

The Skiving Evolution

Machine Tool Providers Discuss the Latest Benefits, Technologies and Considerations

Matthew Jaster, Senior Editor

EMO 2019 (Hannover, Germany) and Motion + Power Technology 2019 (Detroit, Michigan) introduced the latest and greatest skiving technologies available to gear manufacturers. Both trade shows featured several booths with technical experts on-hand to deliver news on flexibility, tool life, machine uptime and the productivity benefits produced from the skiving process.

Liebherr offers machines for various cutting processes

Liebherr introduced the new Gear Skiving machine LK 280 DC at EMO 2019. This machine can handle parts with up to 280 mm outside or rotating diameter. To be able to handle various processes, the machine is equipped with a tool changer with 12 stations.

“Besides identical skiving tools to continue production, roughing and finishing tools can be loaded to reduce the wear of the finishing cutter,” said Dr. Oliver Winkel, head of technology application, Liebherr-Verzahntechnik GmbH, Germany. “In addition to skiving, the machine is prepared for other cutting processes like turning, drilling and milling as well as handling a measuring probe. This gives the customer the flexibility for today and tomorrow’s gear cutting applications not only for internal but also for external gears or shafts.”

Liebherr also introduced a new chamfering process called “FlexChamfer.” Using the 6-NC-axes of the chamfering unit, the machine moves an end mill in such a way that even complex contours like internal gears can be easily chamfered without any



Gleason offers Power Skiving machines in different sizes for internal and external gears. (Photo courtesy of Gleason).

special tools. This is especially useful for job shops or small volume productions and will give a high value to today’s needs of precise chamfering, according to Winkel.

The acquisition of Wenzel Gear Tech gear measuring machines enabled Liebherr to complete its Liebherr Open Connect IoT-solution, where measuring data are transferred back and forth between gear checker and gear cutting machine using the new GDE (gear data exchange) format. This transparent and open kind of “closed loop” give the customer the chance to minimize manual inputs and maximize uptime of the machines while giving the chance to integrate existing machine tools (even, if not made by Liebherr).

Regarding tooling and workholding, Winkel said that the clamping fixtures are very important and often totally different to what customers are used to from shaping and broaching which are more or less “stationary processes” regarding table rpm.

“For skiving, very high table rpms are required, so the dynamic forces are much higher. The clamping fixture design must take care of that, meaning higher prices for tooling. We had a similar situation, when generating grinding of bigger modules came up, and customers wanted to use their existing fixtures that they successfully used for profile grinding many years,” Winkel said.

For Liebherr, the main application for skiving is the manufacturing of internal gears with medium to high batch sizes. Whenever shaping is too slow and broaching is too expensive or geometrically not possible.

“Industrial gearbox manufacturers as well as construction or agricultural equipment manufacturers as well as job shops might benefit the most. But even the automotive industry has in seen an increasing number of applications, whenever collision contours or medium volume outsourcing come into play. This is particularly true for external gears with interference contour or the skiving of two gears



Liebherr's skiving technology works well with internal gears with medium to high batch sizes. (Photo courtesy of Liebherr)



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with a positioning between them,” Winkel added.

Winkel believes that every company with medium to bigger lot sizes should have a gear skiving machine. The flexibility to machine external and internal gears on a high productivity level is very attractive for today and the future. He expects an increasing amount of applications in this area because engineers see great potential for their gear designs. Furthermore, the tool life and the knowledge about skiving technology will continue to improve.

For more information:

Liebherr Gear Technology, Inc.
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Super-Skiving with MHI

With highly engineered maximum rigidity and advanced high-speed spindle synchronization, the MSS300 takes full advantage of the cutting performance of MHI's Super Skiving tools. These three-tiered tools can reduce cycle time by up to 40% while improving tool life 40%–300% compared to an ordinary pinion type skiving tool.

Because of the North American debut of the newest gear grinder, the ZE26C, at Motion + Power Expo, there wasn't room to display the MSS300. However, external gear skiving using the three-tiered Super Skiving cutter is a recently added option for the MSS300.

