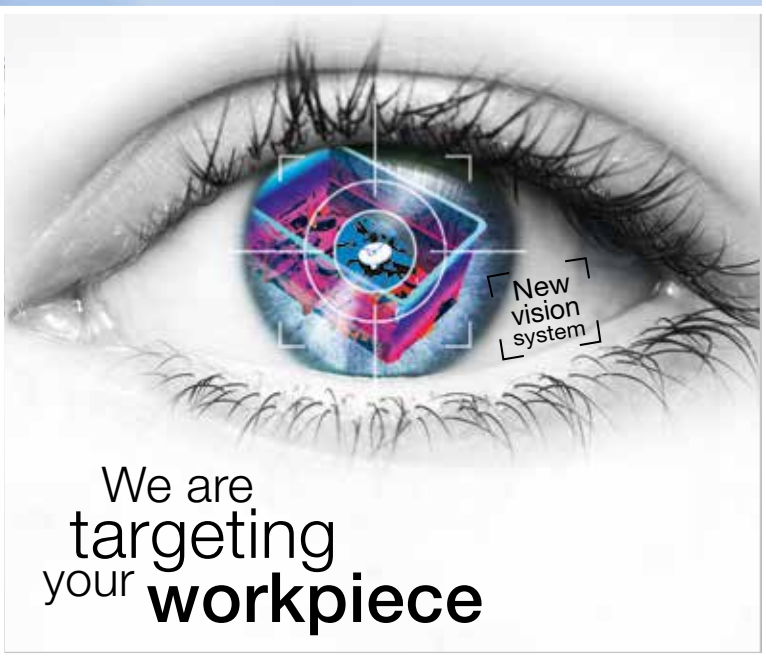
2016 / 2017 **EN** | DE

LIEBHERR MAGAZINE

Gear Technology and Automation Systems



We are
targeting
your **workpiece**

The Executive Directors of Liebherr-Verzahntechnik GmbH (from left to right): Dr. Klaus Finkenwirth, Dr. Christian Lang and Dr. Hans Gronbach

Dear readers,

We're delighted that you are holding the fourth edition of Liebherr's gear-cutting technology and automation systems magazine. This issue will showcase an abundance of innovations – you'll see how we are transforming gear-skiving into a reliable process and thus creating new gear machining opportunities. We will present our new gear-shaping machine, which was specifically designed for high precision shaping of small pinions and multiple gear teeth, meeting the high standards of the aerospace industry. To round off the gear-cutting technology topics is our new grinding heads for internal gear teeth.

Our automation division has revolutionary technology to offer as well – a new image recognition system for our bin picking robot application. Smaller components can now be picked from deeper bins in shorter cycle times. We also showcase the newly developed LP100 loading gantry, which coincides with the "rightsizing" trend. Every user can now find the optimum size of loading gantry for their needs in Liebherr's portfolio.

We would also like to introduce a new colleague, who has joined the Management Board of Liebherr-Verzahntechnik GmbH – Dr. Hans Gronbach. Dr. Gronbach has been the Chief Development and Design Engineering Officer since June 2016, and is responsible for championing innovation. He has a doctorate in mechanical engineering. His CV includes positions in both science and business; in-depth development experience and knowledge of machine tool markets. This makes him a perfect addition to our team – he will help guide Liebherr-Verzahntechnik GmbH into a successful future and enable the company to provide the best products for the markets of tomorrow.

Your needs are our incentive and inspiration. We hope this magazine will provide you with some inspiration in return.

Dr. Klaus Finkenwirth, Dr. Christian Lang and Dr. Hans Gronbach
The Executive Directors of Liebherr-Verzahntechnik GmbH

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New LK 300/500 Gear Skiving Machine

Skiving^3: Machine – Tool – Process

The principle of gear skiving was invented back over a century ago. Yet in practice the highly dynamic kinematics involved in this method frequently caused major problems. Up to now, the process was very unfavourable for the tools. The skiving tools are very complex and an incorrectly designed tool has a negative impact tool life and machining quality. Liebherr-Verzahntechnik GmbH has now mastered both the mechanics and the technology involved, meaning it is now in a position to create the ideal process for either conical or cylindrical tools.

Liebherr-Verzahntechnik GmbH is opening a new chapter in the evolution of gear-skiving with the LK 500

Gear skiving can be classified somewhere between the more familiar methods of gear hobbing and gear shaping. Compared to shaping, skiving enables similar gears to be produced in equal or higher quality and in a third of the time. Skiving is suitable for producing both internal and external gears. This method requires significantly less approach and overruns than gear hobbing and can therefore be used for components where space is more restricted. But why did this method, which was patented back in 1910, not become a standard method straightway?

"To be successful at gear skiving, you need to have an exact understanding of the process – gear hobbing and shaping are significantly more forgiving of mistakes," explains Dr. Hansjörg Geiser, Head of the Gear Cutting Development and Design Engineering team at Liebherr-Verzahntechnik GmbH. "During the cutting process the rake angle can change to high negative values, which can put extreme pressure on the cutting edges." Therefore, gear skiving is creating high cutting forces which can lead to considerable machine vibrations. In the past, rotational axes in particular represented a weakness in the gear skiving process. Nowadays, modern drive systems solve this problem. Furthermore, poor chip removal prevented gear skiving from being a success for a long time.

Principle of gear skiving

The principle of gear skiving equates to a crossed axis helical gear drive with tool and workpiece axes in skewed configuration. During the cutting process the workpiece and tool are rotated, whereby, due the axis intersection angle, a relative velocity is created between the tool and workpiece. "This

Skiving³: machine, tool and process from a single source

Machine:
automation, deburring and tool changer rigidity

Tool:
design, machining, processing

Process:
technology configuration, implementation, optimisation

LK 300 / 500

- Maximum workpiece diameter: 300/500 mm
- Maximum table speed: 3000/1500 1/min
- Maximum tool diameter: 250 mm
- Maximum tool speed: 2700 1/min
- Maximum spindle output: 32 kW

relative motion is utilised as a cutting motion, with the main cutting direction along the tooth flank," (see image on page 9) Dr. Oliver Winkel, Head of the Gear Skiving Applications Engineering and Technology Development team in Kempten, explains. The magnitude of the cutting speed depends on one hand on the size of the axis intersection angle and on the other hand on the rotating speed of the cutting tool. "With an axial feed along the rotation axis of the workpiece the entire width of the gear is machined. Helical gear teeth also require an additional 'differential feed'."

Liebherr-Verzahntechnik GmbH is now very adept at this complex technology and has already achieved excellent results in pilot projects. Gear skiving was around three times as fast compared to shaping with identical tool life. Output quality was up to one class higher. "However gear skiving will not drive gear shaping completely out of the market, since it requires a larger tool overrun due to the axis intersection," is Hansjörg Geiser's assessment. "Still, it is the more cost-effective solution for many applications – gear skiving could also be of major interest for premium-quality hard and soft finishing."

Conical and cylindrical tools

Conical and cylindrical tools have different axis configurations. A conical tool gets the clearance angle by design while a cylindrical tool requires a tilt or an off-centre position. The Liebherr control provides the right configuration for both types of tool. These tools have differing strengths and weaknesses.

- Conical tools: They are complex to manufacture but easy to set up and offer a very robust process. They are therefore suitable for use in intricate processes.
- Cylindrical tools: With their constant profile, they are much easier to manufacture. In contrast their kinematics are more complex, they therefore require greater compromises. That is why they tend to be the right choice for simple processes.

You can read more about Liebherr-Verzahntechnik GmbH's gear skiving tools on subsequent pages.

Important: Tool and machine working in harmony

Practical tests at Liebherr-Verzahntechnik GmbH in Kempten have clearly shown that mathematical mastering of the process and precise harmonisation of tool and machine are the key to success. The new technology has ultimately been realised with the LK 300 and 500 machines, a machine platform that can handle parts up to 500 millimetres diameter. The tool can be pivoted, rotated and moved about every axis. "The first tool can be configured correctly right away; geometrical iterations are not required," is how Oliver Winkel explains the machine's complex motion. "Sound mathematical modelling that does not involve correction cycles is one of the special features of our solution." While the tools are engineered and designed in Ettlingen, they are produced by the Liebherr subsidiary, Liebherr-Utensili S.r.l., in Collegno (Italy).

Liebherr's experts regard the "complete delivery package" of the complete machine, tools and technology from a single source as a major benefit. The first machine is due to be delivered in 2016 – preparative customer trials were successful. The first customers overall package includes the control system and ring-loader-aided automation – Liebherr-Verzahntechnik GmbH is the provider of the complete system. Generally the machine can handle both wet and dry machining. Hansjörg Geiser: "Naturally we have recommendations, depending on the application required. At this juncture chip removal is an important criterion." ■

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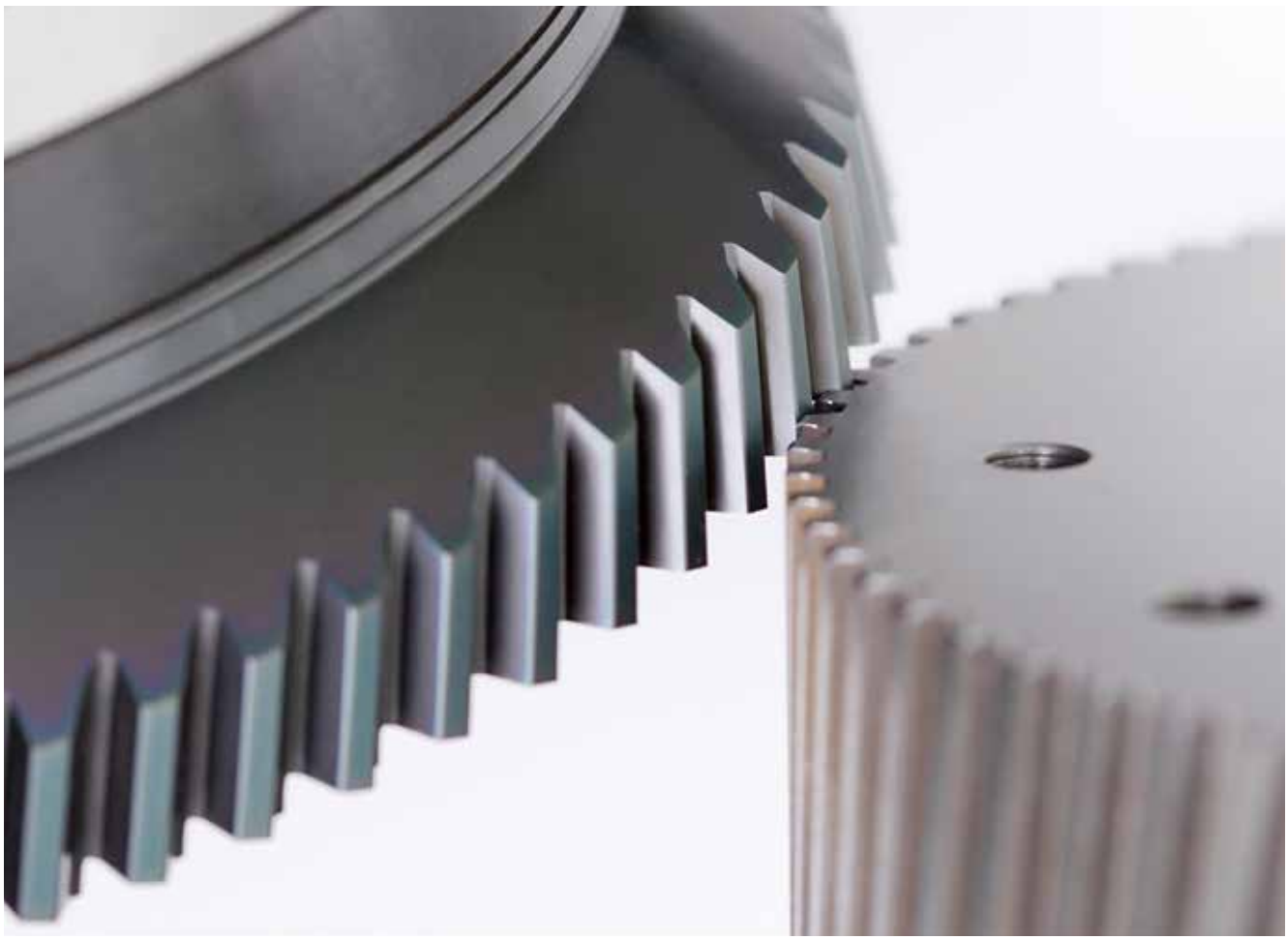
Skiving instead of broaching

Gear Skiving is a challenging machining process. This is true for the geometry and the tool life of the cutting tool, which is exposed to extreme wear. Liebherr-Verzahntechnik GmbH has perfected the design of these skiving tools and is machining those tools with high efficiency and long tool life.

