

2013

LIEBHERR

MAGAZINE

Machine Tools and Automation Systems

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AUTOMATION:

More Efficiency: Batch Size One to High-Volume Production // 22

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Dear reader,

“Intelligence is the general ability of an individual to consciously adjust his thinking to new requirements,” says the well-known psychologist William Stern. “Individual” here originally refers to humans. Yet we increasingly talk about intelligent machines, as in the German initiative “Industry 4.0”. Tasks are becoming more complex, and communication becomes increasingly intensive. Huge volumes of information and data, which need to be processed as rapidly as possible, are shared between people, between people and machines, and between machines.

For manufacturing this means higher efficiency and simplification of machine-operator interface. Intelligently designed machines and automation systems are key components for long term success, in fiercely competitive international markets.

According to the the German Machine Tool Builders’ Association VDW, international use of machine tools has more than doubled in the last 20 years. Accordingly machines nowadays have to meet more individual require-

ments: We are talking about varying batch sizes, several product variants, and sustainability issues.

Our new customer magazine showcases news about gear cutting and automation. This debut issue kicks off with a series of machine tool and automation system innovations, which we are launching onto the market this year. Our intelligent machines deliver sustainable progress to help you consciously adjust to new challenges regarding intelligent, customised, and efficient manufacturing – all in the name of sustainable progress.

We hope you enjoy reading our new magazine!

Managing Directors of Liebherr-Verzahntechnik GmbH:
Dr.-Ing. Klaus Finkenwirth, Dipl.-Kfm. Friedrich Hesemann
and Dr.-Ing. Alois Mundt



From left to right: Dipl.-Kfm. Friedrich Hesemann, Dr.-Ing. Alois Mundt, Dr.-Ing. Klaus Finkenwirth

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Easier Said Than Done

Innovative design of LC 180
Chamfer Cut facilitates chamfering
in parallel with production time

It is easier said than done – if it takes too much time for two processes to run consecutively on a single machine or single clamping operation, then the design must simply allow both processes to take place simultaneously. “As easy as the principle sounds, technical implementation is very complex. We have integrated an entire second processing unit for Chamfer Cut tools – two machines in one, so to speak,” explains Dr.-Ing. Oliver Winkel, Head of Application Technology at Liebherr-Verzahntechnik GmbH. This newly developed solution has eliminated the main disadvantage of previous Chamfer Cut applications, namely that they prolong machining time. ▶



In the past, it has cost valuable time using the Chamfer Cut method to mill and chamfer during the same clamping operation. Dr.-Ing. Hansjörg Geiser, Manager Development and Design Gear Cutting Machines at Liebherr-Verzahntechnik GmbH, explains the re-

it is possible to reverse the cutting direction of the tools, i.e. to chamfer both front sides from the inside to the outside, depending on the customer's preference. Another advantage is provided by two separate machining positions – the workpiece is processed

LC series' familiar machine concept. A Chamfer Cut version for the somewhat larger LC 280 is in the pipeline.

Therefore, the changeover from operating the existing machine is relatively simple once standard user training has been provided. This is backed up by the completely redeveloped interface, which guides the operator intuitively (more on the new user interface on page 9). Besides operational advantages, production workers also profit from easy fitting and the advantage of Chamfer Cut, that no needle chips are produced during chamfering, which reduces the risk of injury.

“We combine the high chamfering quality of Chamfer Cut with short cycle times.”

*Dr.-Ing. Oliver Winkel
Head of Application Technology*



sulting problem that the design of the LC 180 Chamfer Cut is meant to solve: “The main design challenge was to incorporate the Chamfer Cut unit into existing space and at the same time at a reasonable cost.” So the deburring unit was integrated without any impact on space requirements within existing dimensions. After hobbing using the familiar one-cut strategy, the Chamfer Cut tool system's bevel cutters deliver precision, repeat-accuracy chamfering, which is increasingly a market requirement.

In comparison to press deburring and deburring with end mills, the Chamfer Cut process has the lowest chamfering costs, also because the specialist tools are very durable and can be easily re-ground. However, as the Chamfer Cut principle cannot be applied to every application, Liebherr continues to offer all conventional deburring processes, in order to select the appropriate individual solution.

In collaboration with the tool supplier, Liebherr has also succeeded for the first time in chamfering both front sides of the workpiece without the previously obligatory change in rotational direction, which also saves time. Alternatively,

on essentially different devices: gear milling takes place on a stable device with maximum rigidity and chamfering on a simpler, collision-optimised device. The active length of the hob does not need to be reduced, as a result of which total tool costs are reduced further.

The size of the chamfering tools can be reduced compared to the previous standard – after all, the chamfer tool is no longer dependent on the size of the milling tool. Bevel cutters with a tool diameter of 35 mm to 40 mm are feasible, which particularly addresses the issues of collision and accessibility and significantly increases the field of application for the process.

New opportunities using a tried-and-tested process

By applying this completely new principle, Liebherr's LC 180 Chamfer Cut has succeeded in opening up a well-established process to new applications. The new gear hobbing machine, featuring an integrated Chamfer Cut unit for chamfering the front edges of the gear teeth, is based on well-proven machine technology – for workpieces of up to 180 millimetres. Its functionality, operation and CNC programming are based on the

Time and quality – necessary and sufficient conditions

Given the fact that the chamfering takes place in a separate unit within the same machine, while the next component is already being hobbled, this process step no longer lengthens production time. Chamfering tools are no longer located directly next to the hobbing tool, but are in the separate unit, which significantly reduces cycle times.

This technology is an option for all users, for whom alternative methods are too time-consuming or whose tooling costs are too high or who really need to pay attention to the quality of subsequent processes, such as gear honing. The LC 180 Chamfer Cut enables users to meet these requirements in only one cutting operation plus subsequent chamfering using Chamfer Cut.

Oliver Winkel emphasises: “Cycle time is of course the key parameter by which we are judged. But speed is just a necessary condition – reducing costs, process reliability and controllable quality are sufficient conditions.”

Innovation with a major impact

“The fast cycle times qualify the process for a series of applications in the

Results of the three chamfering methods



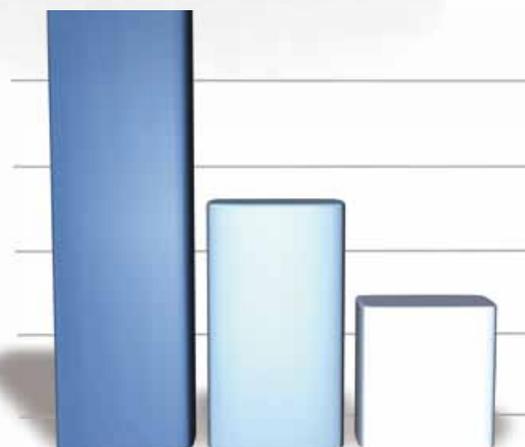
Press deburred gear



Gear deburred with end mills



Chamfered gear



Press deburring Deburring with end mills Chamfer Cut

Comparing chamfering costs of the three methods

automotive industry. The importance of this innovation cannot be overstated – also given the technical opportunities that the users may not even be aware of at present. We have made a presumably minor modification, but overall have come up with an innovation that has a major impact,” summarises Hansjörg Geiser. ■

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Hansjörg Geiser and Oliver Winkel

“The Chamfer as a Design Engineering Factor”

Interview with Dr.-Ing. Hansjörg Geiser and Dr.-Ing. Oliver Winkel

Dr. Geiser, Dr. Winkel, in addition to saving time through chamfering in parallel to production, the new LC 180 Chamfer Cut also facilitates the increasingly precise creation of chamfers. Why is that important to users?

Dr.-Ing. Oliver Winkel: “We know from trends in vehicle manufacturing that the ‘chamfer’ issue is becoming increasingly important. This new machine combines the indisputably high chamfering quality delivered by the proven Chamfer Cut process with cycle times that meet the

requirements of the automotive industry. The increasingly compact design of transmissions is one reason why chamfer quality has moved into the spotlight – in the case of a gear from a vehicle transmission, which is only around 12 mm wide, it makes a huge difference whether the chamfer is 0.5 mm or 1 mm – and this consistently throughout high-volume production.”

Dr.-Ing. Hansjörg Geiser: “Therefore, the chamfer is increasingly becoming a design engineering factor – its actual impact can now be calculated and

therefore its design importance has also increased.”

How is Chamfer Cut distinguished from other methods in this context?

Hansjörg Geiser: “All chamfering processes aim to chamfer the front sides of the transmission components in a defined manner, as uniformly as possible, reproducibly and free from remaining burrs or rough casting. However, particularly with press chamfer/deburring, for example, rolling conditions in the tooth base are not ideal to deliver the required chamfering quality. Applying

the Chamfer Cut principle and the new chamfering unit, in addition to chamfering the tooth base, it is also possible to adjust the chamfer to changing flank corrections without any problem. This calculated generation of chamfers is not feasible using other methods.”

