A Basic Guide to Deburring and Chamfering Gears

Choose the right tools and techniques for the best, most cost-effective results.

Bruce Horst

In today's industrial marketplace, deburring and chamfering are no longer just a matter of cosmetics. The faster speeds at which transmissions run today demand that gear teeth mesh as smoothly and accurately as possible to prevent premature failure. The demand for quieter gears also requires tighter tolerances. New heat treating practices and other secondary gear operations have placed their own sets of demands on manufacturers. Companies that can deburr or chamfer to these newer, more stringent specifications—and still keep costs in line—find themselves with a leg up on their competition.

Wheels or Brushes?

The choice of grinding wheels or power brushes for deburring depends on a number of factors: the type of gear, the material used, the part print requirements, the gear configuration and the customer's specifications, tooling costs and production requirements. In general we prefer to use brushes for deburring because:

1. They create less grit and dust and cause fewer cleanup problems than grinding wheels.
2. They normally give better tool life.
3. They do not require a precision setup.

However, keep in mind that while a power brush can deburr and provide a radius on the tooth, it cannot cut a chamfer. If specs call for a specific chamfer, a grinding wheel must be used.

Fig. 1 — Deburring a helical pinion gear with power brushes.

The particular material of the gear in question also plays an important role in choosing a wheel or a brush. Certain materials, such as plastic or nylon, are "gummy," that is, quite soft. If burrs are removed from such material by grinding, the process often simply rolls the burr into the tooth flank. The grinding wheel also has a tendency to load up, significantly shortening its usable life. Such materials are prime candidates for brush deburring, as are "green" gears.

Which Brush Should You Use?

When selecting the proper brush for a particular application, first keep in mind the type of gear tooth to be deburred. The type of gear will determine how to set up the brush. The severity of the burr will determine the type of brush to use. In general, the more severe the burr, the more aggressive the brush should be. Fig. 1 illustrates a helical pinion with a straight spline on one end. In this case, two standard three-inch-diameter wire brushes attack the gear from different directions, eliminating all burrs in that area. Fig. 2 illustrates a spur gear with a three-inch, nylon-impregnated, 180-grit brush following a grinding wheel. The brush is positioned on top of the gear teeth in such a way as to perform an action similar to surface grinding, which allows both sides of the gear tooth profile to be worked.

Choosing the Right Grinding Wheel

The diametral pitch must be considered when selecting the proper grinding wheel. The wheel must be as wide as possible, but less than the width of the gear tooth root. If it is not, the grinding wheel will ride down the gear tooth flank and begin grinding the adjacent tooth flank, missing the tooth root. Use the finest grit possible, given the particular gear being ground. This will give the best grinding wheel life.

How smoothly the grinding wheel enters the gear teeth also affects grinding wheel life. The size of the chamfer required can be controlled by grinding wheel grit size, speed of the work spindle and air balance control. An increase in tool life can be expected on wet grinding applications.

Helpful Gear Deburring Hints

The closeness of the hub diameter of the tool to the gear tooth root diameter has always been a problem in gear grinding. The hub diameter tends to interfere with the grinding wheel before it reaches the gear tooth root diameter because the grinding wheel will hit the hub first and not grind the root diameter. This causes an interrupted, unacceptable chamfer.

Using power brushes can solve this problem. Brushes will remove most burrs, but, as stated before, they will not provide a chamfer. Brushes do, however, provide a radius, which offers additional strength to the gear teeth. The brush is positioned to miss the hub diameter and deburr the entire gear tooth profile.

If hub interference is a problem, and a chamfer is absolutely necessary, the only alternative is to use single gear tooth flank deburring. This is a much slower, significantly more expensive process. You will probably want to consult with your deburring supplier before proceeding.

When deburring with brushes, the brush should reverse rotation on the gear teeth whenever possible to ensure that both sides of the tooth have been worked. This not only provides a uniform corner break, but also keeps the brush ends sharp. Using a light spray on brushes offers an increase in brush life and working ability.

In some cases, brushing is integrated into the grinding process. This is sometimes necessary when grinding green gears. Green gears tend to roll the burr when grinding, and adding a brush station eliminates any feather edges left. In this method, both the grinding wheel and the brush work at the same time.

