



Absolute Length Gauges for Shop-Floor Metrology

The conditions surrounding production environment metrology place special demands on position measuring systems used for workpiece inspection in shop-floor metrology. The very principle of inductive systems involves disadvantages such as temperature sensitivity or nonlinear behavior. A length gauge recently developed by HEIDENHAIN, now combines the benefits of incremental optical devices and absolute measured value acquisition. Its advantages over previous position measuring systems make it an interesting alternative for shop-floor length measurement.

The requirements for quality, precision and function of products and their components exercise increasing influence on their manufacture. To be able to fulfill these requirements and

nevertheless ensure economic production, an increasing amount of effort has to be invested in the monitoring of the manufacturing process to be able to precisely measure tolerances and deviations from the nominal condition and then correct them.

In automated production with high volume throughput, quality is assured with statistical



methods in as much as the machine and the process capability indices allow. If this is not possible, or if it is not worthwhile under the given constraints, then the quality has to be "tested in." In any case it requires measuring, which can mean significant time expenditure depending on inspection accuracy, parts handling and number of spot samples, because the measuring process must be carefully integrated in the production process in order to keep interactions and dependencies to a minimum. In mechanical production, these tasks are usually fulfilled by displacement transducers in their various forms. They have a wide range of tasks: in the simplest cases, capacitive or inductive proximity sensors test the presence of components during or after assembly. At the upper end, inspection, measuring and testing equipment possess the capability to remeasure dimensional, form and position

Did You Know...

...that a HEIDENHAIN (past Metronics brand) **GAGE-CHEK metrology digital readout (DRO)** is a vital component in the new and truly unique in-process honing and air gaging system now available to high precision metalworking businesses? Called PAGES (Precision Air Gage System), this new technology is available from **Bates Technologies LLC** in Fishers, Indiana, and is being installed for its customers by select global machine tool builders such as Mazak Corporation and others who want to offer a superior, integrated honing and gaging system directly on a machining center.

Typical honing systems are standalone, dedicated machines. The flexibility provided by the in-process PAGES honing system incorporated into a Mazak CNC Machining Center effectively eliminates the need for the dedicated equipment as well as streamlines the process, resulting in a significant cost-savings for the end-user. Common markets for high precision honing (developing a structured surface by abrading metal with abrasive stones) include machine parts for gas/diesel engines, aircraft components, compressor bodies, liners and tubes.

Not seen in the industry before and with patent protected tooling, Bates developed this on-the-fly honing system for CNCs with the help of HEIDENHAIN.

"This really has been a collaboration of experts over the last few years in order to enable this important paradigm shift in honing and air gaging for use on flexible and agile platforms," said Darrell Day, president of Bates Technologies. "The overwhelming support and expertise from HEIDENHAIN has contributed into



GAGE-CHEK metrology digital readout

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allowing our PAGS to talk to our customers' PLCs and make this truly an in-process system."

The particulars of the PAGS in process gaging system for use on CNCs includes the use of a controlled air pressure flowing through orifices located on the hone tool body to measure changes in the bore size as it is honed. This air pressure differential is detected by an A/E (Air to Electronic) box where the pressure differential is changed into an electronic signal. This information is then passed onto the GAGE-CHEK unit which has been programmed to monitor the changes in bore size during the process. This information is visually available to the operator through the unit's DRO function. As the bore size grows larger with each stroke of the honing tool, the gaging unit mounted on the side of the machine displays its dimensions in microns, and when the correct size is reached, the CNC machine PLC is fed information from the GAGE-CHEK to notify it to

complete its cycle, and automatically stops.

Day continued, "At the very initial stages of this project development, we had tried a competitor's gage box but had issues with configurations. The GAGE-CHEK DRO has proven to be extremely flexible and reliable, as well as easy to use. After initially mastering the PAGS with the GAGE-CHEK unit, it has seamlessly provided accurate data to the CNC machine even through multiple tool changes and varying finish bore diameters."