Oliver Winkel: “Workpieces are frequently not fault-free from an engineering perspective if other less precise chamfering processes are used or do not even conform to drawings. This

particularly applies, the more stringent drawing requirements become. Therefore the Chamfer Cut process helps transmission designers and production engineers to get the max out of these components.”

When looking at the prevailing dynamic in target markets – how is this technology designed to accommodate future developments?

Oliver Winkel: “In view of further downsizing trends in industry, the LC 180

Chamfer Cut meets the technical requirements to be able to machine even more precise chamfers for transmission components. That is important because reproducibly created chamfers are increasingly being focused on, the higher the performance requirements are. And the automotive industry is clearly moving in this direction.”

Dr. Geiser, Dr. Winkel, thank you very much for speaking with us. ■

“Unique Multi-Touch Display”

Thomas Karl, Human Machine Interface (HMI) Development at Liebherr-Verzahntechnik GmbH, talks about the completely redesigned user interface, that is for the first time employed with LC 180 Chamfer Cut.

Mr. Karl, the LC 180 Chamfer Cut is already equipped with the redesigned user interface. What does this mean for users in practice?

Thomas Karl: “The user interface’s specific innovation is the 19-inch multi-touch display, which is unique in our market and which is comparable to those found on smartphones or tablet PCs. Users, particularly the younger ones, are familiar with this mode of operation from everyday life and therefore do not take long to get used to the new interface. Anyone who prefers to continue using a keyboard can of course do so as well.”

Which additional innovations or special features does the user interface offer?

Thomas Karl: “We have completely redesigned the data entry function. This is performed in a structured manner using file tabs and directory trees. Basic symbols enable users to spot immediately where data is missing or possibly entered incorrectly. Overall, we regarded it as important to be able to guide users as far as possible through data entry and thereby reduce their workloads. For example, step-by-step user guidance for tooling/set-up is provided.”



Thomas Karl



Multi-touch operating panel

Over and above data entry, which new functions are available?

Thomas Karl: “The software offers the option of displaying mathematical calculations directly via online graphics. 3D views of the tool and the workpiece can also be calculated and displayed live by the system. Users can move and zoom in on these views as they like. Everything functions very intuitively with the aid of multi-touch operation. The entire interface also has a modular structure. This way, each individual user can put together the functions that are relevant to them. The user can determine what is displayed and what is not. These user-defined settings can then be saved for each employee and accessed again if needed, such as during shift changes.”

Mr. Karl, thank you for talking with us.

Focus on Component Quality and Process Reliability

Press chamfer/deburring using the new
LCH 180 two gear hobbing machine



Gear hobbing machine LCH 180 two with automation variant palletising cell LPC 3400

The Chamfer Cut system is not feasible in the case of some workpieces. For these cases, Liebherr has developed the LCH 180 two, which uses a multi-cut strategy incorporating roll-press chamfer/deburring. Regular loading and press-chamfer/deburring takes place in parallel to the main hobbing time.

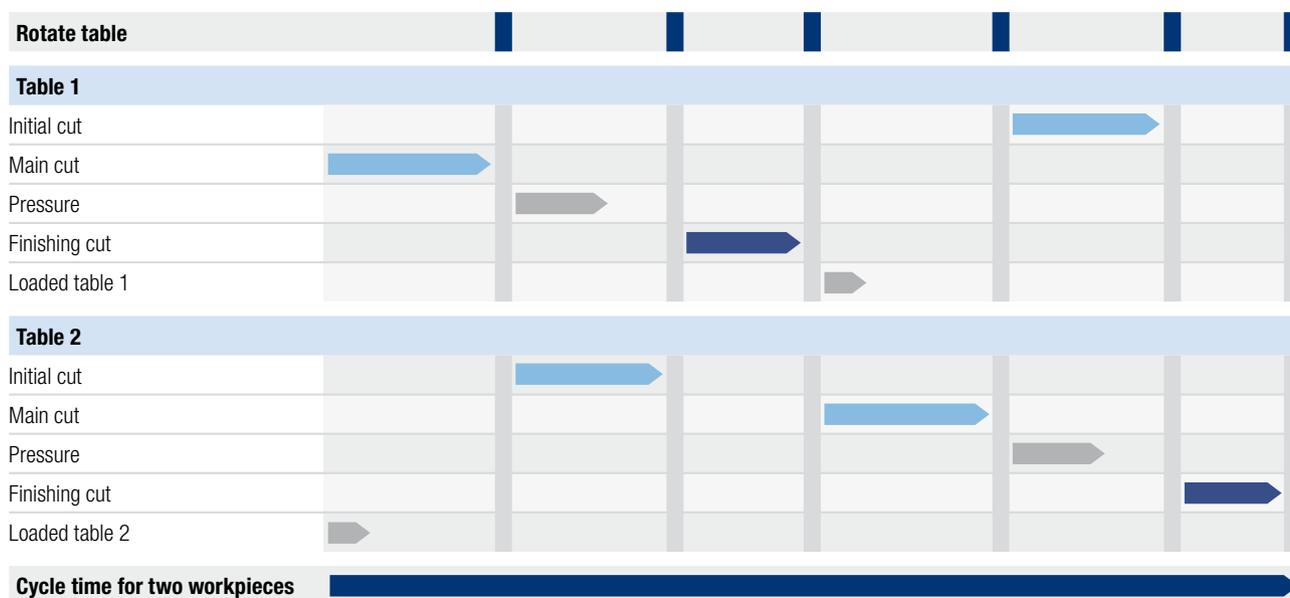
Process optimisation with a double-table strategy

Separate machine operations take place alternately on two easily accessible machine tables, each able to pivot 180 degrees: rough machining in two phases, pressing and finishing. After the blank is fed-in and clamped, it is pivoted and the first cut takes place in two phases on one table, whilst on the other table, the chamfer is press-generated or a new workpiece is mounted. After another pivot, finishing

As far as machine management is concerned, Liebherr-Verzahntechnik GmbH has produced practical and effective user guidance. A specifically developed electronic aid simplifies the complex pressing pre-setting operation for the machine operator. When the operator turns a hand crank, the current position of the relevant unit is displayed on the control panel – this way the tool's position can be adjusted optimally and quickly. Thus, the set-up process is simplified and significantly shortened.

Process reliability and improved quality

Development work on the LCH 180 two focused on premium workpiece quality and absolute process reliability. "We chose the double-table strategy since external mechanical encumbrances need to be excluded during machining,



Manufacturing steps in double-table strategy

is performed to eliminate the burrs resulting from the pressing. The cycle highlight is in the finishing process: this is a stand-alone process not subject to the crossover impacts generated by a parallel process on the neighbouring table.

The blanks are loaded from the attached palletising cell, where they are stored in baskets according to automotive standards.

Good machine accessibility and short set-up times

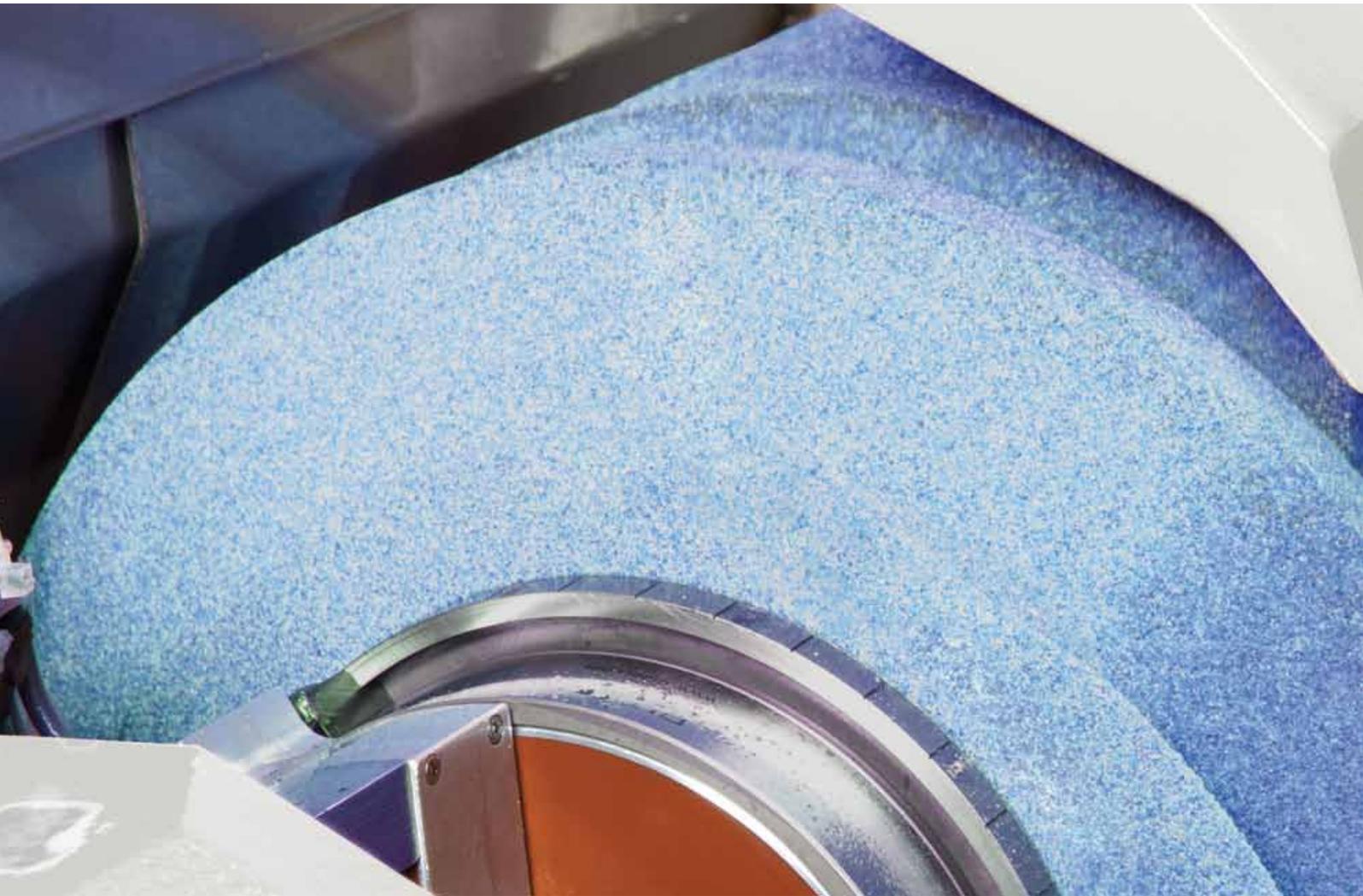
Machine table accessibility has been optimised for quick set-up. The operator has the option of approaching the tables directly through two separate doors (left: hobbing, right: roll-pressing/loading).

