Hobbing Precise, Uniform End Chamfers

Brian W. Cluff

Management Summary

Machining a measurably precise and consistent uniform chamfer on the end faces of cylindrical gear teeth has never been a satisfactory or cost effective process. For manufacturers of aerospace gears, with critical functional and blueprint specifications, width and uniformity of the chamfered end faces has been a cost driver.

A recently developed chamfer hob design (patent pending) has produced a practical hob cutter that can chamfer gear teeth end faces uniformly to a measurably consistent, precise tolerance.

Its developers say the tool is cost effective because the process can be performed sequentially within a normal CNC hobbing machine cutting cycle. It does not require a special machine with its associated capital and maintenance costs for a subsequent operation.

The seemingly simple process of placing a uniform chamfer on the face ends of spur and helical gears, at least for the aerospace industry, has never been a satisfactory or cost effective process. High precision aerospace gears requiring uniform end chamfers have a manufacturing rejection rate, for some producers, as high as 30%. The more critical the function of the gear, the more stringent the requirement for a measurable, uniform chamfer.

Despite the numerous advances in gear production technology, the methods of gear tooth chamfering have remained relatively unchanged. Hand chamfering is still prevalent in gear shops around the world. Grinding, machining, filing, wire brushing or buffing the end faces of each gear tooth constitute the conventional technologies to produce some kind of chamfer.

Figure 1—Teeth are hobbed into a gear in a normal cycle.

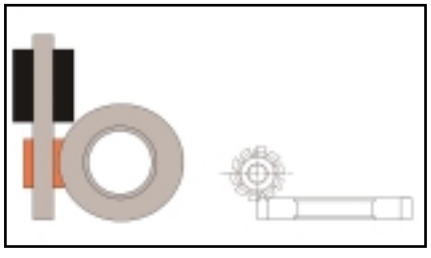

Figure 2—Chamfer hob shifts into cutting position. Hob slide moves to position hob above workpiece and feeds radially to depth.

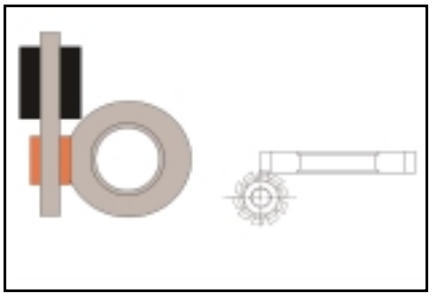

Figure 3—Hob slide retracts hob from depth at top position, moves to bottom face of part, positions hob, and radially feeds to depth, completing the chamfering cycle.

Many gear manufacturers use conventional automated deburring and chamfering machines from companies like Redin Corp., Mutschler & Sons Inc., James Engineering, Gratomat-Rausch GmbH, Chamfermatic Inc., Hurth (a unit of Gleason Corp.), Samputensili S.p.A. and others. Some aerospace gear producers use expensive CNC multi-axis milling machines to produce chamfers on their high precision gears when the drawing specification dictates a precise, measurable, uniform chamfer.

When gears are hobbed or shaped, the end faces of the gear are very sharp. These sharp edges require, in most processes, an edge break or slight chamfer to remove any burrs. Conventional chamfer production machines adequately break the edges and remove the burrs, but they cannot produce a repeatable, uniform, measurably accurate chamfer from the outside diameter (tip), down the flank of the gear tooth into the root radius and up the adjacent tooth flank. CNC machining centers can achieve this type of precise chamfer, but not without individual programming of each gear geometry on an expensive capital asset.

In precision aerospace gearing, chamfer non-uniformity, steps or divots can result in stress risers. These stress risers can lead to cracks and gear failure. Consequently, width and uniformity of the chamfered area is critical.

A recently developed, patent-pending design has produced a hob cutter that can chamfer gear teeth uniformly. Although chamfering hobs are used in the industry for edge break on one flank of a gear tooth, no designs have been previously available to create a precise, measurable, uniform chamfer from tip to trochoid.

The new hob's chamfering technique is relatively simple. It is used in conjunction with standard tooth hobbing and is performed on the same CNC hobbing machine sequentially within the hobbing operation. In the work cycle, the workholding fixturing necessarily is designed to accommodate the clearances required by the chamfering hob.

The technique is illustrated in Figures 1–3.

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For gears cut with a two-cut hobbing cycle, it is possible after the first hobbing cut to shift the chamfer hob into position and hob a slightly oversized chamfer on one end of the workpiece. After completing the finish cut with the tooth cutting hob, the chamfer hob chamfers the other end of the workpiece with a correctly sized chamfer.

The application of the chamfer hob often involves an engineering interference study to be certain that both the cutting hob and the chamfer hob can fit on the same hob arbor without workpiece interference. In addition, because the chamfer hob requires a different radial position inside the root diameter of the workpiece, the workholding fixturing has to be designed to allow clearances not normally associated with standard gear tooth axial hobbing.

The benefits of the process are numerous, such as cost per part (see Table 1). Also, since it is incorporated into the tooth hobbing operation of the workpiece, there

Figure 4—View of gear teeth with uniform chamfer as produced by chamfer hob.

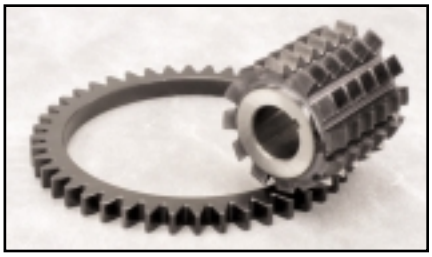

Figure 5—Chamfer hob shown with workpiece.

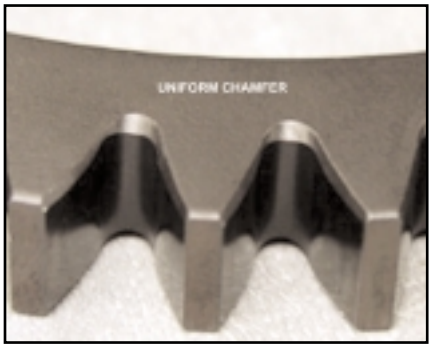

Figure 6—Uniform chamfer as produced by chamfer hob.

Table 1—Price-per-part comparison of conventional chamfering methods and hob chamfering for obtaining a uniform chamfer of 0.015"–0.030" on a gear of 10 DP, 7.5" diameter.

Chamfer Process for Aerospace Gear	Typical Price-per-Part Total Costs
CNC Milling	$70.00
Hand Grinding	$65.00
Deburring Machines	$12.25
Hob Chamfering	$2.50

are no additional setup costs for a separate operation. The chamfer is uniform and is machined to precise tolerances as specified by the blueprint. Typically, the operation takes less than one minute per side. It is certainly less time consuming than hand grinding or CNC milling. Dependent on pitch and number of teeth, some chamfering hob designs have a range of teeth they can chamfer. For more precision applications, though, a dedicated chamfer hob is needed.

The hob chamfering technique is also suitable for tooth rounding, bullet nosing and one-side chamfering, which is used for Bendix starter gears.

As the requirements for higher quality and lower cost continue to push manufacturing, the hob chamfering technique offers higher quality at lower cost, increasing profitability for gear manufacturers.

This chamfering hob design is available exclusively from Star-SU LLC. For more information, contact Star-SU via:
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