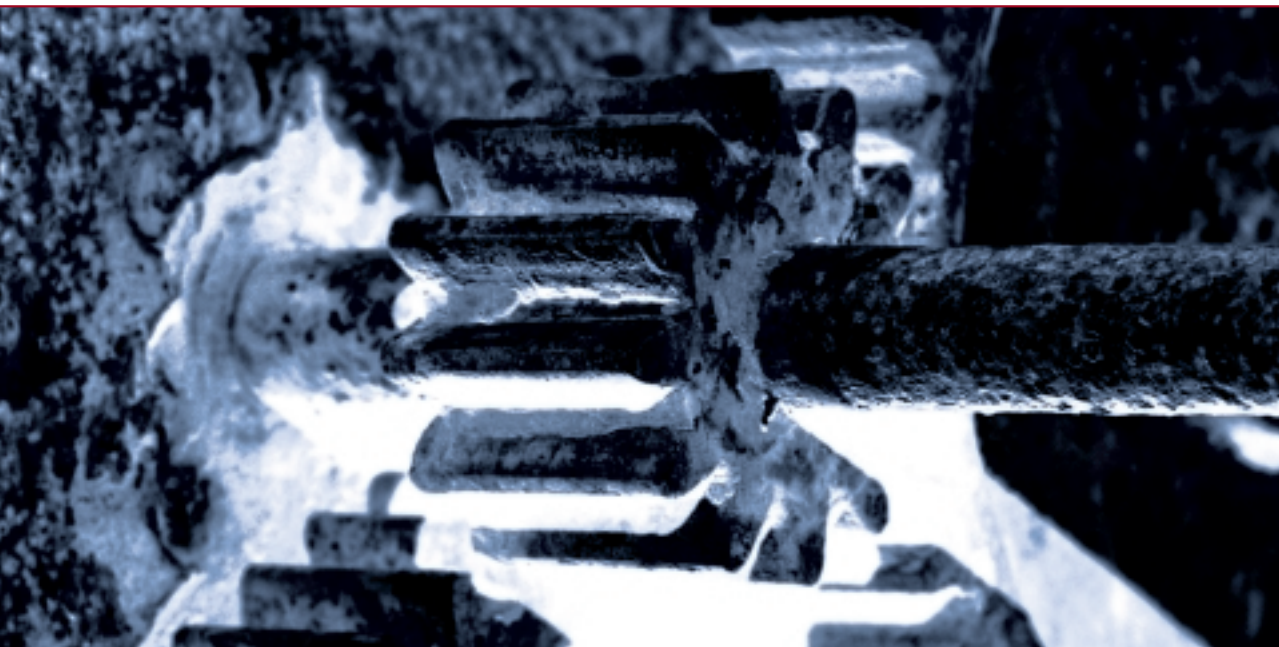

The Next Dimension in Detecting
The Next Dimension in Detecting
The Next Dimension in Detecting

TOOTH DISTORTION

Process Equipment has developed new equipment and software that makes finding flaws a breeze.

By Mark E. Cowan



T

The conventional CNC gear inspection machine will measure and evaluate helix and involute tooth flank deviations that are relative to a theoretically perfect helix or involute form. Any information relating to the actual mean tooth size, relative to a desired tooth thickness, is lost when plotting the traces. This is because the software is designed to equally space the traces on a given graph to allow the user to clearly identify each specific trace plotted to the correct tooth number tested. In addition, the standard analysis packages only specify attributes such as max, slope, and form deviations that are not necessarily related to the actual tooth size. Again, only evaluating tooth form deviations alone, not comparing to an actual position of the tooth form in space.

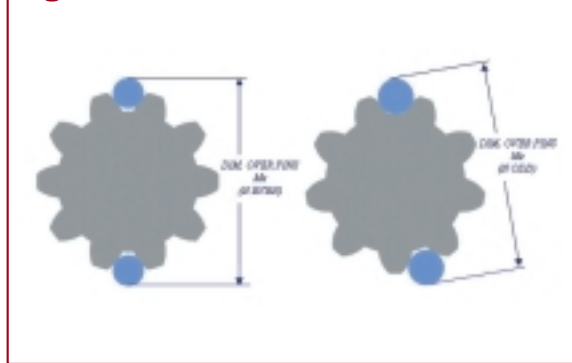
This paper will explain and demonstrate how a new measurement and computer analysis package has been developed to allow the user to observe the helix and profile measurements and how they relate to actual tooth size. In addition, the change in the helix and involute form, along with the tooth size (thickness), can be evaluated for “before and after” studies such as heat treatment and sintering processes. The application for this analysis has broad-based benefits. Tooth form and

