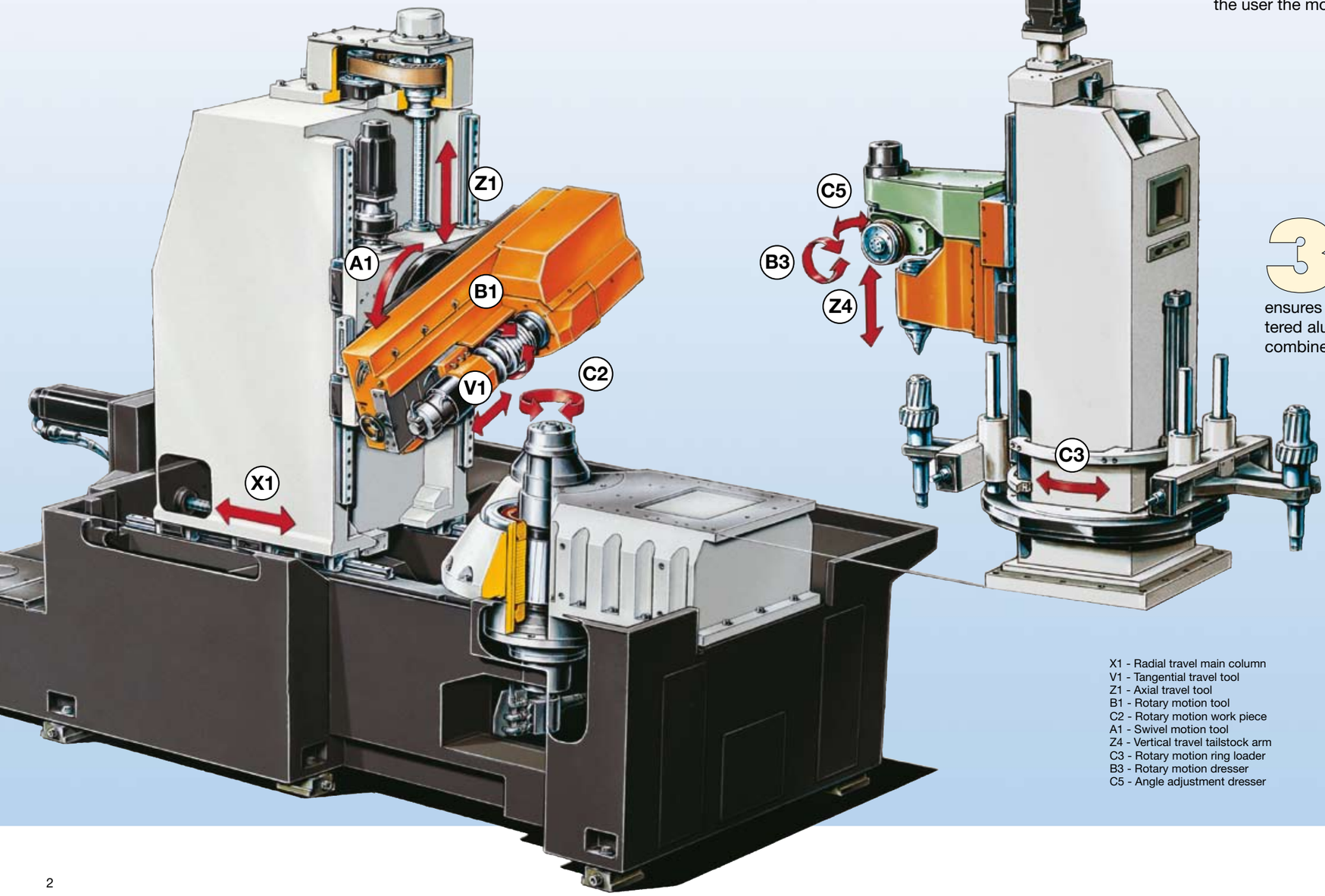
The CNC Generating and Profile Grinding Machines LCS 200, 300 to 1000.

LIEBHERR

The combined generating and profile CNC grinding machines LCS 200, LCS 300 and LCS 380.