Exit Burrs

Excessive shaper or hob cutter exit burrs on gear teeth are another perennial problem. As the cutting tool gets dull, the number of exit burrs increases. A simple rule is, if the burr cannot be flicked off with a fingernail, the grinding wheel or power brush will have difficulty providing a uniform chamfer or radius. The reason is, the wheel or brush will tend to follow this excess material. A simple skive unit eliminates this problem without much additional cycle time. The skive unit uses power brushes, grinding wheels or high-speed cutters. The skive unit removes the excessive burr, and the brush or grinding wheel provides the uniform radius or chamfer. (See Fig. 3.)

The process works like this: The workstation with the skive unit is started first. After the skived area rotates at least 45°, another workstation with either a grinding wheel or a brush mounted on it begins to work the skived area. As many workstations as required are energized accordingly. Thus at some point in time all stations are working simultaneously, cutting down on the overall cycle time.

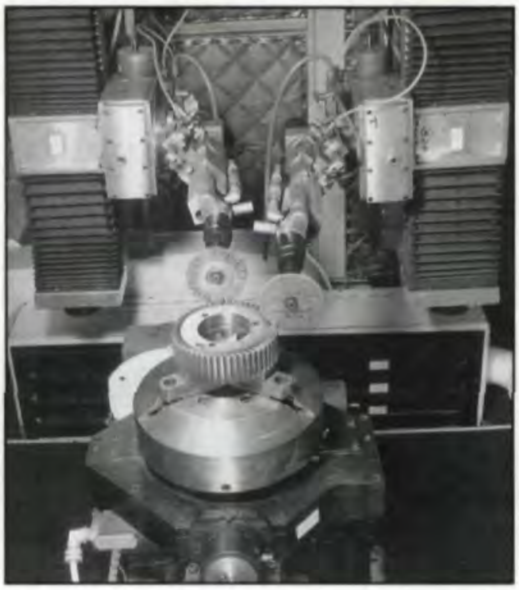

Fig. 2 — Deburring a spur gear with a brush followed by a grinding wheel.

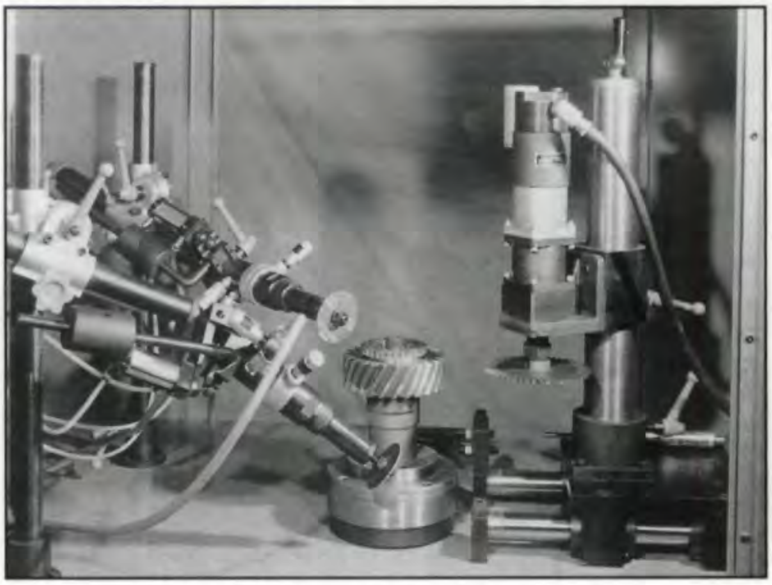

Fig. 3 — Removing exit burrs with a skiving unit and a grinding wheel.

Deburring Spur Gears

When using a grinding wheel on external spur gears, the grinding wheel approach angle is normally 45°. Using the selector switch, the machine is placed in the manual mode so the machine will not run during setup. Then, the grinding head is adjusted to the 45° approach angle as shown in Fig. 4.

The grinding head pivot assembly should be positioned at a 45° angle, with the grinding wheel point of contact angle also at 45°. If this is not done, the chamfer will change on the gear teeth as the grinding wheel wears down. By following the prop-

Bruce Horst
is president/CEO of Redin Corporation, Rockford, IL.

er positioning, grinding wheel life will drastically improve and chamfer consistency will also improve.

Align the grinding wheel to the center of the gear (see Fig. 5). The grinding wheel can be operated from either the right- or left-hand side of the gear. Remember that the gear rotation must be away from the grinding wheel. In some cases, positioning the grinding heads will allow deburring of both sides of the gear simultaneously while rotating 180°. This will increase production.