The HEIDENHAIN GAGE-CHEK (model ND 2100G) metrology display is well known for its use with multipoint inspection apparatuses in manufacturing and quality assurance industries. With inputs for up to eight gages, it is predestined for multipoint measurements from simple pass/fail detection up to complex SPC evaluation.

"And the cost of the GAGE-CHEK is reasonable

too," explained Day.

Day believes the future of their PAGS system will further advance the ability of a CNC machine to offer a closed loop process with the information provided by the GAGE-CHEK unit to allow for automatic size compensation of the tooling (boring, reaming, etc.) that is used prior to the honing process.

Established in the honing business in 1985, along with the purchase of the Micromatic Hone Tool and Abrasive Group from Textron in 2005, Bates Technologies LLC (www.batestech.com) is now a division of Lapmaster International and is one of the leading developers of specialized honing technologies for use on both dedicated honing machines as well as on many flexible and agile machining centers and work centers.

For more information, please go to www.heidenhain.com

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tolerances of a workpiece with precision in the micrometer range. This makes constant or known ambient conditions necessary and places specific requirements on the measuring device.

Production-integrated linear measurement

In the large market for displacement transducers, inductive sensors for path measurement in the range of a few millimeters are employed in millions of metrological applications. Half of these are proximity sensors. The other half are proportional transducers that convert a measured value to a corresponding output signal. In almost all cases, the standard device here is a linear variable differential transformer (LVDT) in full-bridge or half-bridge versions. In this measuring device the complete electronics are relocated in the subsequent electronics, which greatly reduces the size of the measuring device. Further advantages are its low price and the wide variety of available versions. However, the very principle of this type of inductive measured value generation brings with it certain disadvantages.

An LVDT plunger coil system has only a relative small linear range around the center of the soft-iron core so that the utilizable measuring stroke (depending on the mechanical design) covers only a few millimeters. For this reason, LVDTs are normally used only for measuring tolerances that stay

within the limits of their linear stroke. The nominal dimension is fixed by the mounting position of the stylus, which reduces the flexibility and handling of a measuring device if other dimensions are to be measured. Another critical disadvantage of the LDCT's measuring principle in typically harsh shop-floor environments is its sensitivity to thermal influences. Even small fluctuations in temperature can lead to drift of the measured value to such a large degree that a recalibration can become necessary. In spite of these constraints, which are familiar enough to the user, the benefits of LVDTs have sufficed to establish it in the market.

For measurements within micrometer accuracy in automation technology, various nontactile principles are used in addition to tactile linear encoders. These are usually optical devices based on the light-barrier principle (with either transmitted or reflected light). Other devices measure the distance between a measured object by the dynamic pressure of escaping air. Camera systems are sometimes used that can often be integrated well in a manufacturing process.

Optical incremental length gauges, are increasingly being used as an alternative to LVDTs. As the devices become more sturdily designed and provide better protection against contamination, they are beginning to move many demanding measuring tasks from the lab to the manufacturing process.

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The user profits from several decisive advantages of a glass measuring standard compared with other measuring principles:

- High measuring accuracy and linearity over the entire measuring path (up to 100 mm)
- Temperature stability and defined thermal behavior
- High repeatability at high resolution
- Low error within the signal period (= short-range error)

The Specto series of optical length gauges from HEIDENHAIN, have been on the market for many years now.

Absolute measured value acquisition

Absolute encoders feature an immediate connection between position and position information. Even after traverse at high velocities, a reliable measured value is always available. Criteria such as cutoff frequencies and electronically limited maximum traverse velocities therefore play no role.