“Gear skiving, and Super Skiving in particular, have applications primarily for internal gears which traditionally would have been shaped or broached. Faster than shaping and slower than broaching, gear skiving offers enhanced control and efficiency. This is beneficial to automotive as well as truck and off-road industry sectors. The “quick change” concept also applies to agricultural equipment manufacturers and industrial applications with high mix and low to medium volumes. External

parts with interfering geometry, such as a shoulder, are good candidates for gear skiving as well,” said Dwight Smith, vice president at Mitsubishi Heavy Industries America.

To benefit from the speed and greatly improved tool life of the three-tiered Super Skiving cutters, the workholding needs to be designed to allow the cutter to feed past the end of the facewidth of the part. Rigidity and balance are also important due to the high speeds and process dynamics.

Smith said that the Super Skiving tool has three times as many cutting blades involved in the process (compared to conventional pinion type cutters) and a much higher metal removal rate. Therefore, the work holding must have sufficient rigidity to resist these forces. Mitsubishi engineers, using advanced simulation software developed in-house, can model the forces created at each discreet point in the generating process. This data is then applied to the work holding design.

Smith said that the software powering the MSS300 is continuously evolving. Maximizing machine motions to accomplish specific cutting operations will broaden capabilities and flexibility. In the engineering arena, the cutting simulation software provides specific cutting tool design information to improve tool life and ultimate part quality. In the design of the MSS300 and future iterations, advanced FEM and MBD (Multibody Dynamics) analyses are used, and extensive natural frequency analysis is performed to further refine the designs.

By optimizing machine rigidity and axis synchronization, MHI has improved tool life to allow Super Skiving to challenge broaching in high volume production applications. At the same time, Super Skiving can supplant or replace shaping for many internal and external applications and offers much better throughput. The ability to make corrections and the ease of tool change makes gear skiving a viable choice for many jobs.

“Driven by customer needs, MHI will continue to integrate additional features into the MSS series of Super Skiving machines. The recent research project in conjunction with WZL Aachen Gear Research has yielded valuable data to further improve skiving tool life and productivity. Another study, recently presented at the VDI symposium in Munich, showed reduced residual compressive stress in internal ring gears cut with Super Skiving. This suggests a potential reduction in distortion for carburizing and hardening of this type of parts,” Smith said.

For more information:

Mitsubishi Heavy Industries America, Inc.
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Power Skiving enhancements at Gleason

Gleason is building Power Skiving machines in different sizes for internal and external gears including the 100PS, 300PS, 400PS, 600PS, 800PS. Together with these machines, they offer customers technology software to design the process and skiving cutters with all the necessary calculations and analysis. Alternatively,



The MSS 300 Super Skiving machine features FEM and MBD analyses. (Photo courtesy of Mitsubishi Heavy Industries America)



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Process monitoring

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Component monitoring

Recurring automatic testing cycles measure and evaluate all the relevant grinding machine axes involved in the process, and thus enables early detection of electromechanical deviations. Maintenance costs are optimized both in terms of planning and diagnosis, and some potential EOL anomalies may be avoided.

Gleason provides this service including process and cutter design directly to their customers for any new job. On the base of this analysis, they manufacture cutters and also dedicated workholding that is specially adapted to the Power Skiving process and the customer application.

Although “one-way” wafer cutters for the shaping process have been in use for some time, such cutters do not improve the current Power Skiving process by much, according to Dr. Edgar Weppelmann, manager application engineering at Gleason-Pfauter. Resharpener the cutter in the Power Skiving machine enhances the process in virtually all aspects due to the more frequent cutter changes required because of the much faster Power Skiving Process compared to shaping.

“For this reason Gleason has developed for their 300, 400 and 600PS machines an integrated unit to resharpen cutters in the machine in a very short time. The cutter face can now be resharpened fully automatic in the machine after it has cut a certain number of gears — without any operator involvement. The cutter geometry is adjusted automatically considering the removed stock and the serial production is continued without further interruption. Recoating the cutting face is not required because the original coating on the flanks protects the cutter teeth sufficiently,” Weppelmann said.