especially during the precision finishing process," says Dr.-Ing. Hansjörg Geiser Manager Development and Design Gear Cutting Machines at Liebherr-Verzahntechnik GmbH "The quality of the workpieces, particularly the flanks, and the reliability of the process as a whole benefit from this." ■

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Just Cutting Off Materials?

Gear grinding requires more than just the right abrasive and a high-performance machine



According to DIN 8559, grinding is one of those cutting processes that remove material with a geometrically indeterminate cutting edge. The cutting edge is formed by a large number of bonded abrasive grains made of natural or synthetic grinding materials.

So far, so good. Anyone who is even only superficially concerned with the subject of metal processing knows this – everyone else can look it up in seconds. Google needs fractions of seconds in order to supply tons of results for the search term “gear grinding” ▶

“Experience, development, commitment – these are the cornerstones of our grinding expertise.”

Dr.-Ing. Andreas Mehr, Technology Development Gear Grinding and Shaping



– a lot for such a specialised subject. But how do users distinguish between substantiated advice and the pure intention to sell when they are searching for skilled partners?

“Neither the customers nor we would benefit from us selling machines without considering the long-term perspective. We want to find out what the best possible solution is for the user’s specific requirements,” Dr.-Ing. Andreas Mehr, Technology Development Gear Grinding and Shaping at Liebherr-Verzahntechnik GmbH, explains. “But to make this happen you also need to have the resources. We have a substantial pool of technology and skills at our disposal and can therefore provide unbiased advice.”

Asking the right questions

So, what does it depend on? For example, there is the basic question of whether profile or generating grinding is the right option for a specific application. Both hard precision finishing methods have their advantages and disadvantages. The strength of profile grinding is its major flexibility coupled with simple tool design. Different gear wheels can be ground using the same dressing unit. This flexibility is a key factor as far as small batch manufacturing and prototype/single-item production are concerned.

In contrast, where higher unit quantities are involved, the situation is different. This is where generating grinding, with shorter processing times resulting from high cutting speeds and a lower number of cuts, comes into play. When comparing both methods, the gear teeth module to be cut must also be taken into consideration.

“There are good arguments for both methods. For some, it is also a question of conviction. The crucial point is that we analyse each individual application case in exact detail and decide on this basis, which is the right process/the right technology. Our wide range of machinery gives us this opportunity,” says Andreas Mehr in summary. Liebherr even assists customers to select the right abrasive and factors innovations, such as Cubitron II precision abrasive grains, into deliberations (please refer to pages 20/21).

An eye on the future

Andreas Mehr emphasises: “We know how dynamic our customers’ markets are. That is why our machines are always designed to provide reserve capacities to enable customers to react to future developments. This is the logical result of decades of research and development activity, as well as intensive dialogue with users. Gear Grinding doesn’t only involve ‘cutting off material’. Developing a customised solution for a special application that is already able to cope with future tasks – this requires a bit more.” ■



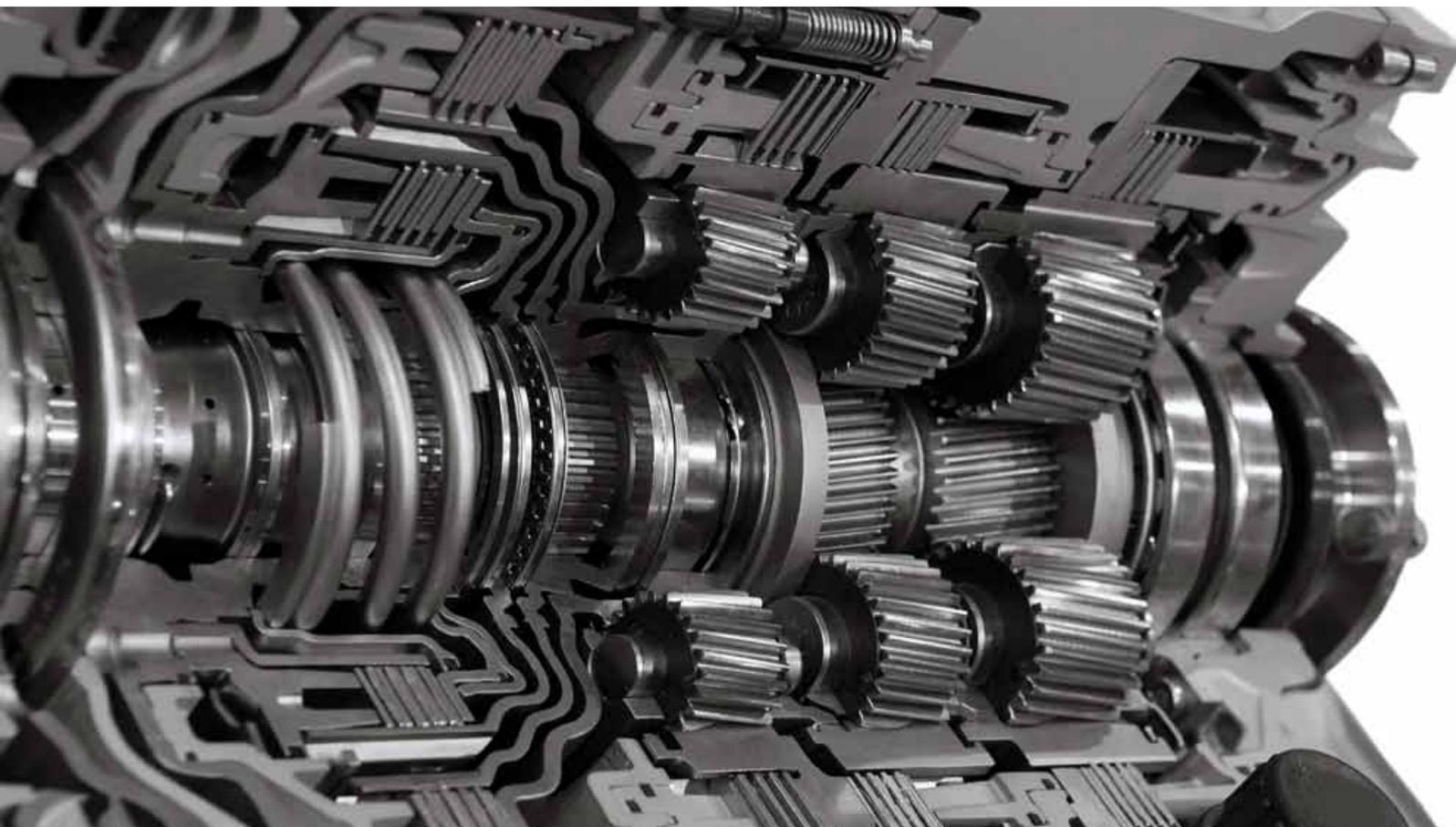
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Example for future-proof technology: the gear grinding machine LGG 180 with automation variant palletising cell LPC 3400

Consistent High-Volume Production Quality

New LGG 180 gear grinding machine for
vehicle transmission components



The LGG 180 grinding machine delivers the quality of a single-table solution at twin-table solution cycle times. Depending on the parameters, such as the material or the geometry of the workpiece, the machine allows chip-to-chip times of four to five seconds for bore-type parts: a time of less than four seconds has already been achieved by using the ring loading technology in combination with Liebherr's palletising cell LPC 3400. Thus, the technology greatly

facilitates production efficiency (more on page 29) while meeting the high automotive standards.

