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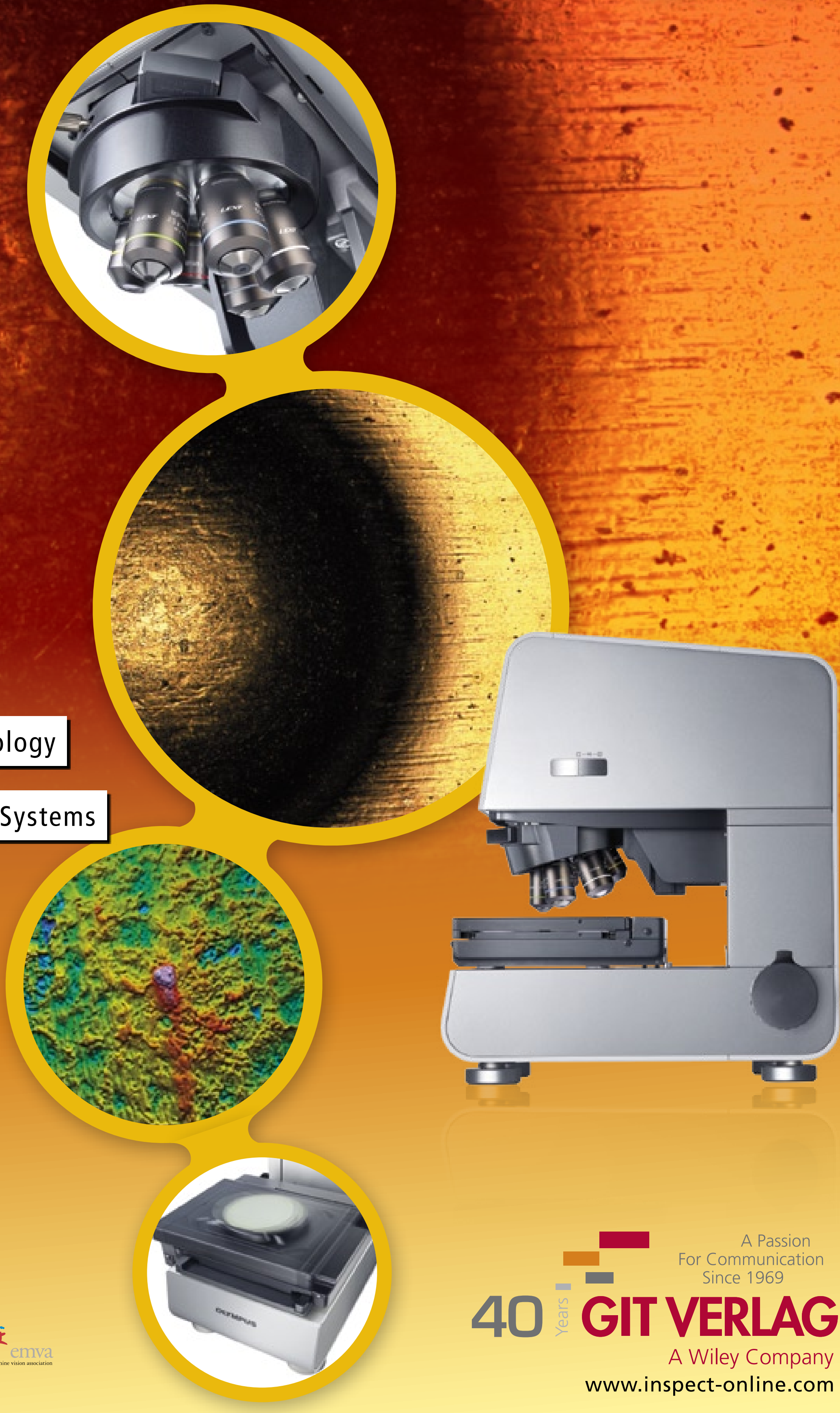
VISION ▸ AUTOMATION ▸ CONTROL

INSPECT



Special: Dimensional Metrology

Performance of Inspection Systems

3D Measurement

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Innovation Management – Management Innovations

As strategy, also innovation is a term of inflationary usage in recent years: strategic being everything that defies causal substantiation. A strategic market needs to be conquered, even without being able to show a positive cost-benefit relation. A strategic customer vindicates special price elasticity even on the other side of otherwise impregnable target margins. And a strategic project does not need any additional justification beyond exactly such label.

The innovation is then found at the implementation of the strategy. Our capacity for innovation distinguishes us, with our innovations we support our customers reaching their goals, and innovation is what we need, especially in these difficult times.

But how do we achieve them, these innovations?

Let´s have a look at the term first: the word innovation derives from the Latin *novus* and *innovatio*, e.g. something newly created. In common unspecific parlance often confused with innovation is the invention, but the latter only becomes the former when implemented in a production process. To accomplish an innovation the following phases have to be carried out:

1. Creativity Phase, e.g. the invention.
2. Evaluation Phase, e.g. the alignment between the invention and the market demands and the feasibility.
3. Implementation Phase, e.g. product development, production and sales.

To be successful as innovators first of all we need the creative guys for the invention. Creativity cannot be ordered ("Staff, we face difficult times, give me innovations!") but thrives in a climate that provides leeway to play. Google, e.g., is considered exemplary in this aspect by encouraging their employees to spend 20% of their working time with projects outside of their normal scope but addressing new and even seemingly abstruse topics.

Essential preconditions for a good innovation climate are certainly the free access to information and information exchange (there are still companies out there trying to divide the workplace usage of the Internet into "job-related" and "private", instead of understanding the benefit of their employees exactly not doing this in their off time), the chance to continuing education (in addition to the trade shows a lot of high-tech companies offer road shows, workshops, seminars and demos especially right now) and the basic belief that creativity needs space (if 120% of the working time is already allocated, the chances for an invention taking place is rather small).

The Evaluation Phase then is about the assessment if the invention bears the chance to be developed into an innovation. The right innovation climate is needed here again, this time for the evaluator(s). More often than not, however, the assessment and thus the "go" or "no go" decision about the innovation-to-be takes place in company spheres neither equipped with adequate information nor own creativity leeway to attend to the new topic sufficiently.

Now a management innovation would be to make use of the cumulative know how of the company while providing the latitude that is the breeding ground for creativity. HP, for example, had quite positive experience with having their employees place bets on the market opportunities of selected products, with real stakes and with real winnings. The reliability of the respective sales forecast could be improved significantly. So let's post our considered innovations in the intranet and let's have our experts place bets on the market success. In this way we will gain a wide feedback at a very early stage and we are able to base our decisions on a much broader base than a pure management decision can ever do in normal course of business. Since all employees can join the bet, we already paved the way for the last step from invention to innovation, the transfer of the invention into the production and sales channels.

On the following pages we'll present to you products and systems that already mastered the step from invention to innovation. And we'll bet you that you'll find some inspiration also for your tasks at hand…

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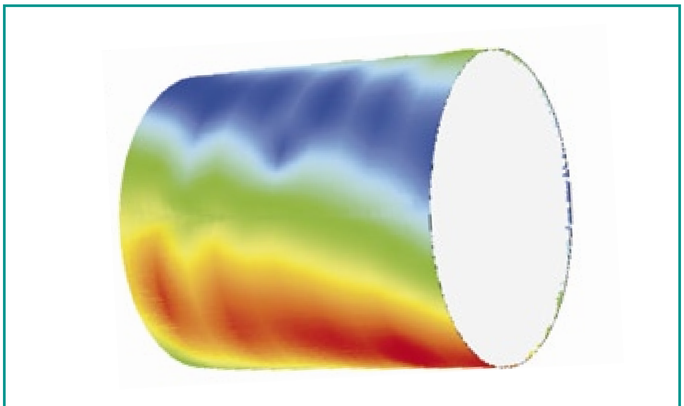
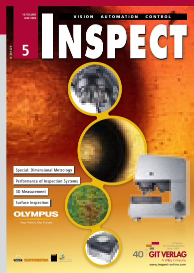


NEWS

COVERSTORY



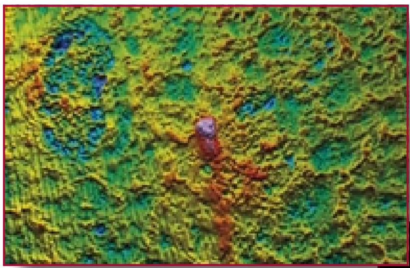
VISION

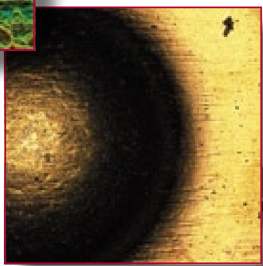
AUTOMATION

CONTROL

Near to REM ... and More

Surface Analysis with Materials Microscopy





Surface metrology is quickly emerging as a critical analytical technique to determine the topology of various materials. It can be used to identify corrosion, surface characterization, or to control the quality of different surfaces.