size changes due to gear finishing processes, heat-treat distortions, and plastic gear shrinkage, can all be determined accurately with the ND430 Next Dimension™ gear measuring system, coupled with the powerful computer analysis. It will be shown that volumetric accuracy and precise tooth-thickness measurements are a prerequisite to this analysis package.

Typically, tooth thickness is measured at one position along the involute, usually the target diameter being the pitch circle diameter. This is usually done by measuring the distance over two pins (DOP) or balls that are inserted into the tooth gaps of 180 degree opposing tooth spaces (see figure one). The tooth thickness is determined from the DOP. The problem with this method is that the tooth thickness size is only measured at one location. In addition, there is no correlation between the tooth thickness and helix or profile deviations at that location, or any other along the trace.

Since the industry preferred method for performing analytical measurements of cylindrical gears is four axes (including a rotary table) CNC generative gear measuring instruments, they will be the focus of this paper. These machines usually measure index (from which pitch, cumulative pitch, and tooth thickness are computed), helix, and profile measurements. Helix and involute (helix/inv) measurements will usually include four teeth evenly spaced around the circumference of the gear (90 degrees apart). The software on these types of machines is written to insure that the gear measure-

Fig. 1



ments adhere to gear industry inspection standards (generating the helix/inv forms as apposed to CMM point-to-point measurements), require no part programming, and analyze the results according to industry standards (AGMA, DIN, and ISO).

The inspection software must include a setup routine that determines the rotational position of both tooth flanks of a setup tooth. If the positions of both tooth flanks are determined as the gear is rigidly mounted on the instrument, the tooth thickness may be determined. This turns out to be

Fellows

Barber-Colman

**YOUR ONE STOP
O.E.M. SOURCE!**

Roto-Tech

O.E.M.

Gear Hobbers, Fellows Shapers, Grinders, HOB Checkers,
Shaper Cutter Checkers, Inspection Systems and Lead & Involute Masters

REMANUFACTURING/RETROFITTING

Of All Makes of Hobbers, Shapers, Grinders, Hob Sharpeners,
Inspection Systems and Other Metal Removal Equipment

PARTS/SERVICE

- Bourn & Koch, Fellows, Barber-Colman, Roto-Technology, Ferguson
- Recalibration of Your Gear Inspection System, Lead & Involute Masters
 - Gear Inspection & Hob Sharpening
 - Manufacture of Your Special Parts/Gears

BK

BOURN
& KOCH

INC.

2500 Kishwaukee Street Rockford, IL 61104
phone 815/965-4013 fax 815/965-0019
www.bourn-koch.com bournkoch@worldnet.att.net
(800)922-8808 Springfield, VT Office


DULL HOBS

Equals Serious Downtime (period)

But We Can Help...


You are well aware that Hobs are assets that need to be maintained.

The investment your company makes on precision hobs can be wasted by incorrect sharpening resulting in *Non-Conformance of gear quality requirements and poor tool life.*



We know you need your tools back **Fast** eliminating downtime and tuned to meet or surpass original design specifications, and that's where we come in....period.

*Stripping & re-coating service also available.



Index Technologies

Hob Reconditioning

PHONE: 440.895.4627 (HOBS) • FAX: 440.331.0516
21135 LORAIN ROAD • FAIRVIEW PARK, OHIO 44126
WWW.GALLENCO.COM

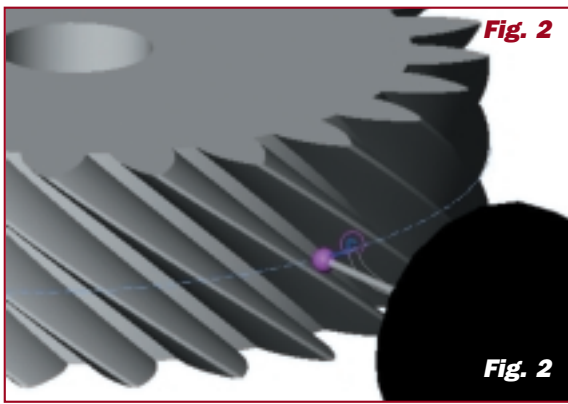


Fig. 2

quite a challenging task on helical gears, since probe forces are exerted on the probe tip shank. These forces are along the direction normal to the tooth surface and affect the tooth thickness measurements.