The new LCS series offers a machine system for finish machining of hardened gears, characterized by its productivity and versatility.
Two methods can now be used on a single machine: The LCS “Combi”
Gear generating or profile grinding with dressable tools or plated CBN tools. Gear grinding with dressable worms or form wheels has been a successful and well established technology for many years. Today, with the use of dressable sintered alumina tools (aluminum oxide, Al_2O_3) it has reached a remarkable level of performance. The CBN method, in comparison, stands out for its high machining consistency over the total tool life. With its exceptional tool life of up to 200 production hours, it offers a decisive advantage for high volume production. The Liebherr LCS series covers both technologies without limitations, opening up totally new possibilities for the user.



X1 - Radial travel main column
V1 - Tangential travel tool
Z1 - Axial travel tool
B1 - Rotary motion tool
C2 - Rotary motion work piece
A1 - Swivel motion tool
Z4 - Vertical travel tailstock arm
C3 - Rotary motion ring loader
B3 - Rotary motion dresser
C5 - Angle adjustment dresser

The high volume production of the automotive industry is extremely demanding. Production equipment must perform without any compromise: highly productive in three-shift operation conditions, operator and maintenance friendly, reliable over the complete equipment life cycle. Liebherr gear cutting machines are internationally renowned for these qualities. Their modern and innovative technologies set the standard for success in transmission manufacturing: High productivity at the lowest cost per piece.

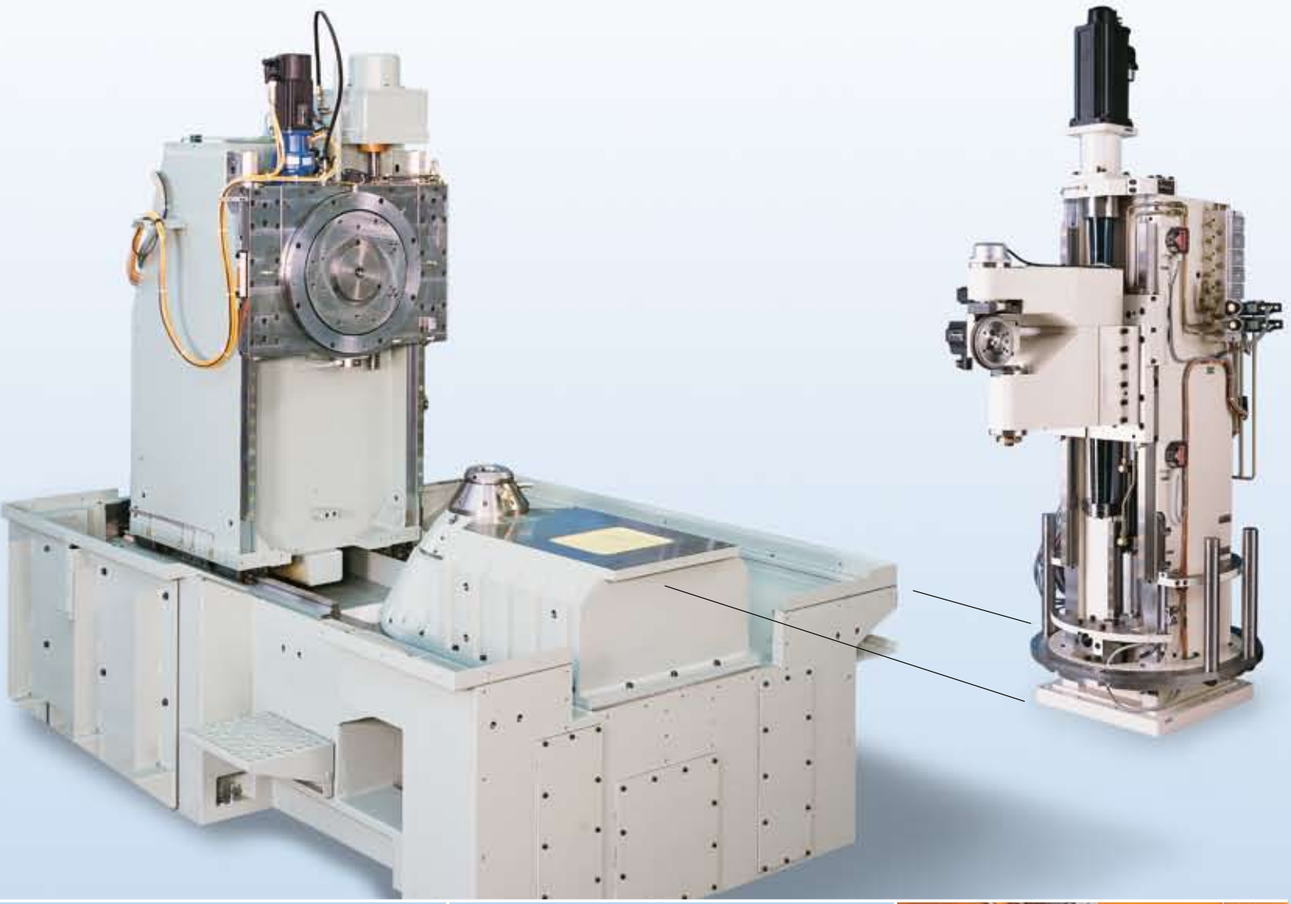
1 The platform strategy:
Optimal cost performance ratio.
The wide range of machine sizes always offers the most suitable model for each application. The basis of the new LCS series of machines is the Liebherr gear hobbing and gear shaping machine platform. Synergy within the modular component system offers the user the most cost effective equipment.

