Automotive differential gears are generally Gleason Revacycle designs. Revacycle gears are cut by a large circular broach, which is extremely productive (Fig. 1). Typical features of differential gears are the high pressure angle of 22.5° and coarse-pitch teeth with near-miter ratios. The wide root fillets of the Revacycle gears have a fully rounded radius for maximum root bending strength. The Revacycle process form-cuts the tooth profiles; the broach cutter moves from toe to heel during the roughing portion of the cycle and then back to the toe in a climb-cutting mode in order to finish the flank surfaces and generate a straight root line. However, the flank profile of the Revacycle blades has a radius that approximates the involute in order to create some profile crowning at the same time. Differential gears require the highest power density of all bevel gear types.

The variety of differential gears compared to hypoid gears in automotive axle drives is rather limited. This opened the door for forging companies to offer forged differential gears, which can be manufactured both in high volumes and very economically. The first electrodes for the spark erosion process of the forging dies were Revacycle-cut copper gears. The promoter of forged differential gears pointed out the possible advantages regarding strength attributable to the grain flow in material structure. Plus, forging presents the possibility to form webs on both toe and heel (Fig. 2) in order to reduce root bending stress and, consequently, further increase power density. However, the webs prevent the free bending that can initiate cracks in the web transition to the teeth; this also promotes early pitting due to the elimination of a “contact breathing” under varying loads. Figure 3 shows a typical forged differential gear with pittings on the left flank. Although there are geometry freedoms like the webs that can be applied in forging—but not in cutting, due to the constraints of a rotating cutter—the forged differential gears with highest strength are those that simply duplicate the Revacycle geometry.

Although forged differentials have near-net quality—thus requiring a calibration process step—the flank surface variations in production parts are significantly larger when compared to parts manufactured by the cutting process. This also influences tooth thickness and backlash; the backlash of differential gears should be zero. During the tool life of a die, the tooth thickness changes and may lead to unwanted backlash and jerking in the drivetrain of a vehi-
Figure 1  Broaching of a differential gear with Revacycle.

Figure 2  Cross-sectional drawing of forged differential gear pair with web-closed heel.

Figure 3  Forged differential gear with pitting.
A progressive gear manufacturer understands it needs to go above and beyond traditional expectations. Today’s customers demand—and deserve—the latest technology, a wide range of capabilities and an unrelenting commitment to prompt and effective customer service. When it comes to exceeding expectations, Schafer Gear is truly light years ahead. Our investment in the latest production equipment assures that we can provide gears for many industrial applications including transportation, medical, mining, gas and energy, agricultural equipment and many specialty applications. And every gear we make comes with one thing standard—the willingness to go to the ends of the earth to serve our customers well.

Find out more at www.schafergear.com or call us at 574-234-4116.

Figure 6 Coniflex design and analysis software.

Figure 4 Coniflex cutting with interlocking HSS cutter disks.

Figure 5 ConiflexPlus high speed dry cutting on a Phoenix 275HC machine.

Dr. Hermann J. Stadtfeld
is vice-president, bevel gear technology R&D for Gleason Corp. and a frequent contributor to Gear Technology magazine.

Best regards,

Hermann J. Stadtfeld