

Skiving: A Manufacturing Renaissance

Matthew Jaster, Senior Editor

Skiving will be front and center when the gear industry comes together in Columbus this October. Attendees will find dedicated skiving equipment, multifunctional machines with skiving options and a slew of new cutting tools, machine designs and modifications to make the process more efficient and robust.

Although the skiving process has been around for a very long time, the industry continues to make adjustments where needed. Companies are reinvesting and reinventing how to present their customers with skiving capabilities. *Gear Technology* recently spoke with several companies to discuss where this highly productive process fits into gear manufacturing in 2017.

Tool Technology

One area that has improved tremendously is the tools used for the skiving process. In the last few years, engineers from Gleason Cutting Tool Corporation in Rockford, Illinois and application engineering at Gleason-Pfauter operations in Germany and Switzerland have developed a new generation of power skiving tools that match the specific requirements of its customers.

“For soft machining, different substrates like G50 and G70 are used which, in combination with Gleason’s AlCrONite Pro advanced coatings, deliver hardness and toughness characteristics needed for both productivity and optimum tool life during power skiving,” said Udo Stolz, vice president worldwide sales and marketing at Gleason.

“Carbide tool development and execution are becoming more important today. Gleason has created capacities to design and manufacture these kinds of tools. For power skiving, we have a very special situation: The best design and execution is not worth much if you don’t understand the process and its characteristics in every single cut. Tool development at Gleason is based on its own, unique simulation software and technology know-how,” Stolz added.



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Of course, better substrates and coatings helped to increase tool life, but the main step forward was the modern cutting strategy of the multi-cut-cycles with sometimes over a dozen cuts, according to Oliver Winkel, head of the application technology department at Liebherr. “This improves the cutting conditions a lot and gives the tool a chance,” Winkel said.

In the beginning, Star SU/Samputensili used its knowledge of the shaping experience to make the choice of cutting material and coating combination. Early on, however, they realized, due to the special characteristics of the skiving process, extreme thermal and mechanical loads were occurring on the tool, which placed special demands on the tool’s design and the choice of the material and coating combination.

“Today, with our experience, our designers choose the geometrical tool features like number of teeth, helix angle, clearance angle and profile corrections to offer our customers a high-performance skiving tool to achieve their process and quality demands. We are providing the market with skiving tools out of high speed steel and carbide. Together with our customers we develop custom fit material and coating combinations to have the best solution for each application,” said Thomas Ware, product manager — gear tools at Star SU.

The tool team at MHI has developed three types of specialized skiving tools. First, the conventional pinion type cutter was introduced. All other suppliers of skiving tools are utilizing this type of tool. To greatly improve tool life, the tapered barrel helical cutter was developed.

“The most recent development is the three piece assembled cutter which was introduced to further advance tool life and metal removal rates,” said Dwight Smith, vice president at Mitsubishi Heavy Industries America. “The patented Super Skiving tools have multiple cutting edges for creating the tooth space rather than just one cutting blade. By using a tapered roughing portion, three blades are involved in the cutting action.”



The Gleason 100PS power skiving machine offers small to medium-sized workpieces in module range up to 2.0 mm.

While carbide cutting tools are preferred, Tim Sadek, engineering director—bevel gear division at Klingelnberg, believes the most critical tooling aspect is the design and the cutting strategy. “At this point in time, we focus on coated PM-HSS cylindrical Monobloc tools with dry cutting.”

The Skiving Market Today

Attend any metalworking trade show and you’ll hear a pitch or two about advancements to the skiving process. This includes new tooling, automated capabilities, deburring capabilities and partnerships that continue to help evolve gear skiving.

Introduced at JIMTOF 2016, the MHI MSS300 Super Skiving machine is the only system designed and built specifically to utilize the productivity of the new Super Skiving tools. These new tools require exceptional machine rigidity and stiff synchronization of the work table with the tool spindle. In the past, skiving was held back by machine tools that weren’t rigid and stiff enough, and lacked robust spindle synchronization, according to Smith.



Liebherr’s LK 500 opens a new chapter in gear skiving.