Extreme concentricity of the gear is not required, because the grinding or brushing head "floats." The head assembly is mounted on a fulcrum, and a column of air provides the counterweight.

After the valve is energized and the grinding or brushing head enters the workpiece, the air pressure is reduced. This allows freedom of the head. The head can be easily lifted by hand, depending on the amount of air still supplied (normally 25 psi). In this way anything rotated under the head raises or lowers the unit. So up to a certain range, the floating head follows whatever profile is under it. For additional ranges, we've added special cams. These cams are integrated into the grinding or brushing heads, allowing irregularly shaped parts to be deburred.

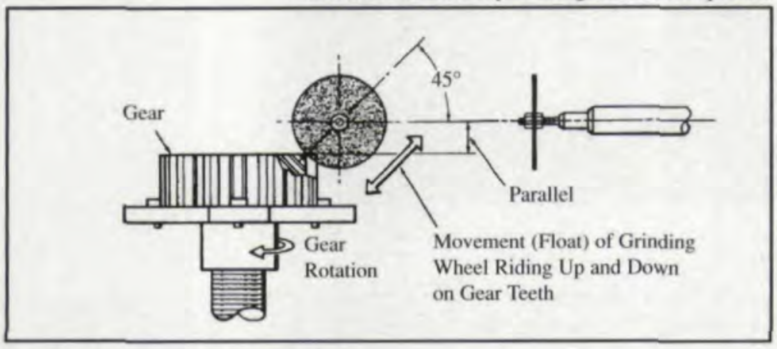

Fig. 4 — Alignment of grinding wheel.

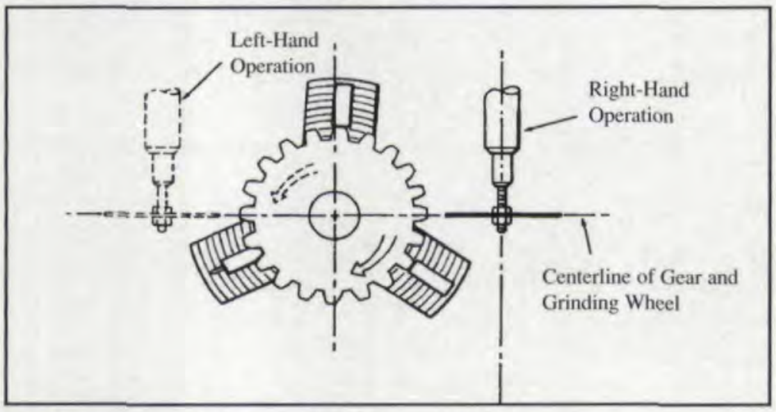

Fig. 5 — Aligning the grinding wheel to the center of the gear.

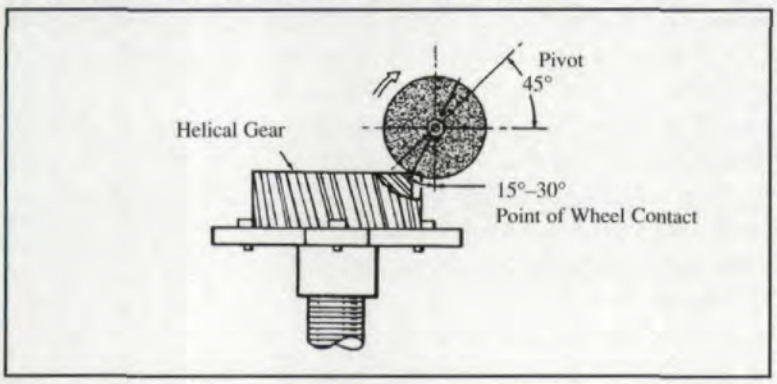

Fig. 6 — Helical gear wheel contact.

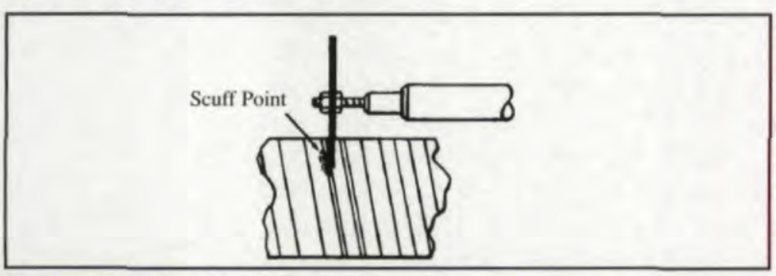

Fig. 7 — Example of wheel set too deeply.

