FVA

PRESENTS LOCAL LOAD CARRYING CAPACITY ADVANTAGES COMPARED TO STANDARDIZED METHODS

The *FVA-Workbench* is a manufacturer-independent tool for the simulation and calculation of transmission systems. As product development cycles become shorter, powerful modeling approaches and calculation algorithms become increasingly important. The predominantly analytical approaches in the *FVA-Workbench* deliver fast and reliable solutions to all important issues related to drive technology. For bodies that cannot be accurately described analytically, the results are supplemented by suitable numerical methods. The intuitive modeling techniques in the *FVA-Workbench* enable simulation of consistent, valid, and manufacturable gears every time.

The calculations are developed, analyzed, and validated in research projects by Forschungsvereinigung Antriebstechnik e.V. (FVA, the Research Association for Drive Technology). Through member contributions and public funding, the FVA is able to organize 17 million euros annually in research projects at leading German universities, chairs, and research institutions. The FVA-Workbench serves as a knowledge platform that makes the results of FVA research projects available and accessible to all engineers, without having to read through and study countless pages of scientific documentation.

Cylindrical gear calculations in the FVA-Workbench

The *FVA-Workbench* features the world's most comprehensive library of standard methods for calculating the load carrying capacity of cylindrical gears. In addition to the latest national and international standards such as ISO 6336, DIN 3990, and AGMA 2101, the library also includes calculation guidelines for all major classification societies, the calculation of plastic gears according to VDI 2736, as well as all older versions of these standards.

The load capacity calculation is always preceded by a rolling simulation with one or two tools to determine the cylindrical gear geometry. This ensures that the gear can realistically be manufactured and will run as intended.

In addition to the geometry and the material used, the load distribution during mesh has a significant influence on the load capacity of a cylindrical gear. In the calculation, the influence of uneven load distribution across the face width is taken into consideration via the face load factor KHß (DIN 3990 and ISO 6336) or KH (AGMA 2101). However, the formulas included in the standards only provide a very rough estimation. A detailed deformation analysis of the complete gear system is necessary to be able to quantitatively evaluate the effective influences on the load distribution across the face width.

In the *FVA-Workbench*, the total gear deformation is calculated based on a method developed for FVA and validated using deformation measurements at the Technical University of Munich Institute of Machine Elements, or FZG (see Figure 1 and 2). The following elastic deformations and static displacements can be taken into account, among others:

- Gear stiffness
- Flank modifications
- Shaft deflection and torsion
- Deflections and clearances of rolling and plain bearings
- Casing deformations
- Manufacturing deviations

The deformation analysis in the *FVA-Workbench* can be performed in a few seconds, even with complex gear structures. The face load factor is automatically determined for each cylindrical gear stage and can be taken into account in the selected load carrying capacity calculation.

The calculation of the load distribution across the face width of a planetary stage can be used as an example (Figure 1). If the load distribution across the face width in this stage is calculated based on the torsion of the sun pinion, as in a simplified calculation according to the standard, the result for this example is a face load factor of KHß = 1.83 with a maximum load on the output side of the sun pinion (Figure 2a). However, if the tilting of the planet gears due to deformation, the play of the planet bearings, and the elastic deformation of the planet carrier including the deformation of the pin are also considered, the result is a face load factor of KHß = 1.65, and with the maximum load located on the

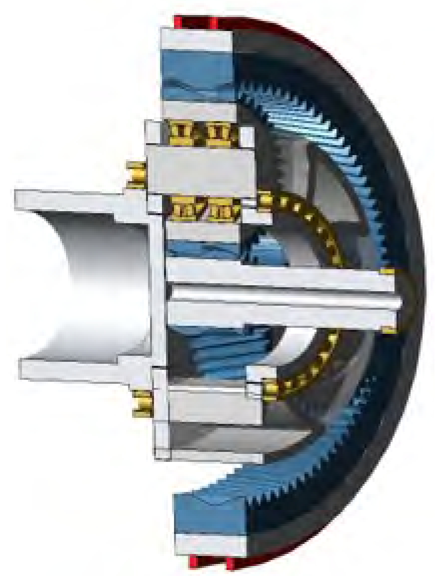

Figure 1 Example of a planetary stage (Source: FVA-Workbench 3D model).