Conventional methods such as profilometry, have involved the use of a stylus being dragged along the sample surface. However, this technique can be problematic; it cannot be used on certain materials, such as adhesives, and the dragging process itself may result in inaccurate data being obtained. As such, the new Lext confocal laser scanning microscope (cLSM) concept from Olympus utilizes optical metrology, enabling non-contact surface roughness measurements to be obtained. The new scanning microscope is the next generation of the Lext concept, providing high-precision 3D surface profile observations and measurements in real-time. Combining advanced optics and reliability with a user-friendly software interface.

Surfaces play a key role in modern material science and engineering. Therefore, the analysis of surfaces is becoming more important than ever across a wide range of applications, including surface texture analysis, carbon nanotubes, carbon fibres, and identifying scratches in glass. Accurately measuring small scale features on various surfaces can be highly problematic. Features such as surface roughness are often on such a small scale that standard light microscopes are not able to resolve the details with the required level of clarity or accuracy.

The Laser Scanning Microscope

The observation and study of small and complex objects presents many challenges. As such, the new scanning microscope is able to simplify the process of visualizing complex materials on the micro-scale. The system features improved functionality, as well as an even higher level of visualization and measurement performance than its predecessors. This extremely reliable system provides exceptionally accurate results to the very limits of optical resolution. Such a high resolution is possible through the use of the innovative dual pinholes, which enable steep slope detection, even at a low magnification. At different sizes, each pinhole represents a different level of sensitivity; the smaller being for exceptional accuracy while the larger is suitable for a higher dynamic range. Situated directly behind the pinholes are two photo-detectors, each with different AD converters to transfer the best possible signal into a computer generated image. Furthermore, the use of high-speed MEMS (micro electromechanical systems) technology provides a resolution which exceeds that normally associated with optical microscopy.

With anti-vibration stabilization, image quality is improved and noise is minimized. Furthermore, this unique microscope incorporates features such as a motorized stage, improved signal to noise ratio, and improved colour quality, to ensure accurate and repeatable results are obtained every time. The advanced XY laser scanner used in the Lext system makes the scanning process exceptionally fast and the results more reproducible compared to conventional scanner technologies. With a complete range of specially designed objectives, optical performance has also been improved. Developed with the world-class optical technology of Olympus, the highest level of optical clarity and measurement accuracy at high magnifications is possible. The entire system has been optimized to provide an exceptional performance, and high order optical artefacts have been created to obtain the best possible results. An optical system is utilized that minimizes the aberrations associated with short wavelengths while maximizing the transmission, high quality images and signal responses are easily achieved.

The Software

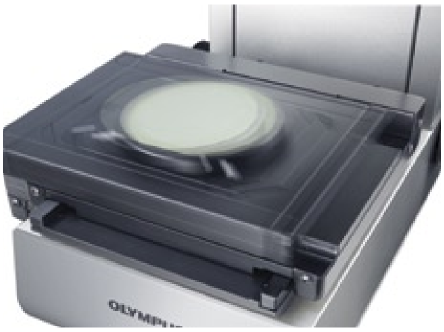
The easy-to-use software provides a user-friendly interface suitable for use by beginners and experts alike. The software builds up a workflow reflecting the users experience level. The essential buttons are visible on-screen from the start and the more complex function keys only become available as and when they are needed. This keeps the on-screen display simple, allowing beginners to navigate the software without any confusion. Furthermore, the new user ID control function enables each user of a shared system to password protect individual settings. This time-saving function eliminates the need to set up the desired parameters every time. Coordinates can be pre-set and retained by the system, making it extremely simple to automatically generate a standard set of measurements.

This unique microscope offers a full range of precision measurement and analysis functions to meet virtually any requirement. Three-dimensional measurement enables step height, line width and the distance between two points to be measured. Upper and lower limit settings, followed by one-click image capture are now exceptionally fast, saving valuable researcher time. 3D images can be freely rotated using the mouse to grab and drag, while a variety of image presentation patterns are provided. With a dedicated surface roughness testing mode, measurements can be gathered using the small laser spot. As well as they can be measured along a single line, much like conventional roughness gauges. Further minute roughness analysis can be made using the unique region of interest (ROI) function. Materials analysis using cLSM enables contact-free measurement, what consequences a wider range of materials with accurate imaging. The use of lasers eliminates the need to drag a stylus across a sample, which may cause damage to the surface of the sample, resulting in incorrect results being obtained. Furthermore, adhesive materials, such as sticky notes can now easily undergo a roughness analysis.

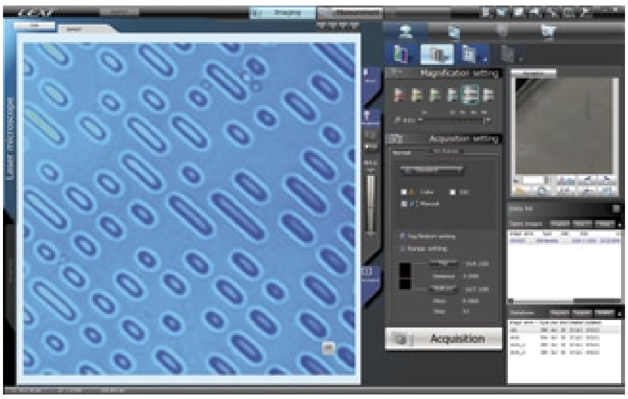
Laser microscopy has evolved beyond basic 3D geometry to enable extremely accurate measuring systems on the micro-scale. The new Microscope combines advanced optics and dual pinhole technology. It provides a unique, reliable and robust confocal laser scanning microscope. 3D reconstruction of topologically complex objects becomes simple, with non-contact surface roughness measurements enabling a more completed image and accurate results. Furthermore, the user friendly software interface is simple to use for beginners and can be tailored to suit the needs of a more advanced user. With outstanding resolution and magnification, the microscope is designed for researchers working between the limits of conventional optical microscopes and scanning electron microscopes (SEM). As the latest evolution of the Microscope family, the total cost of ownership has been reduced, with less energy being consumed to save the laboratory on running costs.

The new metrology system Lext OLS4000 from Olympus

Acompleted range of specially designed objectives guarantees



The Lext OLS4000 Piezo-drive stage ensures excellent precision and accuracy



The easy-to-use software provides a user-friendly interface

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KSW Microtec Appoints New CFO

KSW Microtec has appointed Dr. Heiko Färber as new Chief Financial Officer (CFO), to play an influential role in driving the company's ongoing growth trends. Dr. Färber, who holds a doctorate in business economics and has an impressive track record in the financial field, will be in charge of KSW Microtec's financial division, as well as controlling the company's IT, legal and human resources departments. The primary goals of KSW's highly motivated and innovative team are to develop the company's RFID business across a variety of industry sectors, including Asset Tracking, Access Control & High Security, ePayment and eTicketing. With this in mind, Dr. Heiko Färber will be enhancing KSW Microtec's expertise by coordinating the hiring of key personnel hires to help attain these goals.

www.ksw-microtec.de

Basler Announces 2008 Results

Basler Vision Technologies has released its 2008 annual report. At € 29.7 million, the Basler Components division (digital industrial cameras) increased its turnover by 8 % over the previous year (2007: € 27.5 million). This increase was predominantly due to the expansion of Basler's international leadership in the fast-growing Gigabit Ethernet camera segment. Thus in 2008, Basler Components consolidated its number two position in the global market for digital industrial cameras. The company's entry into the promising video surveillance market forms the basis for further growth outside of the capital goods industry. Just as in 2007, the components' division generated more than half of the group's turnover. Group turnover rose by 10 % to a record € 56.5 million (2007: € 51.5 million). Incoming orders also increased by 11 % to a new all-time high of € 62.9 million (2007: € 56.6 million). Earnings before taxes (EBT) rose by 61 % to € 2.9 million (2007: € 1.8 million).

www.baslerweb.com

Performance of Inspection Systems

Factors Influencing Automated Defect Identification

The performance of automated inspection systems on the factory floor is a frequent source of controversy between equipment supplier and user – often caused by different perspectives. The overall performance as desired by the user does not depend on the technical performance of the inspection system alone. This paper intends to highlight different influence factors and to sensitize for a view of the complete process.