Combined advantages

"The Liebherr LGG 180 combines short grinding times with consistently high standards of high-volume production quality. This machine gives users chip-to-chip times of less than four seconds combined with the quality ▶

advantages of a single-table solution,” is how Dr.-Ing. Andreas Mehr, Technology Development Gear Grinding and Shaping at Liebherr-Verzahntechnik GmbH, describes the basic idea behind this solution.

“In order to minimise any thermal impacts, the machine bed has been manufactured using a thermally stable material – another contribution to high standards of quality,” Dr.-Ing. Hansjörg Geiser, Manager Development and Design Gear Cutting Machines at Liebherr-Verzahntechnik GmbH, reveals. Given its compact dimensions, being 2 m wide and less than 3 m long including the ring loader, the machine is ideal for vehicle and transmission manufacturers and their suppliers. To facilitate

space-optimised installation of facilities for a complete series, the 180 mm and 280 mm machines both have the

gear wheels, as well as drive and pinion shafts, with lengths of up to 500 mm. Choosing a single-table solution means

“The machine is ideally suited for automotive and transmission manufacturers.”

Dr.-Ing. Hansjörg Geiser, Manager Development and Design Gear Cutting Machines



same exterior dimensions. “This enables vehicle manufacturers to set up an entire production run, where all vehicle transmission gearing components can be ground – planetary and sun gears,

one setting, one geometry,” says Andreas Mehr in summary. The advantage of this is higher quality/reliability throughout the entire production run. Every machined part is manufactured



New grinding head of LGG 180

under the same conditions to ensure as much reproducibility as possible. “Delivering statistical capability and reliability in continuously producing controlled μ -range finish quality is a key argument in favour of the single-table solution,” Andreas Mehr emphasises.

High-performance grinding head

“The core of the machine is the newly-developed grinding head. Conventional solutions were chosen here in several areas, to be prepared for even higher quality requirements,” explains Hansjörg Geiser. The grinding wheel is mounted without a counterbearing on the grinding head, at the highest rigidity settings. “There will also be an option with a counterbearing for smaller-diameter LGG 180/280 grinding wheels,” Hansjörg Geiser reveals. Andreas Mehr adds: “It is important that we offer users the appropriate solution for their specific application. We have several model ranges and options at our disposal for this purpose.”

The new grinding head allows rotational speeds of up to 10,000 rpm and has spindle power of 35 kW. “This high-performance capability makes this machine fit for the future. There are also reserve capacities for new developments and more stringent requirements in the future. The LGG 180 utilises the considerable potential of the innovative Cubitron II abrasive,” Andreas Mehr emphasises. When using the new precision abrasive grain, users can reduce grinding times by 20 % to 30 % in combination with appropriate grinding performance (more on the subject of Cubitron II on pages 20/21).

Offset-free grinding is also possible on the machine. Targeted and calculated handling of the tooth flank offset issue enables users to solve production-related problems and generate new gear production options at the same time.

The LGG 180 will enable undulation details to be applied specifically to gear

flanks for noise optimisation purposes for the first time in serial production. “The ability to produce sub- μ range undulation details efficiently gives transmission designers a whole new range of noise and load capacity optimisation options,” says Hansjörg Geiser. In view of increasingly more stringent quality requirements, this provides security for the future.

The fact that these corrections to compensate for meshing excitations are feasible was demonstrated by a comparative grinding exercise conducted by the FZG (Research Centre for Gear Wheels and Gear Manufacturing) at Munich University of Applied Sciences. The institute chose the Liebherr grinding machine in preference to machines from other manufacturers.

Advantages today and in future

There is also potential for future developments to complement the machine’s cycle time and quality advantages that already apply today. These reserves are a particular asset given the increasingly more stringent quality requirements in the automotive sector. ■

Features and options of the profile grinding machine LGG:

- one-table-solution
one fixture, one geometry
for all gear parts up to 180 mm (or 280 mm, respectively) in diameter and 500 mm in length
planetary gears and sun gears, gear wheels as well as drive shafts up to 500 mm in length
- higher quality and reliability along the entire series
- thermostable machine bed
- chip-to-chip times
wheels: 4 seconds, shafts: 8 seconds
- twist-free grinding
- grinding conical tooth systems (beveloids)
- efficient production of sub- μ waviness on the tooth flanks
- reliable process control: rolling calibration of measuring arm
- small space requirements for both LGG 180 and LGG 280:
2,000 mm wide and 2,900 mm long
- hooked machine

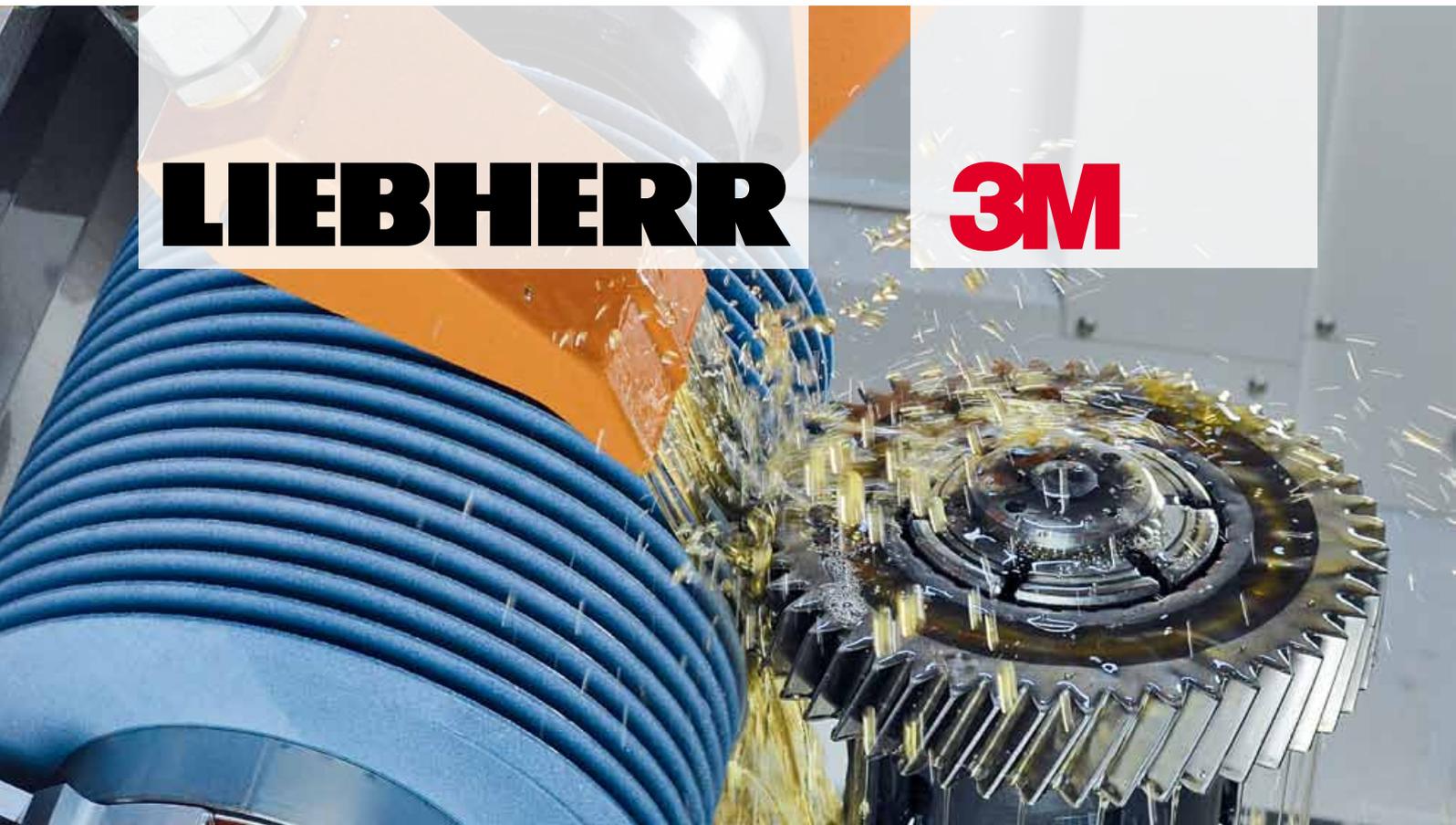
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LIEBHERR

3M

Tiny Triangles Change the World of Generating Grinding

The perfect grain geometry for gear grinding

Cubitron™ II



Macro view of the grinding grain

Increasing raw material and energy prices, high wage levels, and relentlessly strong competition demand continual improvements in all industrial areas. Taking a closer, more critical look at individual manufacturing processes can offer potentials to this end. The perfect interplay of innovative tools and advanced machines can lead to greater productivity and new growth margins.