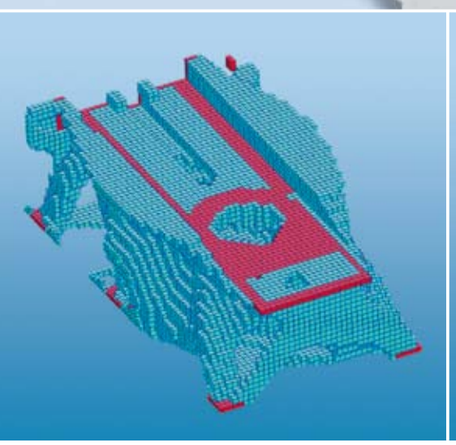
2 Profile grinding or generating grinding?
After many years of experience with CBN generating and profile grinding, we can now optimize each application by combining the specific advantages of both methods. This universal concept opens up new and different possibilities for the user.

3 CBN, dressable sintered alumina or a combination?
Independent of the grinding technology, the user has a choice of using CBN or sintered alumina tools. CBN ensures high production consistency over a long tool life, while sintered alumina offers additional flexibility. Both methods may also be combined.

4 Service perfection:
For highest availability.
Easily accessible control elements, long maintenance intervals (MTBF), short repair times (MTTR). Well thought-out equipment design, coupled with optimal service (R&M principles), reduce machine down times for routine maintenance, increasing productivity and lowering life cycle costs.

1 The platform strategy: Optimal cost performance ratio.





Machine bed

Direct drive work spindle

Grinding head

Machine design
The new LCS machine design is based on the well-proven platform of Liebherr gear hobbing and shaping machines. Roller guideways for the linear axes, direct drives for tool and workpiece spindles, with their backlash free characteristics, guarantee maximum machining accuracy.

Machine bed
The completely symmetric design of the machine frame, with enclosed circulating coolant system of the machine bed, allows uniform distribution of temperature to maintain thermal stability. This is essential for high workpiece quality and process reliability. The rigidity of the machine bed has been optimized for the grinding process by using Finite Element Analysis. High acceleration values can be achieved in the linear axes without influencing the dynamic stability of the system.

Direct drive work spindle
The direct-drive work spindle combines high speeds of up to 800 rpm with an extremely high positioning accuracy. Its high dynamics reduces non-productive indexing times for profile grinding, allowing large rotational table movements without time losses, e.g. “random indexing strategy”.

