Honing:

The Secrets of Hole Finishing

Courtesy Sunnen Products Co.

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Gear manufacturers spend a lot of time worrying about gear teeth. It's their specialty, after all. They have specialized equipment and technical expertise that aren't found at just any manufacturer.

But an often-overlooked, yet incredibly important, part of the manufacturing process is the quality of the gear bore.

Without proper bore size, cylindricity and surface finish, all a gear manufacturer's hard work on the gear teeth could go to waste, especially in parts that use the inner diameter for a bearing surface or that require close tolerances for shaft or bushing fits.

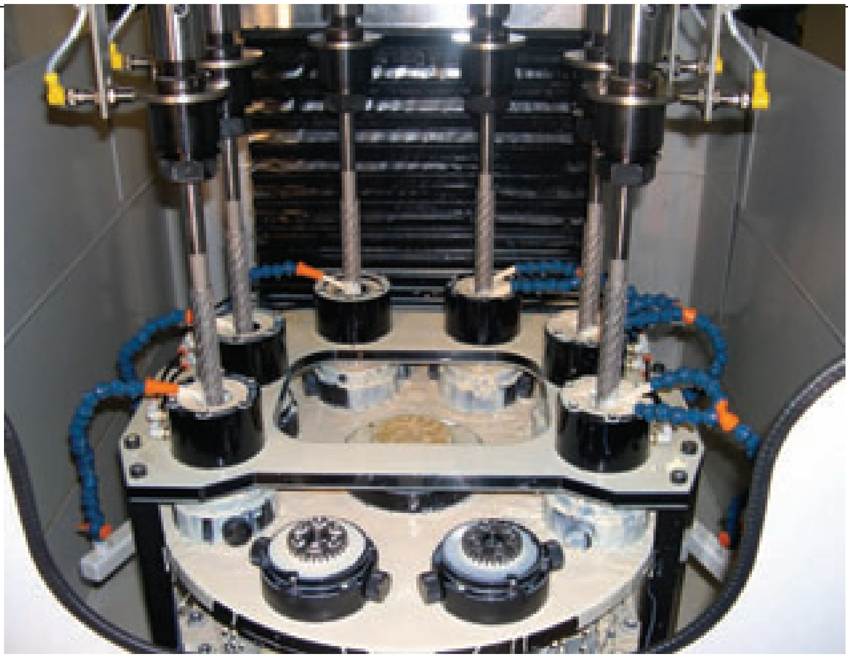
That's why many gear manufacturers use honing to finish the bores. The advantages of honing include proper functioning of bearings, increased life of the gears or bearings, increased accuracy of the powertrain and lower noise levels.

What's Honing?

Honing is an abrasive process that uses a rotating tool to machine metal from the interior diameter of a bore or cylinder. One of the most common uses of honing is bore sizing and finishing the cylinders of automotive engine blocks. But any application that requires precise control over the size and shape of an inside diameter could be a candidate for honing.

Traditional honing tools use abrasive stones mounted in an expanding mandrel. As the tool rotates, the tool—or in some cases the part—reciprocates rapidly. In modern machines, the expansion of the mandrel is CNC-controlled to ensure precise honing of the bore.

Traditional honing stones use bonded abrasives, from aluminum oxide up to



Courtesy Engis Corp.

CBN or diamond, depending on the application. Because the bonded matrix wears down during production, new, fresh abrasive grits are constantly exposed. Also, because the stones are on an expanding mandrel, the size of the bore is automatically adjusted.

Traditional honing has the largest range of applications, says Rich Moellenberg, custom products manager with Sunnen Products Co. "It is compatible with almost all part materials. If the surface finish of the bore is important to the performance of the gear, such as a transmission pinion gear, the manufacturer will choose traditional honing."

Traditional honing is performed on either vertical or horizontal machines designed for rapid reciprocation of either the tool or the part. Generally, a single, rotating spindle carries the expanding mandrel with the abrasive stones.

Electroplated tools offer some alternatives for honing, especially in higher volume applications. For example, the patented Krossgrinding® system from Sunnen applies diamond-plated abrasive to an expanding mandrel. These tools are "typically the most accurate honing tool, but do not necessarily offer the lowest perishable cost per bore," says Moellenberg.