To make matters worse, most CNC gear measuring machines utilize either a 1D analog probe, or a 3D probe that locks out two of the three probe axes during these critical measurements. By not allowing the probe to deflect in all three spatial directions (XYZ), the probe tip shank bends to some extent, inducing an error in the determination of the exact location of the tooth flank in space (see figure two).

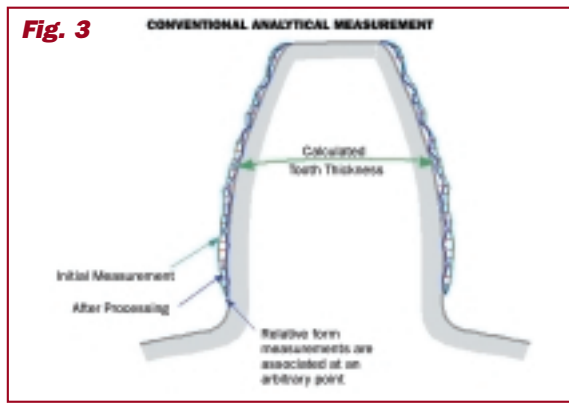


Fig. 3

This location in space is an absolute measurement that also requires machine volumetric accuracy.

Although the ND430 Next Dimension is also a generative gear measuring system that inspects helix and profile according to the industry preferred generative method, it has some unique characteristics. The ND430 utilizes a 3D analog measuring head manufactured by Renishaw. This probe is constantly monitoring the probe tip position in all three XYZ directions and never locks out any of its axes. Couple this with state-of-the-art gear measuring strategies and techniques, and the ND430 accurately determines the gear tooth flank's absolute

Do gear repairs and maintenance have you trapped?

Royal Purple's high performance synthetic lubricants reduce gear repairs and maintenance by 20 to 30 percent.

Imagine that.

For more information, call 866-491-3639 today for a free product catalog.

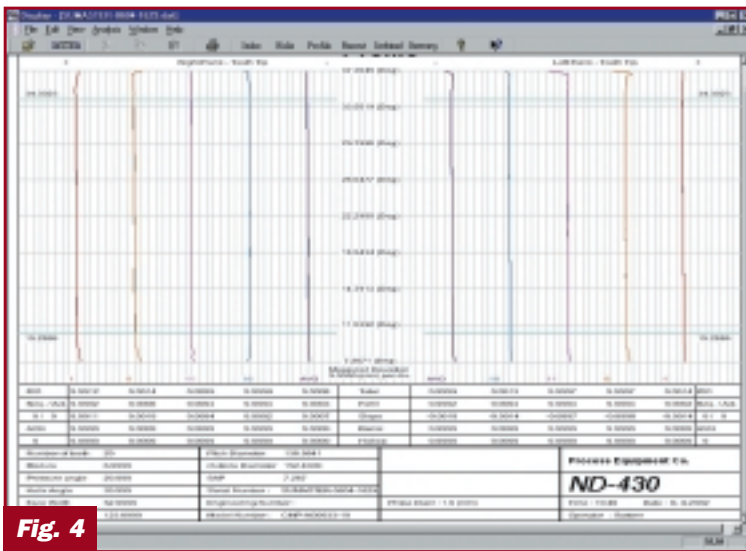


Fig. 4

positions and their relationship to each other. Software compensation for mechanical kinematic and geometric machine errors is an integral part of the ND430's design strategy, which further enhances the volumetric machine accuracy, thereby achieving an accurate tooth thickness determination.

Now that the absolute positions of both tooth flanks are known, the position of each subsequent helix/inv measurement can be determined. As stated before, according to the standards and typical practice, only the helix/inv deviations from a theoretical form are analyzed. The static position of the helix/inv positions relative to the design tooth thickness is not reported. To clarify this concept, refer to figure three. The traces are usually plotted in a way that the elevations of the deviations are set to zero at the starting sample number one. The trend (slope), form, and maximum deviation are determined. In order to plot each trace cohesively, they are equally spaced on the graph as shown in figure four.