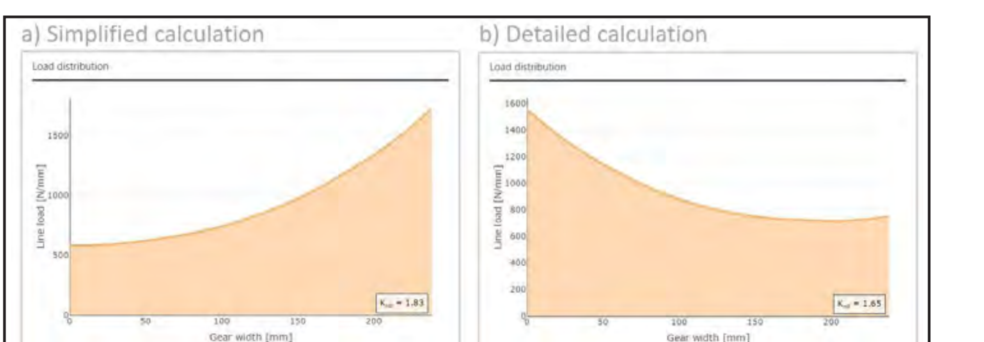

Figure 2 Comparison of the face load factors for a simplified (a) and detailed (b) deformation calculation (Source: FVA-Workbench reporting).

opposite end of the gear (Figure 2b).

The detailed system-wide deformation calculation in the *FVA-Workbench* enables a more precise calculation of the load carrying capacity and a practice-oriented optimization of face modifications. This can be used not only to avoid damage, but also to identify hidden load carrying capacity reserves. Cost savings can then be achieved by reducing component sizes and the associated reduced resource usage.

While the influence of uneven load distribution across the face width can be evaluated in standard load carrying capacity calculations using the face load factor KHß, as described above, uneven load distribution across the tooth depth cannot be represented in detail. The following factors can lead to increased flank pressure in the tooth root area of the flank:

- Edge stress in the contact area of the tooth tip edge for helical gears
- Load peaks due to short lines of contact at the start and end of contact for helical gears
- Small radii of curvature at the pinion base with large tooth ratios
- Small radii of curvature near the base circle of a gear mesh

The standard methods assume a suitable profile modification. Only in ISO 6336 (2019) /3/ does the newly introduced fZCa factor lead to a somewhat qualitative consideration of a non-existent or non-optimized profile modification. With the *FVA-Workbench*, on the other hand, the influence of uneven load and pressure distribution over the tooth depth can be more closely examined during the design of a gear.

The local load of each point on the flank is calculated for this purpose. Here, too, proven calculation methods from /1/ are applied, in which the local gear tooth stiffnesses are calculated on an analytical basis using a plate model. This analytical approach allows a very high resolution with a short calculation time. In addition, the *FVA-Workbench* also offers an FE-based approach, which was developed in FVA Research Project 128 at the Laboratory for Machine Tools and Production Engineering (WZL) of RWTH Aachen University. The local load distribution determined in this way forms the basis for additional local load parameters:

- Local flank pressure

Figure 3 **One-sided pitting on a sun pinion shaft in a wind turbine gearbox (Source: GearConsult).**

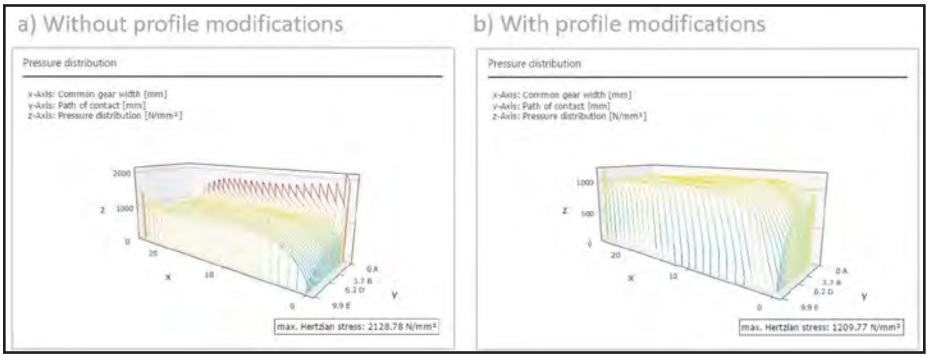

Figure 4 Pressure distribution of a helical gear with tooth ratio 4 (Source: *FVA-Workbench* reporting).