Tool spindle
A proven, highly dynamic motor spindle with a maximum speed of 12,000 rpm (20,000 rpm) drives the grinding tool. This allows cutting speeds of more than 100 m/s.

Grinding head
The grinding head, with main and counter bearings, permits the use of tools up to 210 mm length, for longer tool life. An integrated NC dressing unit is used for profiling dressable grinding tools. Pressure angle corrections for twist-free grinding of crowned helical gears, as well as form dressing of grinding wheels, are possible.

Ring loader
The ring loader, with CNC drives, is extremely flexible, further reducing setup and workpiece changing times. A variety of modular workpiece storage systems are available. Standardized interfaces for workpiece transfer simplify the integration into interlinked production systems.

2 Profile grinding or generating grinding?

The roughing/finishing combination:
The “classic” arrangement of CBN tools is the combination of a roughing and a finishing worm.
High metal removing rates and outstanding machining accuracy are achieved, with grinding allowances up to 0.18 mm per flank

For ultimate tool life.
The “Mono” worm, with maximum shift range, offers the greatest tool life. It is primarily used for small modules up to 2.5 mm and stock allowances up to 0.10 mm per flank. With dressable tools, the range can be extended to module 5.

One interface:
A variety of tools.
All tools have a common interface with quick-release taper for the main and counter bearings. Unsupported tool holders are avoided. Different dressing concepts are available: For universality and highest performance.

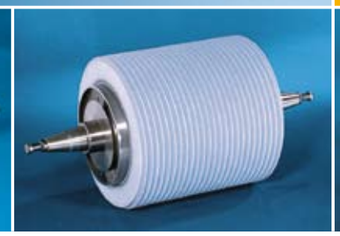
Additional NC advantage for quality and performance:
The NC controlled coolant nozzle, with optional high pressure cleaning, ensures efficient tool use without the danger of grinder burns. The dressing operation also allows NC controlled fHα corrections.









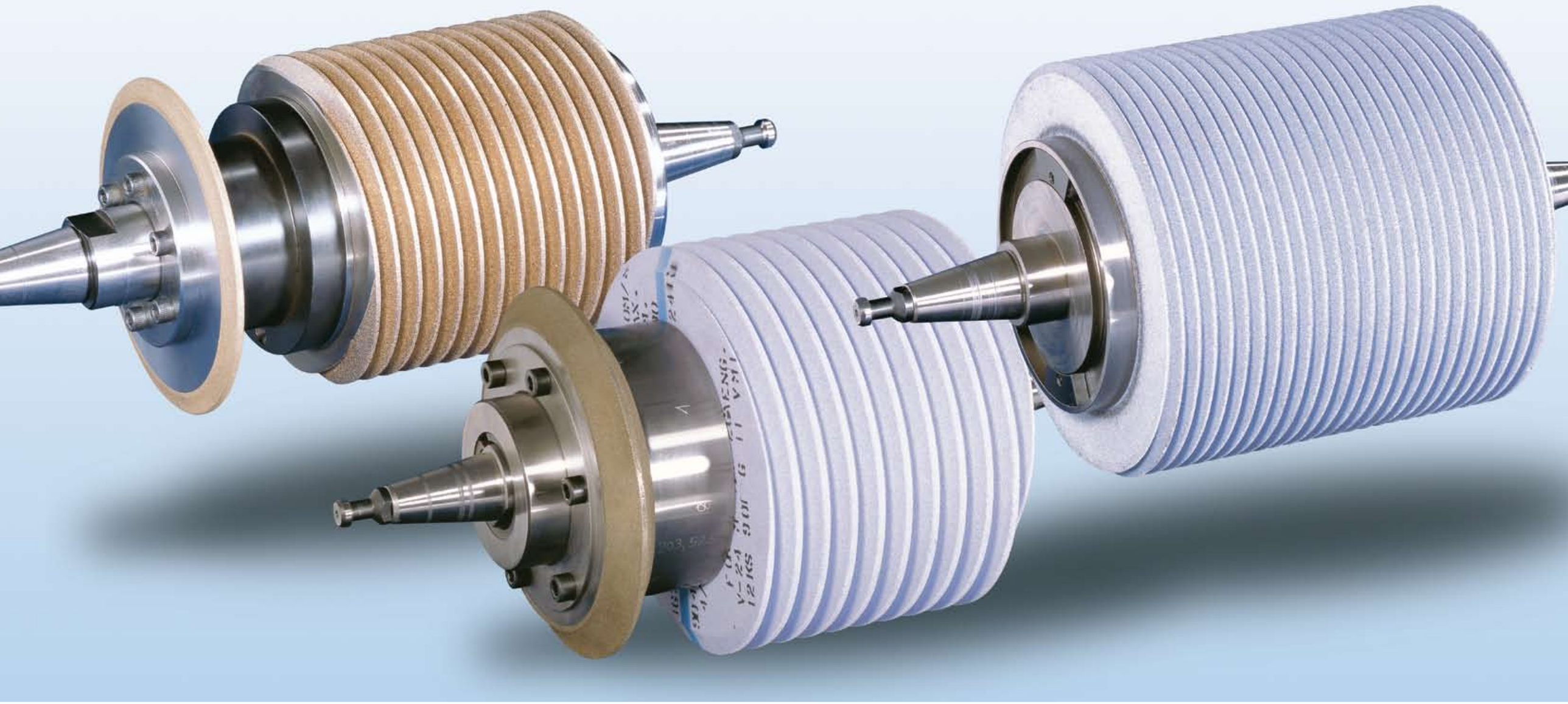
3 CBN, dressable sintered alumina or a combination?