Krossgrinding tools are expanded under CNC control, and bore diameter size can be changed in 0.0001 mm increments, with repeatability within 0.0001 mm, Moellenberg says.

Both conventional honing and Krossgrinding tools are capable of removing relatively large amounts of stock. Also, they produce a "crosshatch" surface finish pattern, which helps hold lubrication. This crosshatch pattern is also essential if the bore of the gear acts as an outer bearing race, Moellenberg says.

Another type of electroplated honing tool is designed for sizing or finishing the bore in a single pass or stroke. Instead of being mounted on an expanding mandrel, the tool itself is a solid substrate, with the abrasive material (usually diamond or CBN) plated directly onto the tool. Examples include the Single-Pass tools from Engis and the Single-Stroke Honing tools from Sunnen.

These tools are used for removing only a small amount of material, but productivity rates are extremely high. When the application is right, this is the least expensive method of honing, with per-part costs of about $0.01.

The single-pass honing process provides a number of advantages, says Bob Marvin, Engis product manager.

The first advantage of single-pass tools is good precision. "In fact, this process can hold quality to better than a 2 Cpk in production," Marvin says.

Also, the single-pass process offers high productivity without complicated tooling. With this type of tooling and machine, productivity can be as high as 600 parts per hour, Marvin says. Although conventional honing can achieve similar high production rates, it requires parts like gears to be stacked in order to do so. This requires complicated fixturing and can result in a loss of accuracy.

Finally, the cost of $0.01 per part is what is most attractive, Marvin says. "This is at least half the cost of conventional honing and much less than grinding. The long tool life also promotes less downtime and overall lower cost per piece."

Moellenberg agrees that single-stroke tooling has its advantages. However, he points out that the process has a more narrow range of applications, compared to traditional honing. It is difficult to use plated diamond abrasive tools with materials that typically develop a "long chip" when machined. Some materials also react with the nickel plating that holds the diamond abrasive to the honing tool. Examples include 300 series stainless steels or 8620 steel. With those materials, the honing chips tend to stick to the nickel, embedding in the part and causing galling. However, if the application is right, Moellenberg says, it's the least expensive method of honing for both the perishable tooling cost and the machine investment.

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In some cases, the single-stroke tools can be used in conjunction with a honing machine that incorporates a rotary index table and multiple spindles, so that multiple tools with increasing diameters can be used in succession. This allows the manufacturer to increase the amount of stock removed without increasing cycle time.

Where Does Honing Fit In?

In most cases, honing is a finishing process, used after heat treating to put the final size on an inside diameter. Generally, this means it's done after the gear teeth are cut.

But in some cases—particularly for higher precision gears—honing is performed before the teeth are cut. "The accurate bore in the gear blank makes the gear blank very accurately fixtured in the gear hobbing machine," says Moellenberg.

"This produces superior gear teeth to the bore centerline tolerance."

Often with such high precision gears, Moellenberg says, the bore is honed, the teeth are cut, the part is heat treated, and then the part is finish honed to remove any heat treat distortion.

Many gear parts have interior features, such as internal splines, keyways or holes for set screws. Although these interrupted cuts often are more demanding and cause problems for many abrasive processes, they can be honed with the right tooling.

"These types of gear bores are typically honed for bore diameter and bore geometry tolerance," Moellenberg says.

Engis has one customer that uses the single-pass process to hone the inside diameter of a component with an internal spline. This creates a good locating surface for a subsequent gear tooth grinding operation, Marvin says.

"Internal recesses or splines can have a negative effect on processes such as grinding, hard turning and conventional honing," Marvin says. "This is due to the cutting insert or honing stone hitting the edges of the cutout during the cutting. The single-pass process does not have this problem because the tool is self-centering in the bore and has full contact with the bore around the periphery of the tool."

No matter the application, though, both Marvin and Moellenberg agree that honing is a crucial step in manufacturing precision gears.

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For more information:

Engis Corp.
105 W. Hintz Road
Wheeling, IL 60090
Phone: (847) 808-9400
Fax: (847) 808-9430
E-mail: *kwerner@engis.com*
Internet: *www.engis.com*

Sunnen Products Corp.
7910 Manchester Avenue
St. Louis, MO 63143
Phone: (314) 781-2100
Fax: (314) 781-2268
E-mail: *bdavis@sunnen.com*
Internet: *www.sunnen.com*