- Local tooth root stress
- Local sliding speed and lubricant film thickness
- Local contact temperature
- Local safety against micropitting

Figure 4 shows an example of the pressure distribution of a helical gear with a tooth ratio of 4, with and without profile modification, calculated with the *FVA-Workbench*.

It can be seen that the local pressure increases as the equivalent radius of curvature decreases toward the tooth root of the pinion. Together with the edge stresses simultaneously occurring in the contact area of the tip edge of the mating gear, this leads to very high local pressure peaks which make a profile modification necessary. The required profile modifications can be easily designed with the *FVA-Workbench*, which then lead to uniform pressure distribution and thus uniform material utilization across the tooth flank (Figure 4b). In this way, damage resulting from these locally overloaded areas in the contact area of the tip edge of the mating gear, such as the triangular flank chipping shown in Figure 5, can be reliably prevented.

Figure 5 Triangular flank chipping (Source: GearConsult).

References

1. FVA-Projekte 30 I – IX: Entwicklung und Erweiterung des Programms RIKOR.
2. M. Otto, U. Weinberger, K. Stahl: Full Contact Analysis vs. Standard Load Capacity Calculation For Cylindrical Gears, *Gear Technology* (November 2018).
3. ISO 6336:2019 – Beuth-Verlag.

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EMAG

VL 1 TWIN ENHANCES CYCLE TIME FOR BEVEL GEARS

With its twin-spindle pick-up turning machine — VL 1 TWIN, EMAG has developed a solution to simultaneously machines two identical bevel gears at high speed within the same machining area. A robot cell and swivel table can easily load this machine. All this brings the cycle time down to 4.5 seconds.

"It's about managing very large quantities cost-efficiently, quickly, and free of defects," explains Daniele Loporchio, technical sales manager at EMAG. "That is exactly why we designed the VL 1 TWIN. The machine is perfect for soft and hard machining of a wide variety of bevel gears up to 75 millimeters in diameter (3 in)."

The basic principle of this pick-up turning center plays a decisive role. It features two pick-up spindles (9.9 kW/136 Nm at 40% duty cycle) that are used to always machine two identical bevel gears in parallel at high speed (OP 10 – OP 10). The two spindles load and unload the machining area in just five to six seconds. The machining steps described above are then performed successively and in a single clamping operation with a total cycle time of about 25 to 40 seconds (depending on type and size of part). The average chip-to-chip time is just under six seconds. A special clamping solution reproduces the negative image of the component's gearing and holds it firmly in place for the entire time. Additionally, the VL 1 TWIN is able to drill into solid material, which is how the bevel gear's center bore is produced.

This machine's whole approach leads to fast production and high output quantities, while significantly reducing the price per spindle with rigorous cost controls — contributing to the low unit costs.

With EMAG equipment, there are a range of standard features that ensure component quality and reliability. For instance, the VL 1 TWIN has a machine base made of MINERALIT, which significantly reduces vibrations during the turning process, leading to longer tool life and lower tool costs. Headstocks

can traverse autonomously, allowing the diameter and length (X/Z directions) of both components to be adjusted independently of one another if there any deviations, e.g., following the change of an indexable insert. The wear-free linear drive in the X-axis, including the direct distance measuring systems, is equally important. It has an acceleration of 8 m/s^2 (1,575 fpm) with precise long-term accuracy. The roller guides in all linear axes guarantees further precision.

EMAG's developers can also combine the VL 1 TWIN with a powerful robot cell and a swivel table. In this case, the gripper is precisely adapted to the shape of the component. Pre-positioned component containers simplify transport as well as loading and unloading. This allows the cycle time to drop all the way to 4.5 seconds and individual process flows are easily reproducible. Additional processes, such as measuring, marking and cleaning, can be integrated in the same cycle time.

In addition to this, two VL 1 TWINs can be loaded with the robot cell mentioned earlier or with EMAG's TrackMotion automation system (OP 10 – OP 10, OP 10 – OP 10). In the latter case, the TransLift (a lifting and rotating device with an electric gripper) picks up raw parts from a feeding conveyor and transports them to the machines. Both machines are loaded very quickly — a solution for four spindles that is both powerful and very compact.