CBN tools
The use of CBN tools is characterized by its high process stability. Over their long tool life the geometric quality of the workpiece is virtually unchanged between re-platings. Complex workpieces often allow only small tool diameters. Here again, CBN offers an economical solution.

Sintered alumina tools
Sintered alumina tools are becoming an increasingly viable alternative to plated CBN tools. They now allow cutting speeds up to 60 m/s. With these speeds, grinding performance almost identical to CBN can now be obtained. Even with the added expenditure for dressing, tool costs per part are significantly lower.

Dressing
Dressing in the machine assures a high run-out accuracy. This results in lower waviness and better profile quality. With an NC controlled dressing angle adjustment, the pressure angle can be optimized or a desired twist can be created along the worm axis. (Liebherr patent)

Combination
The combination of CBN and sintered alumina tools can be of advantage. For grinding of cluster gears, an economical solution can be the use of a CBN profile wheel for the smaller gear and a sintered alumina worm for the larger gear.

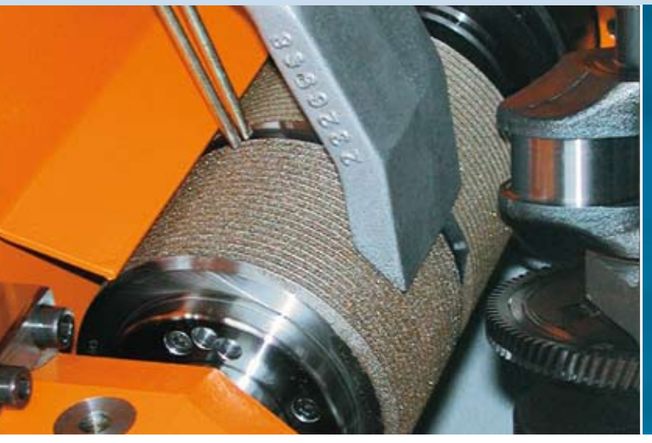


Highest performance: CBN generating grinding.

Short cycle times
The most efficient grinding method for gears is CBN generating grinding. The continuous contact of grinding worm and gear eliminates non-productive idle times. CBN allows cutting speeds of more than 70 m/s. They are achieved with a small tool diameter of 140 mm and high spindle speeds up to 12,000 rpm resulting in very short cycle times. The generating action leads to extremely short contact times of less than 0.003 s between the grinding crystals and workpiece. Despite the high grinding performance, only a very low thermal impact occurs in the grinding zone. This minimizes the risk of grinding burns.