This also applies to grinding machines. Though generative gear grinding has always been considered the most efficient process in gear manufacturing, experts of 3M's Precision Grinding & Finishing business unit have succeeded in bringing it to new levels of efficiency. The business unit, which grew out of the acquisition of the Winterthur Technology Group by the diversified technology company 3M, has developed entirely new grinding worms for grinding ultra hard steels based on ceramic abrasive grains, which replace the conventional sintered alumina grains. ▶



Cubitron II grinding worm

3M specialists have so far developed two new Cubitron II Grinding Worm types: one with 100 % precision-shaped ceramic grains in the 99DA80/80 H8V901W-80m/s wheel, and a second with 30 % proportion of the ceramic grain in 93DA80/80 J18VPLF29/601W-80m/s grade, in which a special white fused alumina grain is additionally embedded to provide further support. The new products, which were launched this July, are produced in the Austrian city of Villach.

For some time now, there has been a co-operation with the Liebherr-Verzahntechnik GmbH based in the German town of Kempten aimed at developing new products and applications. Within the scope of this cooperation, experts of this firm have extensively tested these innovative tools on their LCS series of generating and profile grinding machines – ranging from small gears for automobile transmissions up to large format planetary gears such as those required for the gearboxes of wind turbines – with very positive results.

“In all tests, we were able to see high cut rates within very short times with very little abrasive consumption and yet excellent surface finishes,” said Jürgen Hechler, Abrasive Specialist at 3M, in summing up the advantages of the new generating gear grinding process for grinding tooth profiles.

Grinding Times Cut in Half

“With significantly less pressure between the grinding worm and workpiece surfaces, grinding times are now able to be cut in half,” states Jürgen Hechler. This is made possible by simultaneously increasing feed rate and advance, as well as a two-step strategy for the cutting speed of up to 80 m/s.

Up to Three Times Longer Tool Life

In the tests, the grinding worm itself exhibited a tool life of up to three times longer, “due to greatly reduced shifting and increased tool paths,” says Jürgen Hechler. This increases the efficiency of the grinding worm and also saves dressing time and lengthens the life of the dressing tools.

“At the same time, we can expect less loading of the dressing rolls,” he says. Also during dressing, individual segments of the triangular grains break off cleanly. This greatly reduces the stress for the dressing roll compared to the shattering required for traditional abrasive grains with their undefined shapes. Further abrasive parameters are also improved: the increased advance makes it possible to achieve a higher metal removal rate (Q_{max}) and increased mean depth of cut (h_{mom}).

Burnishing and Heat Stress Risk Approaches Nil

“Last but not least, this combination of machine and abrasive reduces the risk of burnishing and heat stress to

virtually nil,” emphasises Jürgen Hechler. Unlike conventional grinding worms, the triangular-shaped grains do not “plow” through the material while cutting, but provide a clean, machining action on the workpiece. The chips cut from the surface of the workpiece also transport heat directly away from the workpiece, which helps to prevent heat buildup during the grinding process.

In spite of the full-surface and intensive contact between the grinding worm and teeth of the gear, as well as the extreme removal rates of up to 1,000 mm³ per second, the innovative abrasive material does not at all clog up thanks to this clean-cutting chip formation. “Even when seen through a microscope, there is practically no discernible clogging of the grinding worm.”



Grinding process with regular grain



Precise grinding without ohne fraying of contours

Production Costs Cut by More Than One Quarter

When all benefits are taken together, Cubitron II Grinding Worms offer an enormous savings potential with regard to manufacturing costs. "First tests in industrial series production have shown that savings of more than 25 % are possible," says Andreas Mehr, Technology Development Gear Grinding and Shaping at Liebherr-Verzahntechnik GmbH.

Top-Quality Gear Finishing

Another key aspect is the quality of the surface finish of the gears produced with the Liebherr LCS Series of generating and profile grinding machines using the Cubitron II Grinding Worm – as is perfectly illustrated by the measurement results after producing a spur gear for an automobile transmission (2.77 mm module, 40 teeth, 15.5 mm tooth width, 23.5° pressure angle, 25.38° helix angle) on a Liebherr LCS 500 machine with a Cubitron II Grinding Worm 93DA80/80 J18VPLF29/601W-80m/s.

A critical parameter for the quality of a gear is the so-called tooth measurement. This is done by measuring the characteristics of the teeth of the gear with a tooth measuring machine. In detail, the profile, flank lead, twist, runout and pitch are measured. The measurements corroborate highest quality of the product in accordance with automotive standards. The profile form error Ffa (FF alpha), for example, was less than 2 µ, which is "a very good result," according to Jürgen Hechler and Andreas Mehr.

Outlook: Grinding "Full Speed Ahead" for Gears of Softer Materials

"Cubitron II Grinding Worms can also be expected to achieve greatly increased metal removal performance with softer workpieces," says Andreas Mehr, pointing out a further positive feature of the innovative abrasive. This should enable much more efficient and cost-effective production of gears that are needed quickly, for example prototypes, replacement parts or one-of-a-kind parts. "Special specifications for soft grinding, and even for pre-milling, will no longer be needed," he continues. This has already been confirmed by first tests. "We have already planned further tests for generating gear grinding of softer and pre-toothed workpieces, and also for generating gear grinding at full speed. ■"

3M Microreplication Technology

3M has been pioneering the use of tiny, uniform structures that modify the physical, chemical and/or optical properties of a material. Microreplicated prisms, for example, are used on traffic signs, in electronic displays and in the outdoor lighting of buildings to better guide and reflect light. But tiny pyramids are also used to ensure that structured abrasives work better and wear more uniformly.

This microreplication technology was the basis for development of the innovative abrasive named Cubitron II in the form of precisely-shaped triangular ceramic grains. These have now been combined with Winterthur's expertise in the manufacture of grinding worms. Whereas these triangular grains, also known in the trade as "Precision Shaped Grains" (PSG), were previously used by 3M only for fiber wheels, abrasive belts or Roloc abrasive discs, the experts of the new 3M Precision Grinding business unit have now also embedded the abrasive grain geometry into their bonded abrasive discs, and just recently into their grinding worms, which are used, for example, to grind gear tooth flanks.

Winterthur Technology AG

The Winterthur Technology AG, a 100 % subsidiary of 3M, is one of the world's leading manufacturers of innovative grinding solutions. The group holds a unique position in the market in that it is the only manufacturer that offers the full range of grinding tools and machines from a single source. Its bonded abrasives are used particularly in the automotive, aerospace, tool machine, tool making, glass and steel industries especially for the precision grinding of ultra-hard materials.

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More Efficiency from Batch Sizes of One Right up to High-Volume Production Runs

Custom smart automation solutions



The graphic shows where Liebherr automation solutions are used.

Put in general terms, the following applies - efficiency increases and simplified operation are the goals of any smart automation concept. "As this concept is completely case-specific, given different production conditions, we rely on an entire toolkit of varying systems to solve the task we have been given. This way we can handle key design criteria: batch sizes, jig design, component diameters/weights," Stefan Jehle, Sales Director Automation Systems at Liebherr-Verzahntechnik GmbH, explains. "We select the appropriate tools to match the application."

High-volume production runs and batch sizes of one: fundamentally different requirements

Batch sizes are a key factor in configuring an automation system. A distinction is principally made between two main categories, the mass production manufacturer and the manufacturer that produces small batches, right down to batch sizes of one.



Mass producers must load and unload a machine with the same or similar components as quickly as possible and transport them to the next processing operation. At the same time, sufficient buffers must be available for set-up operations in order to avoid a standstill. Combinations of portal and storage systems or palletising cells (please refer to page 29) are often used for this purpose.

Where batch sizes of one and small batches are involved, machines and jigs frequently need to be adapted. Here the aim is to minimise automation system set-up times and to decouple work piece set-up procedures from processing times, thereby improving capacity utilisation. "In some cases nowadays up to 50 percent of machine time is lost due to set-up activities. Automation systems enable an increase in machine utilisation to up to 90 percent to be achieved." Liebherr provides different solutions to achieve this, ranging from individually adjustable work piece mountings to pallet handling systems for heavy work pieces.

"The workers benefit from the easy operation."

*Stefan Jehle,
Sales Director Automation Systems*



Simplified operation

In addition to reducing employees' workloads, the aim is also to design the systems for the simplest operation, particularly as in facilities with a high level of manpower fluctuation, quick employee training is required. Depending on requirements, user guidance is designed so that the automation system as a whole can also be operated by less qualified employees.

Essentially all solutions are based on a modular toolkit of standard or custom automation components. This means that basic solutions delivering process reliability already exist (please refer to pages 24 to 29), having been proven in practice over the course of many years. ■

Facilitating Efficient One-Piece Production

Pallet handling system for automatic loading of machining centres

“Productivity is the ratio of output to input quantity.”* Therefore, the key to working more productively and therefore more efficiently is optimising this ratio. Here the production environment, in which machine tools are located, plays a key role both in terms of performance and optimum utilisation.

