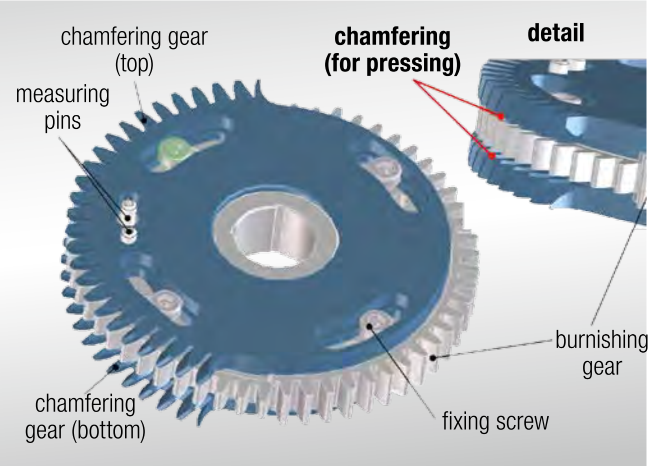
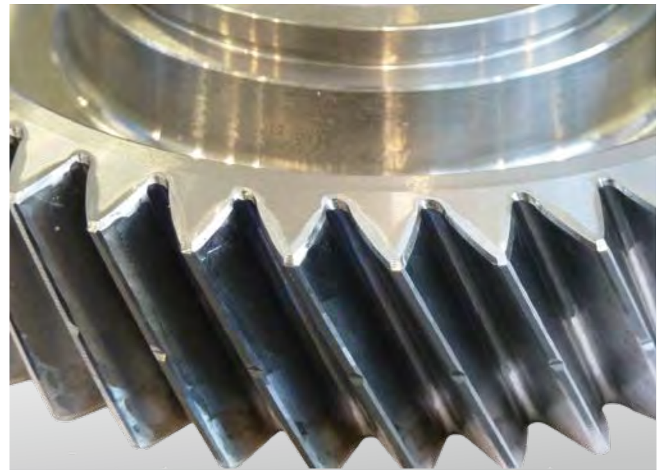
Pressure deburring