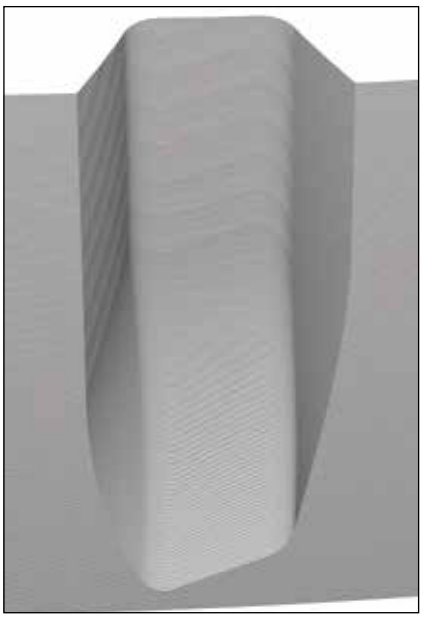


Broaching is usually the process of choice for producing internal gear teeth – for instance ring gears for planetary transmissions. The broaching process however has several disadvantages. Tool costs are the highest compared with all other gearing tools. Ordering lead times of between six and twelve months are the rule. Broaches often feature poor concentricity as well because of unavoidable warpage that occurs during cutting. Investment is therefore very high and only makes commercial sense if quantities are high, as in the vehicle manufacturing industry. The process of gear-skiving offers a new and very interesting alternative.

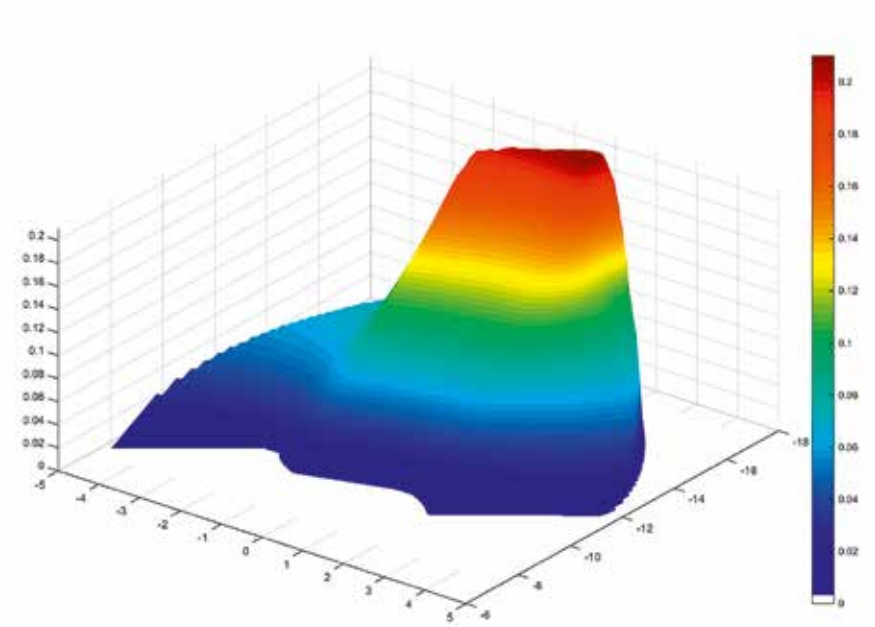
The principle on which gear-skiving is based is more than 100 years old. However the process was never successfully applied to serial manufacturing in the past, because the service lives of the tools were very limited. Liebherr-Verzahntechnik GmbH has now developed special tools, which can withstand the very high stresses that occur during the skiving process.

Process makes more stringent demands on the tools

The tool's clearance and true-rake angles are constantly changing during contact. "Enormous forces act on the gear-skiving tool during the continuous cutting and pressing process", is how Ottmar Kern describes the problem. He is Head of Gear-Cutting Tool Sales at Liebherr's Ettlingen plant and helped develop the cutters. Simultaneous cutting and re-shaping make higher demands of the materials used to make the tools. Liebherr uses two different materials as well as a combination of the two:



A simulated aperture and an unfinished aperture on the workpiece



Chipping during 1st stroke with colour scale, 3D view from above left

1. Tools made of PM steels have a cost advantage, but are subject to greater wear and tear.
2. Carbide tools are more expensive both in terms of material and manufacturing costs and on account of longer grinding times and greater consumption of abrasives. Since they cost roughly three times as much as PM-steel tools, use of carbide tools only makes commercial sense if production quantities are high.
3. PM-steel tools with carbide inserts are a compromise that is not suitable for every application, given the required assembly clearance between indexable insert and fixture. These combination tools can however lengthen rough-machining lifetimes and deliever premium quality post-finishing using conventional PM/HSS skiving cutters.

Ottmar Kern firmly believes in the success of gear-skiving and of his tools: “We anticipate that this process will gain acceptance, given the higher productivity it delivers. Ring gears can be skived in higher quantities for all industries using planetary drives.” Here he has vehicle manufacturing (incl. e-drive trains), trucks, construction machinery, aerospace engineering and many other planetary gearbox applications in mind. ■

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Small and flexible

Liebherr-Verzahntechnik GmbH has expanded its portfolio for small workpieces: the LS 180 F shaping machine will be presented at this year's AMB, the international metalworking exhibition, in Stuttgart (Germany). This innovative small shaping machine is equipped with a movable cutter head slide to shape in different axial positions without having long set-up times.

Shaping continues to be the gear manufacturing technology of choice for gears to be part of transmissions with minimum available space – one of them being cluster gears with limited cutter overrun, which can be machined in one clamping without additional set-up times. To date Liebherr could only offer larger machines for such flexible applications, since its smaller shaping machines did not feature the necessary movable cutter head slide. The new LS 180 F now enables Liebherr to provide the right size of machine with a lot of features for small workpieces too.

This redesign now enables the cutter head slide to be operated electronically, which cuts down on set-up times and delivers greater precision. The feature also enables workpieces with both internal and external gear teeth to be machined in the same clamping operation. In this version the shaping machine is equipped with a twin-track cam as standard. The LS 180 F continues to be available with a mechanical helical guide. The new version is also compatible with older versions, meaning that existing helical guides and removal cams can be used with the LS 180 F.

Customers from the aerospace industry

"One actual application is, for example, a component used to adjust aircraft landing flaps. We will also be showing this component at the trade fair in Stuttgart," says Dr. Andreas Mehr from the Grinding and Shaping Technology Development and Application team at Liebherr-Verzahntechnik GmbH. "Every component features three gears that have to be positioned really accurately to each other. That is why it is absolutely necessary to machine the entire gear tooth machining procedure in one clamping."

But there are also potential customers for the LS 180 F in pump manufacturing as well as in the motorbike and tractor industry.

Benefits at a glance

- Movable cutter head slide
- Short set-up times with NC-axis
- High productivity at up to 3,000 double strokes per minute
- Tool interface SK 40 or HSK-B80
- Small footprint (Platform 1)
- Optional: twin-track cams
- Optional: mechanical helical guide (SKM70)
- Optional: swivel stand
- Optional: automatic stroke length
- Highly efficient automation

Conclusion: the perfect machine for very small workpieces.

Given its wide range of possible applications, this machine is also likely to be of interest for job shops. “This machine is extremely versatile,” Andreas Mehr emphasises. “Given its high stroke rate of 3,000 double strokes per minute, this machine can produce particular small quantities very cost-effectively.”

This is just the beginning; more innovations will follow

The LS 180 F enables Liebherr to combine the small footprint of the Platform 1 with applications that were previously only feasible using larger machines. Modernising our range of shaping machines will play a major role in the future. The LS 180 (without vertical cutter head slide) will be redesigned and an LS 180 E (with electronic helical guide and movable cutter head slide) will be designed from scratch by 2017. “Ultimately we will then be able to offer the same maximum flexibility in the smallest machine class as we have only been able to do with larger machines to date,” says Dr. Hansjörg Geiser, Head of Gear Cutting Machinery Development and Design Engineering at Liebherr-Verzahntechnik GmbH in Kempten (Germany), in summary. ■

The LS 180 F is perfect for the processing of multiple gear teeth

Technical Data

LS 180 F		
Max. normal module	mm	5
Max. workpiece size	mm	180
Infinitely variable stroke rate as standard	DH/min	1,500/2,000/3,000*
Stroke length	mm	max. 70
Centre distance, cutter spindle/machine table	mm	-30 to 285
Axis angle, cutter spindle/machine table	°	+/- 0,5
Column swivel axis	°	-1 to +12
Stroke position range, cutter head slide	mm	275
Radial feed axis, column carriage	mm/min	5,000
Total weight	kg	13,000
Footprint (L x W x H)	mm	5,000 x 3,480 x 2,950

*depending on the stroke length

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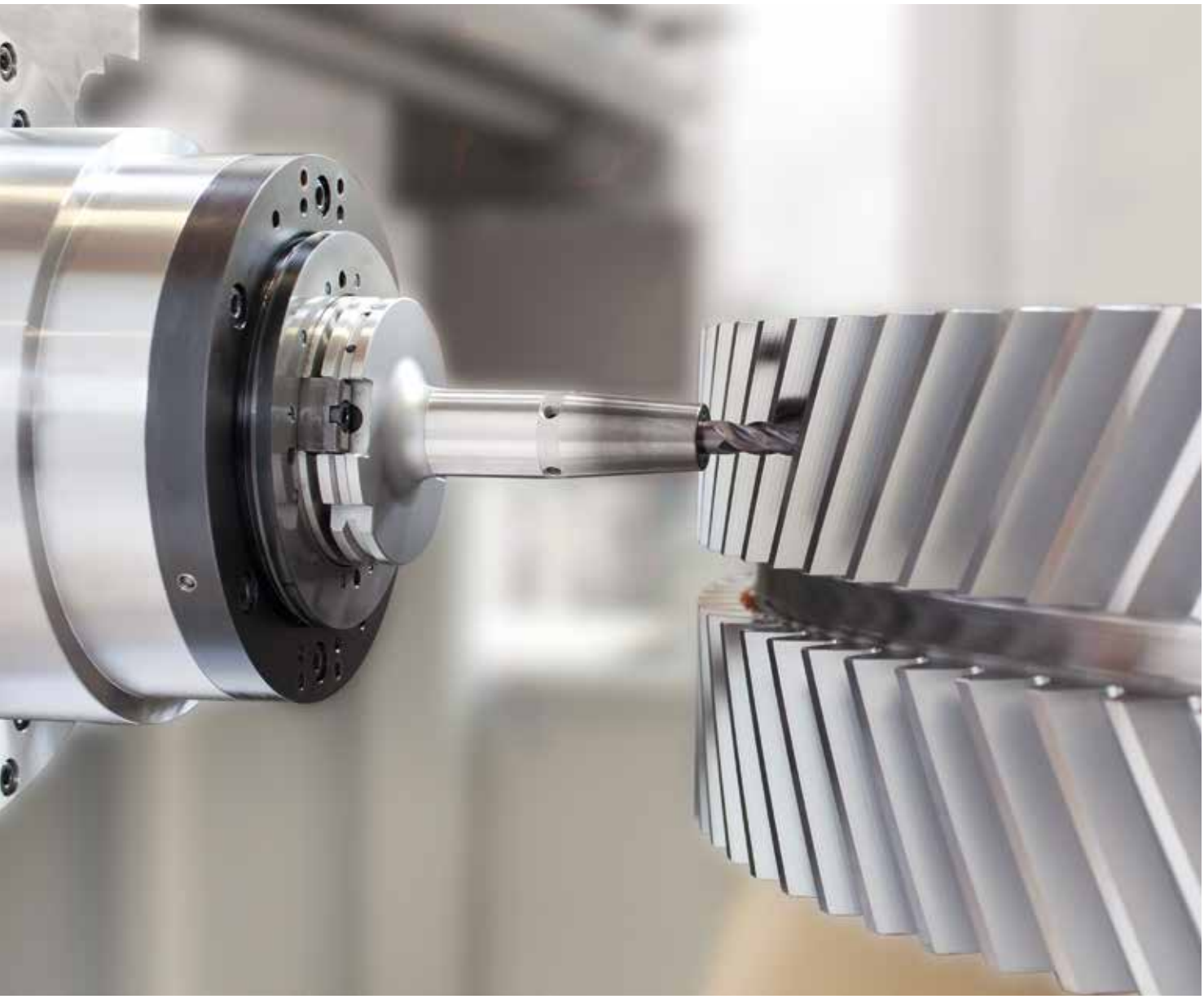


Finger milling 2.0

With the help of an innovative Liebherr technology, a new method for manufacturing of double helical gears, becomes available, as an alternative to the long used process of rack-type shaping. The new method is the base for a flexible process to produce this type of gears for the original equipment manufacturers and spare part suppliers.

Certain types of gear cannot be produced using conventional gear cutting technologies, because they require large approach and overrun zones. Herringbone and double helical gear teeth, for example, do not have this space available. Gears with such limited approach and overrun zones are used, for example, in drivetrains for presses, which in turn are used to produce punched components for the automotive industry.

Liebherr-Verzahntechnik GmbH now provides a suitable solution for manufacturing such workpieces. The gear specialists from Kempten (Germany) have developed a new finger-milling

head for gear hobbing machines from 700 millimetres workpiece diameter. This is particularly good news for all users that require extremely flexible equipment for the spare parts businesses.

Finger-milling for external and internal gear teeth

"The old process of rack-type shaping is about to disappear because it is not cost-effective – the machining times involved are considerably longer than those for other processes. That is the reason why we have made major efforts to find an alternative solution," is how Dr. Hansjörg Geiser, Head of the Development and Design Engineering team at Liebherr-Verzahntechnik GmbH in Kempten, describes where the company is coming from. "With this new finger-milling head, Liebherr has developed a versatile tool that moves on fast roller guides in all three spatial axes."

