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LIEBHERR

MAGAZINE

Gear Technology and Automation Systems

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The process dictates the tempo // **P. 22**

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Dr. Christian Lang joined the Board of Executive Directors in October 2014 at Liebherr-Verzahntechnik GmbH

| Dear readers,

in the third issue of our magazine we take a look at extremes, ranging from nano-level technologies through to automation for heavy-duty applications. As far as the topology of tooth flanks is concerned, we can no longer see improvements or enhancements with the naked eye. We have therefore focused on the micro-geometry of tooth-flank modifications and have illustrated the effect of deviations on flank-modified gear-teeth with the aid of topological measurements. These discrepancies have an impact on load capacities and noise generation. To solve this problem, Liebherr has developed a deviation-free topological generating grinding technique and applied to have this technique patented. The smallest changes sometimes have the most major impact!

In contrast, dimensions at the heavy-duty end of the spectrum are simply huge. This involves the movement of very large workpieces, which are often single, made-to-specification items. Nevertheless automation can pay dividends for batch sizes of 1, since heavy items especially lend themselves to machine-aided handling.

The Board of Executive Directors at Liebherr-Verzahntechnik has a new colleague. Dr. Christian Lang joined the team in October 2014. He assumed responsibility for Sales & Marketing from Dr. Alois Mundt.

This move enhances the company's power to innovate, whilst at the same time opening up new distribution channels for our future products. In globalized markets, technology leadership has to go hand in hand with smart sales strategies – Liebherr is meeting this challenge.

We hope you enjoy reading this issue and we look forward to receiving your questions and suggestions!

Three handwritten signatures in blue ink. From left to right: "f. finkenwirth", "hesemann", and "lang".

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

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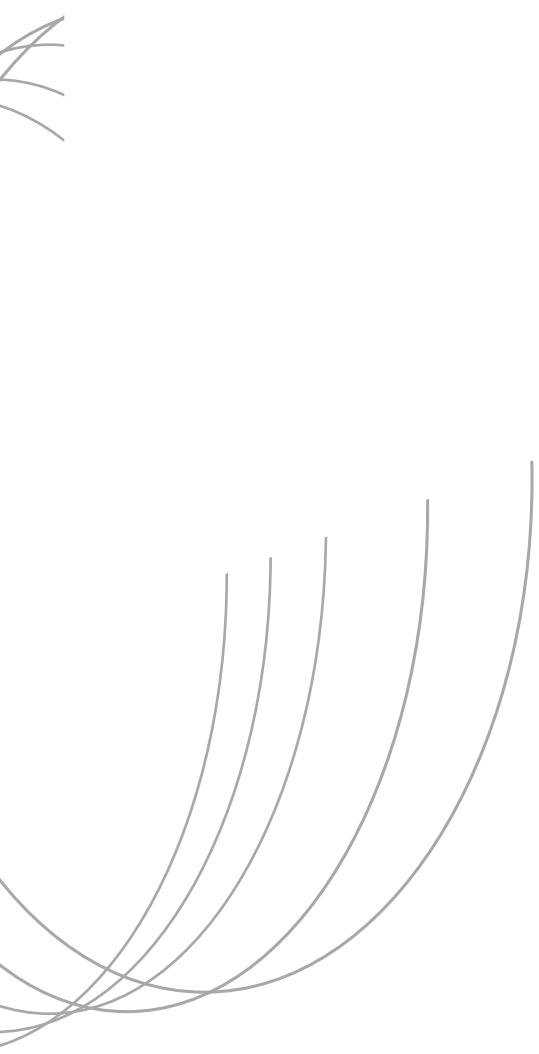
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Benefits of asymmetry

Slanted profiles make sense if one-sided loads act on gears



Gears often rotate in one direction only throughout their entire service lives. This applies particularly in the case of cars, commercial vehicles, ships, lifting gear or generators. In the case of these gear drives, the tooth load on one flank is considerably higher than on the opposite one. This means that little or no load is applied to opposite-coast flanks during a relatively short work cycle. An asymmetric tooth shape reflects this functional difference.

Uneven load distribution requires asymmetric profiles

“One of the design objectives of asymmetric gear teeth is to improve the performance of primary drive profiles at the expense of opposite-coast profile performance”, Dr. Alexander Kapelevich, President of AKGears, explains. He is an expert in the mathematics of tool profiles and other parameters for asymmetric gear teeth. “Asymmetric tooth profiles make it possible to simultaneously increase the contact ratio and operating pressure angle beyond those limits achievable with conventional symmetric gears.” Gear-tooth stiffness can be significantly improved by means of latitudinal and frontal load-sharing as well as by altering dynamic contact. Tooth-flank load capacity also benefits from an increased pressure angle on the stressed tooth flanks. Tooth-root load capacity is also improved.

The main advantage of asymmetric gears is contact stress reduction on the drive flanks. That results in higher torque density, i.e. ratio of load capacity to gear size. Another key advantage is the opportunity afforded of designing opposite-coast tooth flanks differently to drive tooth flanks. This effectively manages tooth stiffness, whilst at the same time retaining the desired pressure angle and contact ratio of the drive flanks. This allows for increased tooth tip deflection, thus damping tooth mesh impact and resulting in a reduction of gear noise and vibration.

Dedicated tools required

Alexander Kapelevich defines asymmetric tooth-root geometry independent of the base model of the gear rack, which distinguishes him from other gear technology researchers. ▶

"One of the design objectives of asymmetric gear teeth is to improve the performance of primary drive profiles at the expense of opposite-coast profile performance."

Dr. Alexander Kapelevich, President of AKGears



Once tooth-root geometry has been optimized, Direct Gear Design® also defines tool profiles and other parameters.

Smart contouring

Roughing, tempering and subsequent hard finishing (skiving or profile-grinding) have been the industry-standard method of producing asymmetric gear teeth for years. Skiving is effective, although it does not quite deliver maximum gear-tooth quality (DIN 6 to DIN 7). Profile-grinding delivers a significantly higher standard of quality, but takes longer than a continuous generating method. Liebherr-Verzahntechnik GmbH developed its asymmetric gear tooth generating grinding method upon customer request. This method combines maximum productivity with superior quality.

Asymmetric gear teeth however represent more of a challenge in terms of the generating-grinding method as well as of grinding and dressing tools rather than in terms of the grinding process itself. Developing this innovative grinding method raised a number of issues all at the same time. "We were faced by twin challenges", Dr. Andreas Mehr, from Liebherr-Verzahntechnik's Grinding and Shaping Technology Development and Consultancy team, explains. "On the one hand we required dressing technology to produce an asymmetric grinding worm. On the other hand we needed to develop the entire grinding process, including centering the grinding worm in the tooth fillet".

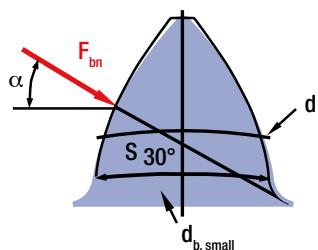
Profile angle adjustment during dressing

For dressing purposes the experts developed a software package that can work with both asymmetric and symmetric dressing disks. "An asymmetric dressing disk is ideal for serial production purposes. For prototype grinding a symmetric dressing disk can be swiveled appropriately", is how Andreas Mehr describes the corresponding benefits. The machine features a swivel range of up to 7.5 degrees. A major challenge as far as dressing was concerned were

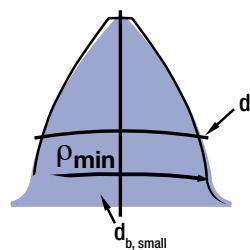
Kapelevich's Direct Gear Design® approach enables asymmetric gear tooth and tooth fillet geometry to be optimized

to achieve maximized performance for specific gear applications. Such an approach of course requires special tools.

Benefits of large pressure angle

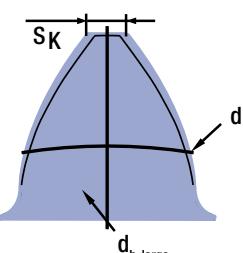


- Larger tooth-root profile

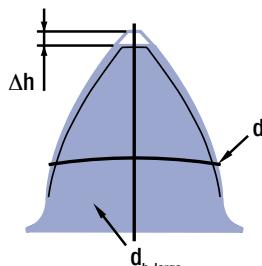


- Large radii of curvature close to root form circle

Benefits of small pressure angle

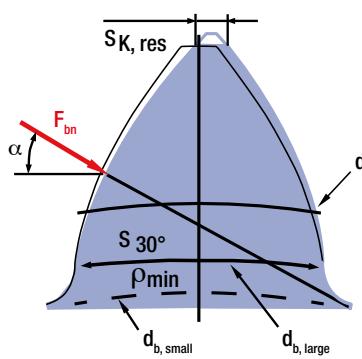


- Large tooth tip thickness



- Increased tooth height

Combination of benefits

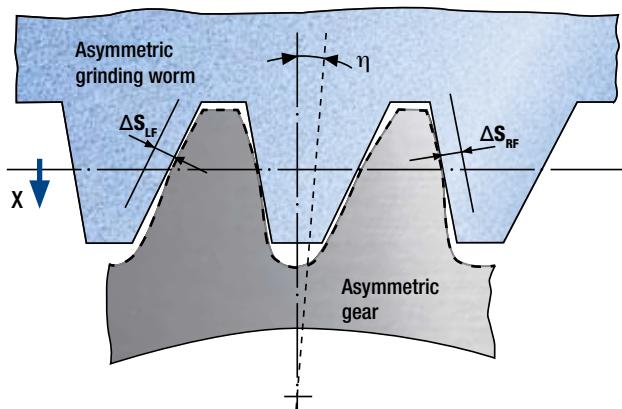


- Positive flank curvature properties
- Large tooth-root profile
- Adequate tooth-tip thickness
- Increased tooth height

Picture source: WZL, RWTH Aachen

Modified centering

- Shifted tool/workpiece center η via radial feed X
- Compensation of different allowances Δs on left and right flanks
- Can be adjusted during set-up process



the complex mathematical calculations of the required swivel movement of the dressing unit. During the dressing process the diameter of the grinding worm is reduced, which in turn necessitates a profile-angle correction – after each dressing sequence.

A quite different dynamic in respect of tooth-flank contact between the grinding worm and workpiece occurs during the grinding process itself, compared with conventional, symmetrical grinding processes. Since stock removal on left and right tooth flank changes during the asymmetric grinding process, given differing pressure angles, an electronic correction is required. This degree of correction is determined by means of modified centering during the set-up procedure. In the case of asymmetric gear teeth, this so-called centering procedure, i.e. centered meshing of the grinding worm with the tooth space, has to be slightly shifted and maintained during the grinding process using precision monitoring and control technology.

Benefits of asymmetric gear teeth in a gear box

- Reduced tooth-root stress and contact stress
- Improved specific sliding
- Increased pitting and tooth-root bending strength
- Increased torque density (ratio of load capacity to gear size)
- Longer life
- Increased efficiency
- Reduced noise and vibration
- Increased operating reliability

Asymmetry's time has come

Thanks to this new grinding process, asymmetric gears will be used more frequently in the future. "Their benefits are obvious and have been generally known for a long time", says Andreas Mehr. "Dr. Kapelevich's calculations have facilitated a simple interpretation of the macro-geometry involved. The generating grinding process can now be reliably managed as well. At the same time our customers can use the generating-grinding process for initial prototyping purposes without any great effort, the software package is up to the job. Customers only need to invest in an asymmetric dressing disks once they get to the serial production stage." It seems that asymmetric gears time has come at last. ■

Dr.-Ing. Andreas Mehr

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Cases of gear teeth, where gear shaping is the only option

The perfect tooth trace

New tooth-trace modification options using the electronic helical guide function on the LSE 200 to 500

The trend towards more efficient gearing systems continues unabated. A lightweight, compact gearing system design frequently results in difficult-to-access machining locations. These include, for example, cluster gears, internal or external gear teeth next to collars, where for design reasons there is only limited space (often less than 5 mm) for tool withdrawal. Machining such gear teeth is a job where gear shaping is the only option.

The request for load-related lead modifications

The requirement of gear system design engineers to undertake load-dependent tooth-trace modifications on these gear teeth has increased steadily over the last few years. To date tooth trace modifications, such as helix crowning c_β , tooth trace angles $f_{h\beta}$ or taper and end relief could only be undertaken on shaped gear teeth using a specially designed back-off cam (B4-axis, see figure at top of page 9). Where taper angles are greater, the so-called taper shaping process can only be activated by tilting the entire machine column (B5-axis). Given the two-flank shaping process, the above-mentioned modifica-

tions on both tooth flanks are symmetrical. This does not permit any degree of optimization in relation to differing demands on drive and coast flanks.

Greater tooth-trace modification design flexibility

Both symmetrical and asymmetrical tooth trace modifications can be undertaken by using the LSE 500 gear-shaping machine's electronic helical guide function in combination with single-flank shaping. Superpositioning the various machining motions also allows you to combine a range of tooth-trace modifications.

