims: the first was to achieve a significant reduction in process times by improving dynamics, and the second was to lengthen the service life of the whirling cutting edges by reducing the chip volume. During the process, we also achieved a by-product – an improved component surface as a result of the modified contact conditions.

What is the main focus of the SchwerSpan project?

The SchwerSpan project, which is also funded by the German Federal Ministry of Education and Research, looks at new production strategies, substrates, coatings, coolants and tool geometries when machining titanium alloys and superalloys.

Which challenges did you have to overcome in this case?

When handling titanium and Inconel 718, the poor thermal conductivity causes the heat to remain at the cutting point. This results in higher thermal stress on the tools. What's more, titanium alloys and superalloys are extremely strong materials, something which exerts significant mechanical stress on tools when high temperatures are present.

What was the aim of this project?

The aim was to double the material removal rate when milling titanium alloys and nickel superalloys (nickel-based alloys, Inconel 718). And of course, all this had to be achieved while maintaining the same tool life or even improving it.

Are there any new research projects on the go?

We are currently in discussions with project partners and a university as part of the planning stages of a new project. If our research proposal receives a positive response, the project could begin towards the end of the year.

What is your personal highlight from the EMO trade fair?

Last year we introduced a new six-edged insert, type S64T. We have now managed to create these cutting inserts with chip-breaker geometries – something it has only been possible to achieve thanks to state-of-the-art pressing technologies. In this case, we also had to conduct a significant amount of research at the outset in order to understand the limits and tolerances of the new pressing technology, particularly when combined with six axial directions. Bringing numerous simulations into play then enabled us to make real progress in developing the product – and the results are exceptional.

TECHNOLOGIES

GeWinDe – EFFICIENT THREAD WHIRLING BY SYNCHRONOUS TURNING


Rotary whirling in action: turning and whirling in parallel.

Motivation

Conventional whirling uses a tool with internal cutting edges, turning at high speed around a slowly rotating screw. These inserts are what create the thread pitch. In the process, the whirling head needs to remove all the material between the raw material diameter and the core diameter of the thread. As a result, the cutting edges are subjected to high levels of wear. Another drawback is the low speed of the screw, in which case simultaneous machining operations are not possible. Turning operations such as screw head machining must instead be carried out after the thread has been created.

Innovation

The synchronous rotary whirling process was developed as part of the GeWinDe collaborative project. The significant increase in the speed of the workpiece that the project has achieved represents the innovation. In contrast to conventional whirling, the workpiece and tool speed are synchronised according to the ratio of the thread pitch and number of inserts. The workpiece rotates with an integer multiple number of rotations around its own axis. This leads to an increase in the workpiece speed, allowing a parallel turning process to take place.

This simultaneous process results in the material between the raw part diameter and the external diameter of the thread being removed by the turning tool. The whirling tool only cuts the thread. As a result of this technique, there is a significant reduction in the machining volume as well as the process forces and, therefore, the wear exerted on the whirling head inserts. In addition, the tool path encircles the workpiece even more closely, tool engagement lasts longer, and the chip thickness reduces. And while the machining volume becomes lower, the feed rates and productivity levels increase. In summary, GeWinDe rotary whirling offers the following benefits:

- Enables parallel turning and whirling
- Reduces the material volume to be removed by the whirling head
- Reduces tool wear on the whirling head
- Increases productivity levels thanks to higher feed rates
- Reduces kinematic roughness due to a larger angle of contact between the inserts and the workpiece

Results

The newly developed rotary whirling process demonstrates significant advantages in comparison to conventional whirling, thanks to its efficiency and robustness.

A whirlwind as a symbolic representation of the rotary whirling process in the GeWinDe research project.

Method:

Cutting

Materials:

Fe Steel

Ti Titanium

Users:

Medical technology

Mechanical engineering

Toolmaking

Example from medical technology: Production of bone screws

In order to implement this rotary whirling process in existing production facilities of screw bone manufacturers, a programme was developed for the purpose of designing the screw geometry and setting the process parameters appropriate for the application.

A general requirement for whirling is that the cutting speed resulting from the workpiece and tool movements is in the same direction as the thread. This happens when conventional whirling is carried out, as the angle of attack lines up with the lead angle of the thread. During rotary whirling, however, the speed at which the screw turns is greatly increased, impacting the resulting cutting speed. This means that it is necessary to adjust the whirling head's angle of attack in a manner that will suit the rotary whirling process. The new process kinematics that are experienced in this case leads to the cutting edges engaging with the component in a different way. The overlapping rotations of the workpiece and tool during synchronous rotary whirling create a larger circumferential contact with the workpiece in comparison to conventional whirling. This in turn results in longer insert engagement in comparison to conventional whirling. There are significant reductions in surface roughness as well as in the average and maximum chip thickness.