A measuring device has to be referenced when put into operation, which means that the position of the measured value must be defined within the external coordinate system. Usually, a physical standard (held in a defined position) is used to set this datum: the length gauge contacts the surface of the measured object and then the surface of the known standard. This is necessary if, after it is switched on, the



Fig. 1. The length gauge combines the benefits of incremental optical devices and absolute measured value acquisition.

measuring device cannot define its position, as for example on incremental encoders without evaluation of a reference mark. On an absolute encoder, the position is known immediately upon switch-on. This advantage alone significantly facilitates handling and commissioning of the testing equipment.

With the new Acanto length gauge, the manufacturer supplements the advantages of incremental optical devices with absolute measured value acquisition (**Figure 1**). These devices now provide the measuring means to profit from immediate knowledge of the absolute position. If the ambient conditions are also included in the evaluation, in the ideal case it is possible to do without recalibration during the test procedure.

Compact design

The Acanto is a length gauge with a compact design and an IP65 degree of protection. It is available in measuring lengths of 12 mm and 30 mm (**Figure 2**). This enables it to be used in a large variety of applications. To simplify installation and handling, versions are available with either an axial or radial, pluggable cable connection. The plunger is moved pneumatically and is available in a spring-loaded version.



Fig. 2. A typical application: Measuring the diameter and length of a shaft automatically.

A ceramic-polymer sliding guide for the plunger ensures low-friction, low-wear operation and a long service life (≥ 5 million cycles). The length gauge is mounted by clamping the shank (8 mm diameter). The positions are physically encoded on the glass scale with a resolution of 23 nm. The system accuracy, which is the linear error over the entire measuring length, is $\pm 2 \mu\text{m}$. The short-range error (interpolation error) is $0.7 \mu\text{m}$. However, this plays a secondary role for repeated measurements in the range of only a few micrometers. The temperature drift is typically $1 \mu\text{m/K}$.

The position information is transmitted over the EnDat 2.2 serial interface. The EnDat master is responsible for communication with EnDat encoders from the manufacturer.

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This allows simple transmission of position data and additional information to the higher-level application.

The EnDat master can be integrated by means of a micro controller (μ C) or a Field Programmable Gate Array (FPGA) or ASIC. Integration in an FPGA or ASIC is chosen for high transmission frequencies with pure serial data transfer. Various versions are available through MAZeT (www.mazet.de) in Jena, Germany. Besides the absolute position information, the EnDat

interface also provides diagnostics for the encoder. Valuation numbers provide information on the current quality of the measured-value generation. Data saved in the device memory can be interrogated, and warnings and alarms are supported. This makes it easy to monitor the length gauge's operating condition, which significantly increases the availability of a testing system, particularly in applications with many axes.

FROM: Dr. Johannes Heidenhain GmbH

Multipoint GAGE-CHEK Readouts from HEIDENHAIN

Continuing to provide the well known and versatile GAGE-CHEK metrology readouts (past METRONICS brand) to the manufacturing and quality assurance industries, parent



company HEIDENHAIN Corporation introduces it with a new dark gray faceplate and many features. Functionally excellent, these GAGE-CHEK readouts have inputs for up to eight gauges, and are designed for multipoint measurements.

These HEIDENHAIN ND 2100G series GAGE-CHEKs will handle machine measurement and inspection tasks with ease,

from simple pass/fail detection up to complex SPC evaluation. They can be configured for basic or advanced operations where inputs can be assigned and combined as desired, along with mathematical, trigonometric or statistical formulas. This makes it possible to measure even complex dimensions such as thickness, flatness, volume and more. Rapid acquisition of measurement data can monitor dynamic events such as the eccentricity of a rotating shaft.

The HEIDENHAIN GAGE-CHEK can manage up to 100 parts, each with up to 16 visible measurement features and 16 hidden ones. Soft and hot keys can be adapted as required. Min/Max functions monitor and store data, and warning and tolerance limits can be set to each display value. The large color graphic screen will display results numerically or graphically as a color bar or a dial, or archived for statistical process control (SPC).