Enhanced gear quality at marginally longer machining times

The increased flexibility provided by single-flank gear shaping means that machining times are a little longer compared to conventional two-flank gear shaping. The increase in machining times is between 5 and 20 percent, depending on the application. The small increase is due to the fact that during this Liebherr-developed process sequence, not all machining operations have to be single-flank. Thus rough machining ►



CNC-axes on a state-of-the-art gear shaping machine

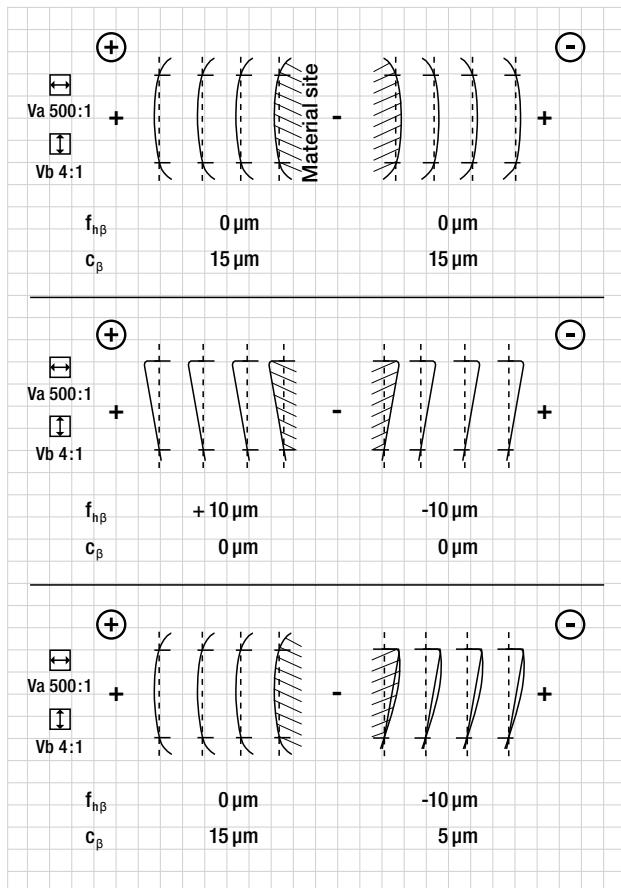
Required CNC-axes

- Z3-axis: tool's stroke motion to generate cutting speed
- B4-axis: tool is withdrawn on return stroke, to avoid damaging the cutter edge
- Z2-axis: machining head moves in parallel to lifting axis, to ready it to machine whatever is clamped on machine table
- C1-axis: roll motion of the tool to produce the gearing and as feed axis
- X1-axis: radial feed
- C2-axis: machine table featuring workpiece rotation

Optional CNC-axes

- Z1-axis: positioning of the shaping head slide where multiple gearing is involved
- Y1-axis: lateral machine base displacement to avoid return stroke collisions, especially where internal gear teeth are involved
- B5-axis: pivoting base for posterior shaping or use of the CAS method for crankshafts
- C3- and Z6-axes: automation
- Z4-Achse: Tailstock arm for shaft processing

Feasible tooth trace modifications using an LSE machine



Symmetric lead crowning

- Possible with back-off cam in double flank cutting
- Possible with CNC-movement in single flank cutting

Symmetric lead taper

- Possible in the micron range with back-off cam in double flank cutting
- Possible up to several degrees with column tilting in double flank cutting
- Possible with CNC-movement in single flank cutting

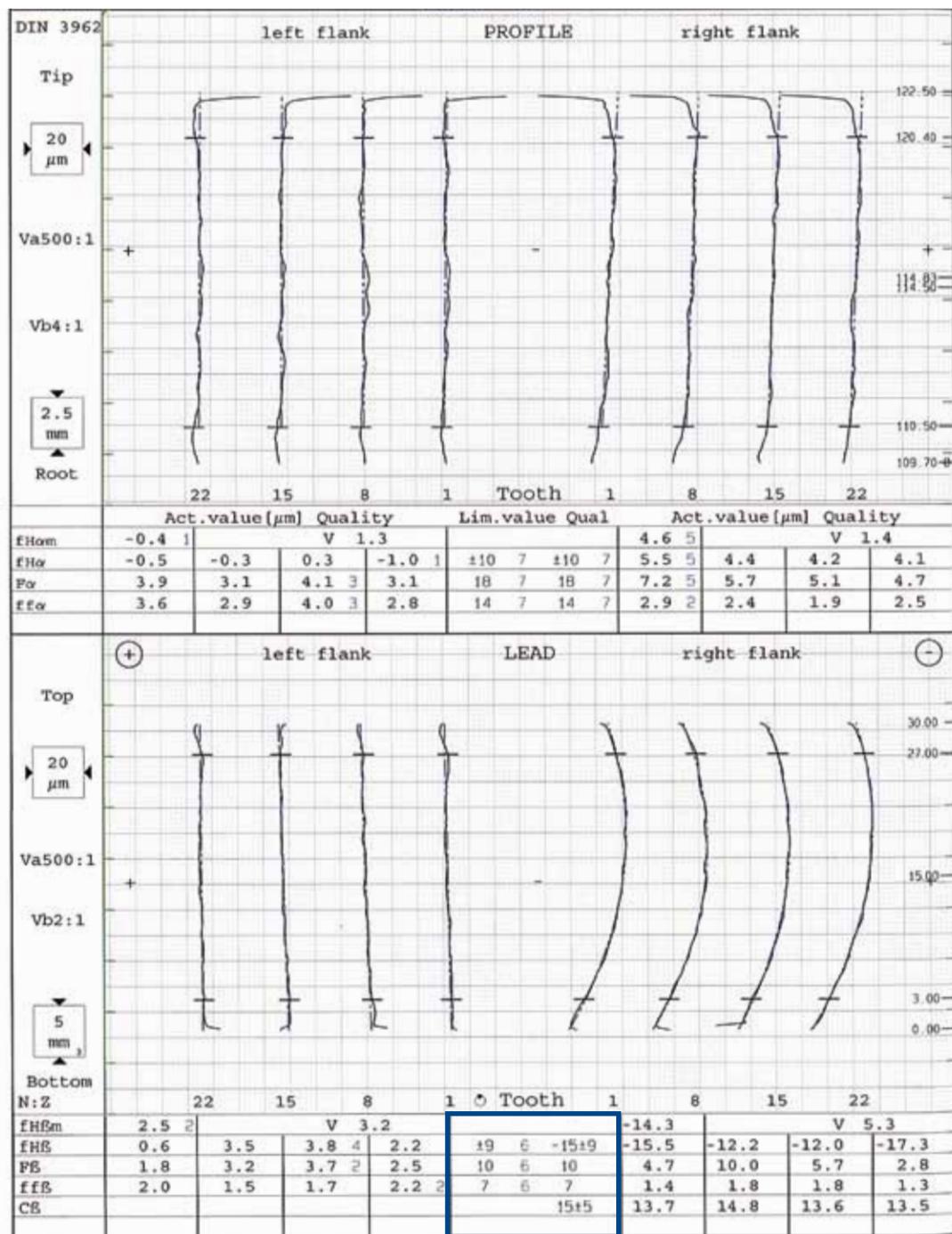
Asymmetric lead crowning and lead corrections

- Only possible in single flank cutting
- Special CNC-movement necessary

Realization of modifications by cutting an actual workpiece on the LSE

Gear profile / Machining example

Number of teeth	28
Modul	4 mm
Pressure angle	20°
Helix angle	-12°



Shaping tooth flank modifications

1-flank, electronic helical guide

Pro

- Modifications can be easily programmed
- Symmetric and asymmetric modifications feasible
- Excellent tooth-trace quality due to correction options accurate to the exact μm (DIN 1 to 3)
- Low chip formation leads to superior profile quality (S-contour)

Con

- Marginally longer machining times
- Reduced stroke rate [DS/min]

2-flank, conventional

Pro

- Very effective double-sided chip removal
- High stroke rate [DS/min] feasible
- Taper gear-teeth shaping facilitated by pivoting machine base
- Symmetric modifications
- Very good tooth-trace quality (DIN 1 to 4)

Con

- Specially designed back-off cam required
- Asymmetric modifications not feasible
- Profile quality (S-contour) can be influenced by meshing interference

and semi-finishing as well as finishing the first tooth flank is performed in two-flank mode. Finishing the second tooth flank is the only operation to be performed in single-flank mode, by in-feeding the cutter in rotatory fashion.

Another positive effect of this final single-flank machining operation is that possible meshing interference between the cutter and workpiece flanks during chip removal is reduced and gearing quality is enhanced. In particular the s-shaped profile-shape flaw, which occurs in gear shaping and which is caused by different chip thicknesses on the leading and trailing flanks, can be significantly reduced or even completely eliminated.

Simple programming incorporating with correction options to the exact μm

Tooth-trace modifications can be undertaken simply by entering correction values into the control system, e.g. 5 μm lead crown for the left and right flanks. All the necessary computations to create the modifications are then performed by the machine control system. After machining and gear teeth inspections of the first workpiece, the machine's control system enables the operator to correct the measurement criteria to the exact μm , e.g. helix crowning c_β . The relevant correction values can be taken from measuring diagram and directly entered into a special correction window of the control system.

“Who needs what?”

The electronic helical guide on LSE machines enables tooth-trace modifications to be performed very simply. Longer machining times are certainly acceptable where small batch sizes or prototype production or individual component manufacturing are involved. In these cases the additional costs and longer lead times for special cams can be avoided. Where large batch sizes are involved, the difference in cycle times will ultimately determine how cost-effectively the required modifications can be performed. ■

Dr.-Ing. Andreas Mehr

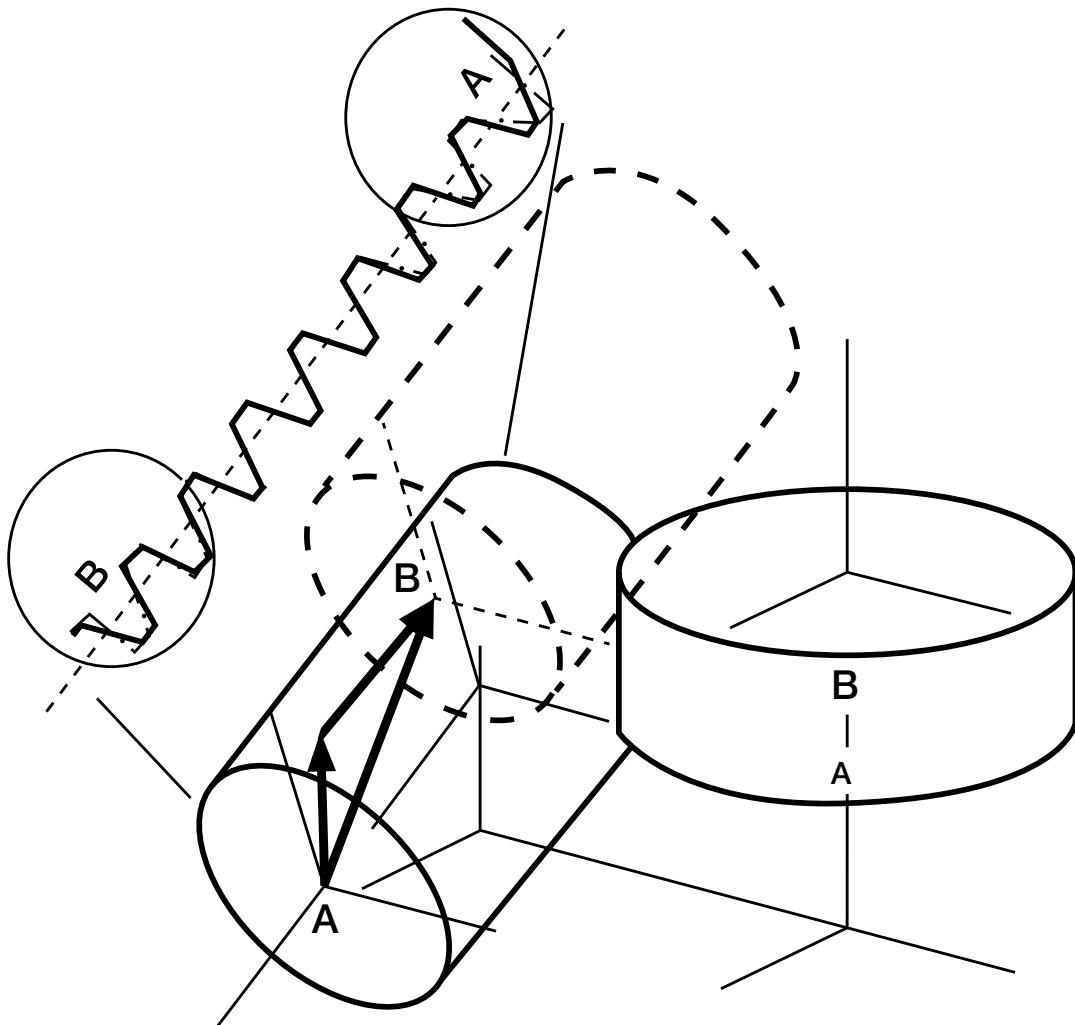
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Microgeometry increases opportunities

Liebherr develops distortion-free generating grinding method for tooth-lead modifications



Drawing from the 1987 patent

By now twist-free generating grinding is a proven industrial production method. Liebherr-Verzahntechnik GmbH registered a patent for Dr. Gerd Sulzer's invention back in 1987. Since then grinding worms featuring length-modified profile angles have been employed to correct the natural twisting that occurs during generating

grinding of gear teeth featuring tooth-lead modifications. During the diagonal generating grinding process the grinding worm is guided past the workpiece in an axial motion, enabling each section of the grinding worm successively to come into contact with the workpiece. This eliminates twisting. "But what this method does not eliminate are geometrical errors", Robert Würfel explains. In Figure 3 you can see that the twisting has been corrected, but an unwanted concave crowning occurs in the profile (Figures 1 to 3). Dr. Hansjörg Geiser illustrates the helical gearing distortion issue using a practical example featuring a rounded end-relief detail (Figures 5 to 7).

