

Klingelberg

EXAMINES FATIGUE STRENGTH AND SERVICE CALCULATION OF GEARS

Bevel gear design is well-established. Flank geometry optimization is used worldwide to ensure satisfactory low-noise emissions and specific values for surface and bending stress.

But what about calculating the service life of gears? To its familiar KIMoS (Klingelberg Integrated Manufacturing of Spiral Bevel Gears) software package, Klingelberg has added a module for calculating the service life of a bevel or hypoid gear set that is based on the latest R&D work in service life calculation.

Designing bevel gears is a rather complex task. Unlike cylindrical gears, bevel gears are always designed in pairs. The design engineer must take numerous conflicting objectives into account, including minimum dimensions, maximum load capacity, noise reduction, and ease of manufacture on shop floor machines.

But one aspect is often left out: What about the gear's fatigue strength?

If the maximum load on a tooth does not exceed the load limits of the material, the tooth returns to its initial state after the load is removed. This assumption is valid for several hundred load applications. But when we are talking about several million load applications, damage will occur at much lower loads than the load limits of the material. This phenomenon is

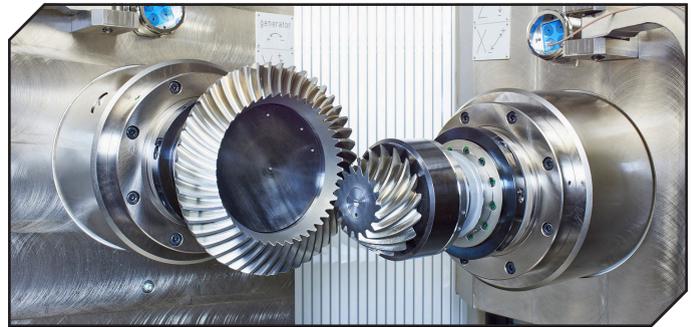


Fig. 1: Automated bevel gear test stand.

known as fatigue.

Fatigue strength testing—a core competence of OEMs and Tier 1 gear suppliers—is accomplished through time-consuming testing of transmissions. These tests are performed with an empirically defined load spectrum that inflicts the same damage that would occur under practical service conditions. One of the machines used for these endurance tests on bevel gears is the Oerlikon TS 30 bevel gear test stand.

What if we could calculate the service life of a bevel gear instead of having to subject each design to costly,