Winkel said that the Liebherr LK300 and LK500 for workpieces up to 500 mm diameter and module 5 mm will be presented at the upcoming EMO fair in Hannover, Germany and Gear Expo in Columbus, OH. The machine will have a tool changer and an integrated deburring device.

“Based on our decade-long experience in designing gear cutting machines, the machines are typically Liebherr-style, thus very rigid and strong to handle the high dynamics of skiving. In combination with the Liebherr skiving tools and skiving technology, this will lead to a full package which we call Liebherr Skiving³ (cubic skiving),” Winkel said.

Stolz at Gleason says that the latest technology developments take place in the field of hard power skiving. “Today, no efficient process for hard manufacturing of internal gears exists. As manufacturing solutions for hardened gears become increasingly important, especially in the context of electric mobility,

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Star-SU Scudding cutters.



Gleason is in the pole position related to hard power skiving developments on cylindrical as well as on bevel gear manufacturing machines,” Stolz said.

Another important feature is the integration of deburring capabilities into power skiving tools for soft machining, where Gleason has developed and implemented a unique solution.

Gleason has successfully tested and installed highly productive power skiving machines for large workpieces up to 900 mm in diameter and module 9, certainly unique for dedicated skiving machines.

For several years StarSU/Samputensili and Profikator have been in an alliance to offer the market a tool and machine tool technology package (*Ed’s Note: See article on page 54*). Profikator’s Scudding process offers the market the possibility to use the skiving process as a soft as well as a hard machining process for internal and external gears. “Furthermore, together with Profikator we offer all customers the advantage to run a dry cutting process which avoids all the negative factors of a wet cutting operation,” Ware said.

Dedicated Versus Multifunctional

A debate that can be applied to many gear production processes is whether or not you should consider dedicated equipment or multifunctional machines for your gear shop needs. (*Ed’s Note: See accompanying Toyota article on page 56 for more on multifunctional capabilities*).

Most dedicated machines fulfill all the needs of the high-speed and high-dynamic skiving process. Winkel at Liebherr says that a customer can reach the best quality and lowest cycle times on serial production parts and believes programming with a dedicated HMI is easier and matches all the requirements of gear manufacturing.

“A general purpose machine has all necessary axes to do the movements, but will never reach the productivity of a dedicated gear cutting machine. And don’t forget about the gearheads

behind the machine,” Winkel said. “Who do you call, if there is an issue? You need the necessary technology knowhow and the skilled application engineers to cover those questions and problems.”

Smith at MHI says that for the mass production of internal ring gears using skiving, a dedicated machine offers the highest productivity and reliability because it has been designed specifically for this application.

“A general purpose machine is just that — designed for general machining. It may be able to skive, but compromises are inevitable if a specific machine is also expected to mill, drill, etc. As we have learned from 56 years of manufacturing gear equipment, the dynamics of the generating process are very demanding. If a company has occasional requirements and small lot sizes for skiving, a general purpose machine may serve this need.”

Dedicated skiving equipment — at least at Gleason — is designed to counteract torque and forces immanent to the power skiving process, resulting in higher productivity and cutter life on dedicated machines, according to Stolz.

He believes general-purpose machines are not designed for the power skiving process but for other processes like turning, milling, drilling etc. While power skiving as an add-on always asks for compromise, general-purpose machines have the benefit of combining different operations in a single production machine. “We recommend the use of dedicated power skiving machines for small/medium and in some cases even large lot sizes if the gear is the focus of the task,” Stolz said.

Sari at Samputensili said that during skiving, the cutting speed results from the rotation speeds of tool and workpiece as well as the set cross-axis angle. Today the cutting speeds, now being implemented with modern machine and tool technology, are up to $v_c = 250$ m/min. These high spindle speeds produce high process dynamics. “To avoid the negative effects of the process dynamics on the process, it is necessary to use a dedicated skiving machine that is tailor-made to control the process,” Sari said.

He continues, “This is the only way to ensure that vibrations



The MSS300 Super Skiving machine is designed specifically for the high-speed manufacturing of automotive internal ring gears.