The proposition of any modern quality management is to have a stable and controlled production process instead of sorting out defective parts. Nevertheless, in practice process control has its technical limitations. Thus, automated inspection systems are often unavoidable at the end of the production line. There is, however, no such thing as a perfect inspection, neither human nor automated. This leads consequently to the question of system performance.

The original task of a final inspection system is to sort out bad parts. From the point of view of the QA, the slippage of bad parts still reaching the customer should be minimal. The intention of the production manager on the other hand is that the inspection should cause as few false rejects as possible. Both figures can be determined by taking samples from the good and the bad parts. Together with the fraction of correctly inspected parts, these figures can be summarized in a 2 x 2 contingency table (cf. fig. 1).

The final figures slippage and false-rejects are driven by the complete process, including the production process and the quality decision as well (see fig. 1): in production, defects of various types are generated with different frequencies, the inspection system does state these properties and depending on the actual quality specifications it is decided whether the part is ‘ok’ or ‘not ok’.

The inspection system may fail, e.g. by making a wrong defect classification. The effect of such a failure depends on how often the particular defects appear (production statistics). Moreover, whether

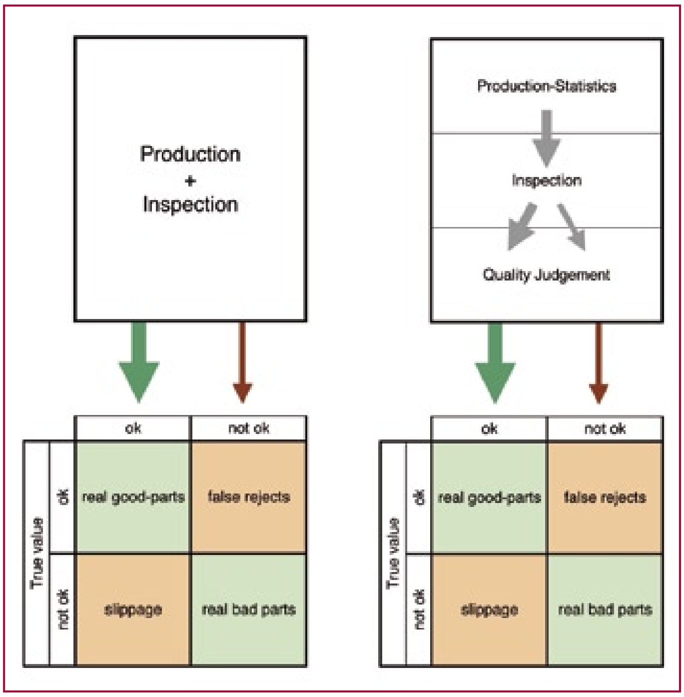

Fig. 1: From a naive point of view, the total production line including the inspection is a black-box, delivering correctly inspected parts (genuine good and genuine bad parts), and incorrect inspected parts (slippage and false rejects). A closer look however reveals that the inspection is just one link in the total process chain.

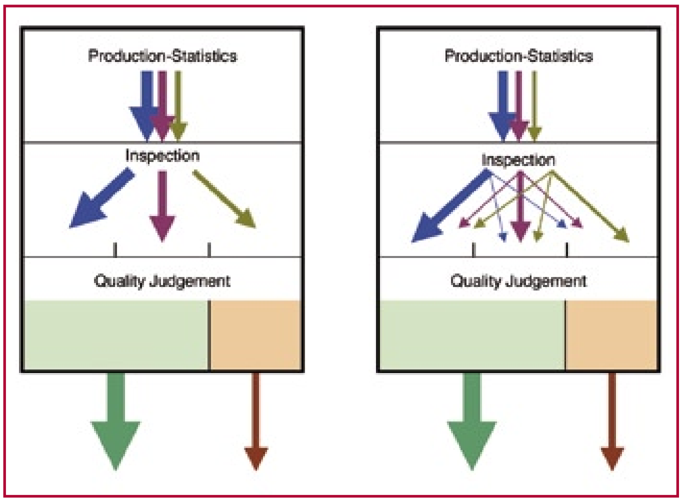

Fig. 2: Ideally, the inspection should unambiguously classify the defects according to their properties (l.h.s.). In reality, misclassifications are always possible (r.h.s.).

such a failure has any consequences depends on the subsequent quality judgment; maybe the misclassified defect still belongs to the same quality category.

Glass for example may contain small bubbles or inclusions, which are hard to distinguish (even for a human inspector) and are easily mixed up. However, this doesn't play a role when inclusions appear only very rarely (production statistics), or when bubbles and inclusions lead to the same product quality (quality judgment).

Inspection Systems

In the following, we will focus on inspection systems, which look for defects, e.g. bubbles, inclusion or scratches on glass products, or bumps and particles on coated sheets. Such tasks are in general performed by optical machine vision systems. However, the following reflections are also valid for any other imaging system, like ultrasound, x-ray etc, and may in parts also be translated to human inspection.

For physical reasons, there is no such thing as a 'perfect' inspection system, in the same manner as there are no perfect measurement systems. In any metrology device there are disturbances like noise, drift, nonlinearities etc. Even more, inspection system often cannot directly access the features that are originally relevant for the quality, but do record secondary quantities. It is for instance widely accepted that a particle's size is proportional to the light intensity that is scattered by the particle. These basic arguments show that no inspection equipment is immune against making errors.

Typically, defect inspection systems contain a signal processing chain of sensor + image pre-processing – detection – feature extraction – classification – quality judgment. First of all, a defect has to be found, i.e. to be detected, before it can be classified. The classification is based on the extraction of suitable image features. The quality judgment is based on the classification, which is mostly the type of defect. In addition to the defect classes, representing a categorical variable, an inspection system can also output continuous quantities. For example, the size of the defects is often used in the final quality decision.

One could assume that it should be possible to derive the performance of an inspection system by determining all measurement errors. In a procedure analogue to the GUM [1] one might then calculate the error propagation in the subsequent image processing and classification steps. Unfortunately, the algorithms involved are mostly by far too complex for such an approach. Moreover, the supplier would have to reveal his vital know-how. In practice it will therefore be necessary to carry out empirical tests, regarding the inspection system itself as a black box.

In such a test, the inspection result will be compared to some reference, e.g. to an offline analysis with a microscope. The reliability of any performance test, amongst other things concerning their reproducibility and repeatability, is completely dependent on the reliability of the reference. This needs to be questioned, particularly when we think about subjective decisions of human inspectors. For simplicity, we will in the following assume to have a reliable reference.

Inspection Failures

The failures of an inspection system have to be considered separately for categorical and for continuous defect features. For categorical features, like the assignment of defect types, misclassifications can take place. For instance, a defect of type 'A' may be classified to be of type 'B' by the system (see fig. 2). The corresponding performance can be described in terms of classification rates p_{ij} (p_{BA}: real type 'A', inspection result type 'B'). These classification rates fulfill the condition $\Sigma_i \, p_{ij} = 1$.
The classification rates may depend on other parameters. In particular one may expect that classification errors occur more frequently for small defects, for which less information can be drawn from the image than for larger defects.