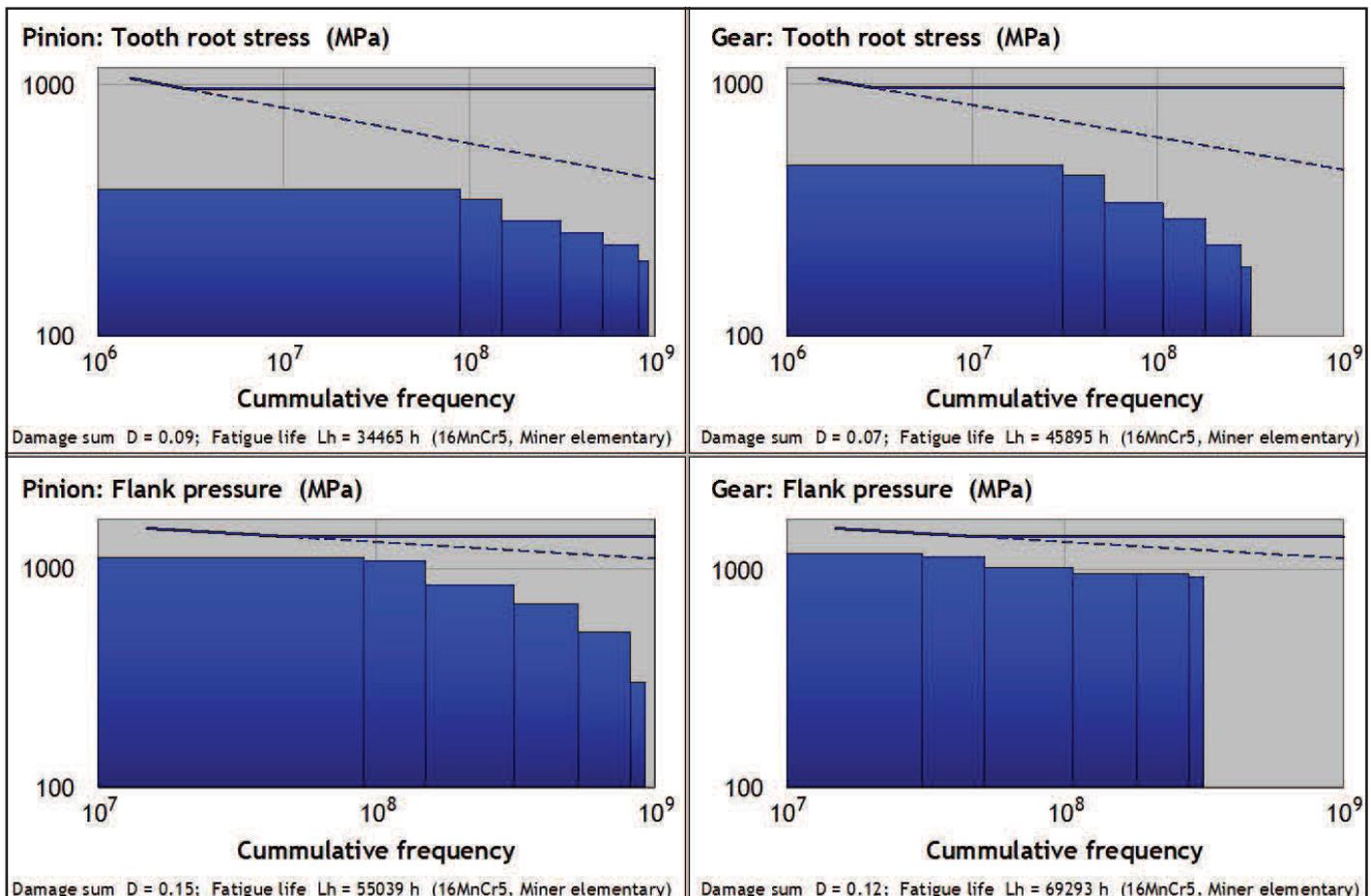


Fig 4: Load spectrum and Wohler curves of the gear without tooth flank modification.

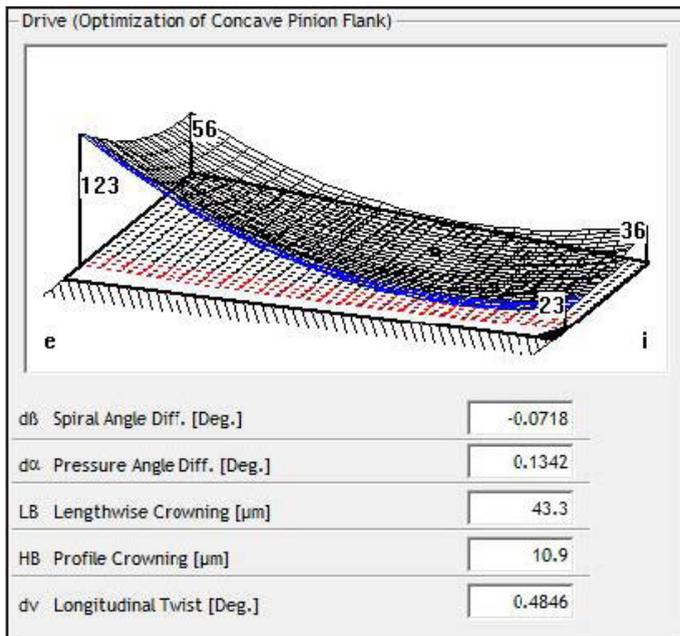


Fig 2: Ease-off without tooth flank modification.

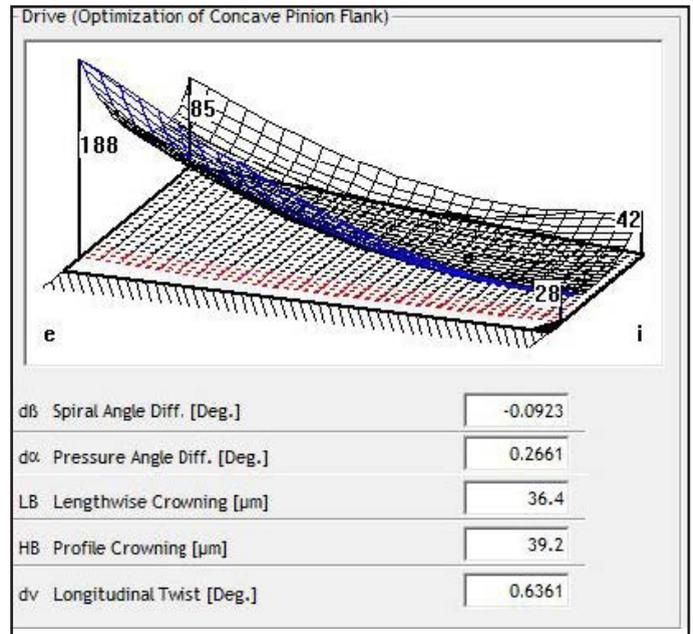


Fig 3: Ease-off with tooth flank modification.

time-consuming tests?

In the latest version of KIMoS, Klingelnberg makes it possible to calculate a bevel gear's service life for specific operational loads, as well as for face hobbing design and face milling.

To calculate the fatigue strength of a bevel gear, three basic elements must be known: the precise shape of the gear, the

properties of the material, and the running conditions of the gear set. All of these elements are taken into account in KIMoS. Fatigue strength is calculated using Miner's rule based on the linear cumulative damage hypothesis.