Roll pressing tools with an example of a press chamfering tool

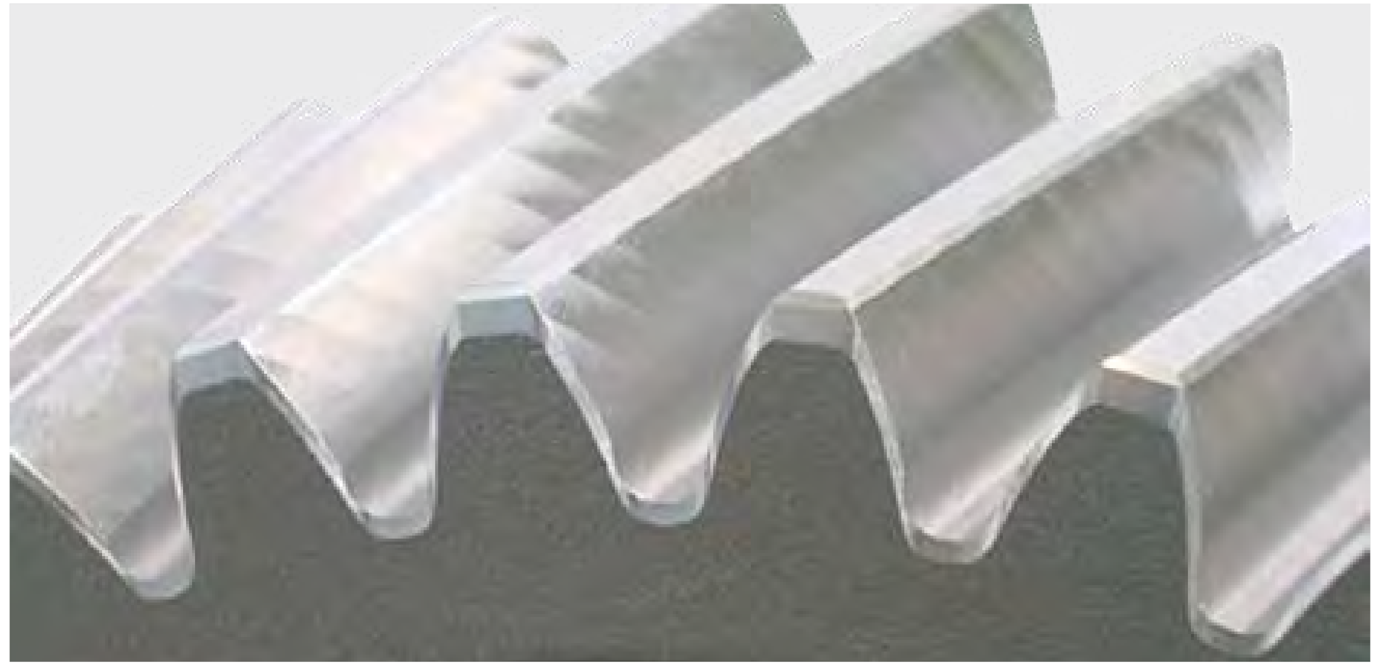


When chamfering using the roller press process, sheared deformations are evident on the faces

The special tools needed make pressure deburring less flexible with respect to workpiece geometry, but this is made up for with extremely short chamfering times. For this reason it is primarily employed simultaneously.
So-called roll pressing tools are used for chamfering by way of pressure deburring (see Fig. 3). These roll off under pressure with the workpiece. The process consists of cold forming the sharp face edges. Displaced material is sheared off at the faces by deburring or filing discs. The pressing tool is a complex system of several gear wheels configured for a specific workpiece. Besides high component strength, the low level of flexibility restricts economy and use is limited primarily to large-scale production.
The chamfering result is illustrated in Figure 4 by way of example. The chamfers in the area of the tooth flanks can be clearly seen. Furthermore, the sheared off deformations on the faces can also be seen. The tooth root can also be chamfered if the tool is configured accordingly, but this will lead to a shorter service life (less favourable rolling conditions).
If the fine-machining procedure (shaving or hobbing) permit, it may be possible to skip the smoothing of the flanks; the deburring gears can mesh over the complete circumference. This will double the service life of the tool, reducing the price and improving versatility. Furthermore, if the Liebherr deburring gear is chamfered on both sides, it can be turned at the end of its service life. That also has a cost-reducing effect.

If the hard-fine machining process (e.g. gear honing) does not permit rejects or deformations in the flanks of the teeth for reasons of process reliability or tool life, rejects can also be eliminated with an additional finishing cut while hobbing.

Gratomat



Owing to the kinematics, chamfers are formed that are greatest at the tooth crest and tooth base and spread evenly over all teeth with the Gratomat process

With the Gratomat procedure, milling cutters are used to cut the chamfers on the contour of the teeth. The hard metal tools are pre-loaded and pressed onto the faces of the workpiece at a defined angle. The procedure is flexible with respect to workpiece geometry as the milling cutters are usually suitable for different components. Furthermore, it is rather insensitive with respect to component strength. With a sufficiently long cycle time for gearing, chamfering can be performed simultaneously. This is true in particular for spur gearing as here the top and bottom are chamfered at the same time. At helical angles > 10°, the faces are machined sequentially, which lengthens the time needed for chamfering.

The main benefits of the procedure are:

- Extremely versatile
- Ideal for gear makers, but also for large-scale production
- Different workpieces can be chamfered with standard milling cutters
- No workpiece deformation
- Root of tooth can be chamfered
- Less sensitive to interference contours (e.g. a bulge close to the root circle of the gearing)

The kinematics of the procedure generate a characteristic, uniform chamfer form (see Fig. 2). Here, the chamfers are largest on the head of the tooth and around the root of the tooth, and smallest in the area of the root form circle. In contrast to the contour line, the width of the chamfer toward to the flank can be regulated with the circumferential speed and contact pressure of the tool. The Gratomat procedure produces rather flat chamfers relative to the face, i.e. rather large chamfer angles with respect to the helical angle.
Integrating the procedure in the gear cutting machine allows Liebherr to offer a chamfering unit which is attached, for example, to the control side of the machine without requiring additional space. The workpieces are handled by a 4¬station ring loader.