Low investment and production costs, short cycle times and high process reliability — provide a base that allow machinery manufacturers to feel equipped to produce bevel gears.

"From classic combustion engines to purely electric drives, differentials remain relevant regardless of drive type. Whoever wants to modernize their production now and prepare for growing unit volumes should take a closer look at this technology," said Loporchio. "We're convinced that the VL 1 TWIN is an ideal solution for many bevel gear manufacturers."

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Marposs

ANNOUNCES GEMGP STAND-ALONE TOOL MONITORING SOLUTION

Marposs has announced its new Artis GEMGP stand-alone solution for detecting process anomalies during metal cutting in machine tools. By measuring force and strain, GEMGP is able to detect and report on tool breakage, missing tools, overload, tool wear and fluid flow in real time. This helps to prevent damage to the machine, reduce scrap and improve productivity.

The GEMGP can accommodate two sensors for measuring force and strain values obtained from the spindle during the machining process. A highly flexible solution, the GEMGP offers three different monitoring strategies and can handle up to 127 different cutting cycles with varying types of limits for each cycle. Any events that exceed the pre-fixed limits are recorded in a log-file.

The compact GEMGP is designed for easy installation and operation and can be housed within machine electrical cabinets, robots, handling systems or other devices. All necessary functions and interfaces are integrated in the module. Featuring a digital I/O interface, the GEMGP is independent of the NC type and can be run from any PLC, enabling a discrete connection to the module.

The GEMGP can be used in stand-alone mode with the operating software run on Windows (WIN 7/10) machine control panels or Siemens Linux systems (TCU). The software can be installed on industrial PCs from Marposs or on any Windows PC (WIN 7/10).

As part of the Genior Modular product family, the GEMGP capability can be built upon or integrated into the Genior Modular system for process monitoring purposes, delivering the strain, force and flow data to the processing unit for further evaluation.

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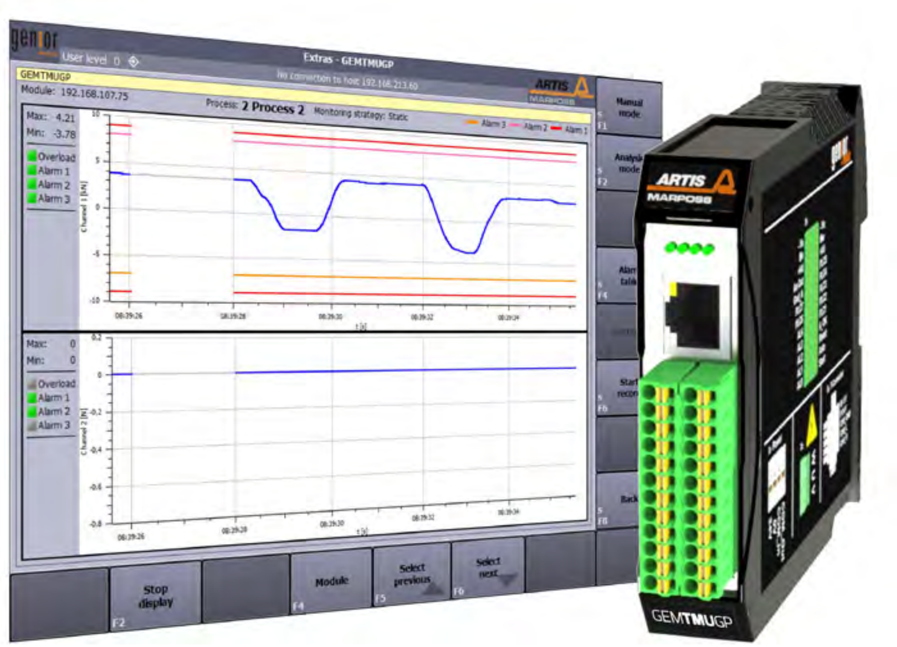
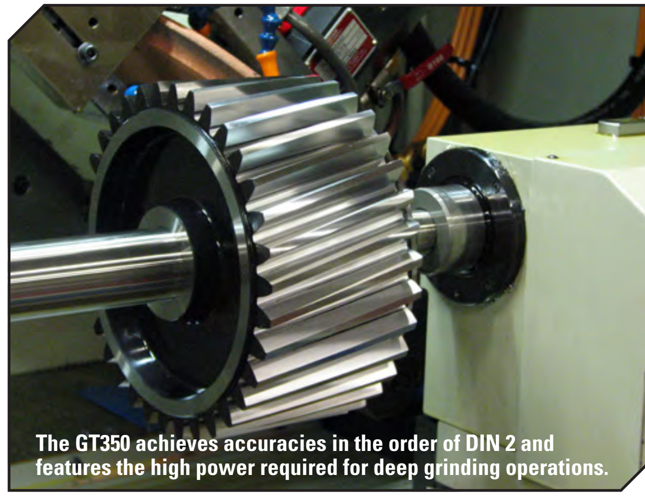