The cumulative damage to a gear pair can be predicted by combining the load spectrum, the load concentration on the

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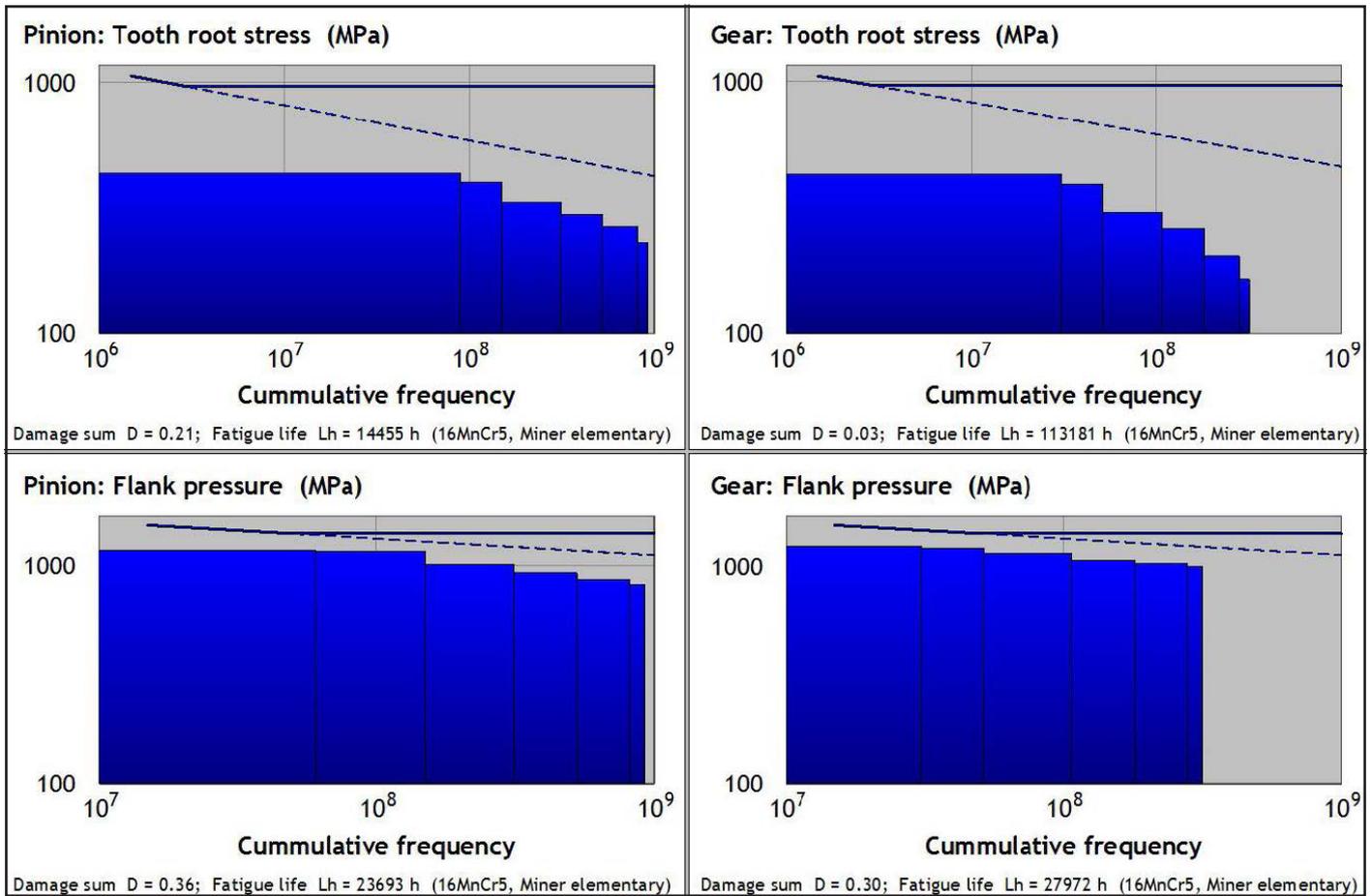


Fig 5: Load spectrum and Wohler curves of the gear with tooth flank modification.

tooth surface, as well as the bending stress in the tooth root and the cyclic stress-strain properties of the material. If the total cumulative damage for pitting and breakage is available, KIMoS can calculate the service life of the bevel gear set.

To generate a load spectrum with an extremely limited number of load cases, one of the counting methods must be used for the load cycles. If real load conditions comprising many different load cycles (for example with the rain flow method) are used to start with, these cyclic events can be counted, making it possible to convert real operational load cycles with an extremely reduced number of load cases into a load spectrum.

Will service life calculation of toothed gears replace endurance testing in the future?

The answer is a clear no. But calculating the fatigue strength enables an extremely effective comparison of different designs. The expected service life of a gear pair can be estimated quite accurately when endurance test data exist for one of the designs.