For any continuous measurand, systematic and random errors of measurement (repeatability precision with standard deviation σ) can be determined according to DIN 1319. Here, all random processes are supposed to be normally distributed (cf. fig. 3). Reproducibility, linearity and stability are additional relevant properties.

From the signal chain described above, one can take that detection failures also influence the performance. On the one side, there are undetected defects, immediately leading to slippage. This detection slippage will mostly depend on the defect size. On the other hand, the inspection system may detect a defect where there is in fact nothing wrong with the product. Such pseudo-defects can be caused by camera noise or by cosmic rays and may lead to false-rejects.

The picture of defect inspection systems drawn here is intentionally somewhat simplified in order to focus on the main aspects. Thus it is neither considered that there are systems with more than two quality categories, that parts may carry more than one single defect, or that systems exist that are trained instead of being parameterized.

Consequences of Inspection Failures

As an example, figure 4 demonstrates how classification errors map onto the overall performance. The defect types 'A' and 'B' are assumed to be harmless, while 'C' has to be rejected. The production statistics indicates how often the individual defect types occur: Multiplying the rates of the production statistics with the classification rates results in the weighted classification rates. Those are then summarized according to the quality categories into 'ok' and 'not ok'. As a result,

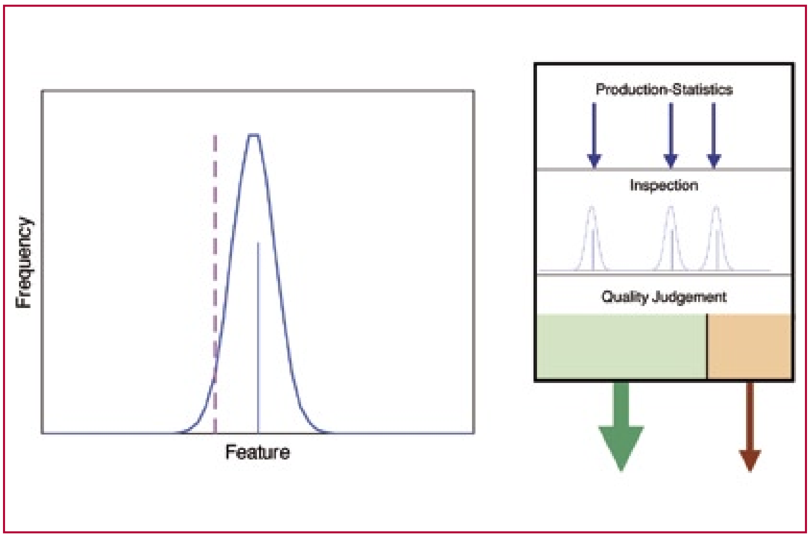

Fig. 3: The measurement value typically deviates from the true value (vertical line) due to a bias (difference to average of many measurements) und due to random contributions (bell-shaped curve). Consequently, measured values can sometimes lie on the other side of the tolerance limit (dashed vertical line), leading to slippage or false-rejects.

we directly arrive at slippage- and false-reject rates. This consideration refers to parts carrying defects only; for a practical application defect-free parts have to be taken into account as well.

For an ideal inspection system, all values on the diagonal of the classification rate matrix would be $p_{ii} = 100\%$, while all off-diagonal values would equal 0. From the diagram in figure 4 one can read that in such a case, slippage and false-reject rates would vanish.

In many cases, continuous defect features are subject to a single-sided limit; in particular the defect size may often not exceed an upper tolerance limit. The closer the measured value comes to this limit, the larger are the effects of measurement errors, more frequently leading to mistakes in the final quality decision. In the extreme case, when a defect is exactly on the tolerance limit, even a perfect inspection would always state the defect to be 'ok' in 50% of the cases and to be 'not ok' in the other 50%.

The said arguments apply to a single measurand, but in general all possible values have to be taken into account. Mathematically speaking, the production statistics has to be convolved with the distribution of the measurement error (cf. fig. 5).

Undetected defects (detection slippage) are neither classified nor measured in any way by the inspection system and end up directly at the customer. The resulting slippage corresponds to the product of the detection-slippage rate and the ratio of 'not ok'-defects in the production statistics. Correspondingly, the contribution of pseudo-defects to false-rejects depends on how often their features statistically lead to an 'ok' or 'not ok' quality decision.

Validated Inspection Systems?

In Germany, an established qualification procedure for measuring instruments is the so-called 'Messmittelfähigkeit' (measurement system and equipment capability). Users of inspection equipment often ask why their equipment couldn't simply be qualified in a similar way. A closer look at the procedure reveals the problems: 'Messmittelfähigkeit' refers to a single continuous measurand. The measurement error is related to a double-sided tolerance band to assure a small false reject rate. The procedure evaluates the error by the measurement instrument only and includes the quality criteria by including the tolerance limits. Using a calibrated standard assures that the true value of the measurand equals the nominal value in the centre of the tolerance band [2].

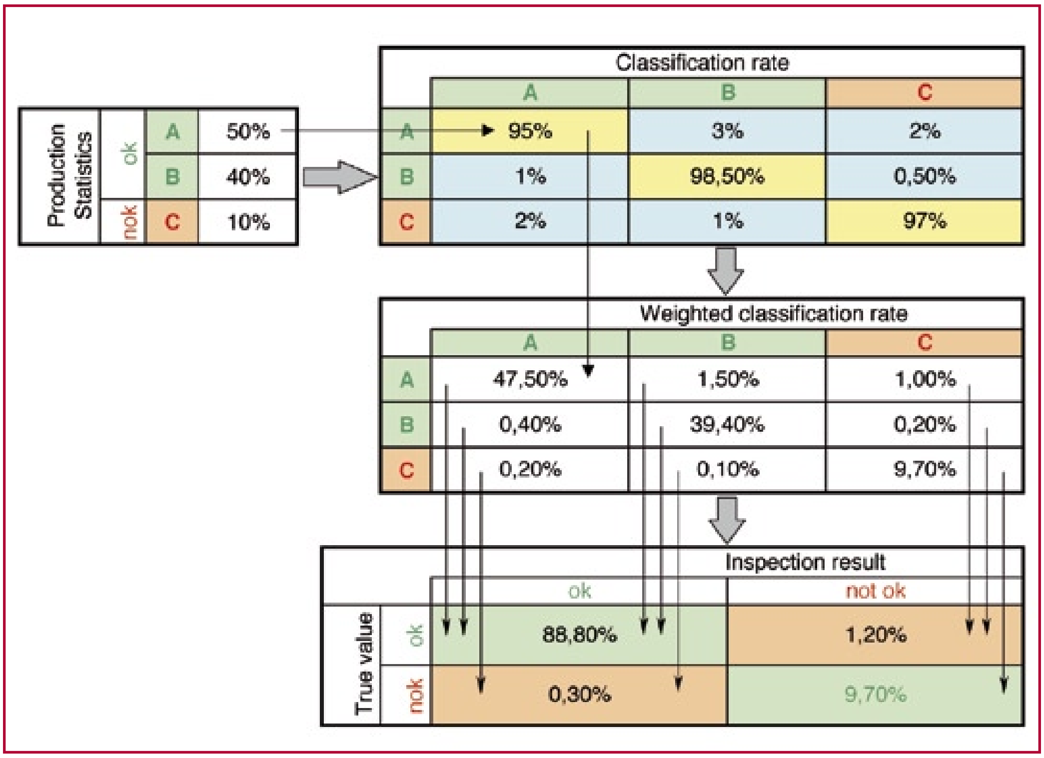

Fig. 4: Consequences of classification errors: the defect's frequencies (production statistics) and the classification rates p_{ij} are taken to derive the weighted classification rates, i.e. the statistics of the inspection results. These are summarized to the two quality categories. In comparison to the true defect types, slippage- and false-reject rates result.