Deburring Helical Gears

Helical gears up to a maximum helix angle of approximately 30° can be deburred. A rather flat chamfer can be expected. Setup for these models is similar to that for spur gears. The point of contact of the wheel on helical gears must be reduced to prevent scuffing one side of the gear flank (see Figs. 6–7).

When grinding helical gears, the grinding wheel angle must match the helix angle of the gear tooth being chamfered (see Fig. 8). If the angle is too flat, the grinding wheel will ride over the top of the gear tooth and will not properly chamfer the corner of the gear tooth flank. If the grinding wheel angle is too steep, it will drop off the gear tooth and scuff the adjacent gear tooth flank. The rotation of the gear must be such that the wheel grinds up the acute angle and down the obtuse angle. This procedure will produce a uniform gear tooth chamfer. The proper procedure used to top- and bottom-grind a helical gear simultaneously is to reverse the direction of the work spindle. This can be completed in one automatic cycle. If the gear teeth specifications are not stringent, both top and bottom grinding can be accomplished simultaneously, increasing gear production. If customer specs allow it, power brushes can be used.

Deburring Spiral Bevel Gears

The alignment of the grinding wheel to spiral bevel gears is similar to other gears with the following exceptions:

- Instead of aligning the grinding wheel with the centerline of the gear, it should be positioned on the gear tooth root that is closest to being parallel to the grinding wheel (see Fig. 9, View A).
- The pivot angle "Z" should be approximately 15° from the gear face being chamfered (see Fig. 9, View B).

On spiral bevel gears, both the heel and toe can be deburred simultaneously using two grinding heads (see Fig. 9, View C).

Deburring Straight Bevel Gears

The alignment of the grinding wheel for deburring straight bevel gears is similar to that of external spur gears (see Fig. 10).

Deburring Square Slots or Splines

Deburring square slots and splines, (either I.D. or O.D.) can be accomplished as illustrated in Fig. 11. With the grinding wheel positioned behind the centerline, one side of the slot and half of the root is deburred, and with another grinding wheel positioned ahead of the centerline, the other side of the slot and the other half of the root is deburred. This operation can be accomplished simultaneously.

The Cell Concept & Deburring

Deburring fits nicely into operations where manufacturing cells are popular. Careful planning can eliminate entire operations, saving both time and money. We recently eliminated a customer's wash station by integrating the cleaning process with the gear deburring, thus reducing production times. Using a wet machine will also drastically increase grinding wheel tool life.

In another case, we are working with a customer to integrate a deburring machine into his present work cell, which manufactures splined pinion gears. Doing so will eliminate the need to handle the parts and move them to a separate deburring station. The longest cycle time in the cell is three minutes. The cycle time of our deburring machine is two minutes, thereby giving the customer "free" deburring.

Sample Gear Deburring

Customer sample gear deburring tests prior to machine quotations are a good idea. They allow us to present the customer with all the information he or she needs to make informed decisions. A computer printout showing tooling used, expected tool life, cycle time, etc., is returned with the samples. This procedure eliminates unnecessary problems that may occur during a machine runoff. Choosing the proper machinery for quality, long life, versatility, ease of changeover, room for expansion at a reasonable price is our goal.

This kind of cooperative effort between customers and suppliers can make deburring operations efficient, accurate and cost-effective, all necessary ingredients for success in today's demanding gear production market.

For more information about Redin Corporation, please circle Reader Service Number A-127.

Tell Us What You Think... If you found this article of interest and/or useful, please circle Reader Service **Number A-128.**

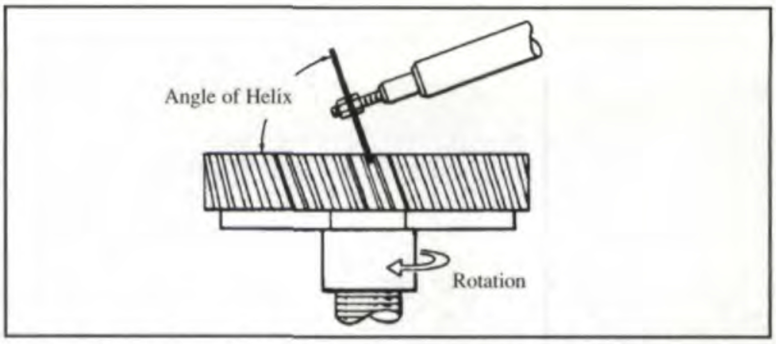

Fig. 8 — The grinding wheel angle must match the helix angle of the gear tooth.