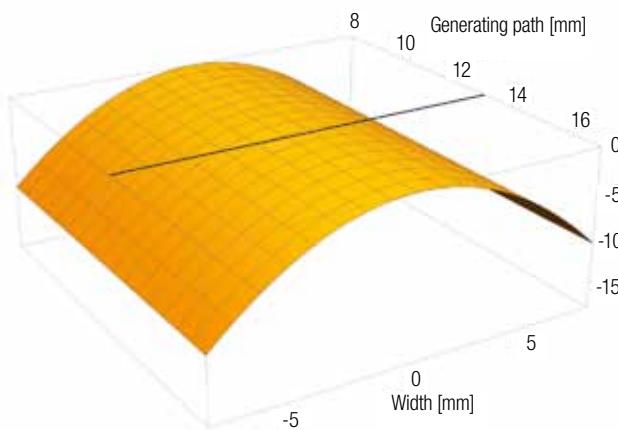


Figure 1: Twist-free tooth-lead crowning specification

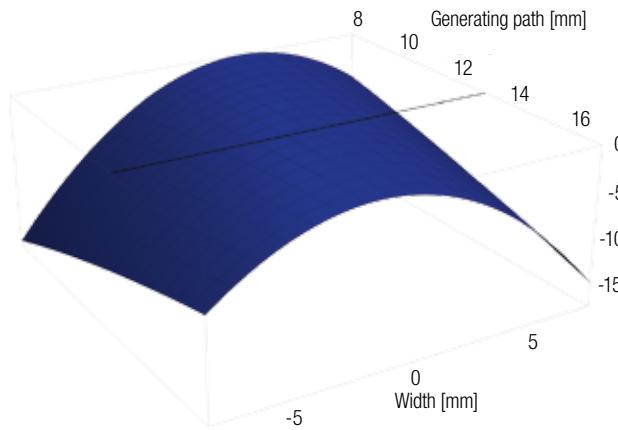


Figure 2: Naturally twisted

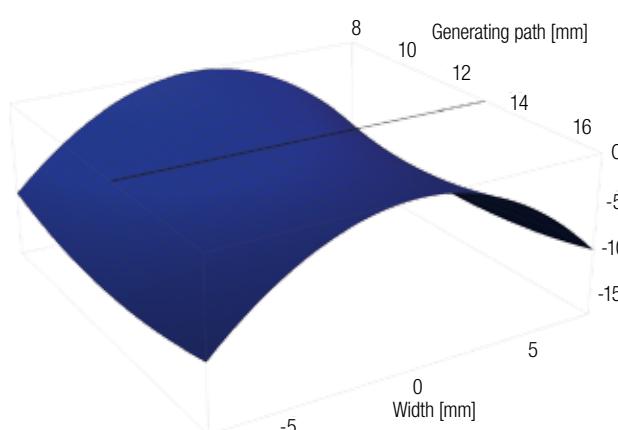


Figure 3: Twist-reduced

The modification can only be accurately achieved at the pitch diameter. "Topological gear measurement shows significant distortions – too much material is ground off in two corners, and too little in two other corners. This impacts on the load capacity of and noise generated by the gears", Dr. Hansjörg Geiser emphasises.

Low-twist grinding alone does not solve the problem

Simple, low-twist generating grinding only partially solves the problem. Geometrical variations continue to exist (see Figure 8), and the modification is ultimately only achieved correctly at the pitch circle diameter.

One option of correcting such distortions would be to topologically dress the grinding worm. It would be dressed line by line, but dressing time would be considerably extended. This would make a cost-effective process impossible. Robert Würfel has developed an alternative: "Liebherr has developed a new grinding method, which prevents this predicament."

Liebherr's distortion-free generating grinding method

Liebherr's new method enables absolutely distortion-free generating-grinding tooth-lead modifications. "We have not exactly reinvented generating grinding, but we are well aware of what it involves", Hansjörg Geiser emphasises. The results delivered by the new method correspond one-to-one with specifications (Figure 9).

"We have not exactly reinvented generating grinding, but we are well aware of what it involves."

Dr.-Ing. Hansjörg Geiser, Head of Product Development & Design Engineering, Gear Cutting Machines



"The new mathematical method enables modifications to be accurately achieved at all measuring diameters", Robert Würfel explains. At the same time, grind and dress times correspond to those of low-distortion grinding. No special tools are required to achieve this; the standard dressing unit is all that's needed to do the job. "We have developed a cost-effective method for serial production. Our method can be used for all free-form tooth-lead modifications."

For load-capacity reasons, this patent-pending method is of major interest for gearbox applications. Up to now no cost-effective grinding method existed.

Generated modifications (GER)

In addition to grinding free-form tooth lead modifications the method described above can be adapted to enable generated modifications as well. ▶



Figure 4: Distortion-free generating grinding is feasible on all Liebherr generating grinding machines

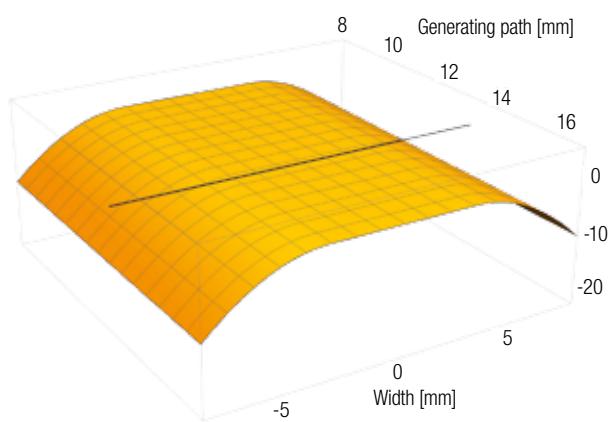


Figure 5: Rounded end-relief detail specification

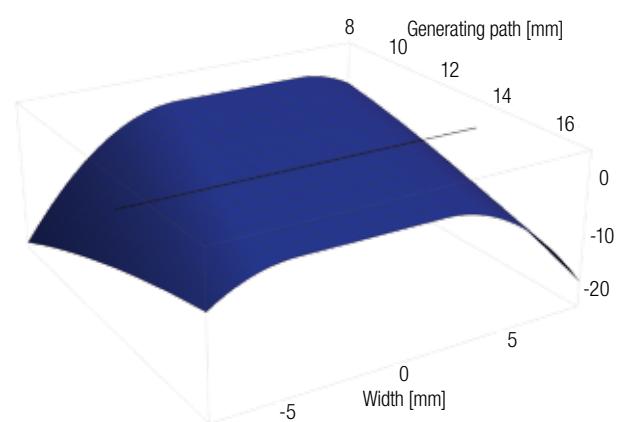


Figure 6: Results following standard generating grinding

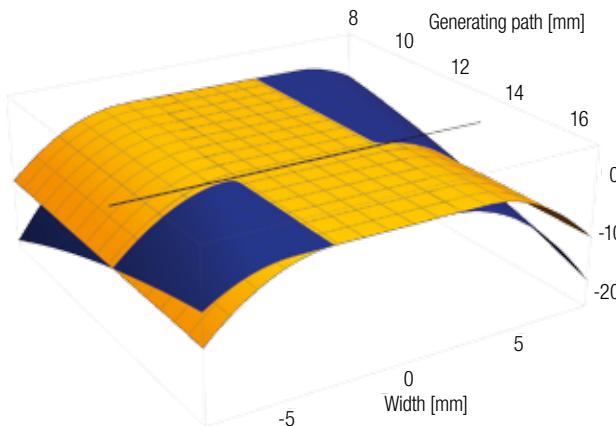


Figure 7: Illustration of end relief that's too small/distortion

The benefits of such triangular end-relief details (generated end relief) in terms of load capacity, have been debated in the gearing industry for many years. Practical application has not been feasible to date, because no cost-effective production method was available. Liebherr has therefore cleared one of the last remaining hurdles (Figures 11 and 12).

Excitation-enhanced modifications

Another application is excitation-enhanced modifications. Time-variable gear tooth rigidity causes a periodic transmission error with tiny amplitudes between two paired gears, which has a major impact on noise levels. During the last few years research into the use of sine-shaped modifications to reduce these errors has been successfully conducted by the Gear Research Centre (FZG) at Munich Technical University's Institute for Machine Elements. This targeted degree of undulation, which typically has a μm -range amplitude, has no impact on load distribution (Figure 13 and 14). ▶

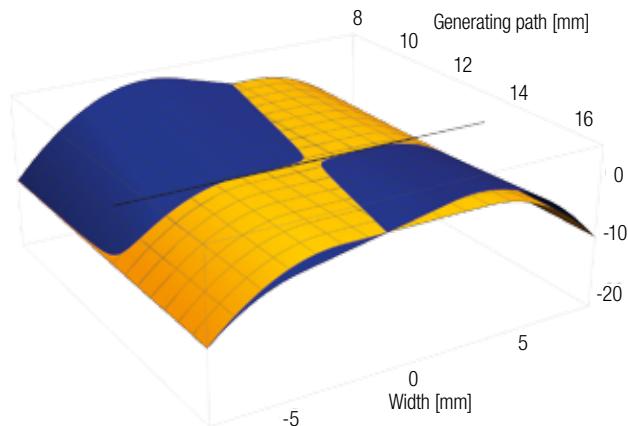


Figure 8: Discrepancies can also occur in simple low-twist generating grinding

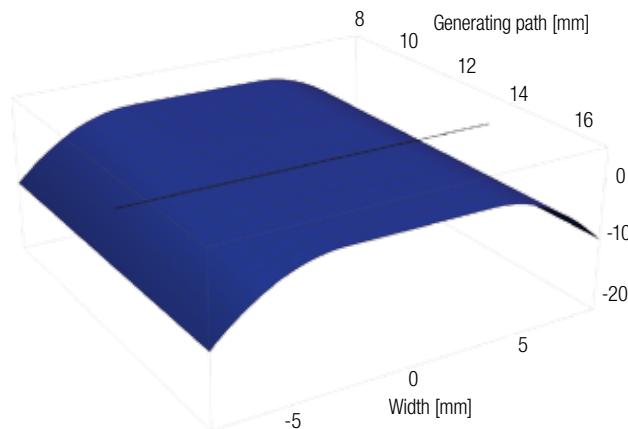


Figure 9: Results delivered by Liebherr's distortion-free generating grinding method

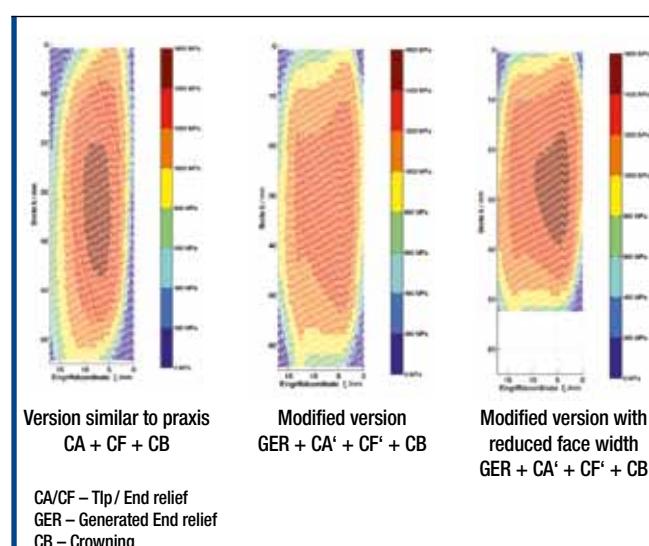


Figure 10: Cost-effective production of generated modifications

The possibility of Generated End Relief (GER) offers a targeted design of pressure distribution in meshing. This influences the maximal contact stress. In this example with constant torque the face width of the gearing can be reduced by using of GER and adjusting the tip and root relief.

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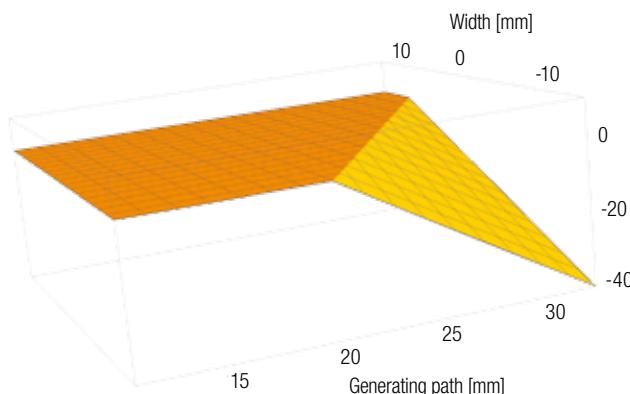


Figure 11: Triangular end-relief specification

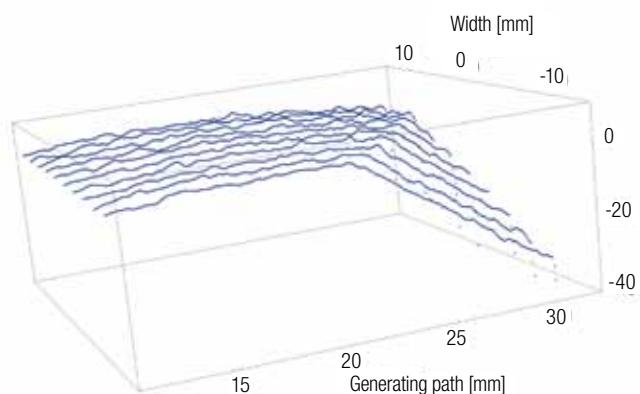


Figure 12: Triangular end-relief readings

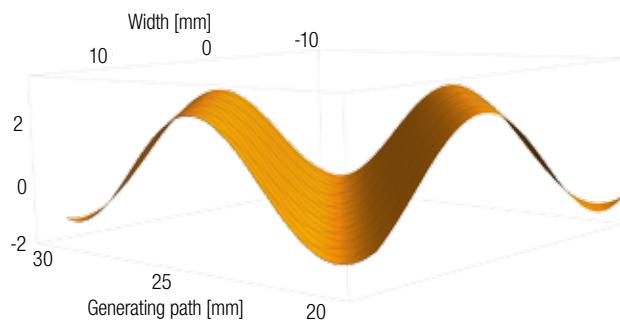


Figure 13: Targeted undulation specification

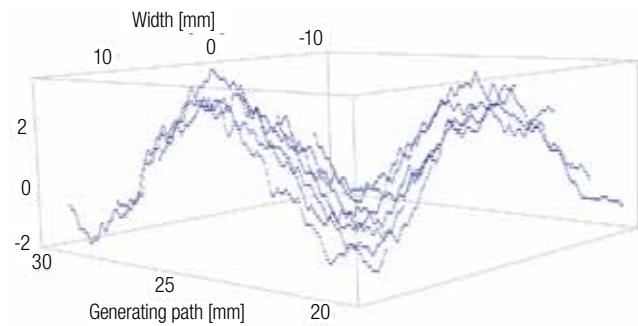


Figure 14: Targeted undulation readings

Benefits (Figures 11 to 14)

- Grind and dress times correspond to those encountered during low-twist grinding
- Standard dressing unit can be used (profile roller)
- Standard modifications can be multiplexed

Conclusion

Liebherr's distortion-free generating grinding method can also be used to produce tooth-lead modifications with relatively large adjustments and short gear-tooth widths – free of errors and distortions. Grind and dress times correspond to those off low-twist grinding. Liebherr grinding machines facilitate cost-effective production of generated modifications. ■

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Bespoke Chamfering

An ideal complement to gear-cutting machines: ChamferCut as a stand-alone solution

The trend towards quieter, more efficient gear units continues unabated, especially in the vehicle manufacturing industry. This means demands on individual components are increasing: specially gears need to have smooth, trim edges. Chamfering helps to avoid workpiece conveyance damage, quench cracks and gear-unit wear caused by sharp edges. Furthermore chamfering makes the assembly process easier and improves the tool life for the finishing process, especially for honing.