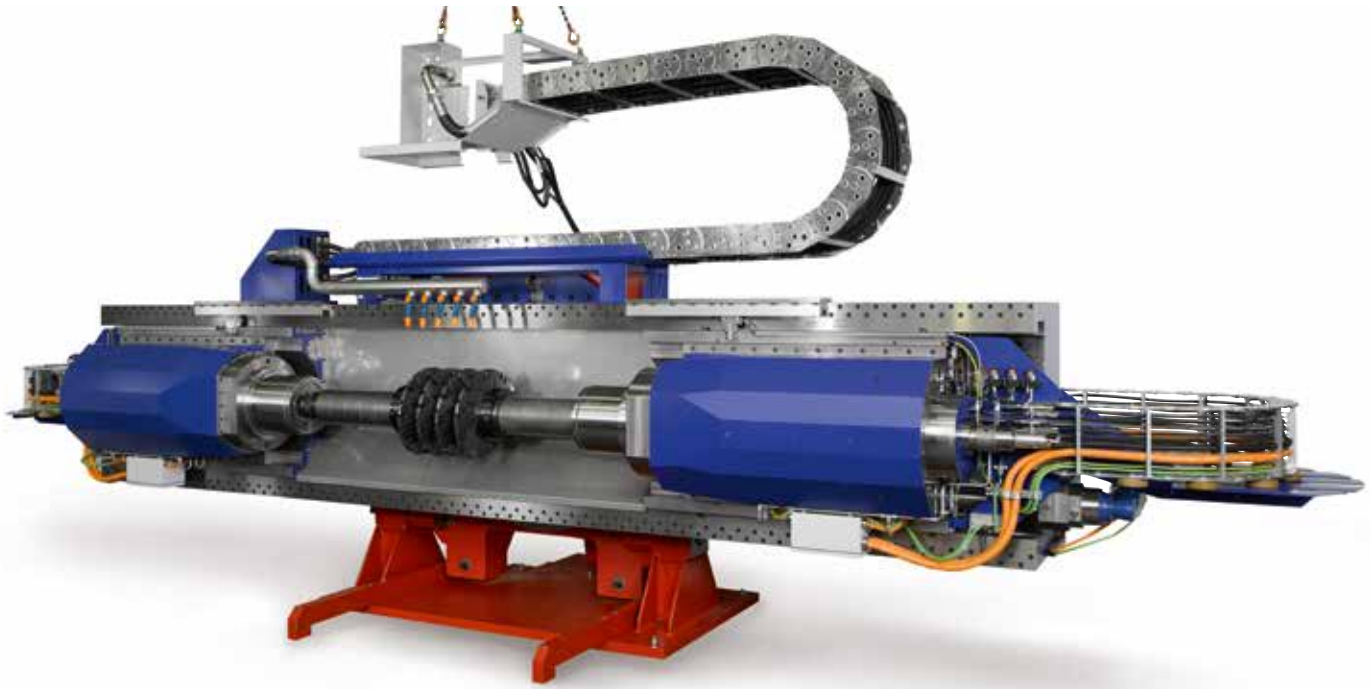
The table axis for finger milling is direct-driven and enables spur and helical gear teeth to be machined. In contrast to 5-axis machining centres, with Liebherr machines, the involute is produced by a generating motion like on the old rack-type shaping machines. This requires a large tangential travel range for the finger-milling spindle, but produces higher qualities.

Automatic tool change

Since end mills have a comparatively short tool life and because several different end mill sizes and configurations are necessary, Liebherr also provides a robot for automatic tool change. This greatly shortens machining times because unmanned operation is feasible. The robot system manages a total of 30 tools, which are pre-mounted on adapters and can be up to 300 millimetres long and weigh up to 25 kilogrammes. Cylindrical and involute tools from the standard repertoire can be used.

"Using conventional end mills means the machine is always ready to operate immediately," Hansjörg Geiser emphasizes.

New Liebherr technology: Finger milling



New: FK 4.2 DD Hob Head

- Direct drive (in main and counter bearings)
- Double-sided drivetrain
- Tool diameter up to 550 millimetres
- Tangential path up to 600 millimetres
- SK50 or Capto C10 interface on main bearing
- P3G-45 polygon shape on counter-bearing
- Low-noise
- Straightforward interface for hob-head replacement

New hob head

The LC 4000 gear hobbing machine's hob head has also been enhanced. The FK 4.2 DD hob head (here DD stands for Direct Drive) features a double-sided direct drivetrain. Thomas Zeller explains the benefit that this feature provides: "Two lateral drivetrains enable us to avoid interference problems when large workpieces are machined. However, for cost reasons, this technology is restricted to the large machine range (2,000 millimetres to 16,000 millimetres)". ■

"That is a major benefit, particularly in the spare parts business, because long lead time for special involute tools are not applicable."

An automatically exchangeable measuring probe is used for measuring the position of the workpiece or for centering pre-cut tooth spaces. This is important for the exact positioning of the apex point on double helical gears.

"Internal gears are the second innovation that we can offer with this finger-milling head", development engineer Thomas Zeller explains. With this new development, an additional spindle on the finger-milling head makes it possible to produce internal gears (e.g. involute or straight-sided splines and keyways) in the same clamping operation, with a maximum depth of 550 millimetres and a minimum bore size of 300 millimetres.

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The best of two machine platforms

Liebherr-Verzahntechnik GmbH has expanded its LGG range of grinding machines. The standard LGG 180/280 machine has been upgraded to an LGG 180/280 L "large version" to cater to special customer needs. A new machine for large workpieces, the LGG 300/500, has also been added to the lineup. Liebherr is introducing new grinding heads for all LGG machines.

Grinding and polishing of a collision-critical gear teeth

The LGG 180/280 L combines typical mass-market requirements with those of job shops. As a single-table solution with only one clamping fixture, it can machine planet and sun gears, ring gears and beveloids very cost-effectively – achieving short load/unload times often less than four seconds. This machine can also grind drive and output shafts – the "large" version can handle shafts of up to 660 millimetres long. Longer shafts can be accommodated upon request. Given its increased working space, it is suitable for machining smaller batches typical in job shops and aerospace suppliers.

The LGG 300/500 provides state of the art grinding technology in a relatively compact footprint for parts up to 500 millimetres in diameter. Modern materials are the basis for a highly thermostable grinding machine. The fully enclosed machine and direct-drive system deliver maximum quality over the grinding machine's entire service life. Like the smaller LGG 180/280, the LGG 300/500 has been approved for the use of grinding tools with cutting speeds of up to 100 m/s. The new LGG 280 L and LGG 500 also utilize the GH 6.0 grinding head featuring grinding worms with diameters up to 320 millimetres.

The new LGG machines are ideally suited to generating grinding of tooth-flank modifications.

- TF – Twist-Free
- DFT – Deviation Free Topological
- NEO – Noise Excitation Optimized modification
- GER – Generated End Relief
- SSG – Silent Shift Grinding
- DIP – Dresser Independent Profile modifications

You can find further information on the subject of tooth trace modifications in Liebherr Magazine 2015/2016 on pages 12 to 16.

Enhanced-design grinding heads

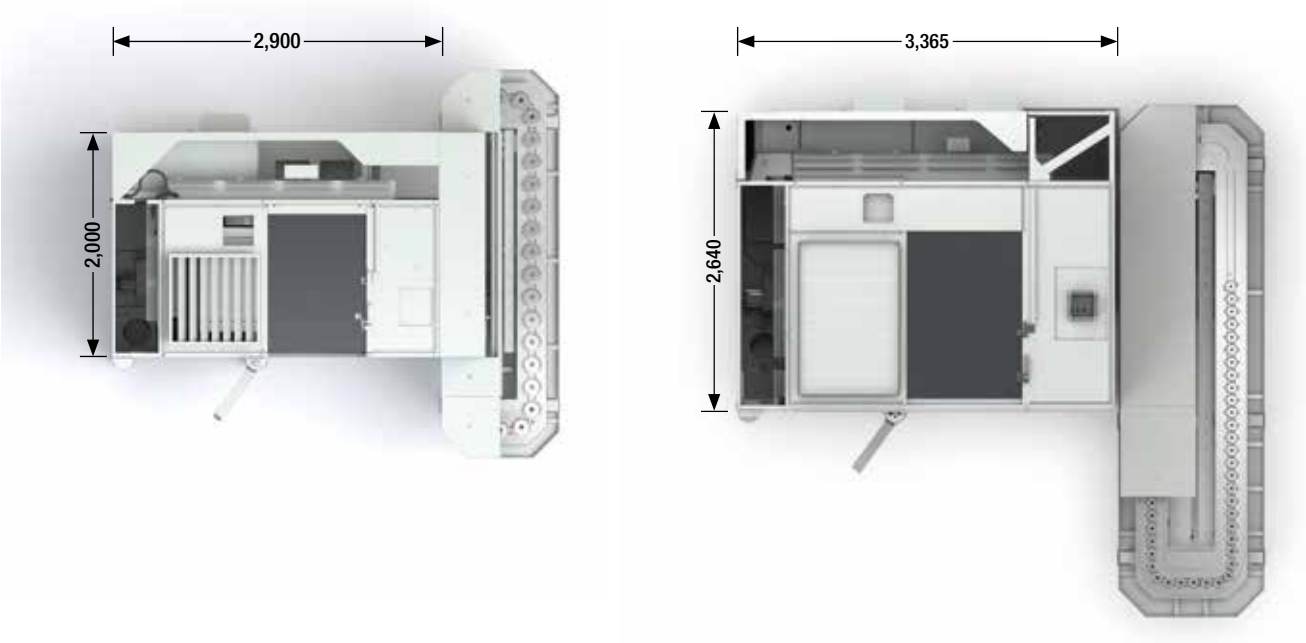
Liebherr uses an automatic, spindle-integrated, two-level balancing system for its new GH 5.0 und 5.1 grinding heads. Depending on which version is used, the grinding arbor is clamped using HSK 50/40 or 40/32 tapers. The smaller interface is located on the counter-bearing in each case. That enables small grinding worms to be used, which is particularly important for grinding of tooth-trace modifications. Smaller worms also make it possible to grind parts with clearance restrictions. Since the balancing heads are positioned outside the grinding arbor, they are less expensive to produce and not sensitive in terms of handling. The larger GH 6.0 grinding head features this two-level balancing system in the arbor. The interface on both sides is an automatic HSK 80. These are even more rigid and can handle even larger tools.

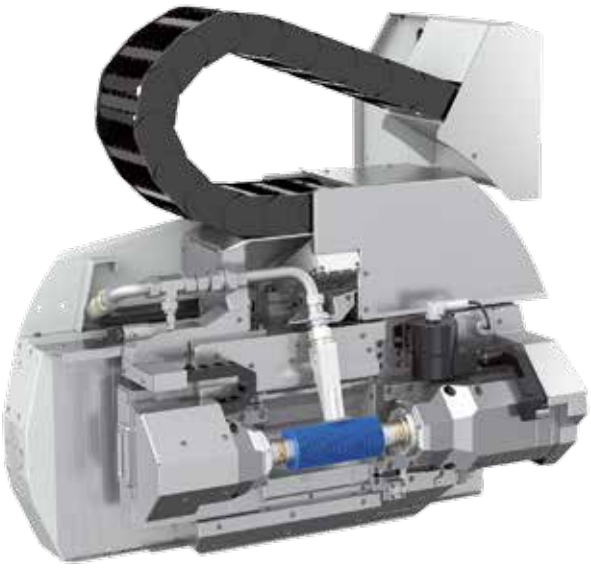
These new grinding heads were engineered to allow for the use of multi-rib dressing tools, without making the grinding arbor unnecessarily long. Short distances between grinding worm ends and spindle bearings ensure maximum rigidity.

All new grinding heads (GH 4.0, GH 5.0, GH 5.1 and GH 6.0) can be used on the LGG 180/280 L machine. Combining the LGG 180/280 L with the large GH 6.0 grinding head enables shafts or gears to be machined on a relatively small machine. All grinding heads can be used on the LGG 300/500, although the grinding head of choice would be the GH 6.0. The proven characteristics of the LGG 180/280, such as a high degree of machine thermostability and fast installation, are retained.

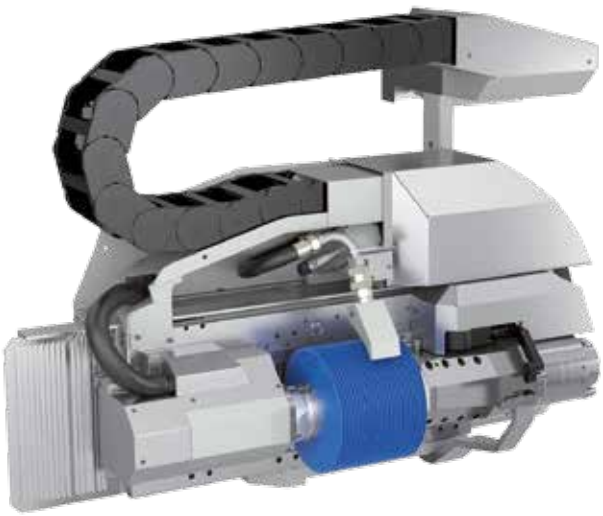
A further benefit is the ability to grinding internal gear teeth (more on this subject on pages 18 to 19) – making the machine an all-purpose basic tool. ■

The space requirement of each machine compared, LGG 280, left and LGG 500, right





GH 5.0: Smallest grinding worm for efficient machining of collision-critical gear teeth



GH 6.0: Largest grinding head for optimum service life and chip removal performance

Grinding Heads – Overview

Type	Industrial field	Max Ø Tool	Min Ø Tool	Tool length	Speed rpm	Tool clamp
GH 4.1	Automotive gears / Mass production	275 (320)	210	160	7,000	HSK-100
GH 5.0	Universal light / heavy	220	60	200	12,000	HSK-50 / 40
GH 5.1	Gears and shafts	200	35	200	17,000	HSK-40 / 32
GH 6.0	New heavy duty	320	110	250 / 230	12,000	HSK-80 / 80

LGG Machines – Overview

LGG 180 / 280	LGG 180 / 280 L	LGG 300 / 500
One column size 600 mm	One column size 1,000 mm	Two Column sizes 600 / 1,000 mm
One machine table 3,000 rpm	One machine table 3,000 rpm	Two machine table 1,000 rpm / 2,000 rpm
GH 4.1 / 5.0 / 5.1 grinding heads	GH 4.1 / 5.0 / 5.1 / 6.0 grinding heads	GH 4.1 / 5.0 / 5.1 / 6.0 grinding heads
One tailstock size and ring-loader system	One tailstock size and ring-loader system	Two tailstock sizes and ring-loader systems

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Internal gears with that Liebherr finish

Gear grinding to Liebherr quality standards is now also feasible for internal gears, using a range of different grinding arms that each fit the GH 4.1, GH 5.0 and GH 6.0 grinding heads (further information about the new grinding heads can be found on pages 15 to 17).