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Änderungen vorbehalten.

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News from the Gear Technology

Chamfering of gearing

LIEBHERR

Chamfering of gearing

Different procedures can be selected for chamfering pre-geared spur wheels on gear cutting machines: Gratomat, pressure deburring and ChamferCut. Know the benefits and limitations of the different procedures and you will quickly find the optimum solution for your specific application.



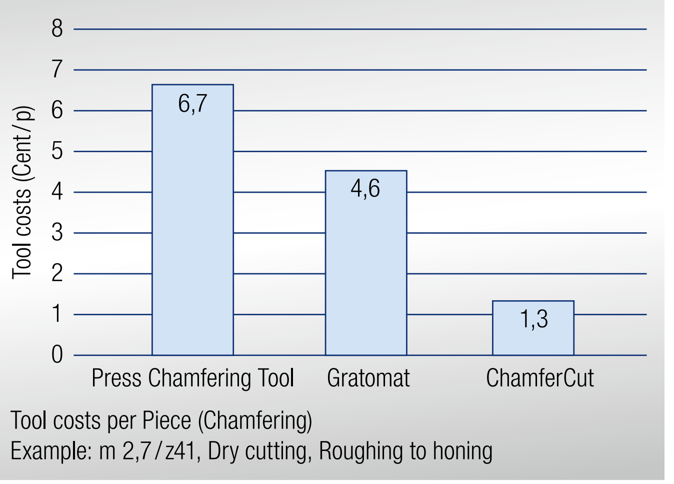
Three chamfering processes that can be integrated in a gear cutting machine (from left): ChamferCut, pressurised deburring and Gratomat

Spur wheels are typically pre-toothed by way of machining, whereby hobbing plays a dominating role. This creates more or less distinct burrs on the faces of the gearing. These burrs do not only constitute a risk of injury. They can also cause problems when clamping workpieces in downstream processes. Should the burrs get into the gearbox, increased wear and noise development can be expected. For this reason, deburring should be performed after gearing.
However, the requirements on the edges of the gearing now often go beyond pure deburring. In many instances, a specific fracturing of the edges – known as chamfering – is required. This should prevent the workpiece from being damage during transport and the tooth edges from becoming brittle due to overcarburation. Other reasons are the avoidance of gear wear due to sharp edges and assistance for the installation process by lead-in chamfers. In some cases, the subsequent hard-fine machining procedure requires chamfering in order to achieve sufficient process reliability and tool life. This is true in particular before gear honing.

There are several different procedures for chamfering the gear wheels, which differ in their suitability according to batch size, the required chamfer form, subsequent machining and component geometry. Chamfering can be performed in separate machines, or ideally directly in the gear cutting machine. This article will discuss the procedures which can be integrated into the machine: Gratomat, pressure deburring and ChamferCut (see Fig. 1) and will present the resulting chamfer geometries on the basis of typical machining examples.

ChamferCut

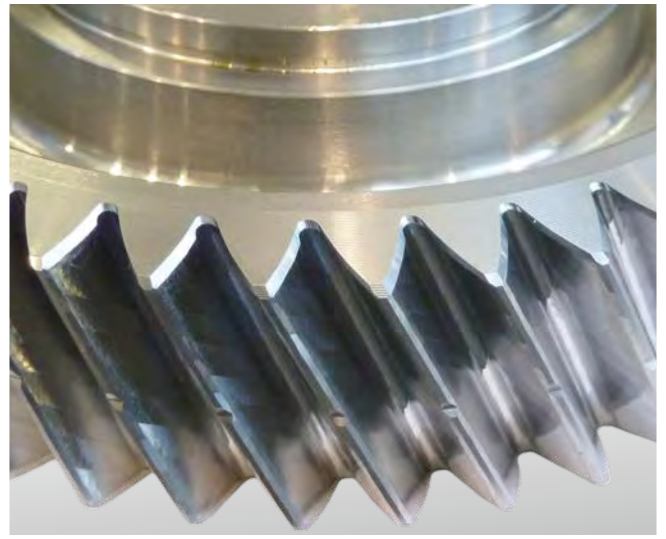
The ChamferCut procedure, in which the chamfer is produced with special chamfering bits, is on the rise. ChamferCut cutters classically enable the workpieces to be deburred and chamfered in the same clamping position directly after gearing. The tool, a workpiece-specific form cutter, works in the continuous process. The chamfers are machined to create a very high chamfer quality and excellent reproducibility. However, the sequential machining lengthens the cycle time. The main advantage of this procedure is the uniform, parallel chamfering along the whole contour of the tooth, including the curvature of the root of the tooth which can also be also chamfered without problem (see Fig. 6). The secret of the tool is its highly asymmetrical profile, which distinguishes it sig-