The ND 2104G GAGE-CHEK covers up to four axes, while the ND 2108G can handle eight. The RS-232 interface is used for communications with a PC, and a connector for interfacing with relays is also included. Users can also connect printers and memory media via the USB port.

For more information on these DROs for metrology applications, go to www.heidenhain.com

RSF Open Linear Encoder Assures Scanning Quality with LED

A new **RSF** open linear encoder equipped with a unique integrated mounting control is now available through HEIDENHAIN Corporation. Called the MS 25, this RSF encoder utilizes a tricolored LED directly at the reading head enabling the user to gage if the mounting and subsequent measurement readings are optimal. Common applications for open linear encoders are stages for medical and semiconductor machines, as well as miscellaneous metrology applications.

Open, non-contact linear encoders are increasingly being used in measurement applications that require higher traversing speeds and operating cycles, as well as lower mechanical backlash and zero frictional force induced by an encoder.

The RSF MS 25 linear encoder fits this bill and offers permanent control of the scanning signals over the whole measuring length. The use of the tricolored LED allows for easy mounting since no test box or oscilloscope is needed, and is helpful for quick troubleshooting during operation.

The RSF MS 25 utilizes a unique single-field scanning principle which allows for high traversing speeds (up to 10 m/s), large mounting tolerances and insensitivity to contamination on the scale. Integrated into the head of the MS 25 encoder is a wide

range of interpolation electronics enabling resolutions from 10 μm to 100 nm. Two end-of-travel optical switch signals are also available directly out of the reader head. The end travel signal locations can be easily set by the user.

The buyer can also choose from six mounting configurations for the graduation, as well as from various substrate options

for the tape and carrier. And due to recent advancements in technology, all of these benefits are now available in a small package design.



RSF Elektronik is based in Austria with North American representation and distribution through HEIDENHAIN Corporation in

Schaumburg, IL, USA. Since 1973, RSF Elektronik has been well known worldwide for offering high quality linear encoders, rotary encoders, digital readouts, and custom measuring systems. In addition to standard product lines, RSF offers customized measuring solutions tailored to the metrology, semiconductor, automation, and medical industries.

For more information, go to www.rsf.net

The Remarkable Year of 2010

By John Thormodsgard, National Sales Manager, Semiconductor, Metrology and Medical Division



John Thormodsgard
National Sales Manager,
Semiconductor, Metrology
and Medical Division

As we approach the holiday season and look forward to 2011, I look back fondly on a remarkable 2010. This year brought a number of outstanding business developments here at HEIDENHAIN CORPORATION: business rebounded beyond any expectation, we completed the merger of a number of sister-company sales organizations, and many exciting new products were launched.

While I was cautiously optimistic about the

economic prospects going into 2010, the speed at which business rebounded in each of this division's core markets – semiconductor, metrology, and medical – was astounding. After the dramatic reduction in business activity through 2009, the ramp up enjoyed at many of our customers this year was largely unprecedented. While certainly a positive development, in many cases this ramp stretched the supply chain to the limit; certainly this applied to us here at HEIDENHAIN as well. We appreciated your efforts and understanding as we worked with you to satisfy your material requirements through this period, and look forward to a much stabilized supply chain for next year. In the end, 2010 will have been a record year in turnover for this division as well as the larger HEIDENHAIN Corporation. That said, we recognize that we are merely sharing in the success of our customers.

Last year also brought about the successful completion of the merger activities which began here in 2009. We are pleased that the sales structure of HEIDENHAIN Corporation and our sister brands – including Metronics, RSF Electronics, Numerik Jena, Renco, and Acu-rite – are now under one umbrella. The result is a stronger sales organization - with

a breadth of product and depth of support and development expertise without equal in the industry. By offering this expanded product range through one sales organization, we provide an ever broader product variety with features to fit the specific needs of each customer's unique application. Equally important, the combined resources of our research and development groups enable us to continue to define the cutting edge of precision measurement and metrology.