Liebherr-Verzahntechnik GmbH has now added a new internal gear tooth profile grinding technology, based on its proven OPAL grinding technology, to its portfolio. This involves a belt-drive spindle, which can be fitted to the standard GH 4.1 grinding head as well as to the new GH 5.0 and GH 6.0 grinding heads. Initially the internal gear grinding arm will be available in two different sizes, while others are to follow shortly. Custom internal gear grinding arms can be developed to match customer workpieces on request.

Dressable Cubitron™ II profile grinding disk

Faster switch between external and internal

"The switch over is really simple. Changing between external and internal gears takes a maximum of half an hour," Dr. Hansjörg Geiser, Head of the Gear Cutting Machinery Development and Design Engineering team, explains. "You detach the external gear grinding disk or worm, hang the internal gear grinding arm on the hardened stop bars to ensure repeat accuracy and fix it in place with a handful of screws, then tension the belt-drive disk and the belt and attach the cover. Internal gears can then be ground using a grinding disk of 100 or 125 millimetres in diameter – an innovation at Liebherr."

Rapid changing between external and internal gears

Triple-ribbed CBN profile grinding disk set from Liebherr

The external gear grinding head does not have to be touched, and external gear grinding quality is again the same as before once the internal gear grinding arm has been detached.

IG Opal 4.0 is the name of this innovation that functions at a maximum spindle speed of 12,000 rpm. A larger version, the IG Opal 4.1, featuring a maximum grinding disk diameter of 125 millimetres, is also already available. Both arms were successfully tested using CBN and corundum disks. Where dressable grinding disks are used, the internal gear grinding arm travels up to the grinding dresser that is also used for external gear grinding.

One sophisticated customer comes from within the Liebherr Group

All internal gear grinding arms are modelled in 3D and can be used in very confined spaces. “Collision inspections are simple and extremely reliable,” emphasises Andreas Mehr, who is responsible for grinding and shaping technology development and consultancy at Liebherr-Verzahntechnik GmbH. “Small-diameter internal gear teeth can therefore also be machined quickly and easily. Colleagues at Liebherr-Aerospace, which uses Liebherr gear cutting machinery to manufacture their own components, have confirmed this to us.” The aerospace engineering specialist is one of three first buyers of this new technology.

Technical Data

Internal gear grinding head		IG OPAL 4.0	IG OPAL 4.1
Spindle speed	1/min	12,000	7,500
Max. module	mm	3	5
Min. tip diameter	mm	80	115
Grinding disk dimensions:			
Max. outer diameter	mm	100	125
Length	mm	8 (12)	12 (16)
Bore diameter	mm	36	50.8

As in the case of external gears, this new internal gear teeth technology works with a multi-rib grinding disk system that can rough- and finish-grinding. That is particularly important to users, who regard speed and costs as important, for instance customers from the aerospace industry. Grinding disks made of dressable corundum or electroplated CBN can be used in conjunction with the spindle. These are also manufactured at Liebherr’s plant in Ettlingen (Germany). ■

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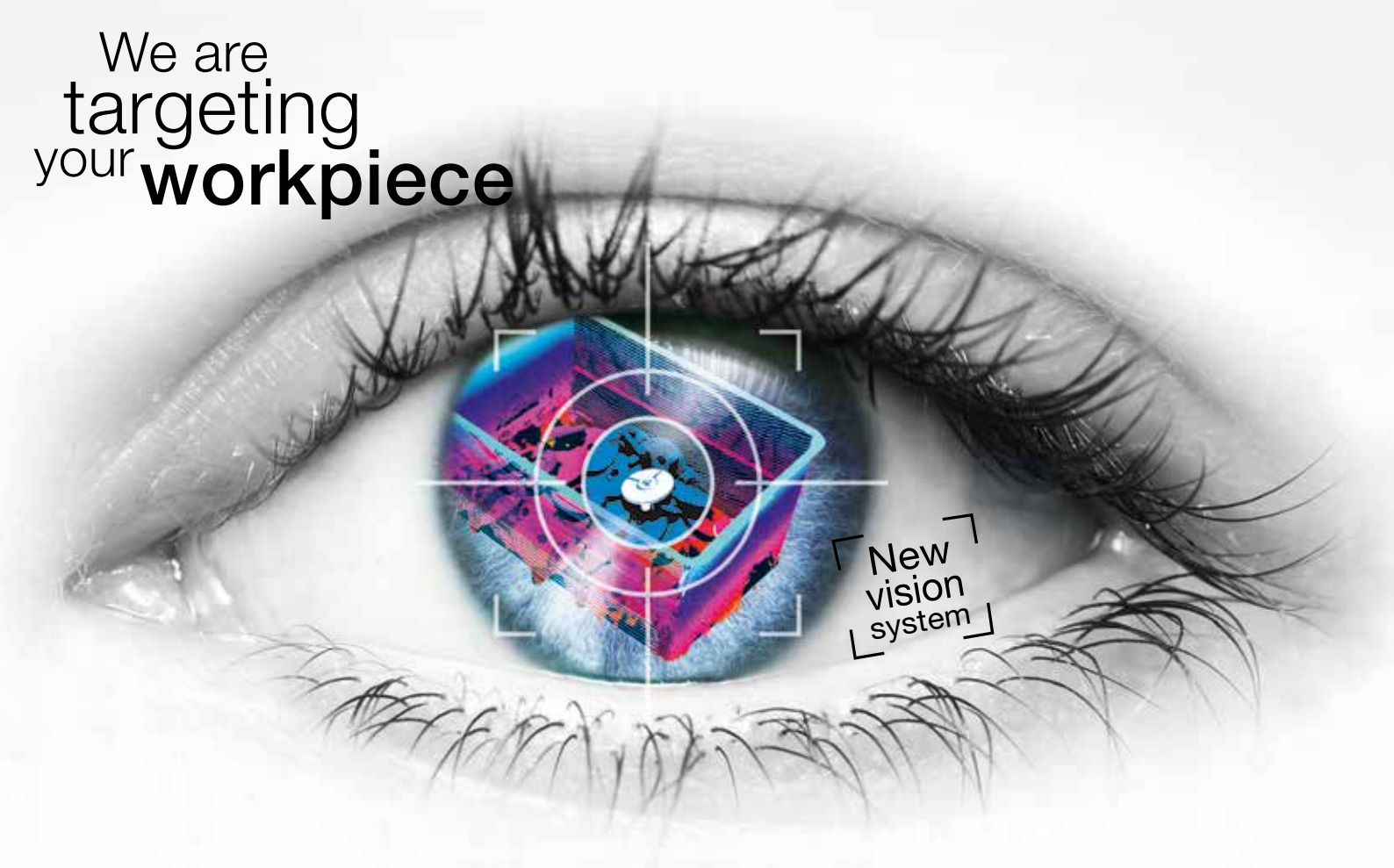


Bin picking: We are targeting your workpiece

A new, previously unique vision system based on the triangulation method improves bin picking – it ensures greater accuracy, better component recognition and faster handling.

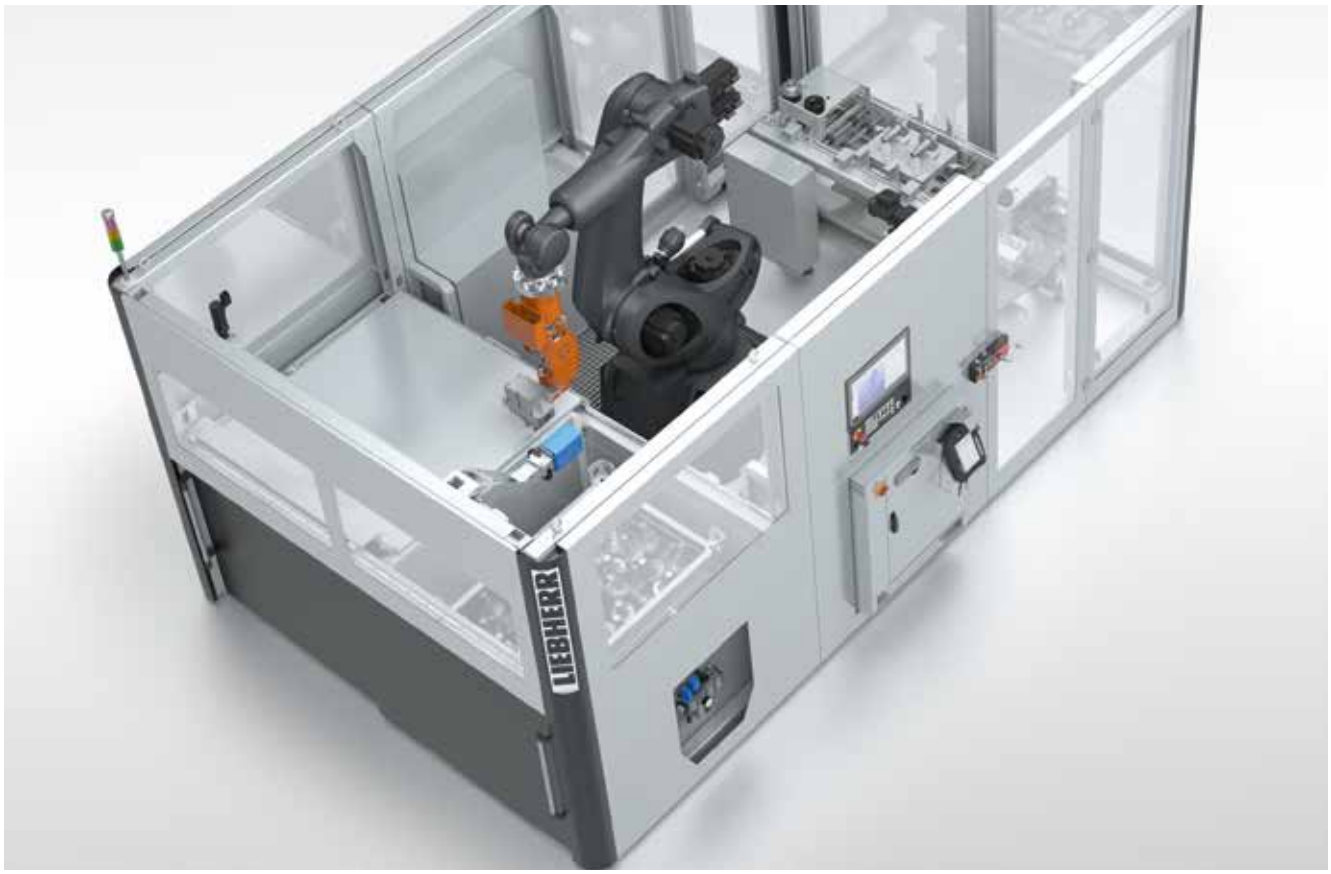
The smart removal of workpieces from a random arrangement, so-called “bin picking”, is a classic automation application. It ensures higher productivity, less burden on human resources and lower unit labour costs. Liebherr-Verzahntechnik GmbH, acting as a turnkey provider, has been developing key robot cell solutions for production lines since 2010. At this year’s Automatica show in Munich, the company showcased its proven bin-picking solution in combination with a new vision system for the first time. This vision system is based on the triangulation method. It was developed and refined according to Liebherr specifications, jointly with a collaborative partner specialising in sensors.

We now apply a two-stage triangulation system, where bins containing components are scanned via a process of laser/camera interaction”, explains Thomas Mattern, Head of Automation Systems Development. This results in significantly improved resolution. “While the previous image recognition system, based on the laser runtime method, was stretched to its limits at three to five millimetres accuracy, this new system enables us to achieve ten times the resolution. This also improves recognition of the mini features required for positional identification and component differentiation purposes.”

Deep bins – without problem

Furthermore shadowing and collision risk are also reduced. This allows eight-axis robot arms to pick components, even from transport bins up to a metre deep, e.g. wire mesh bins or steel bins.

The new image recognition system now features a blue laser instead of a red laser. This captures reflective components even more reliably and recognizes organic or semi-transparent materials as well as metal components. This also makes applications outside the metalworking industry a feasible option.