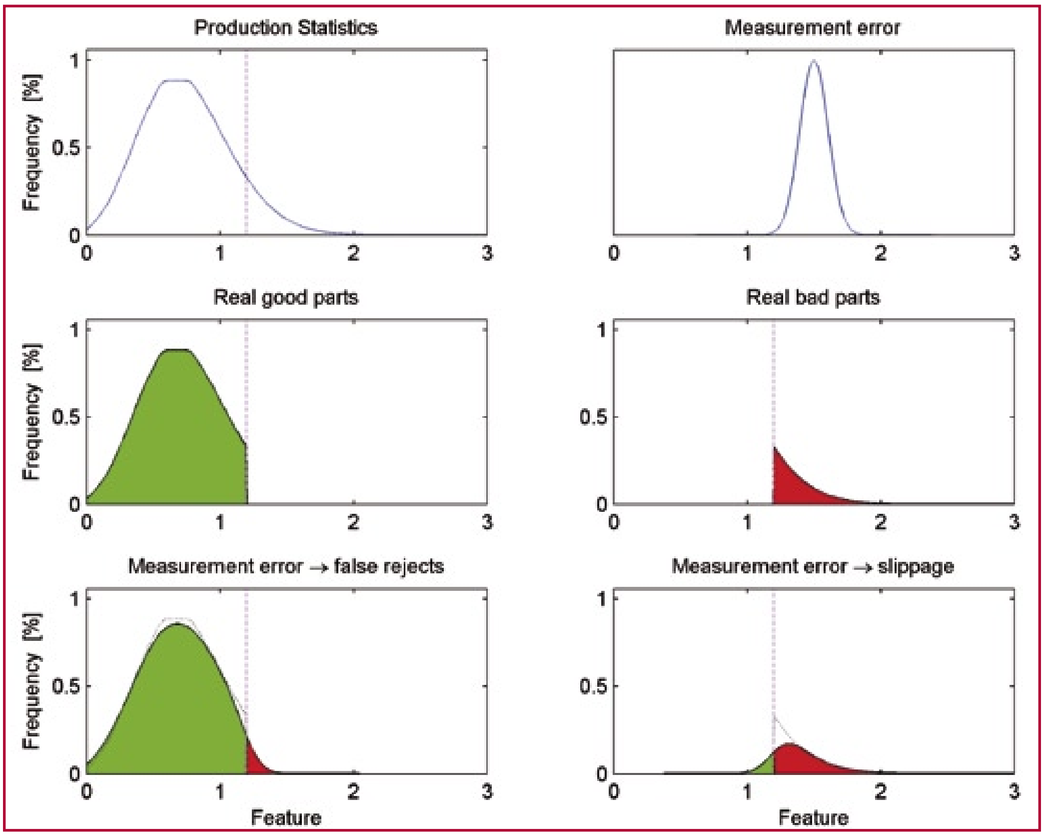

Fig. 5: Impact of the measurement error: the production statistics is shown on the upper l.h.s., the upper r.h.s graph indicates the error distribution. The production statistics is split into the o.k. and the n.o.k. parts according to the tolerance limit (middle row). The washing-out of these distributions due to the measurement error causes fractions to cross the tolerance limit, leading to slippage and false-rejects (lower row).

A stable and well-controlled manufacturing process should yield parts for which the measured value can be expected to comply with the nominal value. Under this condition the 'production statistics' corresponds to the supposition underlying the described method. The manufacturing process, however, is not necessarily stable: false rejects and slippage can grow very large as soon as the manufacturing gets out of control, leading to parts close to one of the tolerance limits. Hence, a measurement instrument complying with the described standard is by no means any warranty against false-rejects or against slippage – which however often is the implicit expectation of many users.

Quantities describing defect features do in general not posses a single fixed expectation value. Hence, without knowledge about the feature distribution, i.e. the production statistics, inspection systems cannot be validated in a meaningful manner. Moreover, the method for 'Messmittelfähigkeit' has to be transferred to categorical quantities. Finally, in the present context continuous feature quantities are mostly not subject to double-sided, but to single-sided tolerance limits. The described method cannot be applied easily to such single-sided limits.

Conclusion

The overall performance in the sense of false-rejects and slippage depends equally on the production statistics, on the technical performance of the inspection equipment, and on the actual quality criteria. Therefore, inspection equipment cannot be designed, set up or validated by itself, independent from the complete process chain. From this interdependency it follows also that any change in the production process or any modification of the quality specifications immediately influences the overall inspection performance.

In most cases inspection systems are individually adapted to the particular application. Still, the steps detection, classification and measurement of continuous quantities are contained in the majority of the systems. As shown here, the respective system deficiencies can precisely be defined and can be used to derive the consequences for the overall performance in a quantitative way. This can be used as building blocks of an individual inspection system validation.

References

[1] Guide to the Expression of Uncertainty in Measurements', DIN V ENV 13005

[2] E. Dietrich, A. Schulze, S. Conrad: Eignungsnachweis von Messsystemen, Hanser Verlag, 2008

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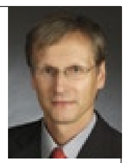

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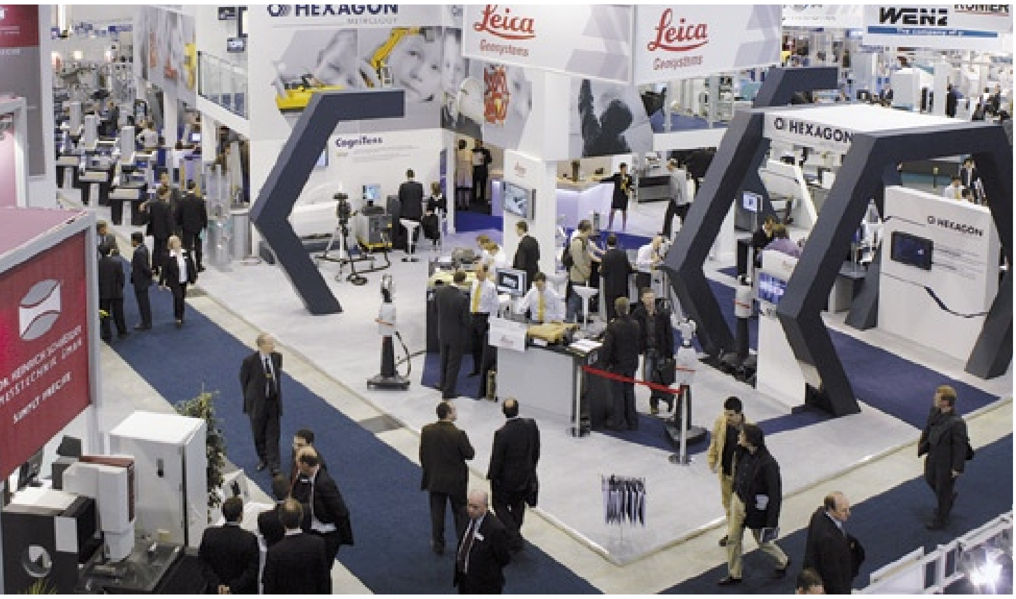
Stuttgart Springtime

Control 2009



Control 2009

Date: May 5th–May 8th 2009

Location: Landesmesse Stuttgart
Messepiazza
70629 Stuttgart, Germany

Opening Hours:

Tuesday – Thursday	9 a.m. – 5 p.m.
Friday	9 a.m. – 4 p.m.

Admission Fees:

Day ticket	€ 25
Reduced day ticket	€ 15
Two-day ticket	€ 40

Organizer:
P. E. Schall GmbH & Co. KG
Gustav-Werner-Straße 6
72636 Frickenhausen-Linsenhofen

This year for the second time, the Control will take place in Stuttgart – and, the organizers hope, again will lure 25,000 visitors to this metropolis of Swabia. What they can expect, beginning of May, what is new, and what will remain as before, the reader will learn on this page.

"Stop this practice of doing business on a lowest-price basis," as William Deming once said, making the phrase immortal in his work on quality management. He was one of the first to emphasize the importance of industrial quality management and by his work to see to it that manufacturers looked for quality in production. Many of those visiting Stuttgart between May 5th and May 8th surely have read his treatises, for, after all, the products, technologies and services shown on the State Fair premises appear under the heading of quality assurance.