High accuracy
A standard tool combination is a coarse grit roughing worm (B251) for stock removal up to 0.15 mm/flank and a fine grit finishing worm (B91) for high accuracy, for stock removal of 0.03 mm/flank. For smaller modules (<2.5mm), longer mono-worms (B91-B251) are available with an extended shift range and, therefore, a longer tool life. The high performance of generating grinding can be further increased by the use of multi-start worms.

Long tool life
CBN generating grinding is ideally complimented by profile grinding. This technology is of particular advantage for workpieces requiring small tool diameters, since the long CBN tool life guarantees maximum process reliability. The combination of a CBN roughing worm with a CBN finishing wheel meets the requirements of both high productivity and accuracy. This arrangement is very economical for machining commercial vehicle transmission parts. For this type of application, the roughing worm can be designed with an extended shift range for longer tool life. CBN form wheels are also used for special applications, such as internal gears or steering segments.

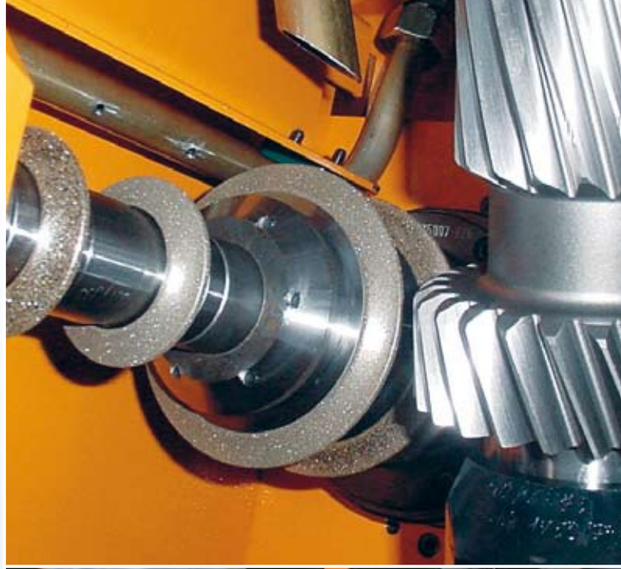


Classic roughing/finishing application

Special application CBN grinding of a steering segment

For complex components: CBN profile grinding.
Long tool life, even with small diameter tools, is the advantage of CBN profile grinding. The high feed rate capability of the machine produces short cycle times.

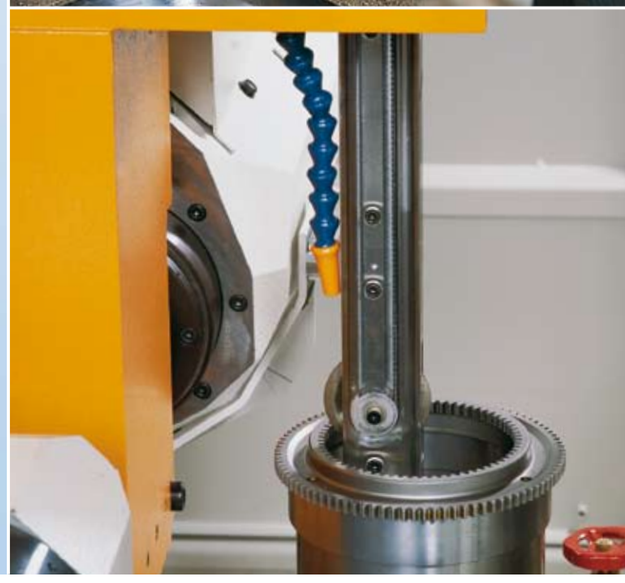
CBN profile grinding Commercial vehicle cluster gear		
Number of teeth	23	
Module	4.75	mm
Face width	47	mm
Stock per flank	0.12	mm
Cutting speed	55	m/s
Feed rates	1.6/4.0	m/min
Machining time	2.29	min



Optimal for commercial vehicle transmission gears: CBN combination grinding.
Multi-start generating grinding and subsequent finishing with a profile wheel. An effective combination of performance, accuracy and protection against micro-structural changes.