In this project, the results are represented using a purpose-developed wear simulation that makes it possible to investigate the temporal and spatial cutting conditions between the workpiece and the tool. This may be carried out for the purpose of determining the variation in the chip thickness or the actual rake and relief angles during machining, for example. These findings create the foundations for further process optimisations, thus ensuring that the machining conditions experienced throughout tool engagement are as consistent as possible.

Shorter production times and longer tool life

Executing the process on a sliding-head lathe made it possible to gain empirical results that backed up the findings from the simulations. These investigations achieved a significant increase in performance when rotary whirling was used to manufacture bone screws made of titanium (Ti6Al4V), a material that is hard to machine. The feed rates achievable through synchronous rotary whirling are significantly higher than those obtained from conventional whirling. Not only that, but there is also no extra stress exerted on the inserts, nor is there any increase in surface roughness. In addition, the simultaneous turning operation made it possible to shorten the cycle time even further. The results were shorter production times with the same standard of surface quality on the workpiece and longer tool life. Rotary whirling therefore offers significant advantages for the production of threaded components and these are reflected in the reduced production times and resulting cost savings that are achieved.

TECHNOLOGIES

SchwerSpan – HIGH-PERFORMANCE MILLING FOR DIFFICULT MATERIALS

Aim of the research project: to increase material removal rate by up to 100 percent.

Motivation

Larger and more complex, one-piece components in the aerospace industry are primarily finished by machining billet or bar. Such components pose a challenge for production engineers, as they are often made from materials that are difficult to machine and result in significant tool wear – even when machining volumes are low. To combat this, industry practice uses low technology parameters for roughing materials that are difficult to machine. This leads to low material removal rate.

Innovation

The aim of the SchwerSpan project was to increase material removal rate by up to 100 percent. To achieve this, machining was carried out while the workpiece material was heated by induction. With this method, the heat softens the material being machined and thus reduces the mechanical stress exerted on the inserts, lengthening the service life of the milling cutters. This in turn allows machining parameters to be increased – boosting productivity levels.

The research focused on designing the inductive process and on developing a new coolant system. Designing the inductive procedure involved calibrating the necessary process parameters in line with the tool technology. In order to add another dimension to the process, inductive machining was combined with cryogenic cooling of the tool. This technique creates more flexibility in the tool technology and machining strategy – but at the same time makes for a more complex set of parameters.

Results

This innovative approach to machining made it possible to increase material removal rate by 100 percent. The new process is based on inductive heating of the material and cryogenically cooling the tool. This combined inductive/cryogenic machining process requires a tool technology that has been adapted specifically for it. It was for this reason that the project focused on developing a technology of this kind, basing it on the design of the cutting materials.

SchwerSpan technology can also be applied to turbine manufacturing.

Method: Cutting, Hybrid processes

Materials: Ti Titanium, Ni Nickel

Users: Mechanical engineering, Toolmaking, Power, Aviation

Inductive heating and cryogenic cooling

If material is softened by heating it to a predetermined temperature, the result is more heat being transferred to the indexable inserts. Cryogenically cooling the inserts counteracts this effect. The impact that inductive heating and cryogenic cooling had on the cutting zone were documented in the form of tool wear analyses of the cutting materials that had been used. As this is a new process, it was essential to calibrate the induction system before embarking on tests – a process that took into account the heat transfer and the tool technology. The purpose of this step was to set the temperature in the cutting zone and, as a result, determine a process window for selecting the machining strategy. During the calibration, it was determined that a depth of cut of 6 mm (0.2362") was the most suitable for milling. The process also revealed that the temperature in the cutting zone should be between 150 and 200 °C. This range is ideal for ensuring both sufficient softening of the material and a low level of thermal stress on the cutting edges.

Machining with carbide inserts

Based on the process definition, machining tests were carried out with indexable inserts made of various materials. It became apparent that the hybrid machining of titanium and superalloys required carbide inserts that are different from those used in conventional machining processes with coolant. This finding was derived from the behaviour of the tools and the characterisation of the tool wear. It was also shown that the low thermal conductivity of the cutting material prevents heat from being transferred to it. Furthermore, an overload resulting in cutting edge breakouts led to the end of the tool life – and this was defined as a failure criterion.

Conclusion

The project partners were able to increase the tool life for specific cutting materials and, as a result, increase metal removal rate. This meant that they were successful in achieving the aim of the project – to double the removal rate in titanium and superalloys. Higher technology parameters and an inductive/cryogenic approach to machining made a significant contribution to this. Targeted heat transfer led to material softening and enabled an increase in productivity thanks to the reduction in mechanical stress on the milling tool.