Stuttgart for the Second Time

This year, Control will take place for the second time on the State Fair premises near Stuttgart Airport. The relocation is viewed as a success by the organizer, Schall Messen: More than 900 exhibitors and about 25,000 business visitors from 78 countries had visited this face-lifted Control last year. This year, even more are expected, exhibiting or viewing products, strolling about the Control's exhibitors' forum, attending the seminars prepared by the great names of the industry and the research sector. Topics, amongst others, will be ISO 9001:2008, Supplier Quality Management, or maturity level assurance for newly-manufactured parts.

Space for Trends

The organizers of Control also have had ideas about a few changes. For example, under the big heading of quality assurance there will be complementary topics for the entire process chain, like vision systems and micro metrology, thus widening the horizon. Related topics like machine vision will receive greater attention in 2009, and also more space will be given to micro metrology (i.e. measuring systems for smallest and micro parts), to industrial weighing and counting technology, as well as to sensor technology, which is evolving at an ever faster pace.

In addition, there are topics representing a trend, like energy efficiency, lightweight design, protection of resources, or recycling, viewed by the organizers as elementary components in research and development of new products and manufacturing technologies.

Trade Fair Location Stuttgart

The favorable location of the fair close to the Stuttgart airport is one of the reasons why people are happy in Stuttgart. A motorway junction is close, as are public transport stops and, in the future, an ICE station, Germany's high-speed train system. This way, the New Trade Fair Stuttgart can be reached in the shortest possible time. Airlines flying out of Stuttgart serve 112 destinations in 33 countries. The location of the fair grounds near the high-capacity A8 motorway and Stuttgart's connection to the ICE high-speed train system can be regarded as optimal, as well as the close S-Bahn (rapid transport) station of the airport and thus of the fair.

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Internal-space Inspection System

Isis sentronics, innovative supplier of optical non-contact sensors for the industrial inspection, presents i-Dex, the first semiautomatic encapsulated-space inspection system worldwide, the core element of which is the RayDex sensor. The system can be extended by a further sensor, to cope with the outer surface of near-rotation-symmetric objects. i-Dex has a working range of 200 x 200 x 200 mm and serves flexible applications in mechanical engineering as well as medical technology for:

- complete 3D interior scan of various components,
- scanning of outer contours and wall thicknesses (with the object rotating),
- registering of surface values (e.g. roughness).

Furthermore, Isis shows a wide scope of optical measuring probe needles, directly attached to the RayDex. Among those is the thinnest optical measuring probe needle with a diameter of 0.7 mm. Objects of a diameter of up to 165 mm can be measured in infinitely small steps with few measuring probe needles. The RayDex c (compact) and RayDex h (heavy duty) sensor series will allow different degrees of freedom in the movement of the probe needles. RayDEx ca and ha, respectively, permits an axial movement of the probe needle and its rotation. RayDex cr and hr, respectively, work with rotation only, i.e. without axial movement of its own. In addition, an internal focusing unit provides work ranges or objects diameters (= double working range) of several mm. The RayDex sensor consists of a sensor head with a probe needle and a remotely positioned Control Unit. With RayDex ca the probe needle is displaced axially by up to 50 mm by an air-bearing actuator, while even 150 mm are possible with RayDex ha. The probe needle, too, rotates on an air cushion with a frequency of up to 3 hertz, but can be switched to positional operation. By means of the optical decoding procedure, an Isis sentronics patent, varying distances to the surface are scanned up to 4,000 times per second. Repeating accuracies of down to 100 nm can be achieved over the entire measuring range of several mm.

Isis sentronics
Hall 3, Booth 3310

Measuring Roughness: Stylus Testing Apparatus

Surface roughness is typically measured with a stylus, having a diamond feeler needle of 2–5 µm radius. While in the past radii of 10–5 µm were used, since a few years smaller-than-standard radii have been proposed. Of course, the roughness measured is correct only with a testing point being intact. Over a longer period of use there will be wear, or it is damaged due to misuse. Then, a defined feeler radius is no longer given. Typically, measured parameters then appear not to be "worse", but are seemingly "better", rendering useless any quality control. With this feeler needle testing apparatus, the only of its kind on sale worldwide, the user is able, without prior schooling, to establish in a second whether the needle is intact or faulty. The apparatus consists of a small special microscope, a minicomputer and comes with specially developed software. It is suitable for feelers of all makes.

Breitmeier
Hall 3, Booth 3008

Computer Tomograph

GE Sensing & Inspection Technologies introduces with the v|tome|x L 300 of their phoenix|x-ray line of products a landmark new CT system. It is equally suited for 2D and 3D examination, as well as for accurate dimensional measurements of components that cannot be examined in a non-destructive way with optical or tactile coordinate measuring devices, due to their complex structures. The newly developed 300-kV-500-watts micro focus x-ray tube opens up a vast scope of applications for particularly high magnification CT analyses of hard-to-permeate components. For the first time ever, a 300-kV x-ray tube will yield a resolution of down to 1 µm. At the same time, the CT system employs a new type of temperature-stabilized GE Digital Detectors with even higher contrast resolution. The possibility to survey completely and three-dimensionally and with high resolution, cast parts, for example, of up to 50 kg and to lay virtual cuts through their interior, makes CT with the v|tome|x L 300 the ideal instrument of quality control. In addition, the system offers a special metrology package, containing all that is required for high-precision and user friendly dimensional measurements, from calibrating bodies to surface extraction modules. Beside 2D measurements of wall thickness, the CT volume data, for example, can be compared with the CAD data, in order to analyze the complete component simply and time-saving for compliance with all dimensions.

GE Sensing & Inspection
Hall 1, Booth 1114

Application-friendly Configuration of Coordinate Measuring Devices with Computer Tomography

From integrating computer tomography into the Werth multi-sensor coordinate metrology have emerged systems with which both complex work pieces and micro parts can be measured quickly and accurately. Experience in their application has shown that these systems will yield a substantial potential for rationalization. At the fair, Werth presents the successor of their TomoScope 200, on sale since 2005. Several extension stages allow an optimal adaptation to the existing demands:

- Basic coordinate measuring device with tomography sensorics, with proven software and system components, based on the standard-of-length as given by Physikalisch Technische Bundesanstalt (PTB),
- supplemented by high-resolution raster tomography for the measuring of smaller features also on larger components,
- extension of application by multi-sensorics, by the combination with further tactile or optical sensors, like the Werth fiber feeler or the Werth laser sensors. This, in turn, makes possible:
- the measuring of work pieces of combined materials (e.g. on the inside steel, on the outside plastics),
- reducing deviation of measurement with tomography to few micrometers, by taking into account the real work piece characteristics by means of the Werth Autocorrection (patent pending),
- total measuring with tomography and additional measuring of functional dimensions with high-precision sensors in one fixing and in one coordinate system.

Werth Messtechnik
Hall 7, Booth 7102

Controlling System for Color and Intensity of LEDs

The user who wants to check on color LEDs or indicator lamps on a LED display, on a LED display unit or on an assembled circuit board in an economic way, will have to resort to camera systems or color sensors that are too expensive for such tasks or cannot be optimally configured. Eltrotec for the first time presents an integrated checking and controlling system which tests light sources at up to 100 measuring points at the same time, either by RGB values or with a more suitable HSI color background.

With today's series-testing systems for electronic circuits and boards equipped with many indicator and display LEDs, the question of the proper function of LEDs or indicator lamps comes up, in addition to the functional testing of the digital logic itself. Furthermore, there is the plain series-testing of LEDs for proper color, color saturation and brightness to obtain certain performance and quality classes. For both testing and classifying tasks the presented testing system colorControl MFA is an economic solution for testing apparatus manufacturers as well as for testers and manufacturers of LEDs, lamps and displays. Also, it will be used by manufacturers of "white ware", and of control and drive systems, automobile lights or indicator displays, including monitoring and control units in power stations and power supply companies.