The integration of power skiving on Klingelberg's bevel gear cutting machines enables the customer to use the full capacity of the machine tool.

are minimal and a rigid machine structure provides an optimal quality result. Most state of the art machining centers for standard milling or turning operations, do not have the stiffness and stability in the tool spindle, to meet our customer's requirements to produce high quality gears. This can only come from dedicated gear manufacturing machines."

Future Considerations

Gear Expo 2017 will give attendees the best industry preview of things to come regarding skiving technology. Many companies asked to participate in this article said they would have much

more to discuss about the skiving process at the show. There is skiving technology today that is only scratching the surface, so to speak, of what machines will be capable of in the future.

"In the next three to five years, Gleason will stay focused on continuous improvement of the process and tool development. Related to the machines, the focus will be on faster changeover of tools and workpieces and integration of additional processes," Stolz said. "Even if significant progress has been made in the past years, hard Power Skiving is still in its initial development phase. Market penetration will increase and Gleason will stay in the forefront of this interesting development."

The gear and transmission industry continually asks for more weight reduction in transmission designs and this will become even more important in the future, according to Sari. This leads to more complex and integrated part designs. If the design is focusing on the objective of weight reduction, other requirements like machinability becoming secondary.

"In such cases, we as gear manufacturers must develop our processes in this direction to offer the market technologies which could reduce overrun lengths of the tool or combined machining steps to realize integrated transmission parts. Skiving offers us the possibility to machine highly integrated parts with different gearings (internal and external) in one machine using one clamping and less tool overrun space. Additionally, skiving machines with integrated technologies like turning or milling will become important," Sari said.

Sadek at Klingelberg believes that the integration of power skiving on bevel gear cutting machines enables the full capacity



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Based on the company's experience in designing gear cutting machines, Liebherr's machines are very rigid and strong to handle the high dynamics of skiving.

of the machine tool. The high stability of the bevel gear cutting machine C 30 gives significant advantages. "From our knowledge in bevel gear technology we work on the integration of the deburring process, automatically loading and closed loop," he added. "This will advance in the foreseeable future."

For Winkel at Liebherr, the future will be introducing carbide skiving cutters in the market as an option to PM-HSS as well as providing the skiving technology for bigger and smaller parts (meaning additional new skiving machine on other platforms).

Skiving technology is always in flux. Winkel describes how Liebherr developed and offered skiving machines way back in the 1960s but with much different results. "We failed like all others due to insufficient tool life and gear quality," he said.

"In the beginning of this century Liebherr looked at reinventing or maybe re-investigating skiving again, with the aim to be faster than hobbing and replace shaping. Unfortunately, the research focused too much on tool improvement rather than on cutting strategies," Winkel said. "So, we did not succeed and postponed the technology. Several years later, we took a new attempt and this time, we did much better."

If at first you don't succeed... 

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Hard Scudding: The Future Has Arrived

Scott Knoy, VP, GMTA

Just a few years ago, the concept of Scudding left the traditional skiving method in the dust, so to speak, for gear production used primarily in the powertrain buildup. This process, 5–10 times faster than gear shaping, formed the surface of the workpiece through several, small enveloping cuts, providing a surface finish and part quality level that was far superior to hobbing, shaping or broaching. Scudding is a continuous generating process, meaning no idle strokes on the machine tool, as when shaping gears.

Ring gears, sliding sleeves and annulus gearing, whether internal helical or spur, external helical or spur or blind spline, synchronizer parts with block tooth features and synchronizer hubs remain among the popular products in the market, made with Scudding technology. Today, this continuous gear cutting process is widely used in production environments for internal, external, helical and spur gears, as well as splines and other components in the powertrain world. The machining can be done without the need for an undercut or groove (clearance) and the lead of the gear can be manipulated via axial motions (crown/taper). It is a demonstrated superior technology and automotive suppliers have embraced its advantages for many years now.

As the science of Scudding has rapidly evolved, the interest in the more advanced process "Hard Scudding" is increasing



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