Frequent cutter changes are no longer required, a single cutter can stay on the machine for several days or weeks before it is fully used up. The time that has been used in the past by the operator for a cutter change is now being used for three to four automatic cutter grinding cycles with a reduced stock removal per grinding cycle to keep the cutter constantly sharp for a high and constant gear quality, he added.



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First part inspection and machine correction after cutter resharpening are no longer necessary because the same cutter is continuing the production which also relieves the cost and capacity in the inspection room.

In addition, cutter management and handling logistics to ordering new cutters in time, to ensure a continuous production, is highly reduced. Cutter inventory can also be drastically reduced because there is no longer the need to circulate cutters through an external re-furbishing cycle.

“Because the cost for external cutter refurbishing is avoided, the tool cost per gear is drastically reduced. However, the total savings are considerably higher if one considers the other benefits described above. When carbide cutters are used for soft or hard skiving the savings from avoiding the external re-furbishing are even higher. Also, the danger of damaging expensive carbide cutters by manual handling is highly reduced as the cutters stay much longer in the process without being touched. The productivity of the power skiving process is not jeopardized by the missing coating on the cutter face because resharpening now happens more frequently compared to the cutter life of the current process with external cutter re-furbishing,” Weppelmann said.

Not all internal ring gear geometries can be skived due to collision and chip evacuation requirements. Due to the cross-axis angle required for Power Skiving the process needs a larger distance to collision shoulders at the end of the cut to avoid a collision between the cutter and the workpiece.

Weppelmann said, however, typical skiving applications are internal ring gears, spur and helical gears in soft and hardened state. Electromobility with the higher quality requirements to reduce noise, light and heavy truck gears, gears for agriculture and construction equipment, aircraft and robotic gears as well as a wider range of gears for many industrial applications, typically served by job shops.

“Power skiving is taking over more and more gears from the shaping process as long as they are suitable for Power Skiving. It is now also used for hard finishing of higher quality gears mostly in electro-mobility and robotic applications which require higher qualities that cannot be achieved without a hard finishing process after heat treatment. Gleason Power Skiving machines with integrated cutter resharpening ideally support these requirements.

Hard Power Skiving is the technology where Weppelmann said we will see significant developments in close combination with integrated cutter resharpening. This is to meet the requirements for quieter and more precise gears. Integrated cutter resharpening will become increasingly accepted to lower cost and tool inventory and to increase gear quality.

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Star-SU Discusses Skiving/Scudding Benefits

Star-SU and its partners Samputensili and GMTA provide the tooling as well as the application knowhow to provide the latest advancements in skiving. These advancements can lower overall manufacturing costs by reducing the longer cycle times found in areas like shaping operations.

“We’re currently working with GMTA on their Profilator equipment,” said Deniz Sari, sales manager at Samputensili. “These machines are designed for dry cutting, offer excellent chip evacuation and increased cutting speeds.”

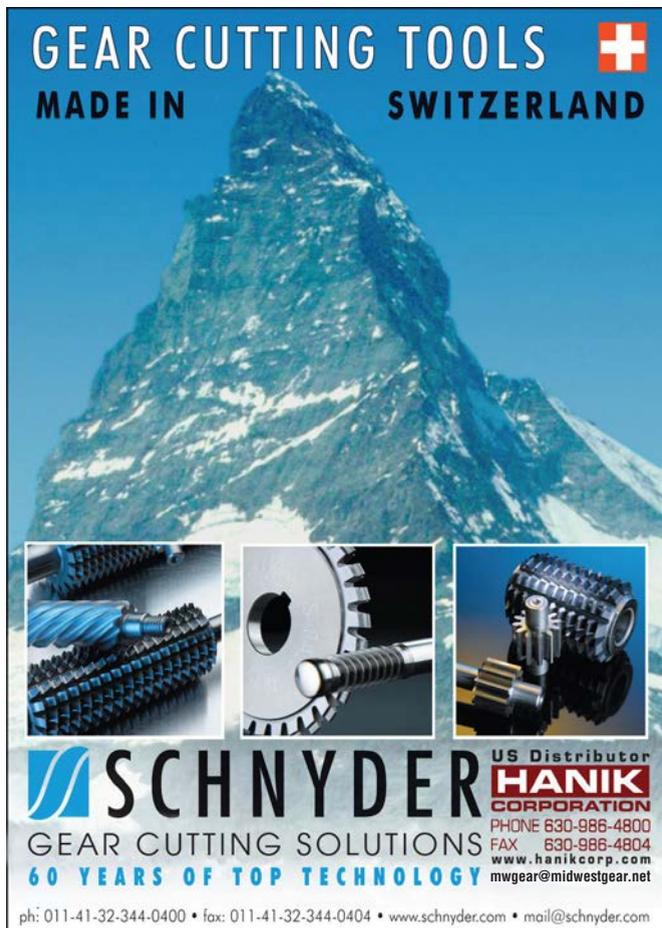
Scudding from GMTA takes traditional power skiving technology for gear production and makes it much more accurate and versatile. The process is extremely competitive in shaping, broaching and other gear cutting applications for gears and splines.