Eltrotec
Hall 1, Booth 1524

Automatic Geometry Testing of Silicon Ingots

Micro-Epsilon presents a completely new system for geometry testing of ingots, named dimensionControl 8260 for Ingots. Under the denomination "Ingot Measuring System", the machine examines the ingot surface, using several laser-optical sensors (line scanners), and, in few minutes, automatically measures side lengths, phase lengths, angles, diagonal lengths and planeness of the lateral surfaces. The automatic measuring machine compares rated data with measured values, thereby classifying the ingot. It calibrates itself automatically for common ingot sizes of 125 mm x 125 mm, 156 mm x 156 mm and 210 mm x 210 mm. Ingot lengths of up to 2,500 mm can be measured. Calibration for a particular ingot is effected by integrated master parts. Faulty spots on the ingot will be marked automatically by a marker unit or manually by a worker. To establish yield, the weight of the ingot has to be taken into account. Therefore, the system can be supplied with an integrated weighing device. During measuring the sensor base plate with the sensor system is shifted along the ingot to be examined, the distance between measurements being specified by the user. Typically, ingot geometry is measured once every millimeter.

Micro Epsilon
Hall 1, Booth 1525

Measuring Shape and Roughness with Only One System

InfiniteFocus is a high-resolution optical 3D surface measuring device for quality assurance in the laboratory and in production. The user profits by the entire scope of functions of an optical profilometer and a micro-coordinate measuring machine. Even with complex shapes and components having varied material properties, the 3D measuring system will yield a vertical resolution of down to 10 nm. The user will measure roughness, shape and spatial orientation with a concentration of measuring points of 2.3 to 100 million, even with geometries having wide lateral and vertical scanning extension. Freely selectable lenses guarantee the high dynamics of resolution necessary with measuring both miniature components and larger parts. Apart from the 3D measurements, InfiniteFocus delivers complete color information for the monitored elevation data. Main users in industrial quality control as well as research and development are the automotive industry, the cutting metal-working industry, micro and precision manufacturing, mold and tool manufacturing, mechanical engineering, medical care and pharmaceutical technology, electronics and printing, amongst many others. Also, measuring of tolerances and wear, or the examination of tribo-processes and corrosive mechanisms count among the standard applications of InfiniteFocus.

Alicona
Hall 1, Booth 1622

First 3D Measuring Microscope with Confocal Microscopy, Inferometry and Color

Leica Microsystems presents a new technology for contact-free 3D surface measuring, attaining resolutions of down to below 1 nm. The 3D measuring microscope DCM 3D, uniting for the first time confocal microscopy, interferometry and color imaging in one sensor head was developed by Leica Microsystems and Sensofar-Tech from Spain. The DCM 3D analyses the micro and nano geometry of material surfaces in a superfast, contact-free way with an accuracy of down to 0.1 nm. Unlimited focal depth and high-precision 3D results are obtained by the confocal micro display positioned in the luminous field aperture, the two light sources and the two cameras. The LED light source and the sensor head without movable parts render the system practically maintenance-free. The DCM 3D is suitable for numerous measuring applications in R&D and quality assurance laboratories, as well as for automated online process testing. For example, the system serves well for the quality assurance in solar cell production. Concerning production testing and quality control, crucial parameters can be measured within seconds: silicon surface texture, roughness, statistical characterization of the etched pyramid structure as well as metallic contact. Other applications of the DCM 3D include the contact-free measuring of micro-structured glass surfaces, of micro-optical components and also of paper surfaces. Integrated into the DCM 3D are two CCD cameras, a color camera for bright-field analyses, as well as a monochromatic camera for metrological detection purposes. The software facilitates the 3D rendering in various color modes, as for example pseudocolor rendering of the elevation information, confocal stacks, infinitely sharp color image and high-resolution confocal luminance by means of the color camera's chrominance signal.

Leica Microsystems
Hall 1, Booth 1324

Imaging Measuring Machine for Large Components

Imaging specialist EHR GmbH has developed an opto-mechanical measuring system, which combines the high-precision mechanism of tool positioning devices with different optical measuring methods. This way, a measurement repeating accuracy of few µm is obtained. One great advantage of the measuring machine is the fact that internal areas and internal gear teeth can be measured. Various measuring principles can be integrated, meeting individual requirements. Mainly, laser triangulation will be combined with telecentric measuring methods. The mechanical base is a Kelch tool positioning device. Adaptations towards additional mechanical design, desired by the customer or required by the application, as well as the control of the entire system are EHR supplied. Mechanical adaptations to various object geometries of up to 1,000 mm diameter are standard. The EHR software TIVIS contains all necessary algorithms for the evaluation and analysis of 3D data and offers the possibility to process even free-form surfaces in very rapid sequences.

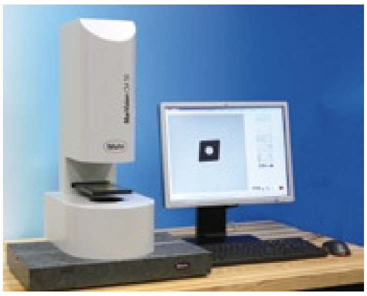
EHR
Hall 1, Booth 1612

Special Show Contact-free Metrology

Accurate adherence to the required geometric dimensions plays an important part with quality assurance during production. Applying mechanical measuring methods is frequently very time-consuming and is mostly carried out on random samples only. Currently, contact-free optical metrology will accelerate by a factor of ten to one thousand, which, together with favorable system costs, opens up a larger scope of application and in some cases even allows the realization of a zero-fault concept in production. On account of the totally different principle of function, compared to mechanical measuring methods, and because of the lack of experience in some applications, there frequently exist reservations and insecurity with potential users. The Special Show Contact-free Metrology during Control 2009 endeavors to contribute towards a wider acceptance of contact-free metrology by demonstrating design principles, characteristics and limits of the new measuring possibilities. The Special Show is sponsored by P. E. Schall GmbH & Co. KG, by the members of the Control Fair Council and Fraunhofer-Allianz Vision.

Measuring Cutting Inserts Faster

The new measuring station MarVision CM 50 was designed for the manufacturer of replaceable cutting inserts. The device is equipped with a large-image lens and a high-resolution camera and thus works very rapidly. This way, the measuring station accelerates production, enhances quality and leads to a stable manufacturing process. Manufacturers of replaceable cutting inserts will gain more speed in their measuring process and analysis of cutting inserts and ultimately in their quality assurance by the new optical measuring device MarVision CM 50. The concept of the device allows it to be placed directly in production. 2D geometries with a diagonal dimension of up to 55 mm will be registered and analyzed through a Carl Zeiss large-image lens. MarVision CM 50 needs no coordinate table. Due to the extraordinarily large focal depth, the thickness of the cutting insert plays a secondary role, rendering superfluous any time-consuming and error-prone focusing. This way, staggered cutting edges, too, can be measured without problems. The high-resolution CCD camera, combined with the large-image optics, delivers accurate and reproducible measuring results. Operation is easy: the cutting insert is placed on measuring table, zero is determined and within seconds the measuring result is presented. By means of the analyzing software Hawk a quick graphic comparison between target and actual geometry is made.



Mahr
Hall 3, Booth 3004

Innovative VEC System

Automated Precision Inc. (API), leading supplier of mobile measuring systems for the industrial use, presents its Volumetric Error Compensation System (VEC). VEC is a completely new method for improving volumetric accuracy of large machine tools by an integrated system, consisting of the API Laser Tracker 3, the API Active Target mounted on a spindle, a calibrating software and a compensating interface for machine control. In a combined function of Tracker and Active Target, the system keeps a constant measuring contact, the machine tool assuming up to 400 predetermined positions which constitute a cloud-of-points within the working range of the machine tool. At these points, the true position is determined by the Tracker 3 and the Active Target and then compared to the required positions. The software, developed by API and Boeing, finally calculates compensation data, which considerably reduce any positioning errors of the machine. In a subsequent step these data then are validated as correct and accurate for the purpose of volumetric compensation by a simulation software, before being fed into the machine control.

Automated Precision Inc. API
Hall 3, Booth 3108

Optical Measuring of Flat, Freely Shaped Parts – Visual Contour Digitizer

The Visual Contour Digitizer allows high-precision measurements of flat parts with freely-shaped contours. One or more scanning cameras register the object, its contours then being transformed into vector images. In this simple way, a dimension-true image of the contour is produced of parts that exist as a template or as a specimen only.