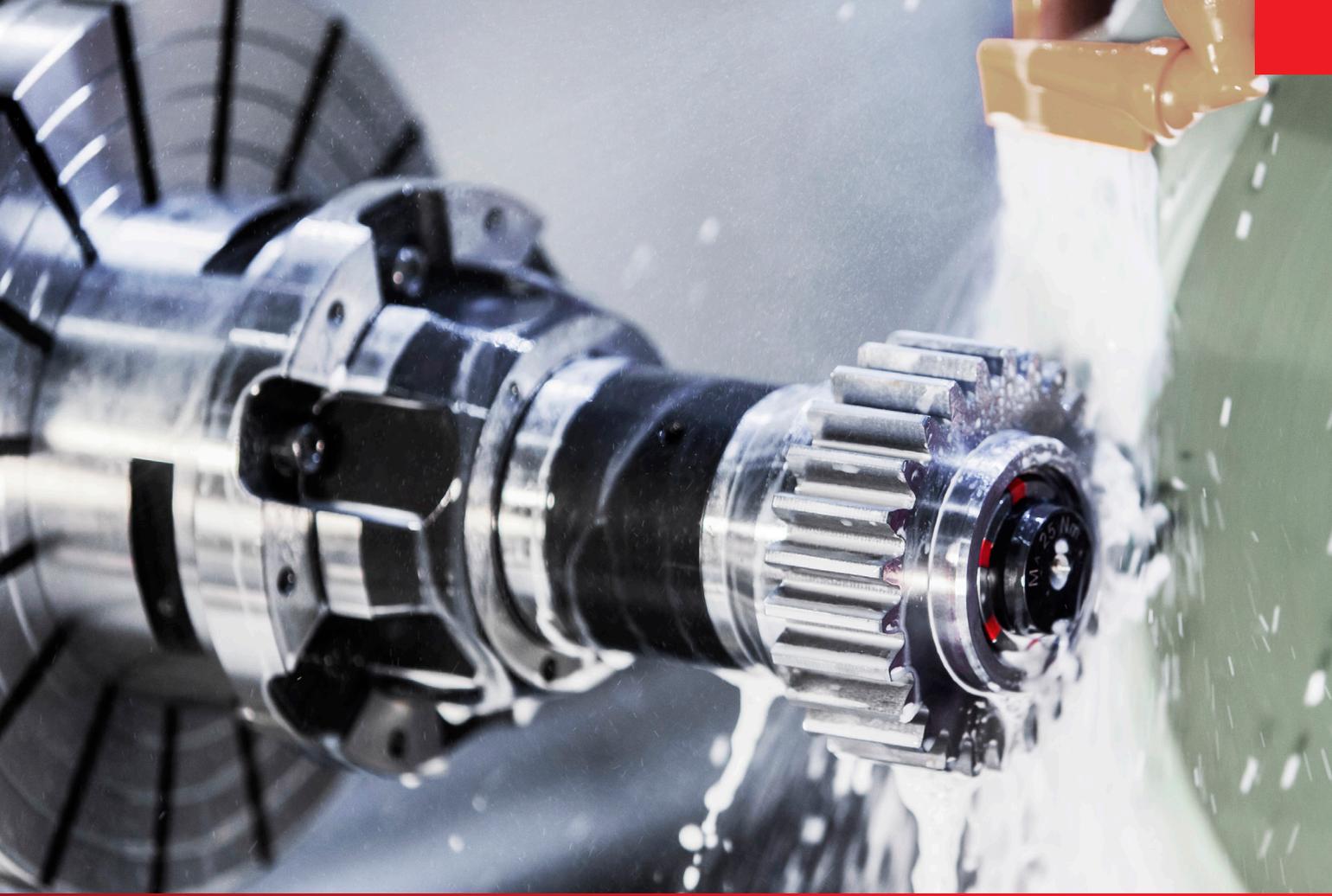
That is why KIMoS gives the design engineer the ability to create a design that not only meets the geometry and noise emission requirements, but also takes fatigue life into account.

The following example shows two designs with the same dimensional data, but different with and without flank form modifications shown in Figure 2 and 3. The toothed gear data are $z=13/38$ teeth, the outside pitch diameter of the ring gear is 250 mm, and the hypoid offset is 20 mm.

This example shows the potential of tooth flank modifications. The design on the left has a service life of approx. 14 000 h, which is limited by the tooth root stress on the pinion. The design on the right has a service life of approx. 34 000 h, but here, too, the calculated cause of failure will be tooth breakage on the pinion.

Not only does KIMoS empower the design engineer to optimize noise behavior and load capacity, but it also enables service life optimization of a gear set for specific load cases. This paves the way for new potential in lightweight design and enables more efficient and robust gear designs.

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Forest City Gear

ADDS ZEISS CMM TO QUALITY ASSURANCE DEPARTMENT

Forest City Gear has expanded the capabilities of its Quality Assurance Department with the addition of a Zeiss ACCURA Coordinate Measuring Machine.

The next-generation bridge-type Zeiss is Forest City Gear's fourth CNC inspection system, and is particularly well suited for very fast, complete analytical inspection of all types of high precision fine- and medium-pitch cylindrical gears. A variety of interchangeable Zeiss sensors provide a high degree of flexibility and faster calibration, approach and scanning for lead, involute, pitch, surface finish and other critical features across a wide size range.

The system also features a particularly compact and ergonomic design, making it ideal for Forest City Gear's fast-expanding, busy Quality Assurance room. The Zeiss ACCURA's bridge, for example, is made of steel and aluminum, making it extremely rigid, yet slim and compact. The reduced weight of the moving parts improves the dynamic rigidity and speed of the machine.

