The P90CD features an integrated chamfering/deburring station to perform chamfer/deburr in parallel to hobbing, thus achieving a cycle time of just 10 seconds chip-to-chip.
(Courtesy: Gleason Corporation)
The Bold New World of Chamfering and Deburring

By Gottfried Klein

Chamfering and deburring are finally getting the respect they deserve, as manufacturers devise ingenious new ways to take the pain out of applying these important auxiliary processes.

IF THERE’S A “RED-HEADED STEP CHILD” AMONG the cylindrical gear manufacturing processes today, it’s chamfering and deburring. Since these operations historically add cost and time to the production process, but practically no value, they generally go unloved, underappreciated, and even ignored. But manufacturers that underestimate their importance do so at their own risk, particularly in hyper-competitive industries like automotive, where premature transmission failure, less-than-optimal fuel efficiency, or unacceptable noise can result from application of transmission gears operating with anything less than a flawless tooth flank.

For both gears and shafts, 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 optimize material plus conditions in the tooth flank prior to the hard finishing operations.

Chamfering and deburring are particularly critical in advance of the honing process, where excessive stock and hardened burrs can greatly diminish honing tool life and, as a result, significantly increase cost per piece. Chamfering and deburring also help reduce the health and safety risks that can result from operators handling parts with sharp burrs.

Fortunately, new machine designs, processes, and cutting tools are today converging to make chamfering and deburring as easy to apply, and just as desirable, as the primary soft and hard processes. What’s not to love? Here’s an overview of several important technologies, and how they’re being applied:

CHAMFER ROLLING

Chamfer rolling, also known as rotary deburring, is an extremely fast, versatile process that is most often applied to smaller cylindrical gears up to module 5 mm to remove the burrs formed by a preceding soft gear cutting operation. Chamfer rolling is a forming process that creates chamfers along the tooth edges with gear-shaped tools that mesh with the workpiece. Excess material flows mainly to the face side of the gear, where it’s then cut away by single blades, deburring discs, or file discs, depending on gear shape and/or machine configuration. However, small amounts of material also can flow into the gear tooth flank itself, thus forming a secondary burr. While the shaving and threaded wheel-grinding processes can easily remove this material, a subsequent honing operation will necessitate that this secondary burr be removed by either edge zone burnishing or a two cut-hobbing process prior to honing — or run the risk of compromising expensive honing tool life.

While chamfer rolling has historically been applied using dedicated stand-alone machines, today chamfer stations are often integrated into hobbing, shaving, and power skiving machines, so the process can be applied either in parallel to the cutting operation with no additional chip-to-chip time — or sequentially when a two-cut process is required.

A good example of chamfer rolling in parallel with hobbing is the new Gleason P90CD Hobbing Machine. By performing chamfering/deburring in parallel with hobbing, it can deliver a remarkable cycle time of just 10 seconds chip-to-chip, with the assistance of high-speed gantry load/unload automation and Gleason workholding with a very fast clamp/unclamp capability. The gear is hobbed, and the rough burr that results from hobbing is removed in a single setup. The gear then is unloaded by the gantry and loaded into the chamfering/deburring station, where chamfer rolling with deburring is performed simultaneously while another gear is hobbed.

Note that if the subsequent finishing operation does not allow any burrs in the flank, it may be desirable to apply special Gleason chamfer rolling and burnishing tools at this station that feature a 180-degree chamfering section and another 180-degree section with burnishing functionality. Secondary burrs on gear flanks generated by chamfer rolling tools are rolled down into the flank surface leaving only the required stock for the subsequent finishing process while still maintaining the required scallop depths.
Chamfer contour milling employs a fly cutting process using indexable carbide inserts. A few insert sets can cover a wide range of modules making the fly cutting process extremely flexible while at the same time relatively inexpensive. (Courtesy: Gleason Corporation)
The new Gleason P90iC Hobbing Machine also integrates chamfering/deburring, but it is configured differently to accommodate mainly shaft-type parts and to eliminate the burrs typically formed by chamfer rolling in the tooth flanks in a subsequent, second cut. As a result, the processing of workpieces on the P90iC is sequential but all performed in a single setup: load, first hob cut including removing the rough burr, chamfer rolling and deburring, second hob cut to remove the burr on the tooth flank and to generate the required scallop depth, unload, and repeat. Note that cutting parameters are chosen for this two-cut process that keep total hobbing time close to that of the single-cut process.

It’s important to also note that, in conjunction with these machines, a wide array of chamfer rolling and deburring tools are available to meet the particular requirements of every process, as well as the customer’s particular application. Solutions range from simple chamfer tools to fulfill basic requirements for comma-type or parallel chamfers, root chamfers and acute and/or obtuse flank chamfers, to highly sophisticated chamfering tools with edge zone burnishing options for producing very tight-tolerance chamfers and being able to adjust to modified compensation for heat-treat distortion downstream and to help optimize subsequent hard finishing operations.

CHAMFER CONTOUR MILLING

For hobbing of larger cylindrical gears even in small batches where flexible lot production is desirable, a new continuous “fly cutting” process offers significant advantages for improving chamfering flexibility as well as reducing machine and tooling costs as compared to chamfering on a dedicated, stand-alone machine. The continuous fly cutting process 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 two to four standard, replaceable indexable carbide inserts — contour mills the chamfer with the desired characteristics. The process enables just a relatively few different standard insert blade sets to accommodate a wide range of gear sizes, geometries, and chamfer requirements.

While fly cutting has been long 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. With the addition of a CNC chamfering/deburring module — positioned at 90 degrees to the main hobbing work area — the 400HCD now has the capability to apply contour milling for chamfering/deburring in parallel with the hobbing operation, thus eliminating the cycle times and cost per piece added when chamfering/deburring conventionally. 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. Even with the added chamfering/deburring module, the machine’s overall footprint is surprisingly compact.

IN SUMMARY

Gear manufacturers globally are recognizing that chamfering and deburring simply aren’t processes that can be overlooked — or under-valued — any more. Fortunately, the application of these auxiliary processes has never been easier, faster, or more economical, whether it be for small gears produced by the many thousand, or larger gears in lot sizes of just a few.

ABOUT THE AUTHOR: Gottfried Klein is the director of Product Management Hobbing, Chamfering, and Shaving with Gleason Corporation.