combination grinding Commercial vehicle transmission gear		
Number of teeth	47	
Moduel	4.50	mm
Face width	65	mm
Stock per flank	0.15	mm
Cutting speed	66	m/s
Feed rate	0.2	mm/parts rev. 3.6 m/min
Machining time	2.31	min

Grinding internal gears:
For internal gears, CBN form grinding is the right solution. Although dimensional limitations require the use of very small diameter grinding wheels, excellent tool life can be obtained.
The internal grinding head is available with three different sizes of grinding arms. With its grinding wheel axis in the center of the swivel rotation, internal helical gears can also be ground. Economical cutting speeds can be achieved with spindle speeds up to 20,000 rpm. Changeover time from external to internal grinding is less than 30 min.



Grinding with sintered alumina: Economical and flexible.

Grinding performance at CBN level
Dressable tools have the advantage of a higher grit density compared to galvanically plated tools. This permits the use of higher axial feed rates. However, the stiffness of dressable tools is considerably lower than for CBN tools with their steel core. Therefore, in general, one additional pass is required (roughing – semi-finishing – finishing). The higher permissible axial feed rates compensate for this to achieve grinding performance similar to CBN.

Mono-worm
The spiral length available within the shift range of a grinding worm determines long tool life. For this, a mono-worm offers the best solution. The ideal diameter to length ratio of the worm is approx. 180 mm diameter and 200 mm length. With this relatively small diameter and long worm length, short grinding times and excellent tool life are achieved.

Long tool life
The diameter of a new worm is 195 mm and can be dressed to approx. 160 mm. For an average automotive transmission gear, this results in approx. 100 parts per dressing cycle and a total output of 10,000 parts per worm.

Economical:
Generating grinding with sintered alumina.
High speeds of tool and workpiece spindles guarantee short machining times. Additionally, single flank CNC dressing produces high accuracy.

Example automotive transmission gear	
Number of teeth	41
Module	2.25 mm
Face width	14.5 mm
Stock per flank	0.10 mm
Cutting speed	60 m/s
Feed rate	0.18 mm/part rev.
Machining time	0.35 min

High flexibility:
Profile grinding with sintered alumina.
Sintered alumina profile wheels are ideal for prototype and small batch production.
Highest flexibility is achieved since each tooth form and profile modification can be produced with a single diamond disc and a parametric NC dressing program.

Example construction machinery planet gear	
Number of teeth	30
Moduel	4.60 mm
Face width	63 mm
Stock per flank	0.14 mm
Cutting speed	60 m/s
Feed rates	1500/2000 mm/min
Machining time	3.40 min

Dressing with high flexibility.
The dressing unit can be used to dress worms as well as profile wheels. If equipped with an additional NC axis, it is possible to make a pressure angle modification for generating grinding. With the programmable speed and rotational direction of the diamond dressing disc, it is possible to influence the roughness of the right and left flanks, reducing the possibility of grinding burns. It is also possible to compensate for the influences caused by wear of the diamond dressing disc.

4 Service perfection. For highest availability.

Easily accessible control elements, long maintenance intervals, short repair times:
Well thought out equipment design, coupled with an optimal service concept, reduce machine down times for routine maintenance - increasing productivity and lowering life cycle costs.

Service friendly ex-works

A distinctive feature of Liebherr gear cutting machines is their service friendliness:
Quick routine checks and long service intervals result in high machine availability.

- For easy access, all components are mounted on the outside of the machine to allow fast routine maintenance and service.
- R+M concepts (reliability and maintainability), used for many years by Liebherr for aircraft component manufacturing, are standard-practice throughout all product lines.

Major automotive manufacturers have shown appreciation for our efforts with international supplier awards.