Liebherr now provides a stand-alone chamfering solution, using the increasingly popular ChamferCut-method – the LCD 300 ChamferCut. At the EMO 2013 Liebherr introduced a hobbing machine with integrated ChamferCut station – the LC180 ChamferCut. In 2014 the machine portfolio was extended with the LC 300 ChamferCut. Soon the industry need for a separate ChamferCut machine emerged, to replace existing chamfering machines. Liebherr now developed the stand-alone ChamferCut machine LCD 300 to meet these requirements.

Basic idea: quick and simple

The basic design idea was unambiguous: "This machine should be simple to operate and fast", Dr. Hansjörg Geiser, Head of Gear-Cutting Machine Development and Design Engineering at Liebherr-Verzahntechnik GmbH, explains. Using a separate LCD 300 machine enables gears clamping operations to be geometrically optimized for chamfering purposes. Clamping operations for the gear cutting machine can then be performed with maximum rigidity. Both processes therefore generate optimum results. This technology and fast set-up times enables the LCD 300 ChamferCut machine to keep up with the production of roughly two or three hobbing machines.

The result is a machine with extremely fast set-up times and streamlined workpiece clamping. The operator can easily enter and correct ChamferCut process settings via CNC axes. New software was developed for the user interface. This is based on FETTE ChamferCut tool settings sheets. Operators can get their bearings quickly with the aid of graphics and settings correction examples, intuitive guidance makes machine operation easier. ▶



LCD 300 ChamferCut

Good reasons for deburring using the ChamferCut-method

- Fast cycle times
- No reduction in hob length
- Hob and ChamferCut geometries can be selected independently
- Rigid fixture for hobbing, adjusted fixture for ChamferCut
- Very small ChamferCutter diameters possible (>30 mm) with broader applicability
- High quality and precision chamfer shapes
- Hassel-free tooth-root chamfering
- Very long tool lives even where dry machining is involved
- No needle-like chips
- Machine settings via CNC axes with simple set-up
- Lowest chamfering tool costs in comparison
- Tools are easy to regrind
- User-friendly data entry

"This machine should be easy to operate and as fast as possible."

Dr.-Ing. Hansjörg Geiser, Head of Product Development & Design
Engineering, Gear Cutting Machines

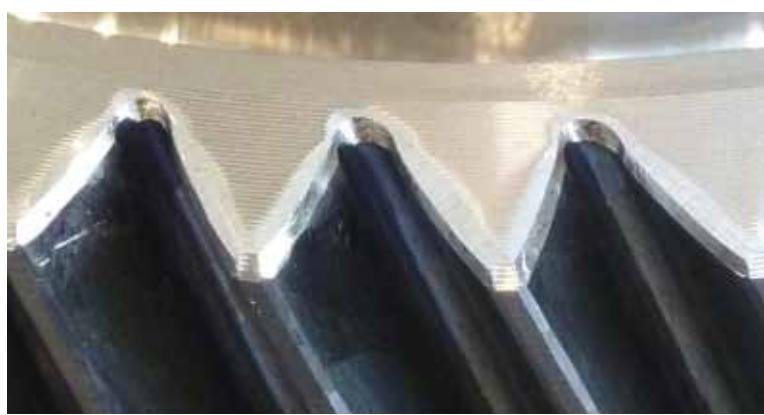
The machine is loaded automatically with the proven ring-loader concept, although the use of robots or gantries is also a possible alternative. This makes incorporation into the automation process flexible, for example via a plastic chain conveyor.

Inexpensive method delivering outstanding results

ChamferCut is growing in popularity compared with press-deburring and tapered-end mills, since this process involves the lowest chamfering costs. The special tools are very durable and simple to regrind. Precision, repeat-accuracy chamfers combined with long tool lives speak for the ChamferCut-process. So it's no wonder that the ChamferCut process has gained in importance over the last few years. Given the high quality it delivers, the process is particularly popular with car and commercial vehicle manufacturers as well as gearbox and engine manufacturers: "Standards in these sectors are naturally very high", Hansjörg Geiser explains. "The increasingly more compact design of gear units makes high chamfering quality an absolute must, which ChamferCut is particularly good at delivering." ■

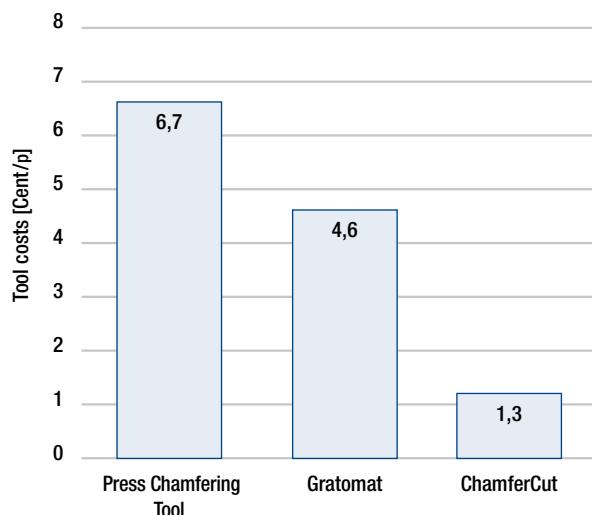


Chamfering formation compared: ChamferCut



Chamfering formation compared: press deburring

Tool costs per piece (Chamfering)



Example: m 2,7 / z 41, Dry cutting, Roughing to honing

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Three brands, uniform quality

Della Ferrera, Lorenz and U.S.P.I.T. gear-cutting tools – made in Italy



Liebherr invested in a new production hall in 2004

Tools for Liebherr machines are not just manufactured in Ettlingen. In Collegno near Turin the production of tools for gear-cutting machines has a long history: The Della Ferrera family business has been making tools since 1956. After Della Ferrera was acquired in 1990 by Maschinenfabrik Lorenz, which was itself bought in 1993 by Liebherr, the Italian plant now produces gear-cutting tools variously branded as Della Ferrera, Lorenz and U.S.P.I.T., after the latter company was acquired in 1997 by Della Ferrera. "These brand names are

established on the Italian market and are well-known for their outstanding quality", Giovanni Della Ferrera, CEO of Liebherr-Utensili (LUT), explains. "We naturally do not want to relinquish this advantage in any way."

In 2004 Liebherr built a new factory in Collegno to produce shaping cutters, shaving cutters, rolling dies, rolling chamfering discs, master gears, rolling racks, rack-type cutters, internally toothed hub cutters, wafer and solid-wafer cutters, clamping and retaining rings. 6000

square metres of factory space accommodate the machinery, in which additional money is going to be invested in the future. "One important target is to optimise our soft machining process and also incorporate a higher degree of automation", is how Giovanni Della Ferrera lists his priorities. Installation of more Liebherr machinery is also planned.

Objective: premium quality

Tools made by LUT are designed to be of premium quality, which therefore requires various machining operations. ▶

After machining and heat treating, grinding machines are then used to deliver a quality enhancement. In this respect the Italian company applies differing grinding techniques and abrasives, depending on the specific workpiece to be machined. All tools are checked individually before and after coating, because cutting edges have to be perfect prior to this operation. To this end both metrological and visual methods are used. LUT targets a final quality grade ranging from AAA (quality categories in line with LIEBHERR standards) to A in accordance with DIN 1829 for all its cutters – the company's best-selling product.

"Quality, service and fast delivery times are key issues for our customers," Giovanni Della Ferrera explains. For express delivery purposes there is always

a stock of heat-treated blanks without gear teeth in standard sizes of four and five inches available, meaning modules sized from two to six millimeter can be manufactured very quickly as required. "Many customers use this service to produce prototypes." An additional service is sharpening and recoating, which is popular with many customers.

Italy is Europe's second largest gear-cutting machinery market. The heart of Italy's gearing industry, especially the automotive sector, beats in the region between Turin and Bologna in particular. Fiat, Bugatti, Iveco, Lamborghini, Ferrari and many other brands are based here and plenty of subcontractors are clustered in the vicinity. From here Liebherr also serves the French market, because LUT is Liebherr's sole subsidiary in

Southern Europe. Peugeot PSA is one of LUT's largest customers in France.

Second mainstay: The Liebherr representative office in Italy

LUT has been responsible for a further business activity since 2013 – sales of Liebherr gear-cutting machinery in Italy. A team of four looks after customers – Luca Lanzetti and Marco Rausa in field sales and Luisa D'Alto and Francesca Fatiga in the office. "Italy is Europe's second largest gear-cutting machinery market and Italian manufacturers are very loyal customers", Giovanni Della Ferrera relates. Liebherr has an excellent reputation in Italy. Small and medium-sized businesses, with to some extent a huge innovation backlog, dominate this extremely fragmented market. "Given rising quality standards, we



The team of Liebherr-Utensili S.r.l.



Quality control at the highest level

anticipate that many small firms will need to invest if they want to survive. Many work with reconditioned old machines, which barely meet modern requirements."

Liebherr provides its customers with a full delivery and after-sales service. Italian companies really appreciate having a point of contact in their own country. "Direct communication gives the customer peace of mind", acknowledges Luisa D'Alto, who is responsible for repairs and servicing. She organises the after-sales service in Italy and liaises with the plant in Kempten, for example to handle ordering of spare parts. ■

Liebherr-Utensili S.r.l.

LIEBHERR

Company size:	90 employees
Founded:	2004
Headquarters:	Collegno, Italy
Total area:	12,000 square metres
Built-over area:	7,200 square metres
Website:	www.liebherr.com

Lorenzo Gambino

Sales-Contact for Gear Cutting Machines



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Luca Lanzetti

Sales-Contact for Gear Cutting Machines
in northern Italy and the Piedmont



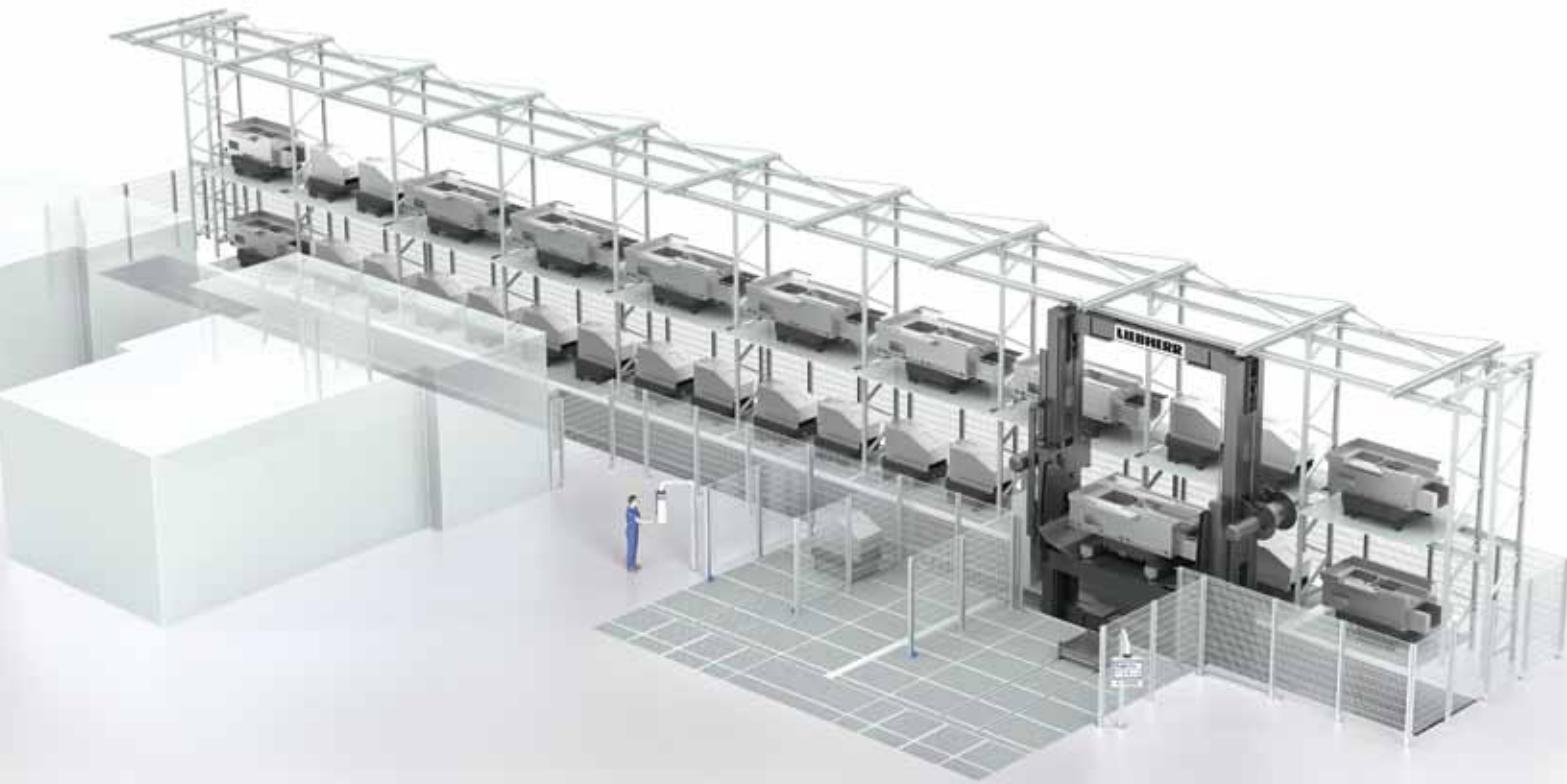
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The new Liebherr PHS 10,000 – for heavy-duty applications

The process dictates the tempo

The PHS 10,000 delivers effective automation for small batch sizes – even for heavy-duty applications

Small-batch manufacturers are familiar with the dilemma: "When set-up and run times do not harmonise well machine downtimes increase". Added to that are distances covered during retooling, which entail considerable inputs of time and logistics efforts. Yet this problem can be solved by separating the set-up station and machine. This set-up station is embedded in Liebherr's proven PHS pallet handling system. Jobs can be set-up in this station while the machine is free to keep cutting parts. Stefan Jehle, Head of Automation Systems Sales, exaggerates the principle involved as follows: "Humans need to take control back from machines. At the moment it is often the machines, as conductors of the orchestra, that dictate the tempo. A smart automation solution enables the process to determine the rhythm at which any machine operates

to capacity. The conductor's rostrum is at the set-up station, where the human operator waves the baton."