"The added capacity of the Zeiss ACCURA has now enabled Forest City Gear to move its existing Zeiss CONTURA CMM to meet the quality requirements of its new, stand-alone gear blanking facility," according to Forest City Gear Quality Assurance Lead, Amy Sovina. "The ACCURA couldn't have



arrived at a better time, freeing up the CONTURA so we could put it in close proximity to the blanking operation and thus

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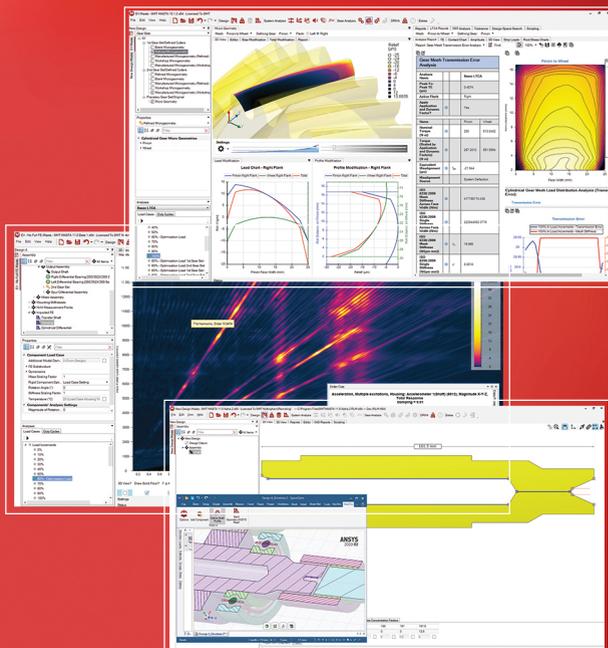
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eliminate the travel time for inspection of blanks,” says Sovina. “The Zeiss ACCURA checks all the metrology boxes. With quality and throughput requirements never higher in all the industries we serve, this system is the perfect addition.”

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Liebherr

EXPANDS GENERATING AND PROFILE GRINDING TECHNOLOGY

Liebherr recently introduced a new series of generating and profile grinding machines for hard machining of external and internal gears on workpieces with diameters of up to 500 millimeters. The LGG series follows the successful Liebherr LCS 300-500 series. With an impressive range of added features, they offer more flexibility and grinding performance with a significantly reduced footprint.

The LGG 500 and its sister models the LGG 300, LGG 380 and the manual solution LGG 700 M are Liebherr's new series to succeed the LCS 300-500 generating and profile grinding machines that have been popular all over the world. The machines are suitable for generating grinding, profile grinding and both processes combined. The new series also retains essential features such as maximum precision, robust machine design and high flexibility. Corundum and CBN tools are available, the latter from Liebherr's own production. The high level of performance and versatility now also extends to hard

machining of internal gears: changing from external to internal profile grinding is possible in less than 30 minutes. There are also newly developed grinding heads and even more machine options.

On the outside, the first thing that catches the eye is the machine's new, compact monolith design. With the footprint reduced by a third, the work area is just as big as the one of the previous model, ensuring maximum ease of use even with manual loading. With an axial travel range of up to 1,000 millimeters, the machine column allows the machining of long shafts, for example for commercial vehicles.

Three different directly driven grinding heads with optimized rigidity are available for the new series, and can be configured precisely as the customer requires. The grinding heads have a large effective speed range, which allows the use of large and small grinding worms at optimal cutting speed. Liebherr is a pioneer when it comes to machining collision gears with dressable and dressing-free grinding worms: the compact counter bearing ensures the highest grinding and polishing quality for critical components. Optionally, the grinding heads can be equipped or retrofitted with an auxiliary spindle or an internal grinding arm.

The most powerful grinding head, the GH 320 CB, can easily handle generating grinding jobs up to module 14 mm. Grinding worms with a volume of up to 320 millimeters in diameter and 250 millimeters in length are used. Cutting speeds of up to 80 m/s achieve high grinding performance for dimensionally critical components at much shorter grinding times, especially for

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The selection of direct drive tables is tailored to the specific component range with regard to the component weight (up to 100 kilograms), required machining speed and optimum pitch quality. The robustly built table allows speeds of up to 2,000 rpm for generating grinding and highly accurate positioning for profile grinding.

The new LGG machine generation offers the best possible compatibility with the available clamping fixtures, so that the existing equipment can be used or inexpensively modified. The Liebherr OpenConnect concept allows GDE data to be imported and exported which, together with the gear check integrated in the machine, ensures short setup times for heavy components.

“With the new generation of machines, the customer is not buying a specialist machine, but an all-rounder that embodies maximum flexibility combined with optimum grinding performance and quality,” explains Martin Schwarzmann, product manager for gear cutting machines at Liebherr. “A fully equipped grinding machine for external and internal gears with immense grinding performance as well as an automation system — that’s a very versatile combination and pretty unique in the market.”

The machine offers flexibility for small and medium batch sizes. With its integrated ringloader automation system and



configurable Liebherr storage systems, it creates a unique basis for highly efficient large-scale production, for example of complete planetary gears, including ring gears. The huge scope of possibilities allows companies, and in particular small businesses, to carry out a wider range of processing so that they can respond much more flexibly to future market requirements.