PTG Holroyd

INTRODUCES NEW GEAR GRINDING CENTER


The GT350 achieves accuracies in the order of DIN 2 and features the high power required for deep grinding operations.

A brand-new gear grinding center from Holroyd Precision promises to bring even higher levels of intelligence and efficiency to the production of specialized gears and tooth forms. Called the GT350, this latest machine from the Precision Technologies Group (PTG) company has been developed for one-off and batch grinding of precision spur and helical gears, worms, and screws of up to 350 mm in diameter. It can also be used to precision grind compressor rotors.

Replacing Holroyd's GTG2 model, the GT350 achieves accuracies in the order of DIN 2 and features the high power required for deep grinding operations. A specially developed extended machine bed allows screws and worm shafts of up to one meter in length to be accommodated. Dedicated software compensates for helical twist, and full topological capability comes as standard.

It is the GT350's data collection and transfer capability, however, that could be of greatest interest to users. IO-Link communication technology, for example, is available with all new GT350 machines. "We selected IO-Link for its data-handling capabilities and its ability to communicate at every level of the production process," says Holroyd Regional Sales Director, Steven Benn. "RFID scanning is a further option that will assist GT350 users in achieving new levels of performance. Particularly suitable for machines destined for production cells, the feature will all but eliminate human error by helping ensure that chuck, collet, cutter and tailstock, in fact virtually any component or tooling item that needs to be switched between manufacturing cycles, is correctly changed for each gear grinding operation."

Maintaining the Holroyd tradition of building machines that simplify even highly complex manufacturing processes, the GT350 combines extreme rigidity with high power for both CBN and conventional deep grinding operations. Setup is rapid for optimized productivity and customers have the choice of either Siemens' 840D controller or Holroyd's in-house CNC and HMI system. On-board features include: automatic coordinate adjustment, in-cycle wheel dressing, integrated profile management and coordinate measurement.

Grinding cycles are included for: spur gears; helical gears; crowned helical and spur gears with root or tip relief; worm gears of the form ZK, ZI, ZN and ZA; dual lead (duplex) worm gears; splines.

The GT350 also features Holroyd's Profile Management System (HPMS) for highly accurate profile grinding, while an advanced touch-screen interface allows the operator to enter design drawing coordinates directly into the machine. Additionally, all gear, worm and spline profiles can be verified using the integrated Renishaw probing system, enabling automatic on-machine corrections to be made if necessary.

Holroyd's design engineers have ensured that the GT350 automatically corrects the problem of helical twist — a condition that occurs when helical gears are 'lead crowned' to improve meshing and to reduce noise and wear. This is achieved through the use of specially written, dedicated software that both calculates and controls additional motions of the grinding wheel during the grinding operation. During the machining process, the workpiece is rotated about its axis and the tool moved so as to vary the angle of inclination of its axis relative to the axis of the workpiece. As a result, generated errors are reduced along each line of instantaneous contact between the tool envelope and groove surface being machined. The result is better tooth contact during meshing and improvements in torque transfer efficiency.

