

The Evolution of Gear Chamfering

The latest technological solutions help keep chamfering and deburring operations in-line—often without increasing cycle times

Gottfried Klein, Gleason Corp.

Many gear manufacturers recognize that premature transmission failure, less-than-optimal efficiency, or unacceptable noise can result from application of transmission gears operating with anything less than a flawless tooth flank. For these manufacturers, generating a chamfer to precise customer specification for size, shape and angle is of critical importance in order to minimize the potential for sharp, brittle edges after heat treat, as well as to avoid material plus conditions in the tooth flank prior to the hard finishing operations.

Chamfering and deburring are particularly critical in advance of hard gear finishing processes. This is especially true of honing, where excessive stock and hardened burrs can greatly diminish honing tool life and, as a result, significantly increase cost per piece. These conditions can occur as well when the finishing process is threaded wheel grinding.



Chamfer size and angle according to customers' specification.

An additional benefit of chamfering and deburring is to help reduce the health and safety risks that can result from operators handling parts with sharp burrs.

Gleason offers manufacturers several highly desirable chamfering and

deburring solutions that are just as easy to apply as the primary soft and hard processes. With the latest series of Gleason hobbing and chamfering machines, users now can apply the optimum chamfering technology for their particular application using forming or cutting technologies—up to and including truck-size gears.

Chamfer Rolling

Chamfer rolling is ideal for planetary pinion applications requiring particularly fast cycle times (10 seconds or less chip-to-chip) or for gears on shafts with little or no clearance below the root diameter. In wet machining operations, this process delivers the lowest possible tool cost per workpiece. Chamfer rolling is a forming process applied mostly for smaller gears up to module 5 mm, which creates chamfers along the tooth edge by pressing material. The pressed material forms a burr on the face side of the gear and a smaller one on the tooth flank. While the gear face burr is removed by single blades, deburring discs or file discs, the flank burr requires special chamfer rolling tools with burnishing functionality or removal by an additional hob cut downstream in



Chamfer rolling on vertical 210HiC for burr free flank with a sequential hob-chamfer-hob process.



Gleason's 100HiC horizontal hobbing machine with integrated chamfering and robot loading cell.

advance of a subsequent hard finishing operation. Chamfer rolling today can be integrated into shaving, power skiving and hobbing machines and performed either in parallel or sequential to the main gear process. Where shortest cycle times are required, chamfer rolling is integrated parallel to the hobbing process on machines such as the horizontal Gleason P90CD Hobbing and Chamfering Machine or the ZSE150 Shaving Machine. When a second hob cut is necessary to remove the flank burr, a horizontal 100HiC or vertical Genesis 210HiC is available. The latest tool design developments increase chamfer rolling tool life significantly, especially with dry operation.

As alternatives to chamfer rolling, several new cutting chamfer technologies are of increasing market interest. Applications can range from the high volume production found in the automotive industry to job shop gear manufacturers with small batches but a large variety of gears. Gleason's two new chamfer cutting technologies respond to this wide range of needs: highly flexible Chamfer Contour Milling for smaller batches of medium size gears and Chamfer Hobbing for higher volume, shorter cycle time production.

Chamfer Hobbing for Lower Cost Per Workpiece

While chamfering with hobs has been known for decades, Chamfer Hobbing takes the process to a completely new level. Chamfering is performed using a Gleason Chamfer Hob, with diameters

similar to a gear hob, made with the latest high-speed steel materials like G30 or G50 and featuring AlCroNite Pro coating for exceptional tool life in dry cutting conditions. Gleason Chamfer Hobbing employs one Chamfer Hob for each tooth flank, with a tooth profile which is specifically designed for the particular chamfer form to be realized.

This design delivers greater flexibility: comma or parallel-chamfer forms are possible as well as chamfers along the tooth edge only, or including the root area. Similar chamfer angles like those commonly produced in the chamfer rolling process are also easily achievable.

In the Chamfer Hob design process, Gleason technology software is used to simulate the required chamfer and

identify and avoid all potential collisions of the tools with the counter flank and with interfering contours above and below the actual gearing.

By cutting into the gap, burrs are avoided on the face side of the gears. With chamfer angles such as those produced by the chamfer rolling process, there are no noticeable burrs on the flank that require removal downstream.

Finally, the Gleason Chamfer Hobbing process offers tool shifting, which delivers increased tool life, minimal change over times and, ultimately, lower cost-per-piece. Additionally, the existing grinding capabilities for gear hobs can be used as well for Chamfer Hobs.



Cutting the chamfer with a chamfer hob.

Chamfer Hobbing in Parallel

The new-design Genesis 160HCD combines the proven Genesis vertical hobbing platform with an integrated chamfering/deburring station to perform the new Chamfer Hobbing process in parallel to hobbing, and thus achieving cycle times to satisfy the requirements for dual-clutch or electric drive transmissions. A high-speed, 2-position NC-gantry loads the workpiece for hobbing, transfers the workpiece to the chamfering station and then delivers the finished workpiece to the parts conveyor. In addition to shorter cycle times, change-over procedures are optimized as well, since the machine includes a new-design operating software to make setup and change-over easier.

Contour Milling: Mastering Chamfers on Larger Gears

While chamfering gets increased focus with automotive-size gears, equally effective solutions for larger, 'truck-size' gears are becoming nearly as important—and more readily available.