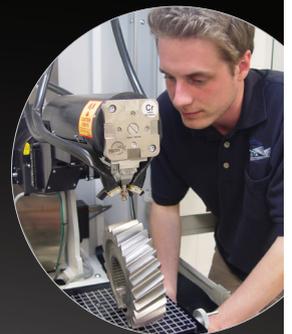
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Motus Labs

OFFERS M-DRIVE SERIES

Motus Labs, a designer and manufacturer of mechanical motion control solutions for the industrial, service, and collaborative robot and automation markets, has announced commercial availability of the Motus Labs ML1000 series of M-Drives. The disruptive drive architecture uses mating blocks or surfaces instead of traditional gear teeth resulting

in a more rigid drive at a lower weight with up to twice the torque density and 15% greater efficiencies compared to competitive strain wave drives. These performance benefits provide a lower overall solution cost, increased precision, reach, speed, and longer life—significantly improving the ROI for robot end-users.



“We are excited to bring to market a revolutionary new drive that enables robot manufacturers the ability to differentiate their robots and create more value for their end-users,” said Joe Pollard, chief executive officer and co-founder at Motus Labs. “Robot end-users gain superior price to performance, often saving up to \$100,000 over the life of the robot and the ability to extend into markets previously unattainable, basically enabling companies to build what they can imagine,” added Pollard.

The M-Drive architecture was awarded its first patent in 2016 after five years of research and development by Carlos Hoefken, inventor, and automation engineer. Hoefken identified an opportunity to design a significantly new robotic gear drive that would increase performance and add value. The drive is the most critical, differentiating, and expensive component of the robot, that determines positioning accuracy and speed of operation. The patented design utilizes a series of cam-driven blocks that engage over 80% of the output ring surface area versus 10 -15% with traditional drives. Motus Labs currently has seven U.S. patents granted and eight additional patents pending.

“Industry 4.0 is on the horizon, and AI-driven robots require smart actuators that require smart gear drives—and that is where we started with the M-Drive,” said Carlos Hoefken, inventor, and founder at Motus Labs. “The M-Drive architecture aims to address three objectives. First, increase precision and drive performance and lower overall robot

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solution costs. Second, be an enabling technology for new applications in adaptive robotics. Finally, continue our innovative approach and bring to market smart robot components as the industry shifts from traditional automation to smart manufacturing,” added Hoefken.

The M-DRIVE ML1000 Series of hollow shaft drives includes standard gear drive sizes ranging from 17–40. The family of drives accommodates the requirements of a fully articulated robot which has up to seven actuators or joints from the ‘shoulder’ or largest drive to the ‘wrist’ or smallest drive. The M-Drive series has up to twice the torque-to-weight ratio of the strain wave counterpart in the same size, resulting in reduced gear drive size and weight at each joint, lower overall arm mass, and moment of inertia, and smaller motor size and weight.

www.motus-labs.com

A new feature on the PdMetrics dashboard monitors incoming three-phase utilities, voltage and frequency on Ipsen’s Titan 2.0 vacuum furnaces. This addition offers further diagnostics for the diffusion pump heater assembly.

By adding these parameters, PdMetrics adjusts the expected kilowatt usage based on incoming line voltage, reporting precise diagnostic data, avoiding the potential for false alarms. Ipsen has nearly 100 Titan 2.0 furnace installations with the software.

Ipsen’s predictive maintenance software for vacuum furnaces was developed in 2016 and helps customers minimize high-cost events and maximize up time. The software is available on any model of Ipsen furnace new or old.

Ipsen’s product development team is continuously working to improve the capabilities of PdMetrics to provide faster and smarter diagnostics. The latest features also include a snooze button to silence alarms while they are being addressed and an automated health report.

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The Mazak Ez Series includes QT-Ez CNC Turning Centers, VC-Ez Vertical Machining Centers and MAZATROL SmoothEz CNCs.

With their space-saving footprints, the Mazak Ez Series fits in any shop without sacrificing rigidity or performance. The redesigned sheet-metal enclosures and structures aren't just more compact, they also pair easily with automation solutions such as Mazak's CC-10 cobot system. To achieve the best-possible price-to-performance ratio for your shop's application requirements, the series also includes a range of standard or optional integrated chip management and coolant systems.