The bin picking cell

The handle in the deep bin

Speeding up the entire system

The two-stage triangulation system captures bin content with just one linear movement, without the 3D vison system having to be positioned beforehand. “Recognition and analysis now take up just five seconds. This facilitates shorter cycle times for the entire system,” Thomas Mattern explains. This higher resolution means that data cloud surfaces are smooth and practically noise-free. The resultant high-quality readings are transmitted to the bin picking system’s main software for further processing. This has also been updated and now features a user-friendly graphical user interface.

“These innovations mean we are forward-looking and have broadened our range of applications considerably,” says Thomas Mattern. “Customers can already benefit from the new vision system. To date it has been one-of-a-kind and is now available in combination with our bin-picking solution.” ■

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Fast, powerful and flexible

The new LP 100 gantry system enables Liebherr-Verzahntechnik GmbH to plug a gap: it is particularly suitable for handling smaller and lighter components. Its flexible design makes it dovetail well with inline production concepts, where workpieces have to cover larger distances.

"Downsizing" is a growing trend in the automotive sector. Engines are becoming more efficient and therefore smaller and lighter. Production facilities are also adapting to these changes. Market analyses conducted by Liebherr-Verzahntechnik GmbH have therefore flagged that the company needs to adapt its range of gantry robots to match this trend, to enable it to offer customers optimum solutions. The new LP 100 gantry robot plugs the gap that previously existed between the proven LP 20 and LP 200 systems.

This new size of gantry robot gives engine and gearbox manufacturers many more options to enable them to find those optimum solutions that work for them. It is suitable for use in the weight category that includes cylinder heads and gearbox housings as well as alternative drivetrain units, like electric or hybrid engines, fuel cells or components of a similar size. What's new is the option of configuring the gantry to deliver 'High Speed' or 'High Load' performance. This variability enables the LP 100 to be employed even more flexibly.

The LP 100 gantry robot operates at the lower end of the LP 200's weight range, where high speed is not required, and represents an inexpensive alternative. It is also an option in the upper weight range of the current LP 20, which is not designed for heavy loads at high speeds. Where this has previously been a requirement, the next largest range, the LP 200, with its resultant higher material and manufacturing costs, has been employed. Additional modules like extra axles, grippers, quick-change systems or similar require an increased

The LP 100 gantry system can also be set uo with more spacing between the uprights

Standard gripper

Gripper with additional axes

load capacity. If several of these peripheral equipment modules are required at the same time, the load range of the smaller LP 20 gantry robot is no longer sufficient. The LP 100 now features a type of gantry that meets these requirements. Changing gantry type during the course of a project is no longer necessary.

Ideal for Inline Production

The design of the gantry robot has been adapted to meet the wide range of modern production process requirements. “The new design enables our customers, for example, to select a wider clearance between uprights,” Thomas Mattern, Head of Automation Systems Development at Liebherr-Verzahntechnik GmbH, explains. “Planners thus have extra production-line design and installation options.”

Nowadays the “inline concept”, featuring long travel ways, dominates production lines. Loading gantries handle transportation of workpieces as well as loading and unloading of machines. Conveyor belt systems for the transportation of workpieces are now only required to a lesser extent. Furthermore the number of machines covered by a single loading gantry is increasing, in order to increase production capacity at minimised use of automation systems. “Changes in production line design have an impact on automation – workpieces have to travel longer distances at higher speeds,” Thomas Mattern explains. “The fact that machinery and machining centres are getting faster and faster is also putting pressure on cycle times. We of course factor in these trends when designing and developing our gantries and provide the appropriate solutions, e.g. high-speed versions.” This new specialism (high-load and high-speed versions) is due to be applied to existing gantry models during the course of the next two years. Liebherr will therefore be able to provide optimum-sized, cost-effective automation solutions for all industries with no limitations on functionality and performance. ■

Extended range

Gantry robot		Workpiece weight	Transport load
LP 10	kg	0.5 to 10	40
LP 20	kg	10 to 40	100
LP 100	kg	40 to 70	230
LP 200	kg	70 to 250	600
LP 2000	kg	250 to 600	1,500

Your Benefits

- Optimum matching of costs and speed (Standard, High-Speed, Low-Speed)
- Parallel assembly operations feasible for short lead and delivery times
- Higher speed for faster cycle times

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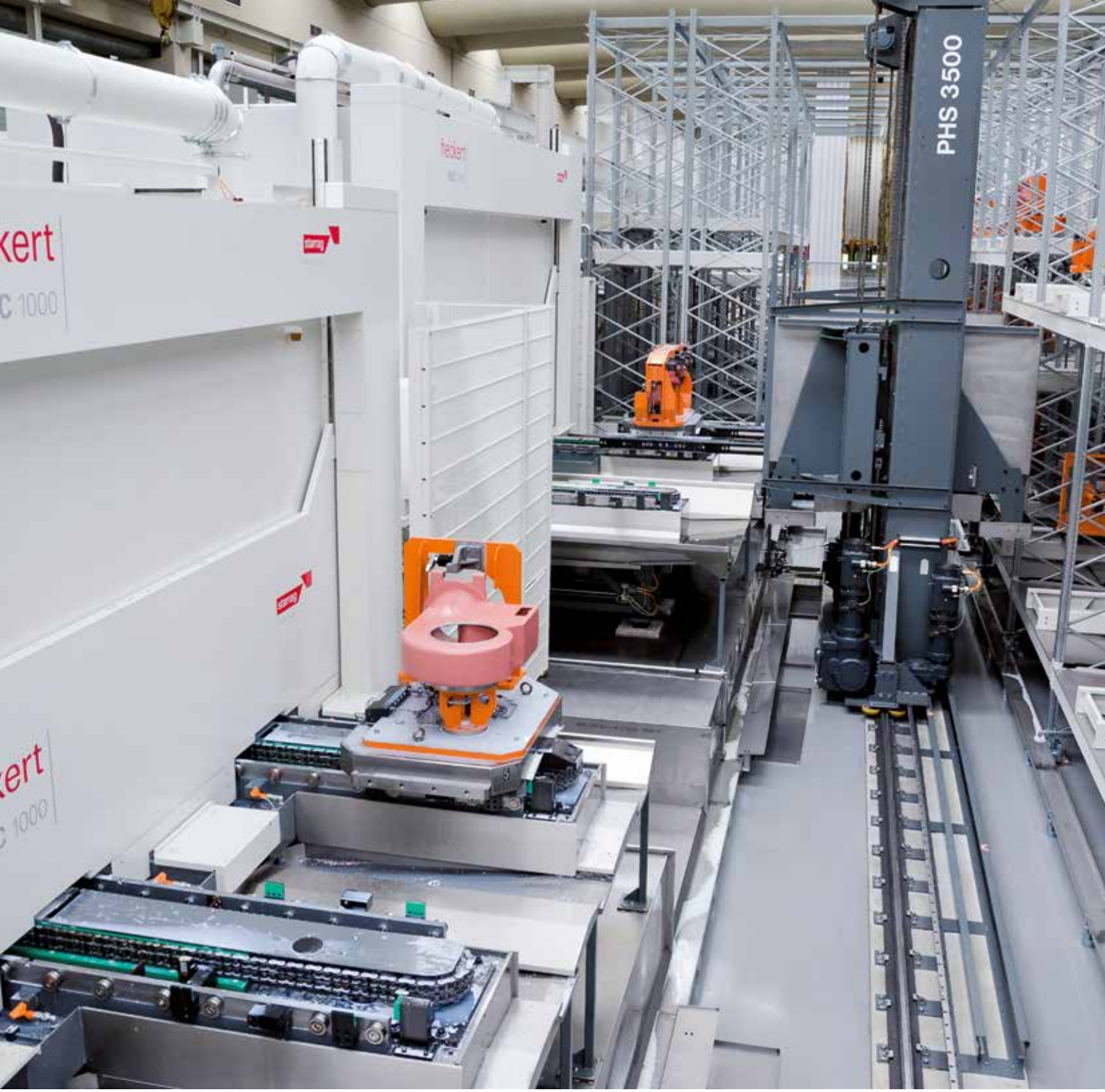


A neat solution

Weishaupt, headquartered in the Upper Swabian town of Schwendi, is a leading provider of burners, heat pumps, heating and condensing-boiler systems, energy recovery solutions, and facility automation. Since mid-2016 Weishaupt's new burner casing production facility has operated using an automation solution provided by Liebherr-Verzahntechnik GmbH.

Figure: Max Weishaupt GmbH

All burners are manufactured at the company's main plant in Schwendi. This state-of-the-art production facility is a showpiece in terms of safety, precision, and cleanliness. Its design also allows operators to work efficiently during assembly of large and medium-sized burners, which are almost always custom-made. These include gas, oil and dual-fuel burners, rated up to 32 megawatts, as used in industrial processes, for example, drying plants in the vehicle manufacturing.

As part of an improvement strategy Weishaupt is reimagining its flexible manufacturing process for cubic machining. This involves the important process of machining burners and casing components. The first stage of improvements included the procurement of two new machining centres featuring a Liebherr-Verzahntechnik GmbH PHS 3500 (Pallet Handling System) integrating the manufacturing processes. This new flexible manufacturing system has been producing workpieces since spring 2016. In spring of 2017 stage two of the flexible manufacturing system will be brought online featuring the smaller PHS 1500.

More capacity – for larger workpieces as well

This new solution enables Weishaupt to significantly increase its flexibility. The PHS 3500 and 1500 have the ability to hold 450 different components on 90 different fixtures and directly feed the Heckert machining centres. Currently the largest machine fixture and workpiece measures 2.3 x 2.0 x 1.4 metres and can weigh as much as three tonnes. This with the ability to machine smaller workpieces enables the plant to work at capacity.

Varying workpiece size and weight required adjustments to the design of the set-up stations. Ergonomics and workplace safety played a key role when the system was being engineered. The set-up stations were designed in such a way as to allow automatic height adjustment to an ergonomic level. Set-up station fixtures can also be rotated to various positions increasing part loading flexibility. Safety for operators working at the set-up stations is guaranteed by ground scanners allowing unimpeded access for workpiece changeover.

Clean cooling lubricant loop

Special adjustments had to be made to meet Weishaupt's high standard of cleanliness and sustainability. Excess cutting fluid from parts is collected in stainless steel troughs, processed and reintroduced to the machining process.

Weishaupt also attached particular importance to excellent service when it made its decision to go with the PHS. Liebherr-Verzahntechnik GmbH guarantees prompt and dependable service. Fast service provision times are a basic requirement. After all there is no alternative to this production line – any downtime would have serious consequences. Furthermore the plant required a wide range of detailed technical solutions, which also had to be design-engineered. In this case Liebherr was able to score point by proposing feasible solutions. Many years of experience working on similar projects was also of major help in this case.

Visits to Kempten and to reference plants

Weishaupt was invited to visit Liebherr's PHS system in Kempten as well as similar installations at client's sites. This helped their employees familiarise themselves with the technology and gain an understanding on how it's slotted in continuous operations.

Liebherr integrated a Soflex-designed production cell controller to coordinate resource management and job sequencing. In addition to its standard tasks, a production cell controller also manages production and ergonomic parameters. Thus, for example, it communicates the optimum clamping tension to every component as well as the working height of the set-up station.

Figure: Max Weishaupt GmbH

Mobile set-up station

Figure: Max Weishaupt GmbH

Mobile set-up station

By investing in new production solutions, Weishaupt has adopted a system exactly tailored to its own needs, setting its future course. Liebherr-Verzahntechnik GmbH's automation solution has helped to secure the long-term future of production at Weishaupt. ■

Technical Data

PHS 3500		
Max. transport weight	kg	4,000
Max. workpiece diameter	mm	Ø 2,800 x 2,200
Max. machine pallet:	mm	1,000 x 800
Transport module control system		Siemens
Cell control system		SOFLEX PCS

Max Weishaupt GmbH

–weishaupt–

Industries:	Energy technology, energy recovery, energy management
Company size:	3,178 (worldwide)
Founded:	1932
Headquarters:	Schwendi (Germany)
No. of locations:	29 branches and agencies in Germany, 20 subsidiaries abroad, representative offices and agencies in more than 40 countries
Production plants:	Schwendi, Rothenburg ob der Tauber, Sennwald (CH)
Managing directors:	Dipl.-Ing. Siegfried Weishaupt, Dipl.-Wi.-Ing. Thomas Weishaupt, Dr. Karl-Heinz Romer
Website:	www.weishaupt.de

“Quality, flexibility, availability”

Bauer Gear Motor operates two new LC 180 gear hobbing machines at its facility in Slovakia, producing gearing for all facilities. These machines are characterised by their operational versatility, given that they are used to produce around 180 different components in a very wide range of different sizes.

Detailed view of motors with worm gears (BS range) and pancake gears (BF range)

Esslingen-based Bauer Gear Motor (Germany) has a proud history. The company, which is now a part of US-based Altra Industrial Motion, was founded back in 1927 by Wilhelm Bauer, the inventor of the geared motor. This has been the company’s core business activity up to this day. “Our drivetrains are used in myriads of applications,” says Raghavendar Kuberan, Director of Gear Technology at Bauer. “We provide application-specific solutions for a wide range of industries. You will find our geared motors used in all industrial applications where materials are moved. The spectrum covered is really huge.” Bauer is a hidden champion in this specialist business.