MATERIALS

NICKEL-BASED ALLOYS

Challenge for HORN specialists

› The operating temperatures of aircraft engines, power plant turbines, rocket propulsion systems, turbochargers and chemical reactors range from 1,000°C to 1,500°C. Temperatures of this magnitude can only be withstood by materials with high thermal, mechanical and chemical properties – such as nickel-based alloys.

A name inspired by mountain spirits

The name of the element nickel (Ni) comes from the Ore Mountains in Germany, which is where nickeline was first discovered. As it was similar in appearance to copper ore, miners hoped to extract copper from it – but since the mineral does not actually contain any copper, it was an endeavour that proved futile. This gave rise to the legend that mountain spirits (known as Nickel in the Ore Mountains) had bewitched the ore.

Hurdles for machining

Nickel-based alloys such as Nimonic 90, Inconel 718, René 80 and Hastelloy have particularly low levels of thermal conductivity. In these materials – which are primarily used for turbine manufacture – this property leads to the formation of built-up edges and strain hardening. The resulting vibrations, together with the high strength that the materials demonstrate, exert extreme stress on the cutting edge. A friction-reducing coating provides a remedy and simultaneously satisfies conflicting requirements such as high hardness and low susceptibility to cracking.

Superalloys challenge our development department

A desire for exceptionally sharp cutting edges and an increase in tool life has led to tool coatings such as the TiAlN-nanostructured thin film with extremely low cutting edge rounding. This coating enables outstanding tool life during milling. It is based on high standards of tool precision and concentricity and aims to distribute stress evenly across the individual cutting edges. Inserts with this carbide grade and coating are also available for grooving. Carbide cutting edges with exceptional fracture toughness, developed in association with the coating, enable cutting speeds of 30 m/min (98 ft/min) to 65 m/min (213 ft/min). Significantly higher machining parameters can be applied when using ceramics with silicon carbide whisker reinforcement as well as wear-resistant silicon aluminium oxynitrides. The high hot hardness and high wear resistance that they demonstrate are highly impressive properties. In the case of whisker-reinforced ceramics, however, production conditions impose significant

restrictions on the process of shaping the cutting edge. During turning involving ceramics, a material removal rate that is 15 to 40 times higher than that demonstrated by solid carbide tools can be achieved with cutting speeds of up to 750 m/min (2,460 ft/min). These materials are seldom used for milling due to their low fracture toughness.

High tool wear, short tool lives

A comparison of material-dependent tool service lives shows how difficult superalloys are to machine. If a service life of several days is usual for machining aluminium, this is reduced to eight hours for machining steel, to 45 minutes for 42CrMo4 heat-treated steel and to between 5 and 10 minutes for superalloys. When machining forged Inconel 718 turbine blades, uncoated carbide tools have demonstrated tool life of under one minute. A TiAIN coating has managed to improve this to approximately 6 minutes, while an additional coating of TiAIN-SN² has increased the life further still, to 25 minutes.

Guide values for machining nickel-based alloys

Cutting material	v_c (m/min) (ft/min) turning	v_c (m/min) (ft/min) milling
Carbide, coated	up to 60 (197)	up to 35 (115)
Ceramics	200 (656) – 750 (2,461)	up to 700 (2,297)
Cubic boron nitride (CBN)	200 (656) – 350 (1,148)	Fracture toughness too low

SchwerSpan research project

The number of applications for nickel-based alloys is increasing. As a result, so too are the demands being imposed on machines, tools (geometry, coating, stable clamping) and coolants – as well as employees' levels of expertise. With a view to achieving greater optimisation of particular machining systems, HORN took part in a collaborative project on milling of cutting materials that are difficult to machine (see page 32). The aim was to increase tool life and material removal volume. Inductive/cryogenic machining proved to be a successful approach. HORN has already gained significant experience in applying this technique to a range of individual applications.

Imprint:	world of tools©, the HORN customer magazine, is published twice per year and sent to customers and interested parties. Publication date: August 2017. Printed in Germany.
Publisher:	Hartmetall-Werkzeugfabrik Paul Horn GmbH • Unter dem Holz 33-35 • 72072 Tübingen, Germany Tel.: +49 (0) 7071 7004-0 • Fax: +49 (0) 7071 72893 • E-mail: info@phorn.de • Internet: www.phorn.de/en
Rights:	Reproduction, whether in whole or in part, only with the written permission of the publisher and text and image credit "Paul Horn Magazine world of tools©". Additional text and image credits: Nico Sauermann, istock title, Benchwerk P. 30–33, fotolia P. 34
Circulation:	24,500 in German, 4,900 in English and 3,800 in French
Editor/texts:	Christian Thiele, Hubert Winkler, Wolfgang Dieter Schenk, Nico Sauermann
Complete production:	Werbeagentur Beck GmbH & Co. KG • Alte Steige 17 • 73732 Esslingen, Germany

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