Here the “capacity” factor is important. After all, what is the use of a high-performance machine, if its capabilities are not fully utilised? In particular, tool manufacturers or companies producing lot size 1 or small batches face this problem. Optimum machine utilisation is impeded by the very low average degree of automation in these kinds of production conditions. The consequences are comparatively long downtimes associated with awaiting parts and therefore low productivity as well as high unit costs. The final consequence is that the loss of productivity due to sub-optimum

machine utilisation leads to a higher demand for machines.

What degree of automation ensures that small batches and varying component geometries are produced most economically? How does one decouple the operator’s working tasks and times from machine requirements?

Automation of tool manufacturing

An increased degree of automation in one-piece production decreases wage costs and increases machine efficiency. “Our PHS pallet handling system for automatic loading of machining centres reduces unit costs by more than 20 %. In the case of units with machining times of two hours, the costs can be reduced by more than a third,” emphasises Stefan Jehle, Sales Director Automation Systems at Liebherr-Verzahntechnik GmbH. Optimum machine utilisation is achieved through a

combination of increased efficiency in staff deployment and reduced total investment.

While the machine is cutting a part, fixtures are set up in parallel at separate workstations, which are available in different versions: moving, tilting and swivelling. Operators can use the machine’s running time to do other tasks, meaning set-up costs are not included in the machine hourly rate. Flexible fixtures with all-purpose clamping systems help to reduce the quantity of pallets required. Multiple clamping extends machine running times and therefore the work inventory in the system. The pallet handling systems facilitate unmanned operation by extending running times – making a third shift and additional weekend production possible.

Increased capacity utilisation - lower machine requirements

Machine requirements are also reduced, explains Stefan Jehle: “By improving machine utilisation by up to 90 %, users can considerably improve productivity using available resources. Instead of two machines with a pallet changer, which only achieve a utilisation rate of around 75 per cent, for example, only one machine with a pallet changer and PHS pallet handling system is required – for nearly the same quantity.” To accommodate further increasing demand, the system can be expanded to include additional ma-



Optional front access with electrically driven pivotable ceiling rails



Fitting area of Liebherr pallet handling system PHS

Liebherr's PHS pallet handling system is available in three different models:

For unit diameters between 1,000 mm and 2,500 mm as well as for weights ranging from 500 kg to 6,500 kg (shipping weight).

Various sizes and the modular storage system facilitate specific solutions and future expansion, delivering a tailor-made pallet handling system.

chining centres at a later point in time. Higher productivity means that additional investment costs are amortised after a relatively short period.

Small-batch series can also be automated

Small-batch production, just like single-batch manufacturing, requires a wide range of components and various different work procedures – even if somewhat larger quantities are involved. Here companies face the challenge of reducing non-productive times and expanding unmanned or minimal personnel operations. Dependent on specific requirements, the pallet handling system also supports the production of smaller batches. The prerequisite is machine loading using an additional robot. This is possible in both unmanned operation and parallel

to one-piece production on another machine. As is the case of batch size 1, this delivers considerable increases in productivity.

Software prevents downtimes

The software is the key to delivering these productivity increases. The cell controller is regulated by the modular Production Control Software (PCS). The software ensures transparent procedures and optimises capacity utilisation. Downtimes due to missing parts or missing NC programmes are reduced considerably. The software communicates via standardised interfaces with all common controllers and all higher-level ERP systems. It regulates unit transports, manages temporary storage, tools as well as fixtures and provides NC processing data.

Optimised output to input ratio

Stefan Jehle concludes: "PHS solutions help users to better utilise the performance capacity of their machines. There is considerable potential to be tapped, especially in the case of one-piece production. Our systems improve the output to input quantity ratio in production – factories increase productivity automatically." ■

Automation Solution for Small-Batch Manufacturers

Compact pallet handling system for one or two machines

“The formula is simple,” Stefan Sattelmayer, Sales Automation Systems at Liebherr-Verzahntechnik GmbH, states: “Optimum machine capacity utilisation and a reduced staffing requirement result in falling unit costs – up to 20 %.” Liebherr’s Rotary Loading System (RLS) is suitable for users from batch sizes of 1 or small-batch manufacturers. For example, these are toll manufacturers or tool- and mould-makers, who produce individual components that involve long operating and set-up times, as well as very substantial cutting requirements. Given its compact dimensions and high storage capacity, the innovative Liebherr circular storage solution is also suitable for users, for whom a linear system is not an option.

Fast return of investment

Liebherr’s RLS offers cost-effective entry into highly efficient production with one or two machines, enabling users to achieve capacity utilisation of more than 90 %. Users can utilise the

machine’s running time to perform other production tasks – therefore set-up costs do not enter into the machine costs per hour equation. Using the RLS to extend the machine’s running time makes investing in an additional machine unnecessary in some cases. “Depending on specific requirements, the investment already pays for itself in less than two years. Furthermore, the system improves the delivery capability and facilitates rapid, flexible reactions to changes in customer demand. This will appeal to anyone producing a range of different workpieces on a daily basis,” Stefan Sattelmayer explains. The system is designed for workpiece weights of up to 800 kg (RLS 1) or 1,500 kilograms (RLS 2) and diameters of up to 1,300 mm.

The solution is also designed to integrate existing machinery. The system can be adapted to accommodate older machines at relatively low cost. Usually a few mechanical adjustments need to be made to establish accessibility.



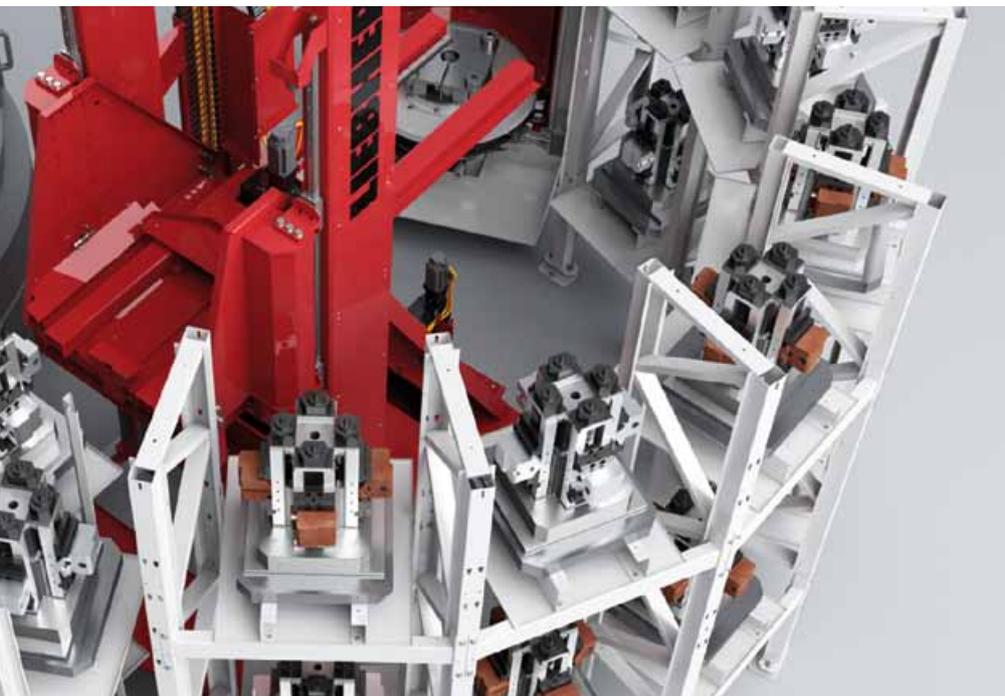
Liebherr’s Rotary Loading System RLS

The machining controller remains in its normal environment on the machine and is easily connected with the RLS via an interface.

Flexibility prior to and after commissioning

The system’s rack columns are of modular design, enabling specific customer requirements to be fulfilled. The racks are designed with every specification in mind. Up to 24 storage spaces on a minimal footprint ensure sufficient work-in-progress for unmanned operation or to by-pass a complete third shift.

The RLS also retains its flexibility after initial start-up. The RST storage tower, which can be added later, increases the number of storage spaces on the smallest footprint. With only a minimally higher space requirement, it creates room for 18 additional storage spaces. “This storage tower, which is unique on the market, delivers the key factor of future reliability in addition to initial layout flexibility,” Stefan Sattelmayer



emphasises. If required, users can add up to two storage units, thus increasing storage capacity considerably. In addition to this, the shape of the storage module allows a second machining centre to be docked at various positions, depending on which position has space available. This guarantees unlimited flexibility for the future.

Cell controller for simple operation

The integrated set-up station is situated directly next to the operating side of the machine – the resulting short distances create space and reduce the effort that operators need to put in. In conjunction with the clearly structured user interface, the windows around the system provide an overview of the as-is status of the machine, which continues to be easily accessible.