When asked what the company’s recipe for success is, the gear specialist replied: “We concentrate on top level performance when delivering electromechanical components, e.g. couplings and transmissions.” Typical users include the metals industry, the food and beverage industry, crane technology, bulk material handling technology, water and sewage engineering, textile machinery or the chemical industry. The company is able to create far more than one million geared motor versions, based on the Bauer 2,000 modular system. “Fast, reliable deliveries are just as much a hallmark of our business as our in-depth industry knowledge. When we make a drivetrain for the food industry, it of course has to comply with local regulations and standards – for example hygiene regulations. Our experts can guarantee that.” Only engineers, who have specialist core business knowledge, work in Sales.

Mechanical production in Slovakia

Bauer manufactures its large geared motors in Esslingen (Germany), the ▸

smaller drives being produced at the facility located in Zlaté Moravce in Slovakia. One particular feature of this production location is the in-house winding room for electric motors. “That makes us considerably more flexible compared to our competitors”, Head of Marketing Philip Crowe explains. In any case flexibility is one of the other ingredients in the above-mentioned recipe for success. The electric motors are combined with helical gears, parallel shaft gears, bevel gears or worm gears. Very different materials, such as aluminium or grey cast iron, are used, depending on the required application. However all versions are manufactured on one production line.

“The comprehensive customer-focused package of machine, technology and software makes gear production much, much easier for us.”

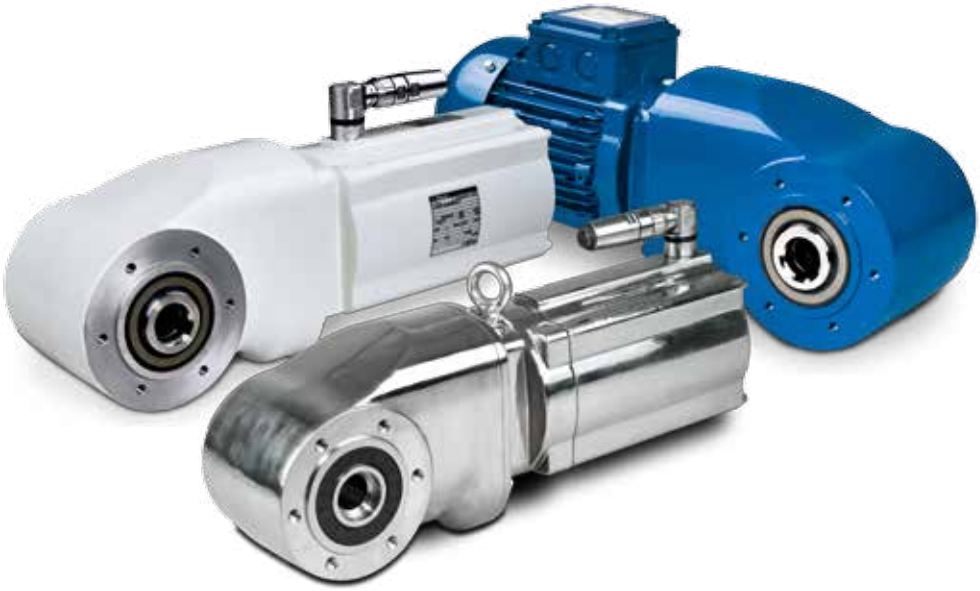
Raghavendar Kuberan, Director of Gear Technology by Bauer Gear Motor

Bauer’s production concept has enabled it to halve average production time per workpiece down to five days since 2012. Inventory, retooling times and “work-in-progress” have been significantly reduced, while improving customer delivery reliability at the same time.

As far as production is concerned, Bauer attaches the utmost importance to quality. In terms of upgrading the machine park at its plant in Zlaté Moravce, potential suppliers had to meet three key criteria – “quality, flexibility and availability”. Raghavendar Kuberan opted for two Liebherr LC 180 gear hobbing machines, which can be used for worm wheels and to pre-machine and finish wheels and shafts. “Prior to making major investments, we always clarify our requirements in advance with suppliers. However to make that hap-

Two gear hobbing machines type LC 180 produce worm wheels, gearwheels and shafts.

pen, the communication has to work, and suppliers need to have the relevant know-how and the ability to manufacture products of excellent quality. Particularly where premium-quality machinery is involved, it is vital that the experts on both sides carefully coordinate their procurement-process activities."



The innovative HiflexDRIVE. bevel-geared motor

Set-up times are crucial

Bauer purchased its first Liebherr machine back in 1986. Back then the LC 255 was located at the company's Munich plant, which has long since relocated. 180 different components are produced on both the new machines, ranging from a relatively small average batch size of 50 up to 200. "Since we need to retool several times per shift, short set-up times were very important for us. We can not accept delays at this point in the process," Raghavendar Kuberan emphasises. Module-wise the pinions and gearwheels range from 0.5 to 3. Components ranging from 5.4 to 180 millimetres can be loaded automatically. "But we also produce components of up to 210 millimetres, by modifying the machine table and loading manually." The steady columns are fitted with ring loaders, which facilitate rapid loading and unloading. Load time is less than three seconds, depending on the component. Grippers can be changed without using any tools. Ring loaders for the LC 180 can load workpieces weighing up to 15 kilogrammes.

Liebherr kitted the machines at Bauer Gear Motor with a specially adapted sensor to handle the smallest of workpieces. Both are used to perform different tasks. One machines hardened components and the other machines malleable ones.

Operation using the new LHGe@rTec interface

Visual displays and animations in the new LHGe@rTec user interface guide machine operators intuitively through the menus. Even complex procedures can be simplified by displaying graphics when data is entered. Furthermore the smart LHGe@rTec control system checks all the necessary data inputs to ensure they are plausible. Data entry errors can be avoided through the use of an online conformity check that includes a visualisation detail.

"We wanted to work with fit-for-the-future software from the very beginning," gearing expert Kuberan explains. The new software controls user guidance for process and retooling cycles, is touch-screen-operated and provides graphical input support. Additional documentation, like e.g. drawings, measurement diagrams, instructions and work schedules can easily be incorporated. The smart LHGe@rTec user interface monitors data input by operators. Functions can very easily be activated or deactivated with the aid of control buttons. They work like apps on a smartphone and facilitate a wide range of user-defined settings. Applications running in the background help operators with data entry.

"This comprehensive customer-focused package of machine, technology and software makes gear production much, much easier for us," says Raghavendar Kuberan in summary. ■

Gearwheels of Bauer Gear Motor

Bauer Gear Motor

Industries:	Various, including metals, food and beverage industry, crane technology, bulk material handling technology, water and sewage engineering, textile machinery, chemical industry
Headcount:	Around 600 employees
Established in:	1927
Headquarters:	Esslingen (Germany)
Locations:	Esslingen (Germany), Zlaté Moravce (Slovakia), Shenzhen (China), Somerset (USA)
Parent company:	Altra Industrial Motion, Braintree, Massachusetts (USA)
CEO:	Karl-Peter Simon
Website:	www.bauergears.com
Maschines at work:	Two LC 180 gear hobbing machines

Smart production lines – all from a single source

Liebherr 4.0

What is so special about the magic number, 4.0? How does Liebherr-Verzahntechnik GmbH approach implementation in terms of its own machines and automation systems? What's the story at its own production facilities?

Industry 4.0 is a trend that has been prevalent for quite some time. This transformation via the "smart product" to the "smart factory" is a continuous process. "Our customers have very different priorities and requirements, which we need to meet to their complete satisfaction. This is a challenge that we are keen to take on," states Florian Schuon, a member of the control systems development team at Liebherr-Verzahntechnik GmbH.

Custom solutions

Teleservices such as data transmission, data backup and remote maintenance have been provided by Liebherr for 30 years. "In this respect we can offer our customers a standard of service that has been enhanced over the decades and adapted to today's possibilities," the engineer relates. Turning customer-specific challenges into reality is also not a problem. One focus of Industry 4.0 thoughts is the digitalisation of operating data and interlinking machines. Given a lack of standardised interfaces, customised solutions are normally used. "There are numerous application examples, where we have integrated our machines into our customers' production lines," Florian Schuon relates from practical experience. "In such cases the issue that normally concerns users is controlled component flow and component tracking along the entire production line."

Prevention 4.0

"Predictive maintenance" is another major issue that augurs plenty of potential. "Many customers already rely on machine diagnostics and the preventive maintenance opportunities that come with them." As an example Florian Schuon quotes spindle-monitoring sensor technology that's interlinked with an MES system. It facilitates wear-and-tear analysis and therefore targeted maintenance.

Onboard gear inspection and analysis has been enhanced substantially over the last few years thanks to a new measurement sensor and a new testing method. Florian Schuon

"Sections of our production plant operate on a paperless basis, a master computer is responsible for a large portion of the control system," Manfred Kaut relates. This is linked with the ERP system, meaning work orders automatically flow into the manufacturing centre and analyses are also automated.

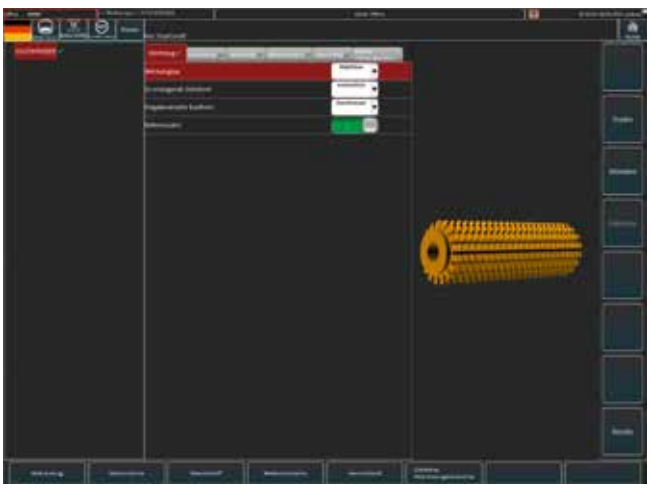
"The most important criterion for our master computer – adherence to deadlines. It coordinates processes and component production sequences on that basis." For operators that means they are provided with setup instructions in digital format. "This system has enabled us to substantially improve parts availability for Assembly purposes," Manfred Kaut remarks. Therefore it is operating on three cells, which are integrated into machine production. During the last four years Liebherr has invested in three automatic manufacturing cells and interlinked these in line with state-of-the-art standards.

Manfred Kaut and his colleagues are monitoring the evolution of 4.0 technologies with great interest. "New technologies need to match manufacturing machinery. We use what what is making sense and what fits with our production environment." Manufacturing is undergoing a digital transformation that is impacting all processes. ■

says: "This enables the quality of the workpieces to be evaluated directly within the machine, and up to ten times faster than with the previous method." Furthermore Liebherr has already created the first "closed loop systems", featuring external measuring devices and GDE-format data exchange, in collaboration with different customers.

"Nowadays operators should be able to perform highly complex procedures as simply as possible," says the expert. "To make this happen, they need the appropriate technical support." This support is to be found in modern user interfaces, which also reduce the incidence of problems due to input errors. "Thus, for example, our new HMI, LHGe@rtec, enables hob data to be loaded directly from the manufacturer into the machine. The tools and tool data are then displayed and can immediately be visually checked for completeness and accuracy." The new HMI's multi-touch function caters for modern forms of machine operation. This graphic input support is also available for operator-created part programs.

What does Liebherr do at its own facilities?
Manfred Kaut is Head of Production at Liebherr-Verzahntechnik GmbH and responsible for implementing Industry 4.0 tasks at Liebherr's own plant. When selecting new machines, he is particularly interested in is what digital data these machines provide him with and in what way. How can workflows be digitally modelled? What instructions have to be issued when and to whom? How is data integrated into the ERP system?