nificantly from classic hobbing profiles. However, apart from that, the ChamferCut cutter is similar to a hobbing machine and can likewise be repeatedly reconditioned by recutting the face at the end of the service life.
Decisive for practical use of this procedure are the functionality and user-friendliness of the related machine software. To this end, Liebherr has developed a software package that takes the data and graphics from the settings sheets of the toolmaker Fette and implements the necessary axial movements. Axial corrections needed due to recutting the tools are performed automatically by the control unit. The chamfer form is optimised by the CNC axes on the basis of the width and symmetry of the chamfer so that no manual adjustment work whatsoever is needed. The procedure is limited by the accessibility of the gearing, for the ChamferCut cutter cuts below the curvature of the root circle to create the chamfer angle and thus deeper than the corresponding hobbing machine. To prevent a collision, it is usually necessary to adjust the equipment. The component geometry thus has a direct influence on the usability of the ChamferCut procedure.
The advantage of the ChamferCut procedure are the low costs. The key drawback of the classic ChamferCut procedure is that sequential machining has the effect of lengthening cycle times. Until now this was often an exclusion criterion for mass production. The solution is to perform the ChamferCut procedure in a separate machining station (chamfering unit). A corresponding machine concept is the Liebherr LC 180 ChamferCut gear hobbing machine (see Fig. 7).
A separate ChamferCut unit (see Fig. 8) offers a number of benefits. Besides the possibility of simultaneous chamfering, the length of the hobbing machine no longer has to be shortened. The separate clamping of the workpiece when hobbing and chamfering allows the machine to be configured with maximum stiffness for maximum cutting performance, while the machine is optimally adapted to the requirements of the ChamferCut procedure for chamfering. The diameters of the chamfer cutters can also be chosen independently of the hobbing machine, opening up additional possibilities for gear wheels which were previously not possible for either geometrical or clamping reasons.
Because the very principle of the ChamferCut procedure prevents deformations in the flanks of the teeth (see Fig. 9), pre-gearing can be performed in the usual manner with a single-cut strategy. Not only does this save time; it also has a positive effect on the tool life of the hobbing machine. The chamfering result is illustrated for the face of the component. Besides the precise, parallel chamfers along the flank of the tooth and in the root of the tooth, the undamaged, deformation-free face can be clearly seen, which is especially beneficial if the component features an oblique face. The chamfer size can be set practically at will via the NC axes. The chamfer angle is in the range of about 15 to 25°.

Conclusion: One of the main advantages of the ChamferCut procedure is the extremely precise chamfer form with no bulging, making it ideal for downstream hard-fine machining procedures, especially gear honing. The root of the tooth can be chamfered without problems as the chamfer cutter can be so configured as standard. The procedure is suitable for both wet and dry machining, whereby a very long service life can be achieved with dry machining. Furthermore, there are no unwanted needle chips compared to the other two procedures described above. The chamfer form (width, symmetry) is set with the NC axes, which has the effect of accelerating fitting. Because the ChamferCut cutter is very easy to recondition by recutting (more than 20-30 times), the tooling costs are comparatively very low (see Fig. 10).
Comparing the specific advantages and disadvantages and the restrictions of the three chamfering procedures that can be integrated in gear cutting machines, it should be possible - depending on the application and taking into account the component geometry, required chamfer form, quantity and cycle time - to choose the most suitable chamfering procedure.

The new gear hobbing machine LC 180 ChamferCut



When chamfering spur gears using the ChamferCut process, a very even parallel chamfer is formed

Chamfering unit of the LC 180 ChamferCut