The software, which also facilitates integrated job planning, is intuitive to use – drag-and-drop via the graphic user interface. “As far as control software is concerned, we rely on the proven

production control software PCS,” says Stefan Sattelmayer. “This has two crucial advantages – on the one hand, the PCS is open and suitable for use by a larger range of machine manufacturers. On the other hand, customers get software that functions right from the word go, as it has already proved successful for many years. Therefore customers do not need to worry about so-called software ‘teething problems’.”

To make getting started as easy as possible, NC programme and tool management still functions using the usual control system directly at the machining centre. Like the entire system, the software is also of modular design. Liebherr can action additional functions for the cell controller to deliver process reliability at any time by upgrading, using existing software modules.

High level of vertical integration

While benefiting from external expertises in software, the company can rely on sources from the Liebherr Group in

component terms. Stefan Sattelmayer explains the advantages of the high level of vertical integration within the Liebherr Group as follows. “In addition to our own automation technology skills, we can also rely on expertise and components from throughout the Group. For example, the RLS incorporates slewing rings made by our colleagues in Biberach (Germany), which are also incorporated in a similar way in construction machinery. This gives us the necessary certainty that we are providing premium quality solutions.” ■

Identify, Access, Position

Efficient bin picking solutions reliably implemented



An especially demanding automation application: the smart withdrawal of a work piece from a chaotically filled container is referred to as random bin picking. Liebherr's industrial applications have demonstrated what is currently being achieved using flexible robotic systems. For example, Liebherr has produced complete random bin picking systems for the construction machinery industry. Non-rotationally symmetric components that arrive unsorted in bins are efficiently extracted from the containers and efficiently presented to the production line for manufacturing.

Besides construction machinery production, a range of industries, such as the automotive industry, the aerospace or contract manufacturers, benefit from bin picking for manufacturing processes where parts are presented in unorganised containers. These benefits are higher productivity, repeatability, greater production efficiency and the associated reduction in labour costs per unit.

Complex interaction

After the work pieces are removed from the bins, even from deep bins, it is all about exact positioning as required in production or assembly cells. Exact positioning requires complex

**“Customers benefit
from our longstanding
engineering know-how.”**

*Thomas Mattern, Manager
Development Automation Systems*



interaction between the image recognition system, software, concise robot movements and an ingenious handling strategy. Furthermore, each individual process must run independently, reliably and at the required production rate. The advances in

image recognition technology and increased processor performance of industrial PCs particularly enhance these process attributes. Liebherr has developed this technical solution in partnership with a German institute and has tested and implemented it for practical application purposes.

Process reliability as a key issue

The automation of work piece extraction offers various advantages: higher productivity, easing of operating personnel's workloads, reproducibility, flexibility and reduction of unit costs. "There is a whole series of solutions on the market in this area. These are mostly complex, high-maintenance or 2D to 2½D camera solutions that can only be used for specific applications. The key point is process reliability. We have generated solutions for customers that have process reliability and cost-effectively achieve the required cycle times, as well as high rates of availability," reports Thomas Mattern, Manager Development Automation Systems at Liebherr-Verzahntechnik GmbH.

The engineering design of the grippers with additional axis facilitates collision-free access and work piece extraction from the deepest transport bins, as well as precise positioning, e.g. on related machine fixtures or conveyance nests. In the event of a collision, a specific strategy enables the system to continue running, with only a brief delay, without the robot's collision monitoring system coming into play and intervention by the operator being necessary.

New solution for an old task

"Given its long-term experience in automation systems for various applications, Liebherr has succeeded in industrialising the bin picking function," emphasises Thomas Mattern: "Our bin picking robot application is one of the first tried-and-tested, process-reliable solutions for this complex task, which has existed in the industry for a long time." ■

Palletising Cell for New Manufacturing Concepts

Liebherr's automation solution is a basic module to facilitate state-of-the-art manufacturing

How do you optimise the logistics chain from raw material to finished component? Standardised transport containers with cage technology harmonising logistics and facilitate a flexible, forward-looking production process.

Parts remain in a wire cage or part rack throughout the material flow process. This facilitates a standardised interface between the machine and automation system, offering significant cost reduction potential. An optimum supply of parts to the processing machine is a basic requirement for efficient production and is the basis for on time delivery in lean manufacturing. Manually loaded or semi-automated machines fail to meet this requirement adequately. The Liebherr palletising cell enables machine capacity utilisation to be increased significantly in comparison to inflexible

production systems. Instead of continuously feeding a machine, there are free capacities now to operate several machines or take on additional tasks, e.g. pre-setting tools for processing machines. The stacks of finished parts are transported by the operator to the next processing position or to a station for automated guided transport. The logistics concept enables the subsequent operation to be individually determined, depending on the particular processing task and part type. Given their modular design, Liebherr palletising cells are especially flexible. Therefore optimum solutions can be applied to any automation task. Liebherr offers two-space, three-space or four-space cell versions with appropriate additional functions to suit specific production processes. Particular attention has been paid to graphic visualisation of

the palletising cell. The smart control system supports the user with retooling for new part and simplifies the monitoring of process flows, resulting in short retooling times, fast production start-up and acceptance as well as a high degree of repeatable quality. ■

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Telescopic Axis for Facilities with Low Ceilings

The LP 200 gantry is now available in a newly designed telescopic axis version – specifically for production environments with low ceilings or with machines that have higher clearances. This model supplements the existing version, which operates with a conventional vertical axis. The Z-axis protrusion features half of the protrusion of its predecessor design. The telescopic axis achieves virtually the same load capacity of approximately 170 kg. As far as positioning precision and rigidity are concerned, it does just as good a job as the non telescopic standard version and is therefore eminently suitable for machine loading. The following applies to both versions – repeat

accuracy per axis is between ± 0.1 mm and ± 0.15 mm, depending on the model and task.

Liebherr gantries provide a wide range of application options for transporting, palletizing, loading and unloading as well as for storage. Five different sizes of linear motion gantries (LP Series) and three sizes of floor robots for work piece weights of between 0.5 kg and 1,500 kg meet a wide range of automation challenges. Liebherr provides a modular system that enables all sizes of gantries and/or robots to be adapted to the relevant application, e.g. cylinder, head, engine block or gear unit production.

Tool Manufacturing Expertise

Liebherr-Verzahntechnik GmbH provides a broad range of gear cutting tools

The division designs, develops and produces top-quality gear cutting tools at facilities in Ettlingen, Germany and Turin, Italy. Gear cutting tool services include solution proposals and custom designs for specific client requirements. Given the degree of specialization, tool sales are structured separately from machinery sales in order to provide an optimum level of customer service. Abroad, additional sales representatives provide on-site support to clients. "Demand for our product range comes from clients worldwide. We offer an excellent after-sales service to complement tool design engineering and manufacturing," says Ottmar Kern, Sales Director Gear Cutting Tools.

Extensive range of services

Aside from gear shaping cutters and galvanised CBN grinding tools for generating and profile grinding, Liebherr Verzahntechnik's product range also includes shaving cutters for all current shaving processes, rolling tools, such as rolling discs and rolling racks, deburring tools for press-deburring,

"Performance and precision are the cornerstones for high process reliability."

*Ottmar Kern,
Sales Director Gear Cutting Tools*



master gears and rack-shape cutters, all in a wide range of custom specs. The after-sales service includes re-grinding and re-coating of gear cutting tools to return products to original manufacturer quality, as well as the reprocessing

of CBN grinding tools by highly-qualified specialists in our own electroplating facility. Galvanic coating of CBN grinding worms and profile discs is customised to specific requirements. Re-coated tools undergo a strict quality control procedure, meaning clients can rely on consistent quality. "Our specialists guarantee maximum gear-grinding process reliability by applying the greatest possible precision when manufacturing the tools," says Ottmar Kern. Liebherr Verzahntechnik also sets itself apart from the competition in this respect by focussing on the production process as a whole. This means that the tool is not considered on its own but in conjunction with associated machinery and technology.

Client advice covering the entire manufacturing process

This practical focus is one of Liebherr-Verzahntechnik GmbH's key success factors. Users receive advice exclusively from experienced sales personnel, who themselves have worked in technical departments, such as design engineering, testing or manufacturing. Here too the advice provided does not focus solely on the tool; consideration is rather given to the client's manufacturing process as a whole. Application engineers are on hand to handle these requests and visit the client's site to perform process analyses and provide optimum support. In order to perform such analyses, the application engineers work, e.g. in gear-shaping-related cases, with Liebherr-Verzahntechnik's own specially developed software. "This software is very powerful and we regard it as a market benchmark," says Ottmar Kern.

Direct customer benefits provided by contract manufacturing

Customers also benefit directly from Liebherr's in-house contract manufacturing, which provides continuous feedback on the performance of the tools and machines as part

of small-, medium- and large-batch production of high-quality components. This feedback is then directly incorporated into Liebherr product enhancement processes.