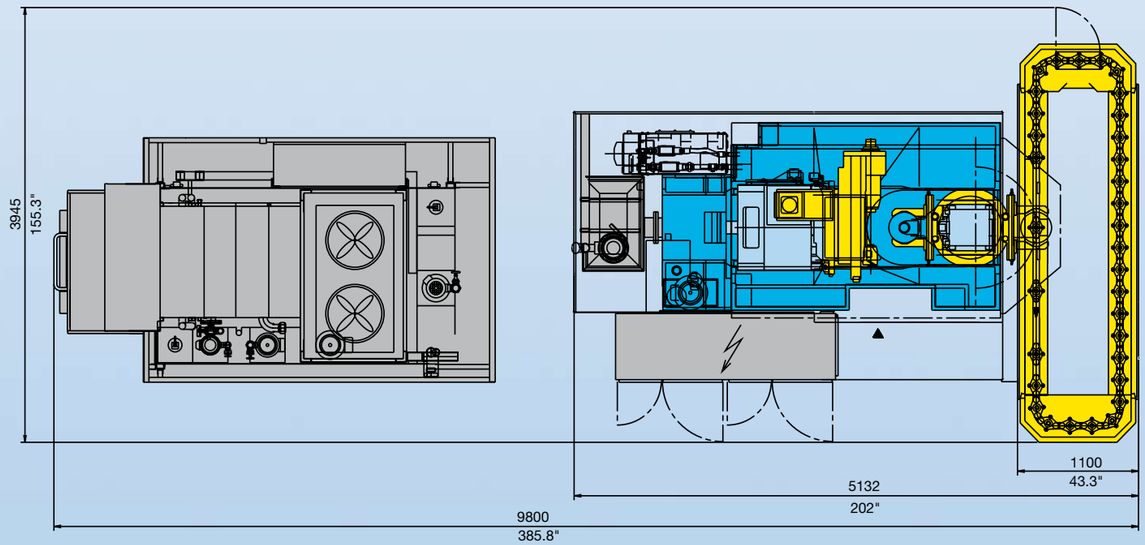
The control and drive technology

The PC based control, in combination with highly dynamic digital drives, guarantees excellent gear quality. Consistent use of standard field busses and highly integrated control modules, allow a minimum of wiring.

The operator and programming menu screens, specifically designed for gear grinding, allow direct input of drawing data into the control. The context dependent menus and real-time feasibility check, provide a safe input of workpiece and tool data. Fast and automatic meshing of pre-machined workpieces is supplemented by software algorithms to average out heat treatment distortion. With data entered directly from the measuring diagrams, the control generates any required corrections.

Technical Data.

		LCS 200	LCS 300	LCS 380	LCS 600	LCS 700	LCS 1000
Workpiece diameter	mm	200	300	380	600	700	1000
Table Speed	rpm	800	800	800	350	350	250
Axial Travel (max)	mm	600	600	600	1000	1000	1000
Axial travel speed	mm/min	10,000	10,000	10,000	10,000	10,000	10,000
Radial travel speed	mm/min	8,000	8,000	8,000	8,000	8,000	8,000
Grinding head swivel angle	deg.	+/-35	+/-35	+/-35	+/-45	+/-45	+/-45
Module (max. generating grinding)	mm	7	7	8	8	8	8
Module (max. profile grinding)	mm	8	8	10	10/16	10/16	10/16
Grinding spindle speed	rpm	12,000	12,000	12,000	12,000	12,000	12,000
CBN tool diameter (max. generating grinding)	mm	145/170	145/170	145/170	170	170	170
CBN tool diameter (max. profile grinding)	mm	195	195	195	320	320	320
Alumina tool diameter (max. generating grinding)	mm	195/240	195/240	195/240	240 (320)	240 (320)	240 (320)
Alumina tool diameter (max. profile grinding)	mm	195/320	195/320	195/320	320	320	320
Tool length (max.)	mm	210/230	210/230	210/230	230	230	230
Tangential travel (max.)	mm	200/300	200/300	200/300	300	300	300
Spindle drive power	kW	28/32	28/32	28/32	32	32	32
Machine weight with tailstock	appr. kg	13,000	13,500	14,000	25,000	25,000	28,000
Total connected load	appr. kVA	55	55	55	80	80	80



Layout LC 380

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