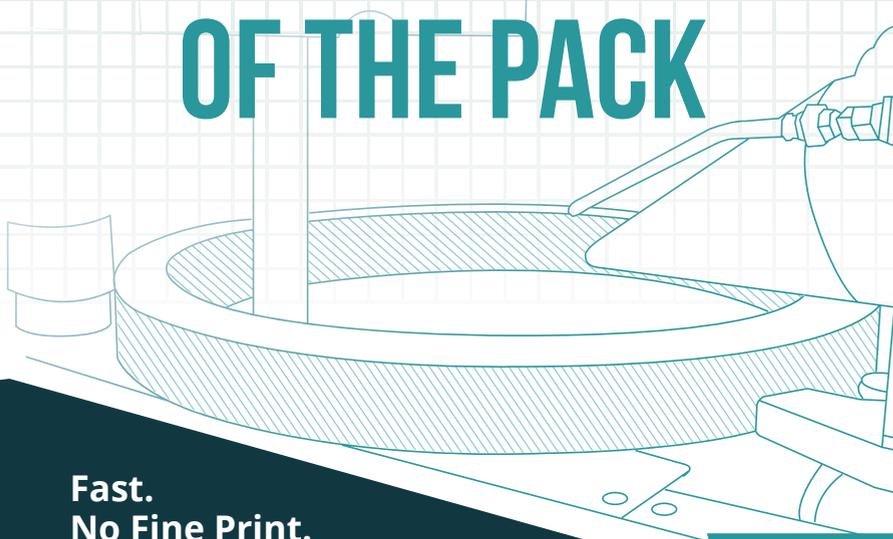
Optimizing per-part costs requires much more than smart product design — every part of the Mazak iSMART Factory production system was rigorously reexamined to make the Ez Series as affordable as possible. The result is a simplified, accelerated machine assembly process that places high-quality machines in customers' shops ASAP.

A key benefit of the Ez Series is its new 200V electrical system, which makes bulky transformers unnecessary for many shops and helps reduce overall power consumption. A single, common electrical cabinet can support the entire machine series, providing efficient production and additional cost savings.

Prudent lightweighting and advanced machine bed design render these machines stiff enough to handle tough applications and materials, yet light enough to transport with a forklift. These machines aren't just "Ez" in terms of usability — the transportation, rigging, installation and serviceability have all been built to be Ez as well, saving everyone time that's better spent cutting parts.

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MHI

INTRODUCES GEAR SHAPING MACHINE FOR SMALL-MODULE GEARS USED IN ROBOTS

Mitsubishi Heavy Industries Machine Tool Co., Ltd., a Shiga-based part of Mitsubishi Heavy Industries, Ltd. (MHI) Group, has newly developed the “SE25FR Plus,” a gear shaping machine dedicated to making high-precision small-module gears used in robots. The company has simultaneously developed a small-module cutting tool specifically for the new gear shaping machine. Full-fledged marketing of both new items will commence in March. By providing this dual support in high-precision gear cutting machines and cutting tools from a single source, MHI Machine Tool looks to respond to the need for reduction gears of increasingly higher precision in the expanding global robot market.

MHI Machine Tool launched its “FR Series” of high-precision gear cutting machines in August 2020. The new SE25FR Plus is a high-end model developed especially for shaping strain wave

gears which require high precision. Outstanding rotation precision has been achieved through the adoption of ultra-high-precision bearings and direct-drive motors in the two core components: the worktable and the cutter head. This provides gear cutting precision of ISO class 3, enabling cutting precision higher than the model SE25FR, which is of ISO class 6.

The small-module cutting tool to be launched together with the SE25FR Plus features a newly developed dedicated tool material and a special coating, “MightyShield μ ” for micromachining. The tool material incorporates carbide particles offering improved toughness and wear resistance, while the new coating produces a uniform thin film below 2 micrometers (μm) thick that has no impact on tool shape error. The result is



outstanding shaping even with difficult-to-cut materials, and the ability to achieve gear shapes down to the sub-micron level. Furthermore, MHI Machine Tool provides one-stop support in gear cutting machines and cutting tools, from the prototype development stage through mass production.

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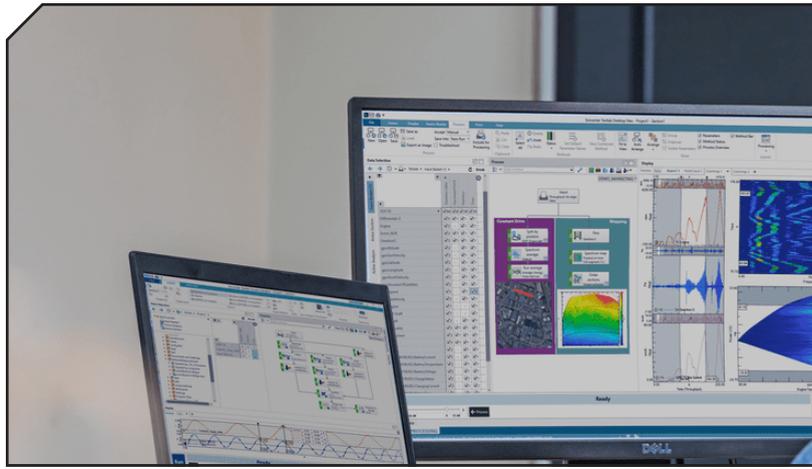
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Siemens Digital

ENHANCES SIMCENTER TESTLAB

Siemens Digital Industries Software has announced the availability of the latest release of *Simcenter Testlab* software. It is part of the *Simcenter* portfolio of simulation and test solutions within the *Siemens Xcelerator* portfolio of integrated software and services. The latest release includes updates to *Simcenter Testlab Neo*, enhanced model-based systems testing, introduces a new technology for accelerating structural dynamics called *Digital Image Correlation*, and frontloads analysis of full vehicle noise,