This works fine when applying the industry standard practices for analytical measurements. However, there are various processes that can induce changes in the

tooth size around the circumference of the gear that must be determined. This "tooth size" cannot be easily related to the helix/inv measurements conventionally.

This is where the ND430 Next Dimension Compare software takes over. Taking advantage of the capability to accu-

Parts & Service for your Gear Machines

With over 25 years in the Gear Industry, I have created an exclusive network that can supply both new and used parts covering Electrical, Mechanical, Electronic and Hydraulic needs. Obsolete parts can be done faster and less expensive than our competitors. Give us a call and find out for yourself!

FELLOWS®
Specializing in
10-2, 10-4, 20-4, 20-8, 50-8, 100-8,
100-12, FS-180, FS-400, FS-630

MAAG®
CNC GEAR INSPECTION
SP-42, SP-65**LORENZ®**
CNC GEAR SHAPERS
"LS" & "MCS" Series

Jim Kirkland
P.O. Box 1019 • Elyria, OH 44036-1019
216-389-5041 (cell)
Office: 440-365-6045 • Fax: 440-365-6059
E-mail: kirk12043@aol.com

Outstanding Quality Price & Service

Cut Metal or Powder Metal

Spiral Bevel
Straight Bevel
Hypoid
Helical
Face
Spur

Loose Gearing
or
Fully Assembled
Gearboxes
Specializing in High Volumes

mG miniGears N.A., Virginia Beach, VA +0757 233-7000
mG miniGears s.p.a., Padova, Italy +39 049 8706430
mG miniGears Trading Co., Ltd., Shanghai, China +021 5889-7205
www.minigears.com

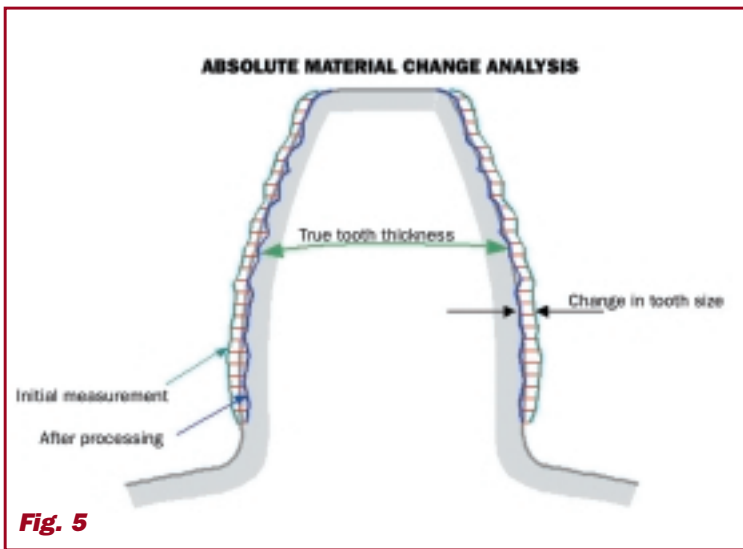


Fig. 5

rately measure tooth thickness, the measuring software develops a linkage between tooth thickness and the helix/inv measurements. Now the actual orientation of each helix/inv trace is shown relative to the designed tooth thickness. You see the form deviations using the standard analysis

The ND430 Next Dimension gear measuring system allows distortions to be quickly quantified without guessing, which means a shorter development cycle for new products.

methods, but the traces are plotted to include their absolute position in space relative to a design tooth thickness, or, optionally, to a previously tested master gear (see figure five).

As you can see from figure six, each helix/inv trace is plotted in a different color to make it easy to distinguish between traces. This is now required, since the orientation of each trace is no longer offset, as shown in figure four. Furthermore, the average of the left and right tooth flanks are graphically set to the center of each flank window, so the user can visually determine where each tooth is located relative to the average or nominal tooth thickness.