In reality things then look like this: by using a resource management system an employee can check whether all the required tools, software and other resources are on-site at a stand-alone set-up station hours before actual machining. Other workpieces can be machined during this provisioning and preparation process. If enough workpieces have been prepared and placed in the intermediary storage facility, even unmanned shifts can be worked. An automation system featuring a stand-alone set-up station can be intelligently controlled, meaning two machines operating more efficiently can do the work of three. "Backed up by a smart cell control system, which han-

dles job planning and resource management, unit costs can be reduced by more than 20 percent", Stefan Jehle reasons.

Safe, simple logistics for heavy-duty applications

From a heavy-duty applications perspective, this system is very likely to be of particular interest to manufacturers. Liebherr has now created a hardware category (the PHS 10,000) with a payload capacity of up to 13 tons, and even 16 tons are an option for special-purpose applications. Demand for such systems is increasing worldwide, especially in this segment, in particular power generation using wind turbines, diesel / gas turbines or hydro plants and pumps for the crude oil or gas industry. The components used in these systems are getting increasingly heavier and larger. Automation is therefore a must-have.



Carriage of the PHS 10,000

Employing an automation system also dramatically simplifies the logistics involved in handling very large components, such as those just mentioned. Heavy pallets with jigs or equipment that in some cases weigh over ten tons have to be conveyed to and from the appropriate machine. That requires complex logistics in a conventional manufacturing environment that does not feature a pallet handling system. If all components are integrated into such a system, transfer routes using cranes and forklifts can be dispensed with. The system therefore ensures operator/user safety and component logistics reliability. Furthermore, given their complexity, many workpieces require several different clamping operations, which complicate the logistics tasks that have to be performed. The same benefits can also be applied to the workpieces. If the system is supplemented by workpiece logistics, the same applies here: workpieces are conveyed safely and reliably from A to B, operators are exposed to fewer hazards and the logistics space required is less.

Proven technology from the Liebherr Group

"In terms of heavy-duty applications in particular, Liebherr systems are able to draw on skills and know-how available within the Liebherr Group as a whole", Stefan Jehle explains. Cable technology and specific components represent a core Liebherr

Group skill that has been proven over the course of many years and are rapidly available. "These systems are extremely compact and energy-efficient", the automation expert acknowledges. The tensile forces of the cables in particular facilitate efficient carriage hoist system operation by applying the pulley effect. The size of the motor can be drastically reduced compared to chain drives, for example, meaning a very reliable and hard-wearing hoist system featuring standard motors can be used. Synchronisation of both drive ends is handled by gantry-operation Siemens servo motors in combination with an independent odometer system. "This therefore delivers synchronous hoist motor operation as well as automatically offsetting any cable elongation", Jehle explains. ■

Stefan Jehle

Sales Director Automation Systems

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Turns old into new

Retrofit is a course of rejuvenation treatment for automation systems

The various components in automation systems age at different rates – whilst mechanical components are robust and made-to-last, control elements reach the end of their service lives considerably faster. Operators of automation systems have to react in good time, otherwise their entire plants are at the risk of stoppage. Liebherr therefore provides a particular service called "Retrofit" which enables old systems to operate with new controls – and provides all the benefits that go with state-of-the-art technology.

When production lines are in operation for one or two decades, it is often individual components that break down. Computers or other control units, which are no longer state-of-the-art and which are often no longer of any use, are usually affected. However, since the mechanical components generally still function properly, it makes sense both from a financial and a sustainability perspective to install new control technology in the existing system.

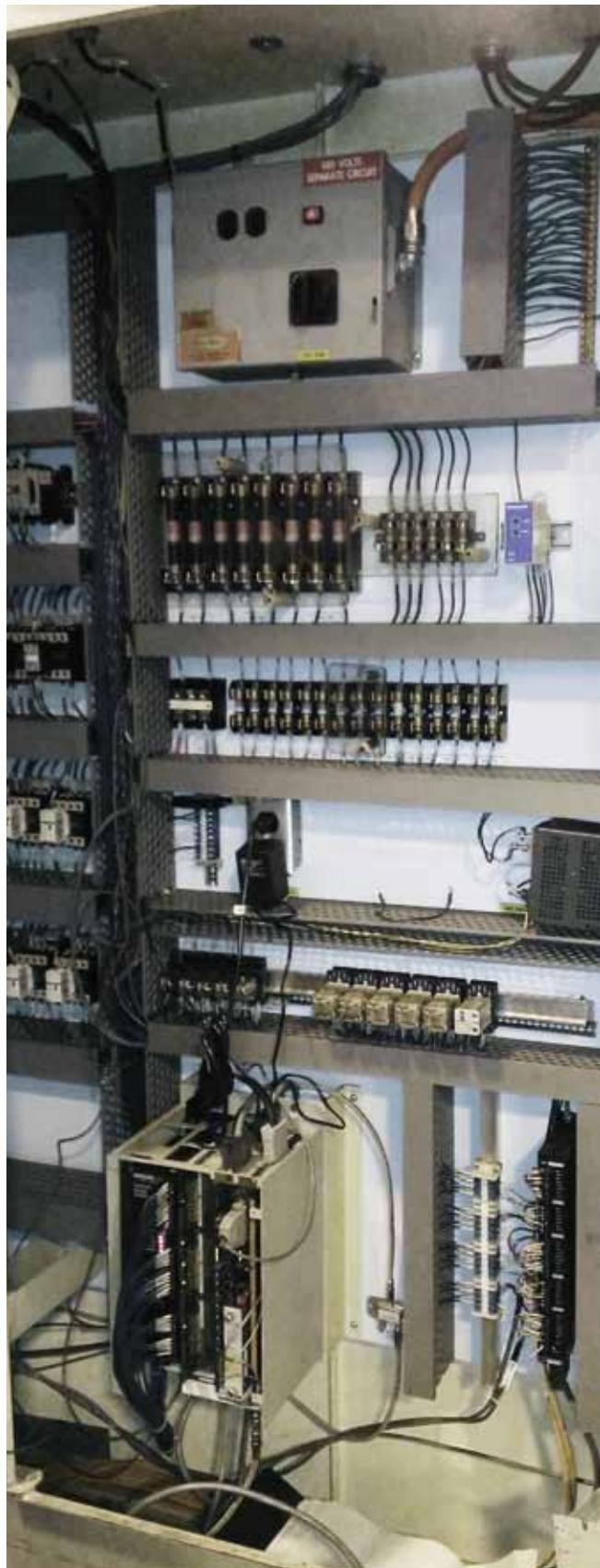
"The ramifications of such a course of rejuvenation are manifold"

Uwe Radigk, Key Account Manager for Automation Systems

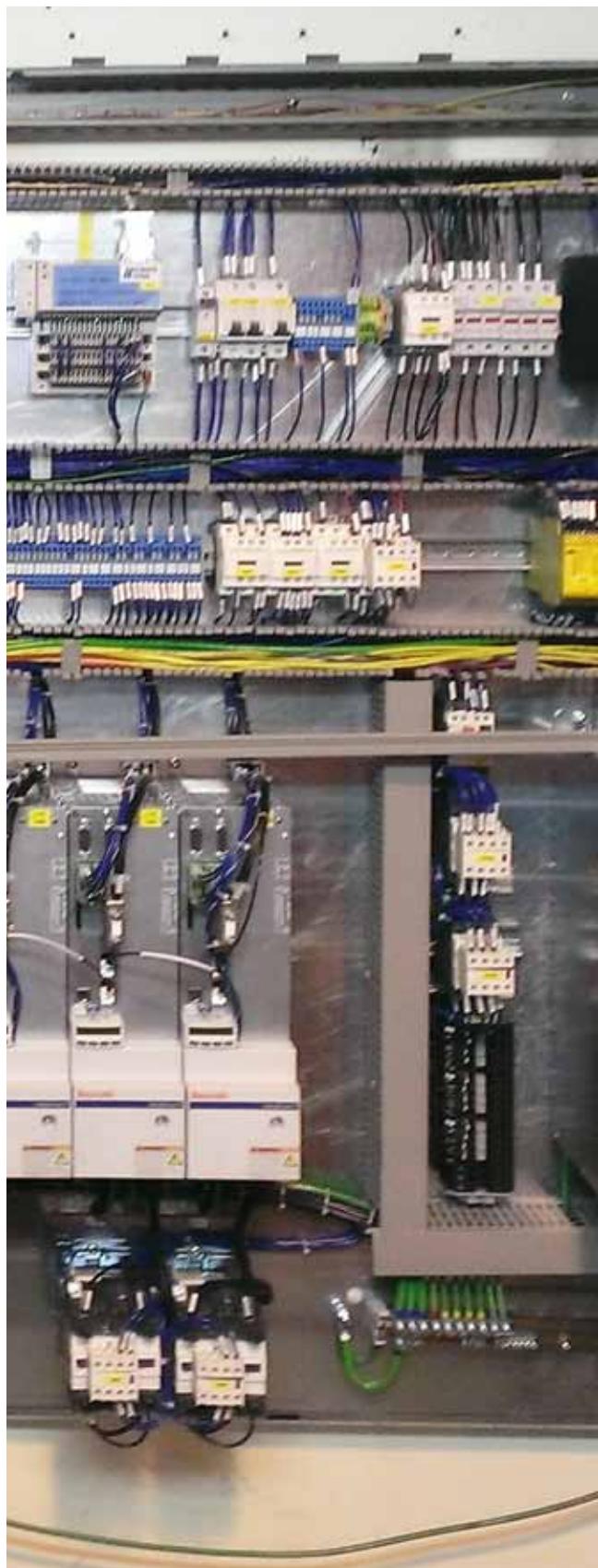
Two possible options

"Liebherr offers two alternative procedures here, both labelled "Retrofit", Uwe Radigk, Key Account Manager for Automation Systems, explains. Option 1 involves the entire control cabinet, including operator controls, being replaced. "Option 1 works like plug-and-play on a computer", is how Radigk describes this approach. "We simply replace the old control system, in its entirety, with a new one in no time at all. We configure the technology in the factory and deliver it ready to use, meaning production can generally be resumed after a weekend break for installation." This solution is quick, but comparatively expensive.

In the somewhat cheaper second option the old control cabinet is not completely replaced, but is augmented by adding the new control system with the aid of a pre-configured hard drive. This can also be the best option if the control cabinet can not be entirely replaced, given the existence of relay



Before ...



... after

Benefits at a glance

- State-of-the-art control technology
- Linkage to current PC technology / IT peripherals
- New data collection and transfer opportunities
- Replacement of wear-and-tear components
- Convenient, modern controls
- Renewed warranty
- Range of different options

circuits. Since this approach involves significantly greater wiring time and effort, it takes correspondingly longer to complete. Both options involve the replacement of motors and gearing in addition to control systems – and that's the full Retrofit package.

Positive impact on productivity and quality

"The ramifications of such a course of rejuvenation are manifold", Uwe Radigk explains. "These modern technological retrofits significantly increase the system's reliability, enables higher numbers of cycles to be achieved and subsequently delivers genuine value and quality to the customer." Updates are also accompanied by a new level of operator convenience – operators are trained and kitted out with up-to-date user interfaces offering a range of new opportunities and benefits such as improvements to system availability. This rejuvenation treatment also has an impact in data transfer terms – it facilitates data transfer and documentation that would not have been feasible 20 years ago. Furthermore, this rejuvenation brings the new standards of system and operator safety to the production system.