Tool visualisation on the new multi-touch HMI

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Product Manager Control Systems Development

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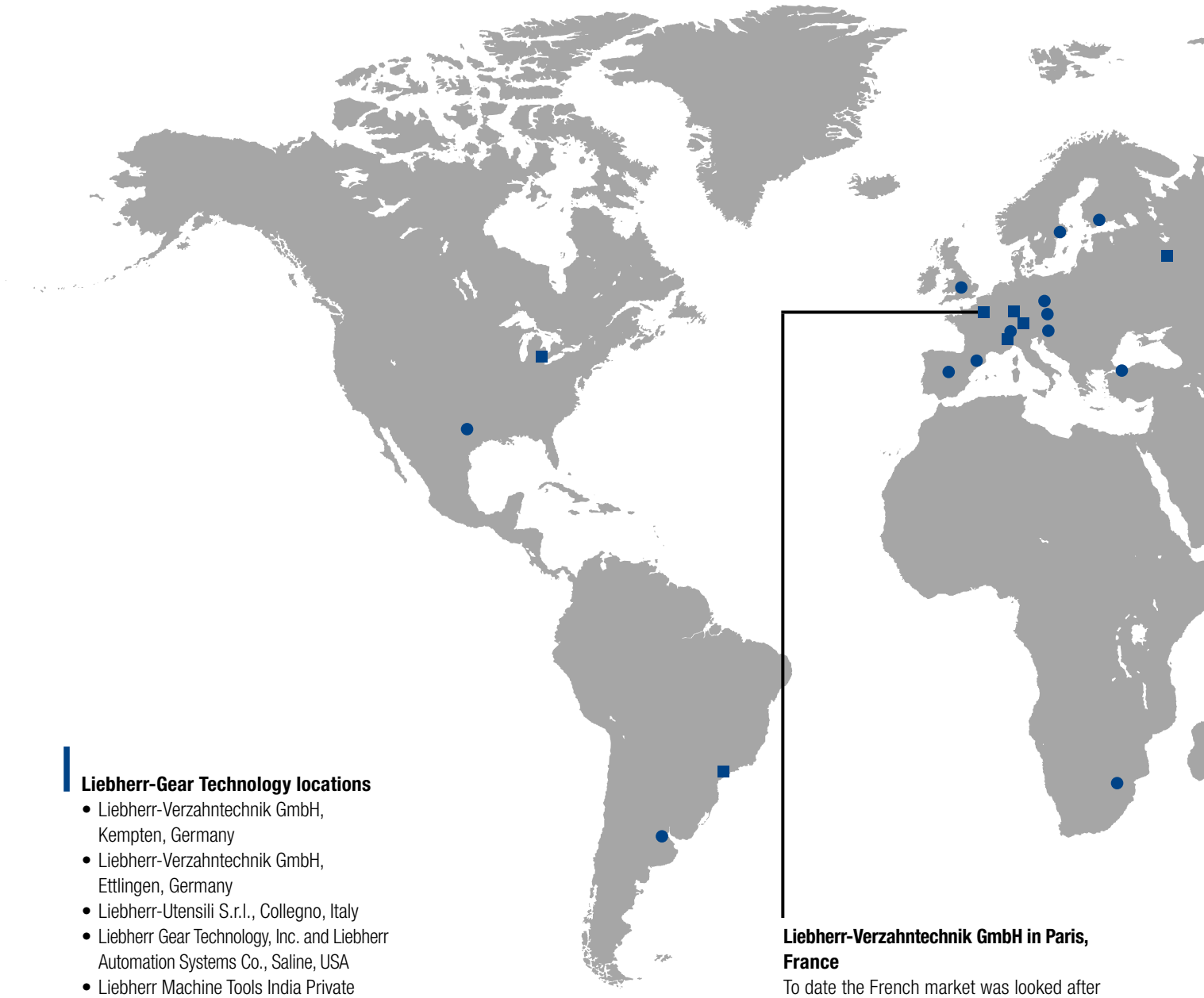
Represented around the world

In order to provide customers throughout the world with the best in sales support and customer care services, Liebherr-Verzahntechnik GmbH has significantly boosted its network of foreign branches. This local market presence ensures that customers will be looked after even better.

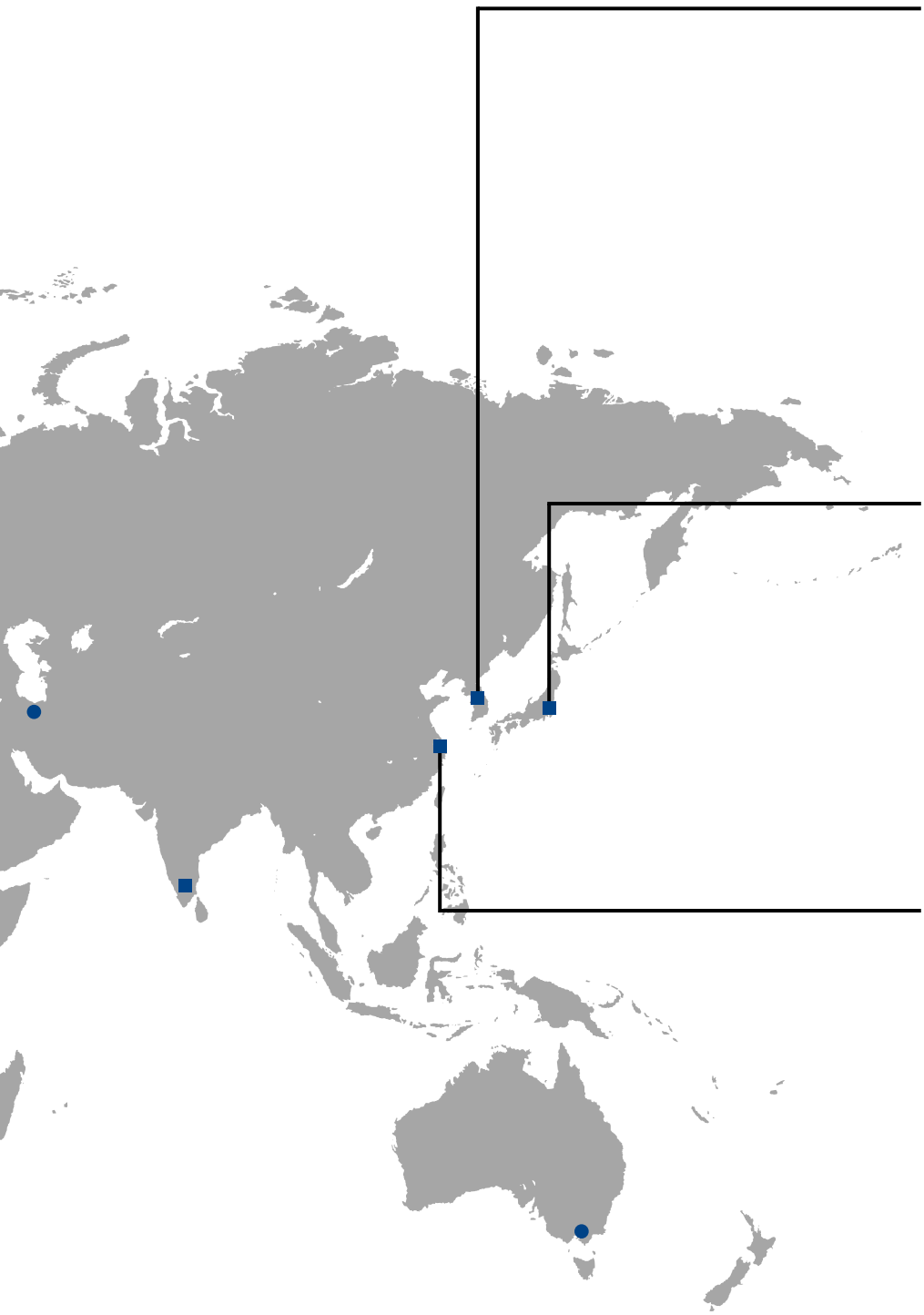


Liebherr-Gear Technology locations

- Liebherr-Verzahntechnik GmbH, Kempten, Germany
- Liebherr-Verzahntechnik GmbH, Ettlingen, Germany
- Liebherr-Utensili S.r.l., Collegno, Italy
- Liebherr Gear Technology, Inc. and Liebherr Automation Systems Co., Saline, USA
- Liebherr Machine Tools India Private Limited, Bangalore, India
- Liebherr Machinery Service (Shanghai) Co. Ltd., China
- Liebherr Brasil Guindastes e Máquinas Operatrizes Ltda., São Paulo, Brazil
- Liebherr-Russland OOO, Moscow, Russia

Liebherr-Verzahntechnik GmbH in Paris, France

To date the French market was looked after by an agency, but that has now changed. Liebherr-Verzahntechnik GmbH has opened a branch office in Paris staffed by two employees. They are responsible for sales of gear cutting machines, automation systems and tools in France.



Liebherr Machine Tools and Automation Seoul, South Korea

South Korea is an important market for Liebherr-Verzahntechnik GmbH in Asia – which is a good reason to boost its local presence. A joint venture with DKTec was therefore launched back in spring 2016. In South Korea the emphasis is now on providing a comprehensive range of services, including customer service, retrofits, spare parts supply or training. To start with this location will focus on gear cutting technology; automation systems will be added gradually.

Liebherr Japan in Tokyo, Japan

In Japan Liebherr concentrates exclusively on gear cutting technology. Japanese customers are mainly from the country's automotive sector. Employees in Japan handle sales, technology transfer and customer service – the latter is a basic prerequisite for being successful in the Japanese market. Liebherr regards high-level technology, e.g. grinding technology, as its best opportunity of being successful locally.

Liebherr Machinery Service in Shanghai, China

In China Liebherr-Verzahntechnik GmbH has enhanced its sales organisation considerably to enable it to provide local customers with direct support and customer service for machinery, automation systems and tools. Last year a first ever sales representative meeting was held in China, where participants were able to discuss the latest machinery and systems. 18 employees now work for the Service and Engineering team in Shanghai. To cover the gear-cutting tools market in China, Liebherr partners with the toolmaker, Seco, which has a strong presence in this market. Seco supplies general cutting tools, which complement the Liebherr portfolio.

■ **Branches** ● **Agencies**

“Our super talent pool”

Presently several hundred former apprentices are permanently employed at Liebherr-Verzahntechnik GmbH. During the last 20 years many of them have completed a special training model, the objective of which is to get the apprentices to think for themselves and to familiarise them with solving problems using their own initiative.

The apprentices develop own models at Liebherr

When Walter Ferstl talks about “his” industrial apprentices in Kempten, it is immediately obvious that the man not only firmly believes in the work he does, but also has a genuine passion for it. He is one of the creators of the modular training system that has often been rated as exemplary and adapted over the last 20 years. Martin Hartmann, an apprentice industrial engineering electronics technician, explains the system. “During the course of our vocational training we have to complete 87 modules, which are structured in accordance with the project method of learning. Each module kicks off with an assignment, the necessary instructions and the theoretical background guidelines that we need to complete the assignment. We then start out on our own and ask for help if we get stuck.”

Completing training with own models

At the start of his training the future electronics technician has built a control cabinet, which he upgraded and modified in subsequent years. Later a model of a loading gantry was added. Cooperation between training workshop, different departments and vocational schools enables these junior employees to learn their trades and get to know the entire company. Furthermore all apprentices get the opportunity to go abroad. For example Norway is a very popular exchange destination. Supplementary English lessons prepare apprentices in language and intercultural terms for their stays in Scandinavia. But Liebherr apprentices also get to work and learn in other countries like USA, India, China, Korea and France.

The gateway to Norway is also open to joint apprenticeship/degree students. They do both in parallel – an apprenticeship at Liebherr and a degree course at the Kempten University of Applied Sciences. Sebastian Böck is now in his sixth semester and is therefore shortly about to reach his goal – graduating as a Bachelor of Engineering. He has already completed his industrial mechanic‘s apprenticeship. For the first 13 months the students work together with the apprentices and are mentored in exactly the same way as the budding industrial mechanics by our training supervisor, Martin Kuisle, before they switch to classes at the University of Applied Sciences. “We also attend vocational school in parallel until we have completed our apprenticeships,” Sebastian Böck relates. “As industrial mechanics, who are studying for degrees, we are in our own class, because the curriculum has been specially streamlined for us.” In David Bodenmüller’s case, he chose the joint apprenticeship/degree model, specialising in electrical engineering, and will not have to attend vocational school from his second year onwards. “We do not have a degree student class. But the company helps to provide the theoretical portion of our training.”

Students praise practical relevance

The students agree on what is so special about the joint apprenticeship/degree course. “The practical relevance is

The apprentices of Liebherr-Verzahntechnik GmbH in Kempten

brilliant," Simon Strobel, a mechanical engineering student in his second semester, explains. "We have already seen a lot here in the company before the degree course starts, so we are able to relate to the theory in a completely different way." After taking their Bachelor exams, the graduates remain for at least three more years at Liebherr. "We train people up to meet our own needs and are keen to retain good people in the company", Hubert Hemmerle, from the HR department emphasises. He is also concurrently responsible for vocational business training.

Since September 2015, in addition to industrial and IT commercial professionals, Liebherr-Verzahntechnik GmbH, for the first time, has been training IT technical professionals, specialising in system integration. That's because the company is focusing on nurturing its own young commercial and technical IT talent. Even the technical product designers that Christian Hörner looks after, are frequently integrated into the apprentice workshop's programs and corporate departments' training programs, to provide them with as substantial an insight as possible into the practical side of the business. After all, technical product designers need this experience.

As part of their work in the training workshop, apprentices in different disciplines conduct joint projects and thus practise interdisciplinary teamwork. "Furthermore we produce our own teaching materials," Walter Ferstl relates. At the training workshop nothing is bought – all models boast a sign saying "Proudly developed and produced by Liebherr apprentices."

The entire Liebherr Group of Companies is very supportive of "its" apprentices

There is broad support for the issue of training throughout the group, right up to the Management Board. "Apprentices are our super talent pool. They are ambassadors during assignments abroad and are the corporate executives of tomorrow. Those, who have already got to know processes in all departments during their apprenticeship, go on to become valued employees," says Walter Ferstl, speaking from experience. He can also tell how well the Liebherr concept works by how often it has been adopted by others. This modular training course has not only appealed to group affiliates, but other engineering businesses have also adapted the strategy for their own purposes. "Action-focused learning in modules enables our apprentices not only to acquire special and interdisciplinary knowledge and skills, but they also learn how to familiarise themselves with new topic areas on their own." ■

See the world with Liebherr

Nine out of ten apprentices now spend three to eight weeks abroad as part of their training. An Erasmus exchange programme with Norway and global installation assignments at customer sites make this feasible. In the last two years apprentices from Liebherr-Verzahntechnik GmbH have spent a fair amount of time in Belgium, China, UK, India, Italy, Korea, Norway and the USA.

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Conferred with outstanding partner award

John Deere, the tractor and agricultural machinery manufacturer, uses its "Achieving Excellence" Award to recognize partners, whose performance is particularly characterised by product quality, technical support, delivery reliability, customer understanding and cost management excellence. Liebherr-Verzahntechnik GmbH is one of the 2016 award winners in the "Partner" category.