In terms of new product development, the output from the R&D group last year was remarkable, with some significant new products launched to each of our market segments. A number of products developed for the metrology marketplace were introduced at IMTS. These include the MSE1000 multiplexer system, the ACANTO absolute length gage, the GAGE-CHEK with absolute ENDAT interface, and a significant new feature within the IK 5000 – Surfacing. Look for an exciting new metrology DRO to be introduced early next year, as well. Tailored to semiconductor industry, the LIP 200 represents the leading edge of ultra-precision position measurement while the LIC 4000 is significant in offering absolute positioning from an exposed linear encoder. Further, the MS 25 exposed linear encoder with integrated mounting LED system - from RSF Electronics - was introduced to our medical customers at LAB Automation. Detail on these and other product introductions of last year can be found on www.heidenhain.com or by calling our product management group at 800-233-0388.

Finally, I'd like to take the opportunity to welcome two new members of our sales division: Rick Lamb and Marc Tian both joined HEIDENHAIN this past quarter. Rick joins us from the former RSF Electronics organization and will serve as a key account specialist while Marc will be a product specialist following his orientation and training period.

I wish you and your loved ones a wonderful holiday season and a happy and successful year to come.

HEIDENHAIN SUPPORTS AMERICAN PRECISION MUSEUM

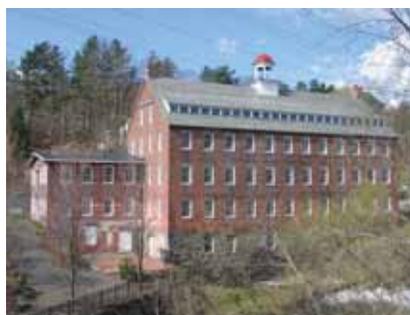
Showcasing the largest collection of historically significant machine tools in the nation, the American Precision Museum (APM) in Windsor, VT now adds HEIDENHAIN Corporation to its long list of members.

Located in the 1846 Robbins & Lawrence Armory where the concept of interchangeable parts was brought to practical perfection, APM gives visitors a look into the history of early machines and their impact on society. The advent of highly precise, exact parts started here with guns and rifles for war, with the concept later making its way to mass produced machines.

"This museum preserves the heritage of the mechanical arts and we understand its significance to all of us even today," said HEIDENHAIN Holding company president Rick Korte. "HEIDENHAIN also has a long, strong past in precision measurement, and we know the importance of maintaining history. We are proud to be a member."

Open from Memorial weekend through October, visitors to the APM will see collections of not only significant machine tools, but also early firearms, measuring devices, sewing machines, typewriters and other unique objects. Museum information is available at www.americanprecision.org

"The richness of history and relevance to our more elaborate lifestyles of today is completely underscored by what took place here," explained Hub Yonkers, APM board trustee since



2002. "The concept of precision manufacturing provides the foundation for modern industry around the world – from mass communication, rapid transportation, modern standard of sanitation and medical care, as well as the basis of abundant food and clothing, and we are pleased to be able to preserve its evolution here at the museum."

Besides supporting an important cause, members receive a subscription to the APM's "Tools & Technology" newsletter, invitations to special events, and free museum admission and discounts on site.

A Machine Tool Hall of Fame is part of the museum's website and began as a joint project with the AMT (Association for Manufacturing Technology) in 1993. This Hall of Fame includes approximately 50

elected members who have made significant contributions to the industry (from 1765 to present).

"It is an extraordinary thing that this factory building is still standing," said Yonkers. "It is so rare to have an event focal point of real historic significance still in existence, and we are thrilled to have preserved it to serve as the home of the museum to house our collection of historic machine tools." Over 150 years old, the well-built gun armory has undergone some significant renovations over the past several years, but more restoration work is necessary.

To view an 8 ½-minute video about the American Precision Museum, please go to: http://www.americanprecision.org/general/video/a_video_introduction_to_the_american_precision_museum/

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