Liebherr is opting to provide a sustainable after-sales service, which combines automation solution longevity with outstanding customer care. For that reason the company offers an additional "Wellness Check" to go with Retrofit. Roughly every second Retrofit customer makes use of the this extra general overhaul service, which involves putting the entire system through its paces, replacing wear components and culminates in the issue of a new warranty certificate. "You almost have a system that's as good as new", is how Radigk describes the results of the check-up. This offering is particularly popular in the vehicle manufacturing industry. ■

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Focus on the operator

Intuitive control system for robot cells

Robot cells are often positioned at the start and at the end of production lines. Liebherr, acting as a turnkey provider of automation technology, has been designing and developing bin-picking systems since 2010. A patented eight-axis system enables transportation bins to be emptied to an optimum level of efficiency. Operation previously required knowledge of source-code programming. Liebherr has now simplified the control system to create as large a group of potential users as possible: "Our new graphical user interface takes data entry to a whole new level. Setting up the bin-picking system is therefore substantially simplified, making the workpiece teach-in process considerably easier", Thomas Mattern, Head of Automation Systems Development at Liebherr-Verzahntechnik, explains.

The user sees "his" workpieces and transport bins and the gripper settings on a touchscreen. He is guided through optional and required settings very intuitively, which makes data entry faster and more reliable. Troubleshooting has also been enhanced. Clear functions ensure that users get familiarised faster with the system. That reduces the training requirement.

Robot cells represent only a fraction of Liebherr's automation spectrum. If required Liebherr provides turnkey integration of fully automated manufacturing systems. Your one stop solution partner who can design and manufacture complex systems containing input and output cells, belt or track automation,



A robot arm picks up every single workpiece

gantry systems, buffers, loading and pallet handling storage systems as your process demands. Additionally no system is complete without the data management requirements in quality tracking, production management and machine performance metrics just to name a few. Liebherr routinely integrates technologies such as part marking (pin-stamp or laser) and data readers, cameras, scanners or RFID tags to safely track all your manufacturing data. Liebherr is thus in a position to provide the entire automation chain from a single source.

Definite trend towards automation

"In many areas bin-picking is the last step in the process that has not yet been automated", Thomas Mattern explains. "Yet here too a definite trend towards a higher degree of automation is discernable, not least because of occupational health and safety regulations. People can no longer be expected to cope with the constant stress associated with faster cycle times." ■



Robot cells offload daily staff workload

Dipl.-Ing. Thomas Mattern

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England's Pride and Joy

Liebherr automates Jaguar

Jaguar Land Rover opened its engine plant at Wolverhampton in the English Midlands in November 2014. A milestone for the UK vehicle manufacturing industry – after a generation a British vehicle manufacturer had finally repatriated engine production back to the UK – and this time it features a Liebherr automation system.

The automotive group invested around 500 million Pounds Sterling (634 million Euros) in its new plant. The first engines to roll off the production line are a 2-litre diesel and a 2-litre petrol engine for the mid-range Jaguar XE sports sedan.

Linking manufacturing stages

The machinery used has the job of delivering engine quality, whilst Liebherr automation systems are responsible for ensuring seamless production processes. Engine blocks, cylinder heads and crankshafts are produced and assembled in the new plant. Jaguar's engineers had very clear ideas about

each individual manufacturing stage and the machinery to be utilised for each stage. Liebherr's brief was to link all these stages, so that the end result is a fully automated manufacturing capability, operating at the required number of cycles.

"Every machine that is used for manufacturing purposes has different requirements that have to be matched to the material handling systems in each case", Stefan Sattelmayer, Automation Systems Sales Executive at Liebherr-Verzahntechnik, who headed up the project, explained. Machine tools and assembly machines from five or six different manufacturers are involved in the cylinder head and engine block manufacturing processes. A greater automation challenge is posed by the crankshaft production process, in which machines from around 20 different manufacturers have to dovetail – including a shaping machine made by Liebherr, which shapes a sprocket on the crankshaft. ▶

Specific customer requests actioned

"Jaguar Land Rover specified the broad framework, and we then handled fine-tuning and designing the process chain", is how Stefan Sattelmayer describes the scope of the task. Liebherr designed the automation cells to feature loading gantries as well as workpiece loading and unloading stations. "Even if engine component production sequences always have a similar structure, there are major differences in terms of detail. E.g. our customers have very specific perceptions as far as the feed-out and feed-in of workpieces for quality control purposes. Such things are difficult to implement and always have to be customised", Stefan Sattelmayer relates.

Liebherr has built up a huge wealth of experience and can provide expert advice on these issues. The tact cycles specified by the customer are pivotal when it comes to design-engineering the production sequence. If a component needs to travel very fast from A to B, a fast NC-axis is certainly preferable to a pneumatic one. However that in turn drives up costs – therefore such issues of detail have to be factored in and discussed from the very beginning. The same applies to simple things like gripper designs and physical layouts, such as the position of the control cabinet etc. "So many different interests have to be accommodated in a design and planning project of this kind", project manager Sattelmayer recounts.

"That's why we had to have a lot of conversations from the get go and get all those parties involved on board." It was a major benefit that in this case a completely new building with a generous amount of space was available.

Loading gantry solution in operation

This project uses the LP 20 loading gantry for crankshafts and the LP 200 for engine blocks and cylinder heads, additionally the crankshaft production line features a Liebherr-branded plastic chain conveyor. This allows the workpieces to be transported safely and cushioned against possible damage between the machining stations. Laser marking stations and other Liebherr peripherals are also in operation. Every workpiece can be tracked at any time by virtue of its laser marking. For machining purposes, engine blocks and cylinder heads are fastened to adapter plates, which are also given a reference number and can be tracked. Interfaces and data transport are also part of the full package.

Safety and prevention of operating errors is always the focus at the design and planning. Ideal processes are those that do not allow human operators to "take shortcuts". If operators attempt to outfox the system, this inevitably leads to imponderables and often results in hazards. Such situations have to be anticipated and preempted as early as the planning stage. ■

Components used

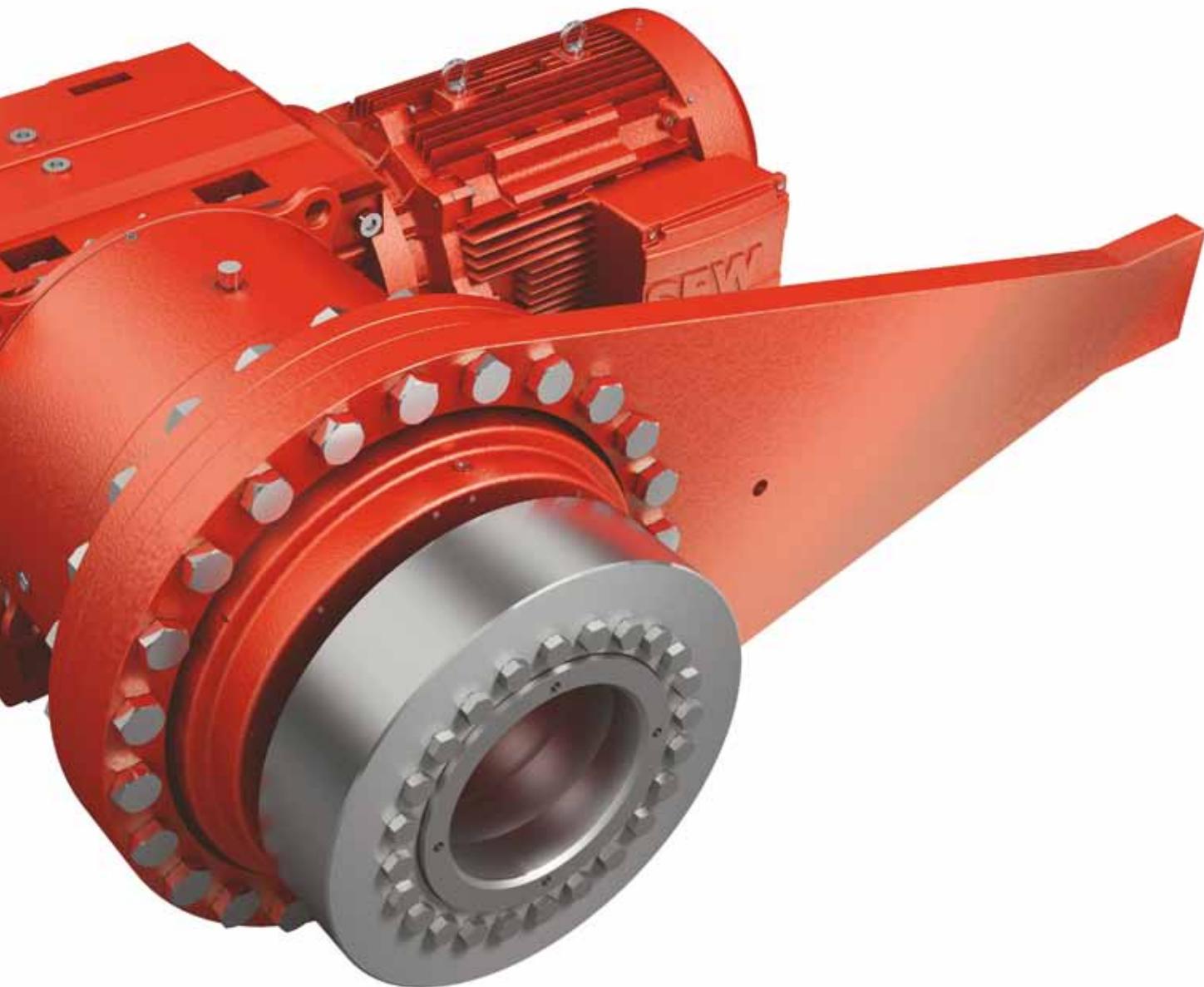
- LP 200 and LP 20 gantries
- Unloading stations
- Loading stations
- Rotating stations
- Visual inspection station
- Camera station
- Pass-throughs
- Adapter fitting station
- Laser marking stations
- Robot integration
- Component tracking
- Plastic chain conveyors
- Pallet handling systems



Jaguar XE

Partnering for mutual benefit

Variable gear units based on a modular system are SEW's speciality



Easy to distinguish: SEW gear typically red vernished

SEW-EURODRIVE has been providing drivetrain solutions for more than 80 years and has been manufacturing gear units using Liebherr machines for around 40 years. "Yet production is not the only key issue", Otto Steinbach, Head of Gear Manufacturing at SEW's Graben plant, emphasises. "We

enhance and refine the machinery in close cooperation with our partners. Both sides benefit from this approach – Liebherr is able to get its machines up to speed in terms of application maturity and therefore practical use. We can incorporate our needs into the machine concept." The first CBN generating ▶

grinding machine to be installed in the production facilities was a Liebherr – and that was one of Otto Steinbach's first projects. "Since that project I have got to know and rate Liebherr as an innovative partner providing creative solutions."

Innovation is the most important driving force in manufacturing, Stefan Rimmelspacher, Head of Large Gear Manufacturing, explains. "Short delivery lead times are an essential factor for our customers. Our level of vertical integration enables us to score points especially in speed of reaction terms. Where other manufacturers have to wait on a particular supplier, we are already in a position to deliver the complete gear unit." SEW-EURODRIVE produces gear units based on a modular system – fit-for-exact purpose gear units can be produced in a huge range of different versions from a relatively manageable range of components. The proportion of made-to-specification gear units, especially as far as large gears for industrial applications (production started in 2008) is concerned, is however very high. Only every fifth gear unit is based solely on the modular system, all the others require specially made individual components, often in batch sizes of one. Nevertheless a state-of-the-art factory with a 20,000-space high-rack storage facility makes efficient manufacturing feasible, even if quantities are minuscule.

Large gears require particular modifications

Industrial gears are – compared to the rest of family-owned business SEW-EURODRIVE's 80-year history – still a recent

business activity. In 2008 a state-of-the-art factory for large industrial gears was built at the company's Bruchsal site. Port cranes and deep or opencast mining machinery are equipped with these gear units. The company's product portfolio includes bevel gears, helical gears and planetary gears. "We use an LC 600 for gear hobbing, an LFS 700 and 800 for gear shaping as well as several LCS 700s for gear grinding", Stefan Rimmelspacher catalogues. "Implementation requires several modifications to be made to accommodate our exceptionally large and immensely heavy workpieces. Handling these to high drivetrain engineering quality standards is a major challenge for any machine tool manufacturer. Using a new workpiece table for the LCS 700 generating grinding machine has enabled us to halve machining times." Here SEW-EURODRIVE's practical experience was incorporated into the design and development of Liebherr machinery. A heavy-duty conveyor, better able to cope with the workpieces, was also employed.

"Retooling times are absolutely critical as far as small batch sizes are concerned", Stefan Rimmelspacher emphasises. "Liebherr takes that fully into account." Another key factor is consistently good quality of results: where batch sizes of one and very expensive materials are involved, defective output must be avoided as far as possible. "That's why we use Cubitron II for grinding purposes. That lessens our dependence on the quality of previous procedural steps. We derive constant gear-



Large Gear Manufacturings are always made-to-specification gear units

grinding process quality. SEW uses an LC 380 to hob planets and small modules for industrial gear units. "Liebherr's modular clamping concept makes the use of these machines an attractive option for us." The LC 380 and the LCS 380 are used for planetary gear unit purposes. An LFS 800 (manually loaded) and an LFS 700 (fully automated) are also in operation. They use shaping blades with indexable cutting inserts to rough-shape large gear rings. "The shaping blades enable us to make 30 percent time savings", says Rimmelspacher. Liebherr machines can machine ADI gear rims. "That is not a particularly pleasant material to machine, yet it is a superb material for gear units."

Mass production team rates training and workshops highly

SEW produces serial-standard gear units in large quantities at its Graben site. The factory produces around 200,000 gears a month on over 100 machines. Pinions, worm gears, jaws (couplings), pinion shafts, wormwheels as well as large and small gearwheels come off the production lines here. Liebherr generating grinding machines, for example, are used in this factory – an LCS 380 grinds using Cubitron II. A centrifuge with an SEW motor is attached to the generating grinding machine to free the workpieces of machining oil. Depending on the particular workpiece, the Liebherr machine determines the rotational speed of the centrifuge, which means that 80 percent of the oil can be recovered and reused. A special solution from Liebherr and SEW, which goes easy on the environment and resources.