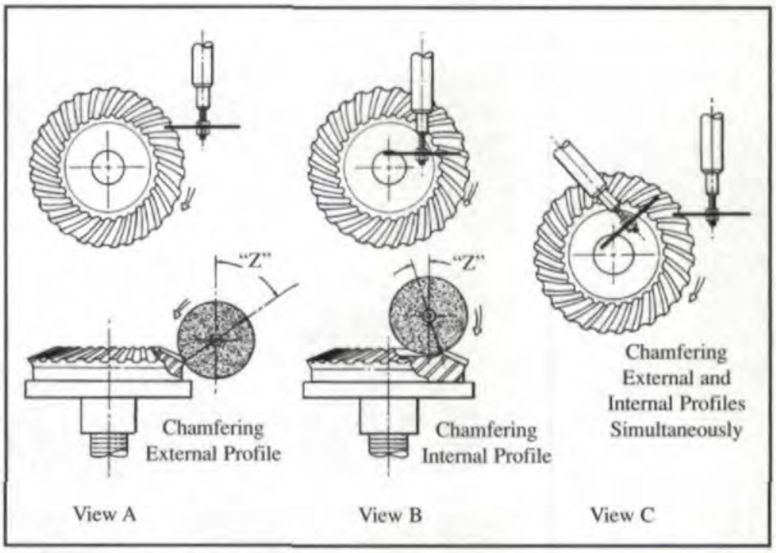

Fig. 9 — Spiral bevel gear setup.

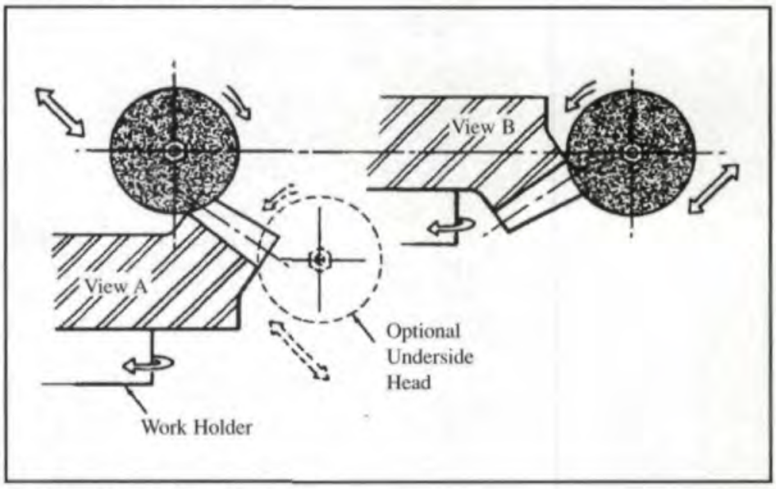

Fig. 10 — Straight bevel gear setup.

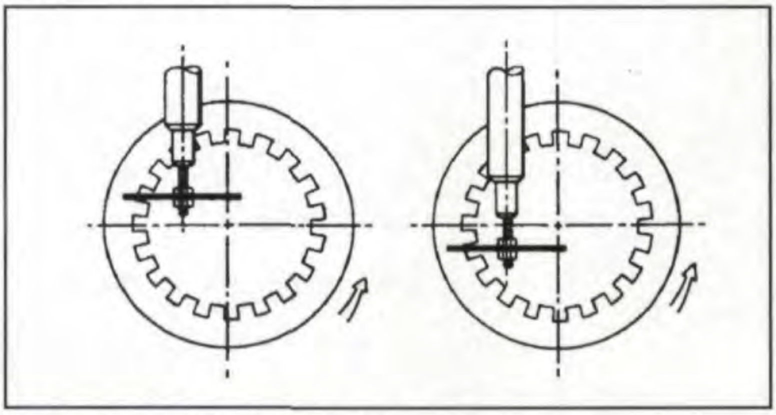

Fig. 11 — Setup for deburring square slots or splines.