Move into the Millennium



with the new
United Tru-Blue II
Hardness Tester

*Meets the new ASTM-E18 and
the new NIST Hardness Standard*

Multiple Locations To Serve You

CALIFORNIA (714)638-2322 FAX (714) 897-8496 (800) 765-9997	MICHIGAN (810)732-2800 FAX (810) 732-2876 (800) 578-2800
--	--

CANADA (905) 669-5327 FAX (905) 738-5051

e-Mail: united@tensiletest.com

United Calibration Corporation
5802 Engineer Drive, Huntington Beach, CA 92649

United

www.tensiletest.com

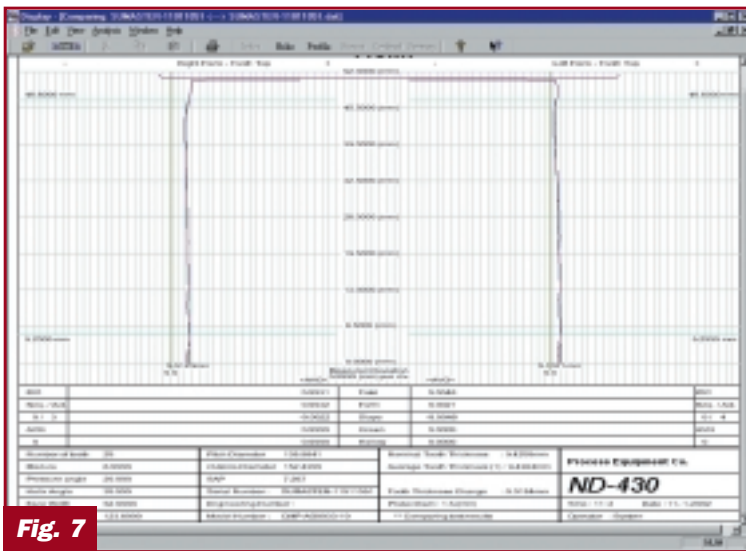


Fig. 7

quickly and clearly shown. Or, if the process removed an appropriate amount of material to achieve the desired tooth thickness, this will also be shown—both numerically and graphically!

An export feature is included that creates a CSV ASCII file of the left and right average “compared” helix and involute traces. This allows sharing of this informa-

tion with the process equipment and finishing tool manufacturers to modify the machines or dies producing the components.

Conclusion

This new machine and its software enables users to quantify what their processes are doing to both the form and size of their gear components. This analysis tool is ideal for determining plastic gear, or powdered metal gear shrinkage, in great detail. The amount of shrinkage is shown, along with any helix/inv form change. Now heat treatment distortions can quickly be quantified without guessing, which means a shorter development cycle for new products. 📄

ABOUT THE AUTHOR:

Mark E. Cowan is director of metrology for Process Equipment Company, which is located in Tipp City, Ohio. He can be reached at (937) 667-7105 or mcowan@processeq.com. Also please visit the company’s Web site at [\[www.processeq.com\]](http://www.processeq.com).

4 REASONS TO USE COLONIAL TOOL GROUP, INC.



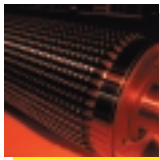
1 SPLINE ROLLING RACKS

- Threads, Helical and involute
- Straight or Tapered Splines on Shafts & Production Rolling



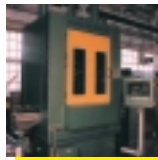
2 PRECISION MACHINE SPINDLES

- Patented Motorized Boring, Milling, Grinding & Cluster
- Repair or Design & Build



3 BROACH TOOLS

- Helical, Spirex, Large Involute, Flat, Concave & Special Forms
- Patented CNC Manufactured for Consistency



4 BROACHING MACHINES

- CNC Helical/ Table Up, Pull Down, Surface and Horizontal
- Complete Turnkey Setups

1691 Walker Road
Windsor, Ontario
Canada N8W 3P1
519-253-2461
FAX 519-253-5911

In the U.S.A.:
5505 Concord Street
Detroit, MI 48211

12344 Delta Drive
Taylor, MI 48180

313-965-8680
www.colonialtool.com

Colonial Tool Group, Inc. has been a leader in the machine tool industry for over 60 years. Our reputation can only be maintained by the manufacturing of all of our products in-house, including a complete heat treat facility. Let us tackle your tooling needs or process problems from our previous experience, balanced with today's ingenuity.

