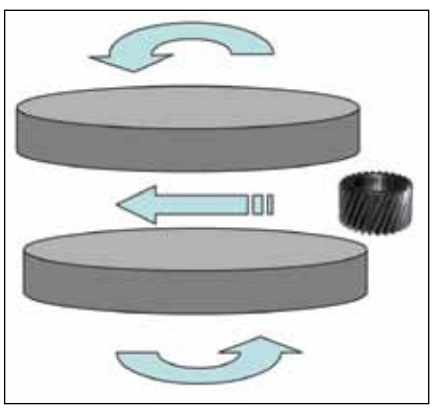
# Faster Honing to Mirror Finishes

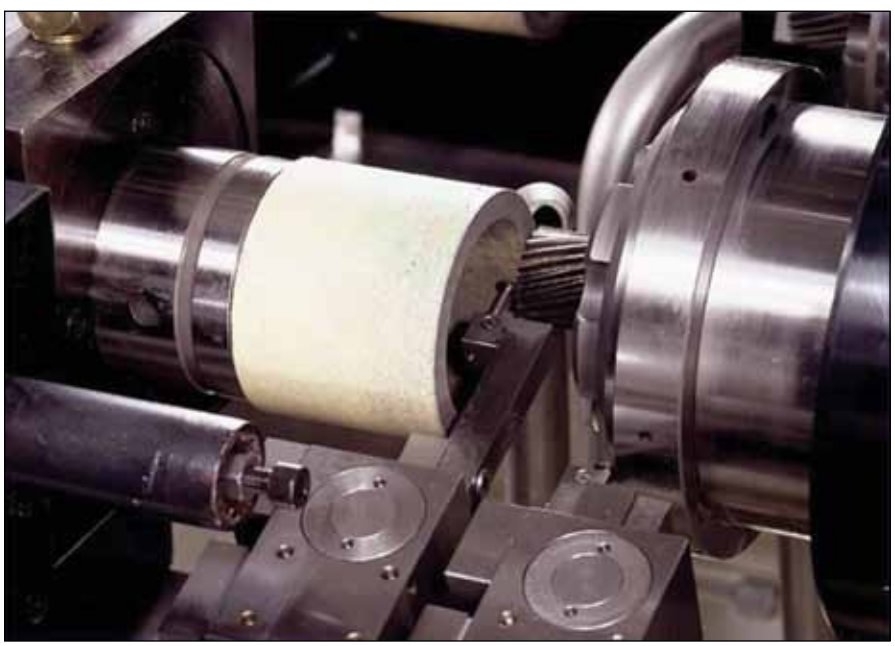
## ON GEAR FACES AND BORES

Stringent NVH requirements, higher loads and the trend towards miniaturization to save weight and space are forcing transmission gear designers to increasingly tighten the surface finish, bore size and bore-to-face perpendicularity tolerances on the bores of transmission gears. Increasingly, most gears used in high-load applications are following this trend.

In the not-too-distant past, a surface finish of 0.15 µm Ra on bore faces was considered good. But today, increasingly, we see gear design engineers seeking finishes finer than 0.05 µm Ra and sub-micron bore-to-face perpendicularity tolerances.

Historically, achieving such a fine finish would require a 4-station honing machine— with two honing and two gauging stations—a double disk grinder to generate face geometry, a lapping/polishing machine to achieve mirror finishes on the face and, finally, expensive automation to tie all three machines.





If the volumes are fairly high, this process is fine as the equipment utilization is high. But this becomes undoable for low- and medium-volume applications as the utilizations remain very low. Also, this process has a quality drawback—in that a double-disk grinder does not impact the bore-to-face perpendicularity, and it basically carries it over from the prior operation.

In order to address this issue for low- and medium-volume manufacturers, Nagel Precision (Ann Arbor, MI) has developed a single machine that can take a heat treated gear and yield a mirror finish on both the gear face and bore—with excellent bore-to-face perpendicularity.

The heart of this innovation is seamless systems integration:

- A new Nagel ECO Series 40 flexible honing system that combines gauging and honing into a single spindle, eliminating multiple gauging stations.
- A Nagel SPV cup wheel face finisher.

In the ECO 40 Honing system, gauging is engineered into the honing spindle. Now the honing spindle also gauges the part while performing the honing operation, and this is integrated with a tool expansion system to automatically compensate tool wear.

The tool wear compensation system is designed to further minimize non-cutting time while enhancing bore quality. Once the tool is inserted in the bore, the tool expands at a rapid feed of 200 mm/sec and at high torque (45 percent of available) until it reaches a predetermined position close to the bore; it will then switch to a rapid stock removal mode of about 4 mm/sec at lower torques (15 percent of

available) to avoid tool damage; and towards the end of the cycle, it will further reduce the expansion rate to about 2 mm/sec at 10 percent of the available torque. The system constantly monitors both the tool feed (mm/sec) and the applied torque (as percent of available). If the desired feed is not reached at the preset torque, the operator can either reduce the tool expansion rate if tighter tolerances are desired or increase the torque if quicker cycle times are needed. This is an added key process control parameter available to the operator.

The tool expansion is rapid when there is no cutting and is slowest for the final finishing cut, which results in a consistent bore in terms of finish, size and cylindricity.

In addition, the Nagel ECO 40 automatically senses the form error (for example taper, hourglass, barrel shape, ovality, bend, etc.) and makes automatic adjustments to correct it.

Most of the bore honing machines on the market today have a fixed stroke that is designed to hone a perfect bore, which, as we are aware, is not the case.

However, some machines do provide the operator the capability to dwell for a longer time at the bottom of the blind bore or to program a different stroke length to correct form errors. But this requires that the operator know the exact nature of inaccuracy coming in and generate a program to address that particular form error. The configuration will not be effective should the type of form error change. It therefore would require a skilled operator to inspect the incoming part and modify the stroking accordingly, which is not always feasible and could be time consuming. The Nagel ECO 40 can sense the form error coming in on each and every part and make automatic adjustments in stroke to more effectively correct it.

These enhancements in the honing technology have enabled Nagel to replace a multi-station system with a compact single-spindle machine without sacrificing part quality.

The SPV 150 Face Finisher differs from conventional grinding operations. The accuracy of ordinary grinding operations depends on rigid fixturing, as well as the accuracy of the grinding wheel's position relative to the part. Whereas the SPVE 150 utilizes free-cutting cup wheels and the tools self dress and conform to the contours of the part. This automatically compensates for inaccuracies in the machine.

**continued**

During this operation, the gear is clamped on the internal diameter of the bore and rotated in a direction opposite that of the cup wheel at a high surface speed. To prevent variations in flatness or axial runout when finishing flat surfaces, the cup wheel tool substantially overlaps the surface of the part during machining. The machine can remove as little as a few microns of stock to a few hundred microns very quickly. The automatic cup wheel changer enables wheel switching for each part, eliminating batch processing. In-process gauging (Fig. 8) accurately controls the part thickness.

Gear manufacturing is significantly improved by using this process. The conventional process to finish these gears—grinding them with a double disc after heat treatment—yields an axial runout of approximately 40 µm, and cup wheel finishing reduces the runout to less than 10 microns.

Heat treating to a mirror finish with excellent bore-to-face perpendicularity is now a possibility in just one machine. Multiple sensors incorporated in the machine constantly monitor the process and support "lights out" manufacturing for low- and medium-volume production.

**For more information:**

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# Dry Cutting System

## MANUFACTURES STRAIGHT BEVELS

Gleason Corporation recently introduced Coniflex Plus, a high-speed dry cutting tool system for manufactur-