John Deere's definition for the category "Partner" is a supplier that goes above and beyond our performance standards, reaches world-class levels, and has a measurable effect on our level of customer satisfaction." Liebherr-Verzahntechnik GmbH has achieved this standard during the course of its long-established partnership by providing technological concepts that have facilitated substantial savings. "We have worked with John Deere for many years and at different locations around the world," reports Karl Sauterleute, Head of Gear Cutting Technology Sales in Kempten. "This award makes us proud and validates the approach we take – always focusing on quality and technological partnership."

This ambition is very much in keeping with John Deere's Excellence Initiative. Chief Executive Officer Samuel R. Allen describes its objective as follows: "The main relevance of Achieving Excellence is to drive continuous improvement in our supply chain in a way that benefits our suppliers and John Deere." Progress and development help both parties as they head down the road of the future together. ■

Automation division boosts presence

Liebherr-Verzahntechnik GmbH's automation systems have a wide range of applications and are gaining a firm foothold in many sectors. For that reason the division is boosting its presence at France and Shanghai Liebherr branches while entering into sales and distribution partnerships around Europe.

"Liebherr-Verzahntechnik GmbH's automation systems are gaining a firm foothold in new markets and industries," Martin Winterstein, Head of Automation Systems Global Business Development & Market-Based Sales, explains. "We are adapting our sales structures in line with this positive trend by boosting our presence in important business regions." Liebherr is taking two approaches to make this happen: on one hand the Automation Systems division is making more effective use of existing Liebherr branches / subsidiaries and boosting its presence, for example, in France and Shanghai. "On the other hand we have concluded the first exclusive distributorship agreements with partner companies that will sell our products."

New commercial partners are already playing an active role in the German, Dutch, and Belgian markets. The Dutch company Ertec, which specializes in production process optimisation, operates in the Benelux countries. Schlegel & Volk provides professional services to businesses in the German federal states Rhineland-Palatinate, Hesse and Saarland. Otto Balz, a reliable Gear Cutting Technology division partner, represents Liebherr-Automation in Baden-Württemberg. "We are currently negotiating with other potential partners and will continue to develop this strategy," explains Martin Winterstein, whose remit includes marketing of new products, business development in new markets, like China, and the development of market-based sales and distribution teams / capabilities. "Our objective is to significantly improve our customer focus in regions of high industrial concentration, which will enable us to provide our products and solutions to a wider group of users." ■

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Grinding machine for the aviation industry

Liebherr-Verzahntechnik GmbH enhances its LGG 280 gear generating and profile grinding machine to meet the needs of the aviation industry.

The new grinding head with CBN grinding disk

For the high quality standards of the aviation industry the LGG 280, which can handle profile grinding as well as generating grinding, was fitted with an innovative automation solution. With the new OPAL-based internal grinding heads, internal gear grinding is now also possible.

To change from external to internal grinding, the new grinding head needs to be attached to the machine, which takes around half an hour. “The internal grinding head features easy and exactly repeatable changing of both, CBN or dressable profile wheels,” says Dr. Andreas Mehr of the Grinding and Shaping Technology Group at Liebherr-Verzahntechnik GmbH.

“Overall, set-up times are very short, which means that small batches and even individual components can be produced cost-effectively,” Dr. Hansjörg Geiser, Head of Gear Cutting Machinery Design & Development, explains. The machine features an optional automation solution for that very reason – larger quantities can be automatically loaded via an unmanned conveyor. Manual loading is also feasible for smaller jobs. “Given the high quality standards that exist in the aviation industry, the automation solution has been customised accordingly, also in terms of flexible clamping fixtures. The current solution enables the range of components to be machined very effectively – within significantly reduced machining and set-up times,” says Hansjörg Geiser.

Colleagues from Liebherr-Aerospace Lindenberg GmbH and Liebherr-Verzahntechnik GmbH at the handover of the new LGG 280

A new grinding measurement system is also available. It determines the amount of grinding stock and warpage before and after grinding and documents these figures. The LGG 280 has now been in service at Liebherr-Aerospace Lindenberg GmbH since March 2016. The machine was fully integrated into serial production just one week after commissioning. ■

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"As I see it, the crane's rope is its heart"

Sometimes an innovation is better described as a sensation. Together with the wire rope manufacturer Teufelberger, Liebherr is developing a new type of high-strength fibre rope which will replace wire ropes for various applications in the future. It was presented to the public for the first time at various open-air exhibits throughout the Bauma 2016 trade fair.

It is truly an extreme location. Temperatures can be as high as 80 degrees Celsius here, or as low as five degrees Celsius below freezing point. Sand or dust may swirl through the air to simulate conditions on a construction site in the desert. A moment later, monsoon-style rainfall sets in. Is this an adventure on some faraway continent? Far from it – we are in Biberach an der Riss, South Germany, and this is the new climatic chamber, which Liebherr put into operation in February 2016. A team led by Dr. Ilaka Mupende, Research and Experimental Manager at Liebherr-Components Biberach GmbH, is testing a pioneering innovation for use on cranes: a high-strength synthetic fibre rope that was presented to the public for the first time at this year's Bauma trade fair. Dr. Mupende explains: "The rope is extremely light but nevertheless very strong. It has the same load capacity as a steel rope and spools up excellently, especially when the load has to be lifted at a considerable height."

This innovative product is being tested under extreme weather conditions as well as different load patterns. "The fibre rope has to withstand severe temperature fluctuations if it is to be suitable for use in Saudi Arabia, the Middle East and Siberia. This is why we set up the climatic test rig," says Dr. Mupende, an engineer born in the Democratic Republic of the Congo. Together with his team he is subjecting each prototype of the new rope to thorough testing on various fixtures for at least three months.

Extreme weather conditions are simulated in the climatic chamber

A team led by Dr. Ilaka Mupende has developed the new high-strength fibre rope

The idea to develop a high-strength fibre rope emerged at Liebherr about ten years ago in response to a steady increase in demand for higher crane load capacities and greater lifting heights. Every reduction in the deadweight of the crane in the jib area leads to a direct increase in load capacity. Up to that time the rope had scarcely been investigated as a means of reducing the crane's 'dead weight', which is required for load handling but otherwise has no specific advantages. For Ilaka Mupende, the rope is only one element in the overall lifting gear, but a decisive one. "A high tower and a long jib may make the crane look highly spectacular, but without the rope the entire structure would be pointless. As I see it, the crane's rope is just as essential as a human's heart."

The project began officially in 2009 and is being led by Ilaka Mupende, who had previously chosen the topic 'Ropes and rope drive systems' for his doctor's thesis. After studying mechanical engineering at the University of Kinshasa (Democratic Republic of the Congo) and working as project engineer and production manager for Unilever in the central African country, he came to Germany as part of a promotional programme and studied at Clausthal University of Technology. "I had always been enthusiastic about German technology," he says. His plan at that time was to become a university professor.

Together with him, engineers from several Liebherr Group companies contributed to this pioneering project. Dr. Mupende: "The fibre rope is as much as 80 percent lighter than a conventional steel rope, and can therefore be almost entirely disregarded as an operating factor." This advantage applies to its use on mobile, crawler and tower cranes as well as in the maritime crane area, where ropes up to three kilometres long are by no means uncommon. The weight at the hook is also lower: with a steel rope it can be as much as two tonnes, this can be cut to about 600 kilograms with the new synthetic fibre rope. There is an enormous gain in rope operating life as well. "The fibre rope we have developed has an operating life ten times longer than a steel rope," says 51-year-old Dr. Mupende. Translated into customer benefits, this means the rope must not be replaced so frequently and therefore the crane availability is increased considerably.

During development work on the synthetic fibre rope, close attention was given to the correct spooling formation on the rope drum and to identifying the need for renewal when approaching the crucial rope wear limit. "A visual check on the outer sleeve of the fibre rope is all that's needed," says Dr. Mupende, who has been with Liebherr in Biberach since 2006. "People here evidently enjoy life." The local Swabian dialect does not cause him too many problems: "My colleagues soon taught me enough to get along!" he says with a smile. After ten years in scientific research, Ilaka Mupende brought a large amount of accumulated know-how with him when he joined Liebherr. He remains fascinated by rope technology, and will press ahead with intensive research work until the high-strength fibre rope is ready for the market. An important aspect of his team's work is identification of the wear limit. "Our aim in the next few years is to modify and optimise the rope to make it suitable for a variety of practical applications." ■

The rope is extremely light but nevertheless very strong, it has the same load capacity as a steel rope and spools up excellently

In retrospect: Liebherr catches the Bauma bug

Three exhibition stands, more than 100 exhibits and 14,000 square metres of open-air exhibition space, as big as two football pitches – the Liebherr Group left a major mark on Bauma 2016, the world's leading construction machinery trade fair.

Following the "Be Part of Something Bigger" motto, the family-owned company showcased its impressive range of construction machinery and mining equipment at one of the largest exhibition stands of the world. The showcase was completed by Liebherr's latest developments in mechanical, hydraulic and electrical drive and control technology.

For example, one of the exhibits was a T 264 mining truck, manufactured in Newport News (Virginia, USA). During the trade fair a superlative sporting event was staged in its 130-cubic-metre dump body – the "Match in the Mining Truck" between the German and Austrian national table-tennis teams, captained respectively by record-breaking European Champion, Timo Boll from Germany, and Austria's 2003 World Singles Champion, Werner Schlager. The Germans won this match of a somewhat different kind by the narrow margin of 3:2.

Lots of visitors, who stopped by during the 7-day show, were impressed both by Liebherr's stands and by its wide range of products. Building expert and German Beard Champion, Franz Pill, was visiting Bauma in a business capacity. "No matter whether it is a crane or a refrigerator – to my mind Liebherr represents quality and superb workmanship." The trade fair's closing résumé was very positive. "Bauma 2016 was a complete success for Liebherr. We obtained plenty of orders from a wide range of different markets. In some segments our expectations were even exceeded," said Stefan Heissler, member of the Liebherr-International AG Board of Directors.

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1. The Liebherr motto at Bauma 2016: "Be Part of Something Bigger", 2. This trade fair has been staged in Munich since the 1950s, 3. A real eyecatcher: Liebherr's T 264 mining truck, 4. Liebherr's booth was one of the largest anywhere in the world, 5. Impressed by Liebherr's showcase: construction expert Franz Pill, 6. A German victory against Austria in the 'Match in der Mulde', 7. The LH 110 C High Rise Port Litronic makes its world debut

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BKT

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Be Part
of Something
BIGGER
LIEBHERR

7


Be Part
of Something
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Product and services overview

Gear cutting machines

Liebherr offers a wide selection of high quality gear cutting machines. We are constantly developing our machines and, in the process, place great importance on high energy efficiency. From the automotive industry to wind turbine manufacturers, customers around the world trust in our machines. With the new control screen, the gear cutting machines from Liebherr are particularly intuitive and comfortable in operation. ■

	**Generating- and profile-hobbing**	LC 60 to 130 mm	LC 80 to 180 mm	LC 200 to 500 mm	**Integrated automation:** • Deposit station / lifting station • Ring loader • Swivel loader • Chain-storage • Chain-storage friction • Lift / Swivel loader
		LC 500 to 2,000 mm	LC 2,000 to 6,000 mm	LC 6,000 to 16,000 mm	
	**Gear-shaping**	LS F / E 80 to 180 mm	LS F / E 200 to 500 mm	LS F / E 500 to 1,600 mm	
		LS H 800 to 1,600 mm	LS H 1,600 to 4,500 mm		
	**Generating- and profil-grinding**	LGG 180 to 280 mm	LGG M 400 mm	LGG 300 to 500 mm	
		LCS 200 to 500 mm	LCS 500 to 1,200 mm	LGF 800 to 1,250 mm	
	**Chamfering and deburring machine**	LCD 300 mm			
	**Gear-skiving**	LK 300 to 500 mm			

Gear cutting tools

Liebherr is one of the world's leading manufacturers of gear cutting tools. We offer a comprehensive portfolio of high quality gear cutting and stock tools. We develop proposal solutions for our customers. Included in the scope of services are special designs for all gears capable of being made through shaping. Moreover, Liebherr ensures high quality machining of gear cutting tools from all manufacturers. ■

	CBN-grinding tools	Shaping cutters	Wafer	Solid Wafer	Rack type cutters	Rolling deburring discs	Indexable insert shaper cutters
	Shaving cutters	Rolling dies	Rolling chamfering discs	Calibration tools	Rolling racks	Gauges	Skiving tools

Automation systems

Liebherr offers a comprehensive range of automation systems that support modern high-efficiency production. Changes in demand come with short notice, Liebherr automation solutions enable flexible responses which reduce production costs. All our automation solutions are designed for economy, ease of use, quality and reliability in combination with a high degree of flexibility. ■

Machine-automation	Plastic chain conveyor	Hinged chain conveyor	Drag frame conveyor	Heavy weight conveyor	Rotary Buffer	Palletizing cell	Pallet changer
Standard – automation	Rotary loading system	Pallet handling system					
Flexible production cell	Gantries	Conveyor systems	Storage-systems	Robot integration	Additional equipment		
Flexible assembly line	Gantries	Conveyor systems	Storage-systems	Robot integration	Additional equipment		

Services

All our product offerings are complemented by a diverse range of services to enable you to use our applications to optimum effectiveness. ■

Service	Spare parts	Modifications	Engineering	Retooling
Trainings	Application technology	CNC-Programming	Component manufacture	Contract manufacture
Sharping and coating	CBN-Reconditioning	Gear-cutting software	Seminars	

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