EMO 2013: debut showcase of shaping tools in Triple-A quality

“The tool division benefits greatly from the latest machine innovations. We develop our own gear cutting tool production engineering solutions”, says Ottmar Kern. “The technology developed remains within the company. We therefore have, to a certain extent, our own internal know-how pool.”

At the trade show EMO 2013 Liebherr will be showcasing shaping tools in Triple-A quality for the first time. Another new product introduction will be shaping tools with replaceable inserts. “Our tool manufacturing innovations give us a unique selling point, enabling us to secure a competitive advantage in the market,” says Ottmar Kern in summary. “Innovative solutions and the latest developments in tool manufacturing will enable us to strengthen our position.” ■

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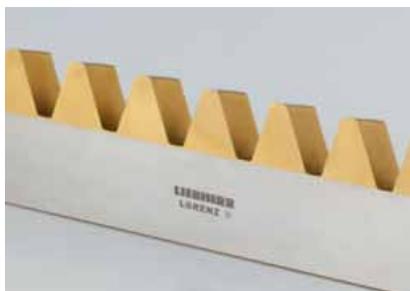
Gear cutting tools



CBN grinding tools



Gear cutting tools



Gauges



Technological Knowledge as a Core Competency

Its diverse range of seminars enables Liebherr Verzahntechnik GmbH to provide a variety of advanced training options

On the one hand, introducing new employees in particular to the topic of modern gear manufacturing, and familiarizing them with the sometimes complex relationships between tools, kinematics and gear performance, is becoming increasingly difficult. On the other hand, however, this is also an important aspect of creating and consolidating a competitive advantage in the long term.

That is why Liebherr-Verzahntechnik GmbH offers its clients a wide choice of training and advanced seminars, to enable their employees to gain professional qualifications. To this end, Liebherr appoints highly-qualified specialists to provide clients in Germany and abroad with an optimum level of support – even on-site, if requested. “This enables us to place at least three specialists in each Liebherr technology at the disposal of clients worldwide. Our seminars are geared

towards a wide range of employees; from machine operators, foremen and planning engineers, to schedulers or design engineers”, Dr.-Ing. Oliver Winkel, Head of Application Technology at Liebherr-Verzahntechnik GmbH, explains.

Wide range of seminars

Liebherr-Verzahntechnik GmbH offers a wide variety of seminars, designed to enable as many specialists as possible to achieve different qualifications and undertake suitable advanced training. The technology workshops have a four-stage structure: overview, basics, advanced, and theory & practice.

The overview workshops impart the basics of gear technology and give a broad overview of the many different manufacturing processes and their features, as well as gear-



The application technology team

specific measuring technology. The seminars are held twice a year on specific dates in spring and autumn, but can also take place at a client's facilities on request. The only requirement of participants is that they have basic technical knowledge. "We practically start from scratch here, so that even newcomers are able to get their bearings," Oliver Winkel adds. The basics seminars are technology-related and provide specific gear hobbing, shaping and grinding training. They are typically offered in a custom format, in terms of location, date and content. All that the participants need is a basic understanding of technology.

The advanced seminars are geared solely towards advanced-level participants, who for example have taken part in an overview or basics seminar. These are provided above all to build-on and reinforce existing specialist knowledge about the respective technology (if the participant already has gear technology expertise).

The range of technology seminars is rounded-off by theory & practice workshops. These take an in-depth look at the topic, and participants' know-how must extend far beyond the basics. In these workshops participants are presented with typical requirements, and they have to perform independent process analyses, (e.g. based on wear and tear or quality assessments, and then discuss process improvement options with the application engineer). Oliver Winkel explains, "These theory and practice seminars include an intensive theoretical component, yet focus on direct practical use of the machines. It is about applying acquired knowledge to the everyday manufacturing environment to improve process analysis and error detection skills, and to enhance overall understanding of the specific process," Oliver Winkel explains.

Increasing demand for seminars

In order to meet the increasing demand for technological knowledge, Liebherr-Verzahntechnik GmbH attaches a great deal of importance to the qualifications obtained by



"Theory and practice" workshops

its experts, who have undergone years of intensive training and who have worked in the relevant specialist areas themselves. "Technological skills are one of our strengths and we are able to transfer this application know-how to our clients via our extensive range of seminars", Oliver Winkel emphasises. In this regard, it is important that clients are able to acquire professional advice and support they can rely on, for the long term. Consequently, qualified application engineers can generate process improvements together with clients, help with current problems, or provide support for the serial launch of new technologies.

"We give the client a complete package - our services extend far beyond the purchase of machines. We provide support by communicating our professional know-how and are forward-thinking when it comes to further and advanced training." ■

Workshops

On top of the extensive range of workshops, Liebherr offers a variety of training options, focusing on mechanics, electronics, maintenance and control. They educate the operating personnel with regards to the machines and maintenance and help to operate optimally.

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Partnering with Universities

Research excellence at RWTH Aachen involving Liebherr gear-cutting machinery

Liebherr-Verzahntechnik GmbH has a long tradition of supporting universities of applied sciences and other established universities. Liebherr machinery and innovations have been used successfully in research and teaching at such educational establishments for many years. Liebherr-Verzahntechnik GmbH has particularly close links with RWTH Aachen University's Laboratory for Machine Tools and Production Engineering (WZL). In-depth gear-wheel production, design and testing studies have been conducted in Aachen for nearly 50 years. As a member of the WZL Gear Research Circle, Liebherr-Verzahntechnik GmbH has extensively supported the WZL's research since 1962.

Gear-cutting machinery in use

Liebherr-Verzahntechnik GmbH is currently placing an LC 120 gear hobbing machine and an LCS 380 gear grinding machine at the disposal of RWTH Aachen's WZL. The machines are used in particular for public-sector sponsored research projects and bilateral contract research into gear hobbing and generating grinding process optimisation. The LC 120 machine is used to hob spur gear teeth. This machine has been specifically modified for the research operation. It facilitates force and performance measurements. The WZL is using the LC 120 to research the task of dry hobbing. Current projects deal with the avoidance of surface defects. Another aspect of research focuses on finish hobbing. The LC 120's high-performance spindle facilitates cutting speeds of up to 2,300 m min⁻¹. Fundamental principles of hobbing are research topics as well. The findings are used to enhance existing cutting machinery models and the SPARTApro production simulation software, developed at the WZL. The LCS 380 gear grinding machine is suitable for generating grinding as well as profile grinding. Dressable and non-dressable tools made of CBN or modern corundum materials can be used. The machine facilitates force and performance measurement during dressing and processing. The LCS 380 is used for research projects into generating grinding technology development. A current research topic is generating grinding of large-module teeth systems. An example of this fundamentals research is the measurement of cutting forces during generating grinding.

The WZL is developing a thermo-mechanical process model on this basis. An innovative approach to analysing generating grinding is the GearGRIND3D production simulation programme. This is validated using measurements taken on the LCS 380. As part of a bilateral research partnership between Liebherr-Verzahntechnik and the WZL, technology tests involving ceramic-bonded CBN grinding wheels were conducted. These tests verified that these wheels have long service lives and a positive impact on tooth flank load ratings, thereby favouring a serial production launch.

„From Liebherr-Verzahntechnik GmbH's point of view, partnerships with universities of applied sciences and other established universities represent an important contribution to enhancing competitiveness and to training highly qualified young talent,” says Dr. Alois Mundt, Managing Director of Liebherr-Verzahntechnik GmbH. ■



WZL gear group

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Leading in the Production of Titanium Components

Core competencies expanded

A supplier of the aviation industry, Liebherr-Aerospace Lindenberg GmbH, Lindenberg (Germany), has developed the machining of titanium components for flight control and actuation systems into one of its core competences in recent years. At the beginning of 2013, the company put into operation a new, ultra-modern machining center to manufacture hydraulic valve blocks for the Airbus A380 and other parts from titanium.

In addition to the fact that titanium as a high-strength material is difficult to machine, the complex geometry of the hydraulic valve blocks also places great demands on the cutting technology of the machining center: Various special tools and tooling machines are just as necessary for component manufacture as high-precision processes. Liebherr-Aerospace therefore developed the design of the technological systems in a three-year research project in collaboration

with the Institute of Manufacturing Engineering Technology at the Laboratory for Machine Tools (WZL) of the Technical University of Aachen (RWTH) in Germany.

Automation by Liebherr-Verzahntechnik

In the automation of the machining center, the company was able to benefit from competences within the Liebherr Group: Liebherr-Verzahntechnik GmbH not only developed an external storage and distribution system for 700 tools, but it also manufactured a special pallet-handling system. Amongst other things, this system supplies the machine with workpieces from a shelf magazine accommodating 80 pallets. The new machining center, in which around 2.7 million € were invested, will allow Liebherr-Aerospace Lindenberg GmbH to further build on its core competence and increase its productivity in the production of titanium parts. ■

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