Yet it is not only Liebherr machinery that is highly rated in Graben, SEW-EURODRIVE is also very keen on using the training and customer care services provided. "Regular training is very important, especially in serial production", Otto Steinbach emphasises. He is also delighted to accept offers of on-site technical training. "Manufacturing needs to continuously improve and speed up, therefore employees need to keep pace with the times", is his motto.



Stefan Rimmelspacher (left), Head of Large Gear Manufacturing and Otto Steinbach, Head of Gearwheel Manufacturing in Graben Plant

Liebherr's customer care service is also greatly appreciated. SEW-EURODRIVE itself offers a 24-hour service in local languages and is therefore reliant on partnering with service-focused companies. "In this respect we have only had good experiences with Liebherr", Otto Steinbach relates. "We can rely on fast reaction times to enquiries. All joint projects are well-mentored and supported beyond actual machine installation." ■

SEW



Industry:

Automotive, Beverages and liquids, Transport and logistics, Airport baggage handling, Building materials and glass, Wood processing and more

16,000 employees worldwide

Founded: 1931 by Christian Pähr

Headquarters: Bruchsal, Germany

Places: Four plants in Germany, 79 branches worldwide

Jürgen Bickel (President), Johann Soder, Dr. Jürgen Zanghellini

Managing directors: www.sew-eurodrive.de

Website:

Liebherr machines at work: Gear hobbing, gear shaping and gear grinding machines



Superb communication delivers success

Liebherr-Hausgeräte: new packaging facilities reduces burden on employees

Liebherr-Hausgeräte Ochsenhausen has for a long time been planning the upgrade to its packaging facilities. Needs in effective process flow within the building presented a welcomed reason to act on these plans. Three objectives needed to be achieved: improved packaging quality, cost reduction and lower employee workload. Because packaging refrigerators is a demanding task from an ergonomic perspective. Up to now Ochsenhausen employees filled up cardboard-box storage cubicles manually and even slipped cardboard boxes over the appliances by hand – activities that put a lot of strain on shoulder and elbow joints. It was therefore high time to roll out a system to ease the burden and to ensure the health of all our employees.

Furthermore, Liebherr-Hausgeräte wanted to enhance the quality of its packaging process. Since these improvements to the

new packaging line went into operation, every appliance is now wrapped in dust-cover sheeting before being packaged in a cardboard box. This precise automated process of slipping cardboard boxes over appliances cuts out human error during packaging. The cardboard jacketing also remains undamaged and the products are properly secured for shipping purposes, which in turn lowers cost.

Allowing for existing building structure

Building regulations and restrictions limited planning flexibility for the new packaging line. Liebherr-Verzahntechnik eventually altered the entire layout design, originally planned for a newly constructed facility, to a layout that would accommodate installation into the existing building. "Overall space was very limited. For example, we had to factor in certain ceiling construction details. In several places there were

beams, which restricted gantry travel. But dealing with such issues is our day-to-day business, because automation solutions are not just created in a vacuum", Thomas Mattern, Head of Automation Systems Development at Liebherr-Verzahntechnik GmbH, explains. The problem of low factory building height was solved using a dual-telescopic design. This delivered the necessary degree of gantry travel at a significantly lower building height.

High number of cycles – wide range of different models

The varied output of the production lines in Ochsenhausen also required an appropriately flexible system to package individual refrigerators. Benjamin Maucher, in charge of the project at Liebherr-Hausgeräte Ochsenhausen GmbH, explains: "At this plant we manufacture a wide range of different cooling appliances. The



Fully mounted devices are ready for packing



A dust-cover sheeting offers protection



A robot takes the folded cardboard box

packaging line has to be flexible enough to cope with this product diversity. It has definitely met our expectations in that respect."

The plant's global production demands a daily output of more than 7000 appliances. "Reliability requirements were particularly stringent", Thomas Mattern relates. "Since this is an integral part of the ongoing production process, we can't afford to make any mistakes, because a refrigerator arrives every twelve seconds. If something fails, then the entire production facility grinds to a halt." The reliability demands we typically see and deliver to other industries such as in automotive production systems were nothing new to our specialists.

Various sizes of cardboard packaging are stored folded in special cubicles positioned along the 40-metre packaging line. A loading gantry travels above these cubicles, selects the appropriate cardboard box in each case and then hands it on to a robot handling system at the start of the actual packaging stage. This robot handling system then slips the cardboard box over the pre dust cover wrapped refrigerator. Once boxed, the packaged is labelled. Finally, a station secures and closes the cardboard boxes using strapping tapes and then product is ready for shipping.

Constructive comprehensive collaboration

Given the high degree of product diversity, various cardboard box sizes are required to be quickly available and automatically retrievable on demand. "That's why a gantry solution was the obvious choice. In addition to the key issue of 'costs', Liebherr-Verzahntechnik also made a persuasive case as far as speed was concerned", says Benjamin Maucher, adding: "Initial ideas were all generated internally by the production planning team and were then agreed with the suppliers. Without the know-how of the suppliers and superb communication between all those involved, we would never have been able to provide a solution to this project."

As general contractor Liebherr provides full solutions, consisting of its own components and those made by special partners. "We are the central point of contact for our clients", says Thomas Mattern. "Our deliverable as general contractor includes coordinating interfaces, especially when different suppliers are on board." One of those partners was Schliebach-based Ernst Friedrich Heuer GmbH. They developed a gateway function for transferring the different cardboard boxes from the storage cubicles to the gantry, matched to the specific low-space-requirement at the facility.

Clean interfaces

Overall there are two effective interfaces responsible for the success of this project. On the one hand you have the people mentoring the development and implementation process, and on the other the systems supplied by the partners involved, which dovetail so well: Liebherr-Verzahntechnik's gantry, Heuer's storage cubicles, FPT Robotik GmbH & Co. KG's robot cells and J. Schmalz GmbH's gripping system for cardboard packaging.

Benjamin Maucher is very satisfied with the results: "Communication between all parties involved was excellent. If something needed to be clarified, the issue was dealt with uncomplicatedly and quickly. As project manager I also regarded it as important having Liebherr-Verzahntechnik as the central point of contact, because that makes communication a whole lot easier. This solution has enabled us to find a cost-effective way of investing in the health of our employees." ■



Robots slip cardboard boxes over the appliances



Ready packed refrigerators on their way to the logistics center

When cylinders wear masks

Exceptional standard of automation for an award-winning technology

Technology leadership is what Mercedes-Benz aspires to, and the company underlines that by investing huge sums of money in research and manufacturing. It is indeed reaping the rewards of success – the vehicle manufacturer won the “R&D 100 Award” together with Nürtingen-based Gebr. Heller Maschinenfabrik GmbH for its NANOSLIDE® cylinder coating technology – one of the 100 most important high-tech innovations in 2014. NANOSLIDE® is an innovative process that reduces combustion engine fuel consumption and therefore CO₂ emissions. Liebherr planned and supplied the automation systems to enable this technology to be rolled out in mass production applications.

Four and six cylinder diesel engines are manufactured on the production line in Untertürkheim, which was kitted out by Liebherr. One of the features of the crankcase is a thermal coating on the cylinder bore, which delivers longer and quieter engine performance. Using the twin-wire arc spraying technique, the inner surfaces of cylinders in aluminium crank-

cases are given an extremely thin iron/carbon alloy-based coating. This delivers a nano- to ultrafine, extremely non-wearing material structure with micro-porosity properties. These ensure optimum lubrication of piston assemblies and enable heavy, multi-millimetre-thick grey cast-iron cylinder liners to be dispensed with in aluminium cylinder blocks. The result is a mirror-like surface with up to 50 percent less friction between pistons, piston rings and cylinder linings, as well as weight savings of several kilograms. Since up to a quarter of fuel energy is used to combat in-engine friction, particularly in part-load range terms, the new technology achieves fuel consumption savings of several percent.

Delicate process

This technology is regarded as extremely cost-effective and technologically superior compared to other thermal coating methods. During the actual coating process all the parameters that have an impact on quality, such as current, voltage, wire feed and process gas flow have to dovetail with



A cup mask prevents the coating from being sprayed in the wrong places

each other and with the coating process, according to the experts at Heller. "This coating posed a considerable challenge as far as the automation system was concerned", project manager Stefan Sattelmayer from Liebherr Automation's sales team relates. The workpieces are brought into the highly sensitive and therefore partially enclosed coating facility on a friction roller conveyor. The surface to be coated is initially roughened and then cleaned using compressed air. From this point onwards the section of the workpiece to be coated is so sensitive that even a fingerprint would render the workpiece unusable. Therefore a measuring device initially verifies whether the surface meets the requirements.

The next step involves a Liebherr robot cell grasping the component and transferring it to a furnace to be heated up. After that the heated component is transported by the robot to the Heller coating machine. A so-called cup mask is initially fitted by the loading gantry. This prevents the coating being sprayed in the wrong places. One (cold) mask per cylinder has to be precision-inserted at minimum clearance to the (hot) cylinder rim – a process that represented a real challenge in terms of getting the required timing for mass production just right. "The process had already been proven where small batch sizes were involved, but we had to plan and test the process very thoroughly for large quantities. Thereafter the client's employees were given thorough training on the equipment to enable them to actually utilise this sensitive but highly effective process from SOP onwards." ■



Friction roller conveyors discharge heavy and damageable parts

Efficient small batch production

Contract manufacturer Berger opts for Liebherr's Rotary Loading System (RLS)

Small batch production automation poses particular challenges in terms of work processes, logistics and availability. The Berger Group has reacted to the markets' increasingly more stringent requirements – by rolling out Liebherr's Rotary Loading System (RLS) at its plant in Wertach, Germany. This now enables the contract manufacturer to meet customer needs more flexibly, quickly and cost-effectively.

"The markets have become faster-paced", explains Armin Berger, who has been head of production at the identically-named company for around 18 years. "That is why we have to keep on adapting more and more quickly to changing market circumstances." The concept applied in the past served its purpose but there was still room for optimisation. The issue of a suitable automation solution had to be raised.

A key reason for this: the components to be manufactured – complex components for innovative hydraulic power units – feature different bore and threading finishes and are therefore available in a wide range of different versions. Even the manufacturing process itself is challenging.

More flexibility thanks to the Rotary Loading System

Staff at Berger's plant in Wertach, which manufactures components predominantly for mechanical engineering firms, spotted the potential which a suitable automation solution could provide. The company decided to opt for Liebherr's Rotary Loading System (RLS) to meet its small batch and single-item production needs.

Featuring up to 24 storage bays the system has an outstandingly high storage density per footprint at low space requirements. Furthermore the design of the storage module allows another machining centre to be docked on. That ensures the required degree of flexibility in the future too. Given its modular design, this automation facility can be matched to current production needs in

no time at all. The two installation sizes, RLS 800/RLS 1500, cover a wide range of applications. Berger specifically operates an RLS 800.

"Our focus above all was on reducing expensive set-up times. We needed to significantly extend our machine-side tool storage capability", explains Philipp Schneider, Head of Department at this



The integrated set-up space is located right next to the operator's side of the machine

branch of the group. Thus the tool storage was upgraded upon request from 80 to a total of 320 spaces. Furthermore the modular, flexible-configuration rack columns were designed to enable even customer-specific requests to be promptly met.

Cooperation in both directions

Handpicked Liebherr specialists took responsibility for implementing the system. The equipment featured an all-purpose design, to provide as much flexibility as possible. During the period when the RLS was integrated into the existing solution, Liebherr worked closely together with the milling machine manufacturer, Heckert. Together the two companies sorted out the interface issues between both systems. Close contact is still maintained between the Wertach plant and the Liebherr team.

Another important point is that operators like working on the RLS. Because the integrated set-up space is located right next to the operator's side of the machine, a lot of unnecessary back and forth movement can be dispensed with. The system's special design enables users to access the automation details easily. The surrounding window panels in combination with the well-laid-out user interface provide an overview of what's happening in and around the RLS. Through the intuitive-to-use cell controller software and the graphic user interface the required functions can be conveniently activated via 'drag and drop'. The software, like the entire system, features a modular design. A range of different add-on packages can be hitched onto the basic package to enhance functionality. Liebherr can therefore supply new applications to deliver process reliability – without having to specifically modify the exiting computer system.

Set-up times significantly reduced

The switch to the RLS for small batch production is paying dividends for Berger, particularly in terms of efficiency, customer focus and delivery capability. Given its newly acquired flexibility, the company



Pallet handling system RLS 800 for up to two machines

is therefore able to react immediately even to really short-notice changes in demand. Customers are supplied on time with exactly the models in the quantities they require and are therefore capable of reacting faster in changing market situations.

The RLS has also reduced set-up times significantly. Process-chain optimisation facilitates improved planning reliability and therefore a more targeted use of resources. The operator can use the machine's run-time to complete other production tasks – set-up costs are therefore not absorbed in machine-hour rates. Even an unmanned third shift would be feasible. Another effect of this changed production philosophy was that Berger was able to reduce its inventory. On balance one can say that this acquisition is likely to have paid for itself within a comparatively short period. ■

Berger Group



Industries:

Automotive, hydraulics, textile, electric and electronic industries, power tools as well as mechanical engineering, plant construction and other industries

Company size:

2,400 employees in twelve plants in five countries

Founded:

1955 by Alois Berger

Headquarters:

Memmingen/Allgäu, Germany

Places:

Germany, Poland, USA, Canada and China

Managing directors:

Karin Berger-Haggenmüller, Oswald Berger

Website:

www.berger.de

Machines at work:

Machine pool with over 800 machines/facilities



Alois Berger, company's founder

First-class spare parts made in Italy

Euroricambi supplies the truck market with first-class gearboxes and spare parts

When a truck gearbox malfunctions, the truck's owner has the agony of choice – a large number of manufacturers offer spare parts at different pricing and very different quality levels. One of the biggest providers in this market is Euroricambi, based in Bologna/Italy. The company has the broadest product portfolio, at nearly 7,000 individual components, gearboxes and differentials for nearly all European and many US brands. The company's own aspiration is not quantity but technological leadership in particular. "Our main objective is customer service excellence", President Pierluigi Taddei, son of the company's founder Orazio Taddei, emphasizes. "We provide immediate availability from our warehouse, a fast and efficient logistics service, competitive prices and standout quality on the spare parts market." To ensure quality, Euroricambi is constantly investing in state-of-the-art technology. "Our strategy has always been to invest continuously and keep pace with the times. You are only successful in the long term if you offer really good products that keep your customers satisfied."