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GWJ Technology

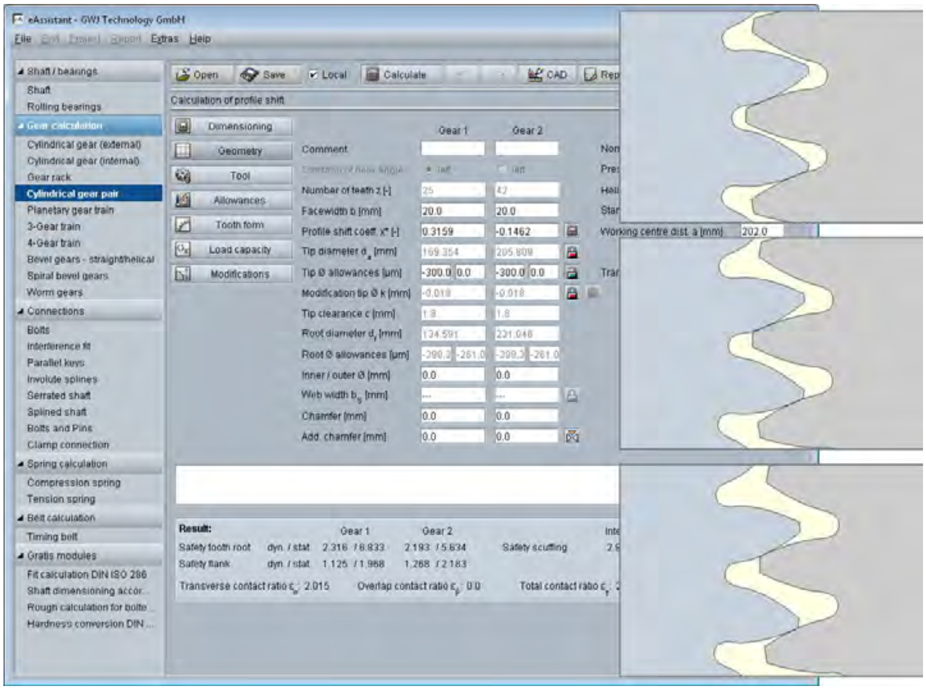
OFFERS ENHANCED CALCULATION OF CYLINDRICAL GEARS

GWJ Technology GmbH from Germany has updated the calculation module for cylindrical gears in its web-based software solution *eAssistant*.

In addition to various dimensioning functionalities for the distribution of the profile shift, a new function for disconnecting the center distance from the profile shift was added. By using the function "Fixed working center distance (recalculation)," the profile shift coefficients can be defined independently from the center distance. This enables, for example, the calculation of existing gear pairs that are to be installed in the housing with the "wrong" center distance. Transverse contact ratio, backlash and load capacity are also calculated correctly in this case. This function can also be used for the calculation of small-module gears.

The functionality of tools with shifted profile reference line has been extended. Additionally to the addendum coefficient haMP0* of the shifted profile, the dedendum coefficient hfMP0* is displayed and visible in the calculation report. The dedendum coefficient hfMP0* can also be defined by clicking the "Lock" button so that the dedendum coefficient hfP0* of the converted, non-shifted basic rack profile is always 1.0 according to DIN 867.

The option "Full radius" for the tip form of gear shaper cutters has now also been added to hobs. For the definition of load spectra, the user can specify the face coefficient KHbeta and the temperature for each load case. This enables the automatic transfer of values directly from the system extension



"SystemManager" to the "Cylindrical gear pair" module in the background. The user can see directly the effects of flank modifications on the root and flank safeties of the gear in the system.

In addition to the common calculation methods for the load capacity DIN 3990, ISO 6336 and ANSI/AGMA 2101, the calculation method VDI 2736 for plastic gears was added to the cylindrical gear module.

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Big Kaiser

EXPANDS JET-THROUGH HYDRAULIC CHUCK LINE FOR 5-AXIS MACHINING

Big Kaiser expands its jet-through hydraulic chuck line to include the BCV interface and additional inch sizes.

The HDC jet-through type holders are ideal for high-precision 5-axis machining with maximum rpm of 35,000 and clamping range of ¼" to ½" and fit nearly any application in the automotive, aerospace, medical, and die and mold industries.

An exclusive thread features allows for convertible coolant delivery between jet-through coolant and center-through coolant. Jet-through hydraulic chucks are ideal tool holders for finishing applications that would benefit from improved coolant delivery. The coolant flows through the end of the tool holder and is angled to direct coolant to the cutting tool tip, greatly improving surface finish and tool life.

Big Kaiser HDC tool holders are simple to use; only 1 hex key wrench is needed to clamp or loosen the cutting tool, making tool changes fast and easy without special equipment. Every HDC toolholder is guaranteed to .00012" TIR at 5 times diameter.

For more information:

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