Sari says that many customers today are looking for machines that combine a variety of machining operations (with skiving) on a single platform. This seemed to be the consensus from attendees at both EMO in Hannover and the Motion + Power Technology Expo in Detroit.

The challenge, according to Tom Ware, product manager, gear tools at Star-SU, is when machine tool providers want to include skiving in their 5-axis milling operations.

“They typically do not have the background in gears that is necessary, so they rely on the tool supplier to be the process engineer,” said Ware. “This can be a huge drain on the engineering capacity of the cutting tool provider. There are some inherent mechanical issues regarding horsepower and rigidity that need to be carefully examined in order to optimize the skiving process.”

Sari said that Star-SU and its partners are finding ways to work through these various challenges.



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Star SU provides the tooling and application support for GMTA's Profilator equipment. (Photo courtesy of Star SU)

“These 5-axis machines are capable of producing gears now, mostly low-quality splines or prototypes and this makes a lot of sense,” Sari said. “They will never adequately replace dedicated gear equipment when you start looking at larger batch sizes, however.”

Ware believes the greatest benefit of skiving today lies in the internal ring gear whether it’s for an automotive application or a more elaborate gear design in truck or tractor applications. “Wherever you can move away from the helical broaching process, I think we’re going to continue to see growth in skiving. Double gear applications are another area that can benefit from skiving.”

Sari agrees that automotive holds great potential for the skiving process moving forward, particularly the electrification trend taking place today. “The electric gearbox with all of its advanced, integrated parts offers new opportunities for the skiving process.”

While the tooling for skiving has not required a lot of new manufacturing technology recently, Ware said they are focused on developing high-speed skiving tools that will provide longer machine runs and better performance, “Anything new that is happening in the skiving process is currently taking place on the design side.”

But for flexibility, productivity and enhanced machining operations, scudding/skiving continues to provide gear manufacturers with additional cutting options.

“Gear designers like to use all the profile and lead

corrections,” Sari said. “This is something that cannot work with broaching. In skiving, you can add the lead corrections into your machine control with the latest CNC technology and it’s not an issue.”

For more information:

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The Evolution Continues

Those manufacturers looking to manufacture quieter, more precise gears will continue to consider skiving technology. The changing landscape of both the aerospace and automotive industries will provide plenty of opportunities for the skiving process. What’s fascinating in 2019 is the different styles, methods, tooling and workholding procedures that each machine tool provider is focusing their efforts on. These different technologies were on display at both EMO and the Motion + Power Technology Expo and it’s fair to say that the technology will continue to evolve by the time IMTS 2020 rolls around next fall. 

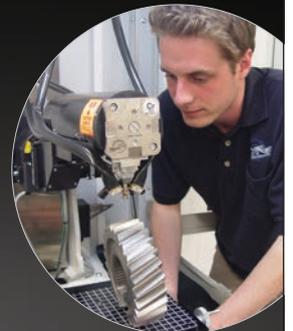


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