It is precisely this quality and technological leadership aspiration that makes Liebherr gear-cutting machines so interesting. When the company decided to invest in new gear-hobbing machines around ten years ago, it opted for Liebherr for the first time. "From our point of view two criteria tipped the scales", Pierluigi Taddei recounts. "On the one hand there was the very flexible ring-loader system, which provided us with major benefits. On the other hand the LC 300 enabled us to hob larger workpieces. Collectively this greatly increased our flexibility." Given the large number of different com-



ponents that are mostly manufactured in small batches of between 50 and 300, set-up times and significant workpiece size range are key factors for the Italian manufacturer. This enables faster and more flexible manufacturing. The first Liebherr machine did such a convincing job that the company has now ordered its 20th machine. Euroricambi's assemblage of fully automated machinery totals eleven gear hobbing machines, six gen-

erating grinding machines and three gear shaping machines.

The last purchase from Liebherr was an LSE 300 with electronic helical guide function for the cutter head. Precision lead angle adjustments to μm -accuracy enable lead crowning to be produced at the touch of a button. This enables premium-quality gears to be produced.

Solutions-focused partnership

Together the gear specialists have developed a new grinding technology for precision machining. "We have to keep pace with technological innovations in the market and need partners to help us to do that. With Liebherr we have a partner that takes a solutions-based approach and designs the right machines for our business", Pierluigi Taddei explains. That includes the development of software as well as of customized tools and seminars. Liebherr organizes on-site seminars and workshops in Italian for Euroricambi's employees. Euroricambi is also provided with support by Liebherr-Utensili (LUT).

Euroricambi's production facilities operate on an automated two-shift basis: one person loads and operates three to four machines. The machines can continue to operate beyond the 14th hour without human supervision, because they can be stocked in advance. A worker requires some two to three hours to load up "his" machines. "We have developed a really smart automation solution for small quantities of between 50 and 2000 components", the President relates. Liebherr was also involved with this automation solution. ■



Giovanni Della Ferrera, Managing Director of Liebherr Utensili, the company's founder Orazio Taddei and Managing Director of Euroricambi, Pierluigi Taddei (from left to right)



Versatile: the generating- and profile-grinding machine LCS 300

Euroricambi: an Italian success story



From the very beginning this company has been a success not just in the Italian market. 98 percent of products are exported from Italy and 80 percent to countries outside of Europe. Euroricambi is part of the FATA Ricambi Group, which is based in Italy, Romania and Poland. Euroricambi is the nucleus and still the largest company within the family-owned group of businesses.

Industry:

Automotive industry

Company size:

over 400 employees

Founded:

1979 by Orazio Taddei

Places:

Italy, Romania and Poland

Managing director:

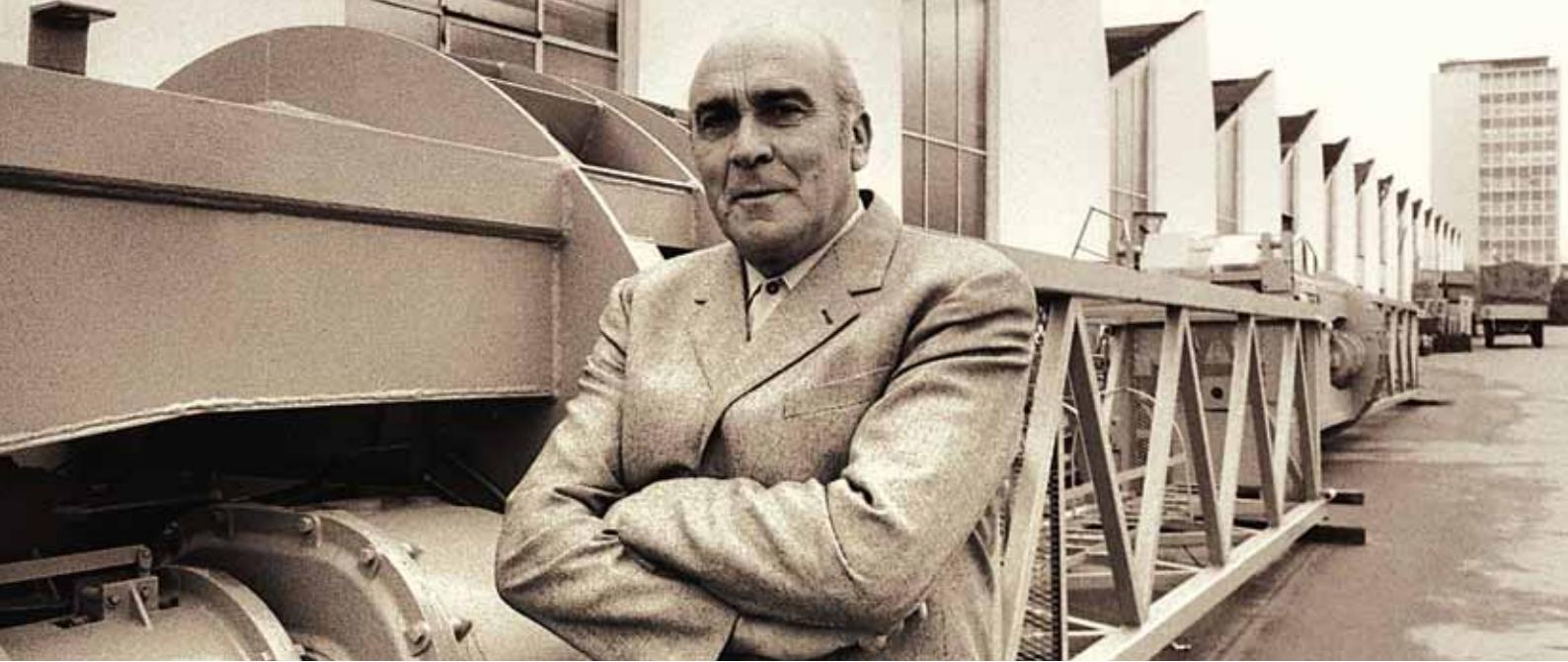
Pierluigi Taddei

Website:

www.euroricambi.com

Liebherr machines at work:

Gear hobbing, gear shaping and gear grinding machines



100 years Hans Liebherr

Entrepreneur, inventor, visionary

His groundbreaking inventions include the mobile tower crane and the first hydraulic excavator in Europe. He was one of the great pioneers of the German post-war economy: Hans Liebherr. He would have celebrated his 100th birthday on 1st April 2015.

The history of the Liebherr Group is inextricably linked to its founder – a skilled architect, a tireless tinkerer, a pragmatic businessman and a successful pioneering entrepreneur. Hans Liebherr, born on 1st April 1915 in Kaufbeuren (Germany), had many talents. One of these was his keen instinct for promising products and emerging markets.

When large parts of Germany were being reconstructed after the Second World War, Hans Liebherr recognised the demand for tools and machines for the building industry and housing construction. Together with draughtsmen and craftsmen, he developed the first mobile tower crane in 1949. The TK 10 could be easily transported and assembled at building sites. It accelerated and simplified the reconstruction of Germany after 1949 and laid the foundation for the present group of companies. This success could not initially be foreseen, as the presentation of the product at the Frankfurter Herbstmesse trade fair in 1949 was a disappointment. Hans Liebherr would later recall that “after the trade fair, I actually could have given up on producing cranes.” Instead, he displayed perseverance and worked with determination to realise his plans – until the first commissions finally came in and production began.

As an entrepreneur, Hans Liebherr banked on step-by-step expansion. In doing so he financed his enterprises primarily with his own capital. The profits were mainly put back into the firm, in order to further optimise research, development, production and distribution. By the middle of the 1960s he had long since established this once-small construction firm as one of the leading manufacturers of construction machines worldwide.

Hans Liebherr was among the greatest German entrepreneur personalities – and yet he always remained humble. “You know, I’m actually just a master bricklayer,” he said upon the conferment of an honorary doctorate by RWTH Aachen University in 1964. He still oversaw his works himself and, in his down-to-earth manner, paid close attention to the needs of his customers.

After his death in 1993, three of the five children of Hans Liebherr, who was a family-business entrepreneur through and through, took over the management of the company. To this day, the shareholders of the Liebherr Group are all family members – by now into the third generation.

Hans Liebherr built up the Liebherr Group and made a lasting impression in the building industry with his inventions. His work still earns him accolades today; the Handelsblatt, a significant German business publication, has included him posthumously in the Family Business Hall of Fame at the beginning of 2015. ■

“Winner” of the Dakar Rallye 2015

Liebherr Engines convince in Kamaz Trucks

The Dakar Rally 2015 was a great success for the Kamaz Master truck racing team. Aside from occupying the whole of the podium, the Russian team also secured fifth place. All trucks were equipped with powerful V8 diesel engines from Liebherr, which have once again proven their worth in tough desert use.

Torrid heat, dusty air and a challenging route across the Andes and the world's largest salt lake: The Dakar Rally through Argentina, Bolivia and Chile exposes drivers and vehicles to the most extreme conditions. The Kamaz Master truck racing team took to the start this year with four trucks – each of which was fitted with an 8-cylinder D9508 A7 diesel engine from Liebherr. Ayrat Mardeev was the first to cross the finish line after 44:42:01 hours. His racing stable colleagues Eduard Nikolaev and Andrey Karginov followed in second and third place.



“Success in racing depends not only on the performance of the engine but the probability of failure and repair times. Here, we place trust in the engines from Liebherr that have proven their worth in similar extreme conditions, above all in mining,” knows Vladimir Guba, Technical Director of the Kamaz racing team.

To engineer the components to be even more reliable and, at the same time, dynamic for special conditions, Liebherr worked closely with Kamaz to specifically further develop the drive system for the Rally. In the race configuration, changes were made above all to the charge air system to achieve higher charging pressures. Remarkably, no modifications were made to supporting structures of the engine. These have already been engineered sufficiently in the standard version.

The engines, which are built at Liebherr Machines Bulle SA in Switzerland, are distinguished by a maximum output of 770 kW (1,047 HP) and a highest possible torque of 4,500 Nm. The engines accelerate within 10 seconds from 0 to 100 km/h. The 8,900 kilogram trucks reach a top racing speed of 140 km/h. ■



Liebherr opens new logistics centre at Oberopfingen

Spare parts supplies for the Earthmoving Equipment division will be managed from a new central location

On 19 June 2015 attended the opening ceremony of the Liebherr Group's new logistics centre at Oberopfingen, Germany. From the district of Kirchdorf an der Iller, the family-run company will in the future supply customers around the world with spare parts for earthmoving machines. The logistics centre is the new central hub from which Liebherr customers around the world will be supplied with spare parts for wheeled and crawler excavators, wheel loaders, crawler tractors and other earthmoving machines.

Until 2013, the management of spare parts supplies was more decentralised. In view of the growing product range and increasingly complex material flows, Liebherr decided to centralise its system, initially organising it from smaller, existing warehouses. In mid-2013, the company finally began to build the new, larger and more modern logistics centre.

"Our customer now get their spare parts faster," explains Martin Barth, managing director of the operating company Liebherr-Logistics GmbH. "This important step guarantees that we will remain competitive in the future." Around 1,000 guests at the

opening ceremony – including the Liebherr family – were given an insight into the technology, proportions and processes. In his address, Dr. Heiko Schmid, district chief executive of the Biberach district, stressed the importance of the Liebherr Group for the region and welcomed the decision to strengthen existing commitments with new logistics centre.

Fully automated material flow and maximum supply reliability

The new central warehouse has an area of 47,000 square meters – about the size of six football fields – space for about 100,000 different spare parts for the Earthmoving Equipment division. Parts are taken into and out of stock in the automatic warehouse areas – which can be up to 36 meters high – by energy-efficient operating machines. The responsible persons at Liebherr-Logistics GmbH employ extremely short throughput times: "Our modern warehouse technology and order picking systems make it possible to ship 1,600 individual orders to many European countries – almost all of them on the day the order is received," explains Martin Barth. Redundant IT systems, the ability to conduct



The new Liebherr logistics centre at Oberopfingen near Kirchdorf an der Iller



Manual warehouse area and shipping at the new Liebherr logistics centre at Oberopfingen

preventative maintenance work during ongoing operations and modern fire prevention measures guarantee maximum supply reliability.

Strategically important location, best transportation connections and future potential

The location at Oberopfingen was chosen deliberately. Not only is the site directly next to the A7 autobahn, it is also in the immediate neighbourhood of the major production site for Liebherr earthmoving machines at Kirchdorf an der Iller. Other plants from the construction machinery and components divisions in France, Austria and Switzerland are also not far away. "We considered, analysed and evaluated various locations for the warehouse," Martin Barth continues. "In the end, Oberopfingen was the favourite." In the final expansion phase in a few years time, the site should grow to a total of 360,000 square meters, or more than 50 football fields, and hall space will be created to secure the logistics processes for the decades ahead. In the long term, the Liebherr Group is planning to merge the spare parts logistics of other construction machinery divisions in Oberopfingen. ■



Dr. Heiko Schmid, Jan Liebherr, Wolfgang Remlinger and Martin Barth (from left to right) open the new logistics centre

Martin Barth

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