With larger gears, requirements are changing. Smaller batches, larger variety of parts and longer cycle times are typical. Therefore chamfer rolling and Chamfer Hobbing with dedicated tools may not be the best fit since tool investment could be significant. A more flexible solution is necessary, but it should



Two chamfer hobs for independent chamfering of left and right flanks.

be just as easy to use and deliver low tool cost per part.

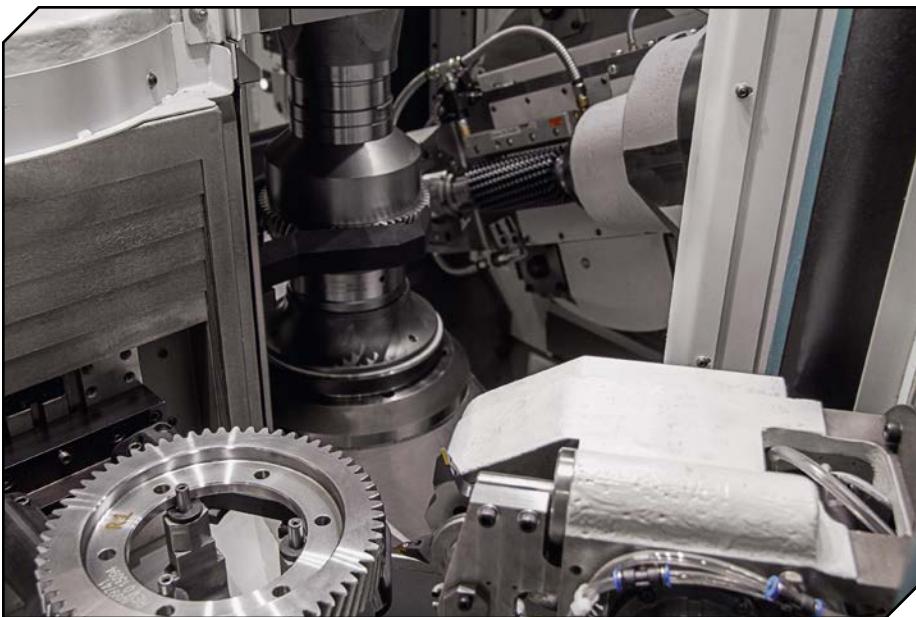
The continuous 'fly cutting' process offers significant advantages for improving chamfering flexibility as well as reducing machine and tooling costs as compared to other chamfering processes. This process, called Chamfer Contour Milling, generates a chamfer along the gear edge contour by synchronizing fly cutter and workpiece rotation such that the fly cutter—generally a star-shaped body with four

standard, replaceable indexable carbide inserts—contour mills the chamfer with the desired characteristics.

The Chamfer Contour Milling process is continuously indexing and creates a cutter path that envelopes the tooth geometry from the outside of the part in. All six axes in the chamfer unit are used during generation of the tool path, and the tool seeks to use the straight side of the indexable blades to optimize the process and tool life. Since each edge of the tooth is done separately and the chamfer

Gleason's Genesis 160HCD: small footprint, parallel hobbing and chamfer hobbing.





Chamfer Contour Milling and gear hobbing in parallel, interlinked with 4-station ring loader.

size and angle depends on machine movements and not on the tool design, the process is quite universal. It can, with only a few sets of indexable carbide inserts, cover parts ranging from module 2.5 mm to the maximum machine capacity of module 8 mm. The process enables just a relatively few different standard insert blade sets to accommodate a wide range of gear sizes, geometries and chamfer requirements. Due to the size of the cutter, some clearance below the root diameter is necessary to avoid collision. This requested clearance depends on chamfer angle, root chamfer requirements and tool diameter. Therefore best results with this chamfer contour milling process can be expected with disc-type parts or shaft-type parts with some distance between the root diameter of the gear and the shaft itself.

Genesis 400HCD Hobbing and Chamfer Contour Milling Machine

While fly cutter chamfering has long been successfully employed on bevel gear cutting machines, it has just been adapted for the first time as a viable chamfering process for cylindrical gears on Gleason's new Genesis 400HCD Hobbing Machine, designed for workpieces up to 400 mm outside diameter and module 8 mm. The optional Chamfer Contour Milling station, positioned at 90 degrees to the main hobbing work area, allows parallel hobbing

and chamfering processes to increase productivity. A four-station ring loader transfers workpieces between the machine's central worktable and the chamfering/deburring station, which is equipped with the aforementioned fly cutter. The new operating software allows an easy and fast learning experience for smooth set up and operation.

While available for wet cutting, the 400HCD is also optimized for dry hobbing and chamfering. A machine bed with steep angles and large openings

Gleason's Genesis 400HCD: Hobbing and flexible chamfer contour milling in one machine.



directs hot chips away from machine components. Additionally, hob head and workpiece spindle speeds can accommodate the latest tool materials like G50 or even G90 with AlCroNite Pro coatings for high performance cutting.

Designing the machine for dry hobbing also enables the chamfer process to run dry without limits.

In Summary

Manufacturers now have a variety of integrated and automated chamfer/deburr options available, whether the well-proven chamfer rolling process for shortest cycle times, these newest Chamfer Hobbing process for precise and burr free operation with lowest tool cost per part, or the Chamfer Contour Milling process for highest flexibility and low tool investment even with a large variety of gears. 

BONUS VIDEO: Watch and listen to the author give a live interview about chamfering and deburring technology in our new *Revolutions* segment on *Gear Technology TV*.

www.geartechology.com/tv/

Gottfried Klein is Director of Product Management for hobbing, chamfering, shaving and rack manufacturing at Gleason Corporation