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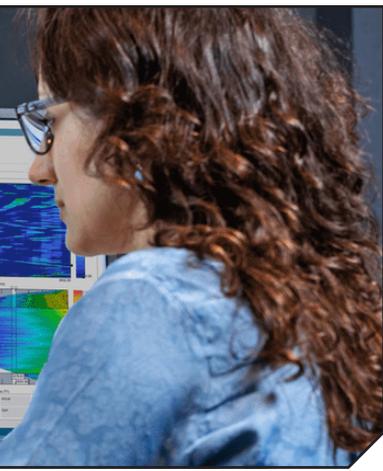
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vibration and harshness (NVH) during the design process. Test and simulation engineers as well as test campaign managers can benefit from this latest release for multi-disciplinary test-based performance engineering, specifically designed to offer test and simulation teams new capabilities to innovate smart products more productively.

The latest developments within industry can bring innovation, but also bring new demands and requirements, including the need to achieve realistic and predictive results more efficiently than ever before. Test teams are now working closely together with simulation teams, as the ever-declining number of prototypes available calls for the use of digital twins in the early stages of development. At the same time, there is an ever present need to obtain the most information possible from massive amounts of data, collected by testing and generated by simulation.

In *Simcenter Testlab*, test engineers have access to new technologies that can increase productivity when collecting and processing data. The effort to compare and correlate test and simulation results is minimized, and validated simulation models - digital twins - can be used during the physical testing activities to generate valuable extra data. At the same time, *Simcenter Testlab* provides direct data access to many simulation results formats, enabling simulation engineers to benefit from the data processing capabilities within the software as well as the consistency of selected processing functions and parameters between the physical and virtual tests.



Characterizing the structural behavior of materials and structures under load is a key enabler to improving designs and developing high performance products. New developments in digital camera technology in combination with high-performant *Digital Image Correlation* (DIC) techniques allow users to extract full-field 3D geometry, displacement and strain information, under any load and for almost any type of material, with limited instrumentation. DIC can then be used to identify material properties, validating numerical models and assessing the strength of materials and components, and analyze structural vibrations and dynamic responses to enable faster and more responsive development cycles.

The component-based transfer path analysis solution with *Simcenter Testlab* also enables the evaluation of vehicle performance in early design stages. It maximizes the usage of all available information on sub-systems and components, whether that be measurement data or simulation results. This unique and comprehensive solution can measure, post-process and publish accurate and consistent component NVH models, offering users improved component characterization methods and predictive NVH synthesis supporting performance evaluation of virtual prototype assemblies.

The new *Simcenter Testlab 2021.1* software release brings these and many other enhancements to offer test and simulation teams a solution to integrate physical testing and virtual simulation throughout the development cycle, bringing new capabilities to innovate smart products more efficiently.

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Schunk

IMPROVES ACCESSIBILITY WITH 5-AXIS VISE

The KONTEC KSX-C2, a 5-axis vise from Schunk, provides new opportunities for high-precision 6-sided machining. With a striking, upwardly tapered outside contour, the KONTEC KSX-C2 improves accessibility with standard tools. With its active jaw pull-down the KONTEC KSX-C2 achieves excellent results in terms of plane-parallelism and perpendicularity, and therefore creates ideal preconditions for challenging 6-sided machining.

The vise is also setting benchmarks with its adjustable center, even when it comes to set-up times: due to a tool-free jaw quick-change system, reversible jaws for enlarging the clamping area as well as a unique basic jaw stroke of 130 mm which is second to none on the market, the vise can be quickly and precisely converted for a new range of parts. A broad range of quick-change jaws is available for this purpose. Moreover, the clamping range can be enlarged with a standardized piston rod extension.

Integrated elastomer damping

A torque wrench is used for continuously adjusting the clamping forces of the KONTEC KSX-C2, and a maximum of 40 kN at a torque of 120 Nm can be achieved. Therefore, this expert vise in 6-sided machining has a lot of power for safe holding — even in the case of

minimum clamping surfaces. The forces for clamping sensitive parts can be finely adjusted. The long guiding system and the arrangement of the clamping mechanism ensure a rigid, dimensionally stable set-up. The integrated elastomer damping absorbs occurring oscillations during machining, resulting in excellent workpiece surface quality and tool service life. The drive and adjustment mechanisms of the 5-axis vise are fully encapsulated, making it perfectly equipped against chips, dirt, and coolant.

Comprehensive standard program

The Schunk KONTEC KSX-C2 is maintenance-free and is offered in four base body lengths (330 mm, 430 mm, 500 mm, 630 mm, 800 mm) and in two different heights (175 mm, 214 mm). It seamlessly fits into the modular system for high-efficient workpiece clamping from Schunk and can be quickly combined with the VERO-S quick-change pallet system or exchanged at a maximum repeat accuracy on the machine table. The necessary clamping pins can be directly integrated in the base body of the 5-axis vise without requiring adapter plates. As clamping is done by tension, no bending load occurs on the base body if a quick-change pallet system is used.

Schunk.com