3D Geometry Measuring Robot with Free Positioning of Test Object

This robot will realize contact-free measuring at several points of an object, the position of which is not exactly known. In an industrial environment, the part to be measured could, for example, have been placed on a conveyor belt or a pallet.

Optical Modular Testing and Sorting System Bue-top

Various manufacturing industries have a requirement for 100%-measuring systems on the basis of distinctly improved measuring and testing procedures for parts produced by turning, milling, punching, injection molding or pressing. The optical testing system Bue-top will analyze, measure and test objects of nearly all metals, plastics and their compounds. All exterior as well as several interior contours can be tested for faults.

White-Light Interferometry for Measuring Thin Layers

Risen metrological requirements in nano-technology have called for more up-to-date methods of analysis. Talysurf CCI Lite will allow the analysis down to 20 nm, even of multilayer systems.

3D Surface Inspection

The new system SPARC (Surface Pattern Analyzer and Roughness Calculator) is based on the principle of Shapefrom-Shading (SfS) and is capable of delivering three-dimensional images of objects with only one exposure, thus also facilitating the analysis of moving objects.

Mobile Optical 3D Measuring System

The optical 3D measuring system µsurf mobile was specially developed for measuring purposes on large objects, like for example cylinders and car bodies. The device is based on the µsurf confocal technology and is therefore suited for the use in a rough production environment.

Micrometer-exact Contact-free Measuring

Measuring large objects down to micrometer precision is difficult, due to complicated geometries or large dimensions. This conflict is solved by EHR with their precision measuring machines, combining several optical measuring methods and high-precision mechanics, such as are used in tool adjusting devices.

Very Rapid 3D Measuring

Laser triangulation by means of a camera allows the three-dimensional measuring of objects down to the µm range. Using a system consisting of several cameras, laser and software, it will be demonstrated how a rapid 100%-testing can be achieved, for example of cast parts directly within the production line.

Contact-free Measuring Spectral Photometers for Color Quality Control in Production

The spectral photometer systems by X-Rite Optronik have been designed for contact-free color measuring in various production environments. For color measuring with automotive effect paints the CarFlash systems is used. The color on moving webbed material and of bulk goods is automatically measured by TeleFlash system, color deviations being reported. For laboratory use, a compact version, TeleFlash Compact, was developed.

Special Show "Contact-free Metrology"
Hall 1, Booth 1612

Put in Perspective

Optical Metrology Basics: Telecentric Lenses

Conventional lenses for industrial image processing are "entocentric" with image formation in central projection. This perspective often is quite a nuisance for metrology. Telecentric lenses are designed for parallel projection and thus eliminate the warping produced by central projection. This article explains the concept of telecentric imaging.

Conventional Lenses

The typical task in industrial image processing is to view a conveyor belt with a camera mounted directly above, producing a sharp image of an object in the detector-plane by means of a standard-lens. The lens may be treated as a simple single thin lens for rough calculations of basic parameters like the field of view, the format of the sensor, the focal length or the distance between camera and object. The object, however, will only be in focus, when focal length, object distance and image distance obey the lens formula. When two of these parameters are fixed, the third parameter is unambiguously determined by the laws of optics. The well-known simple lens equation for the paraxial approximation usually is well suited and quite sufficient as the first step for the optical layout of an image processing application [1]. With a conventional lens, the object can be brought into focus by slightly moving a part of the lens along the optical axis, thus choosing the proper image distance and producing a sharp image. For many applications, adjusting the focus ring is sufficient to reach the milestone for the optical part of the project. What happens, however, when oscillations of the conveyor-belt occur during production and the image processing has to deal with a considerable range of object distances? Three-dimensional objects like holes, tubes, screws, bolts or springs per se have structures at different distances and will inevitably confront the application engineer with more complex optical effects in imaging. In this situation, two effects occur: the image will be blurred, and the image height will change with the distance. Both phenomena may lead to problems when the dimensions of objects are to be measured by image processing.

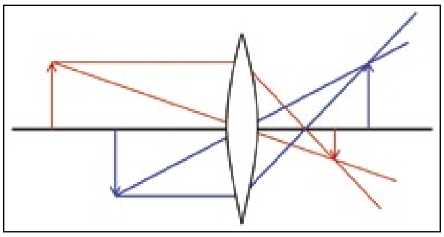


Fig. 1: For conventional lenses, the image size depends upon the object distance

Simple Lens Equation

To get a better idea of the situation, we first look at two identical objects positioned at different distances from the lens. Figure 1 shows a red and a blue arrow of the same length, both based on the optical axis, but pointing in opposite directions perpendicular to the optical axis. For each of these arrows the position of the sharp image can simply be constructed geometrically by tracing only two rays. Rays, which enter the lens parallel to the optical axis, will pass through the focal point on the optical axis. Rays, which aim at the center of the lens, will exit the system without changing their direction. For the construction of the image, the tip of the arrow is used; the sharp image of the tip is the point, where these two construction rays intersect. The same construction is possible for the center of the arrow, leading to the observation that the image is formed in a plane perpendicular to the optical axis. In particular, the base of the arrow is imaged back to the optical axis. The construction immediately shows that the two arrows, although having the same height, will produce images of different heights, the smaller image corresponding to the larger distance. The magnification, that is the ratio of image height and object height, is different for the two positions, it depends upon the object distance. The two corresponding sharp images, however, will not only have different heights, but will also appear in different image distances. When the object distance varies, such as in the scenario mentioned above, re-focusing would be necessary to obtain a sharp image. Only special applications allow for such a procedure. Usually, image processing on the factory floor will choose a fixed image plane and will be quite happy with a clamping device at the lens body to secure focussing, humbly looking at some blurred images for objects outside of the specified object distance range.

Figure 2 shows how a blurred image can occur in a fixed detector plane when the object is moved away from the proper object distance. The geometry of the situation is the same as in figure 1, and the positions of the images for the red and the blue arrow are already known from the previous construction. In figure 2a, only the base points of the arrows are shown. Their images are formed by a cone of rays which can enter the lens through an aperture which may even be just the lens mount. We assume that the detector is positioned in the image plane for the blue arrow. The rays for the red arrow which come from a larger distance will intersect in front of this image plane and will reach the detector as a divergent bundle, thus producing a small disc as an image instead of a sharp point. The same holds true for an object-point which is not on the optical axis like the tip of the arrow as shown in figure 2b. The whole image of the red arrow on the detector will thus be blurred due to this geometrical effect. A closer look to figure 2b shows that this image will be smaller than the image for the blue arrow which is in proper focus. We thus will expect that an object will appear smaller and smaller when it moves away from the camera even with a fixed detector plane – we may easily verify this fact within a minute in every laboratory where a camera is mounted on a vertical Kaiser-stand with height adjustment by a hand crank. As an alternative, we might just take a break, gazing off into distance with eyes wide open, and think about what we see: our eyes basically are entocentric lenses in this situation. For quantitative calculations, however, more elaborate methods of technical optics are required. The simple lens equation is not sufficient for this task. In particular, the influence of apertures and diffraction effects has to be taken into account [2].

Central and Parallel Projection

Imaging with a conventional entocentric lens is a central projection. This is illustrated in figure 3, where both objects from figure 1 are drawn in both distances, and the image

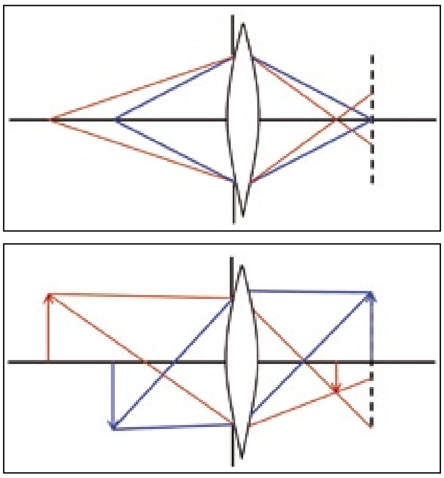


Fig. 2: A detector placed at the image plane of the blue arrow will see a blurred image of the red arrow; figure 2a shows the image formation for the base point, figure 2b for the tip of the arrow

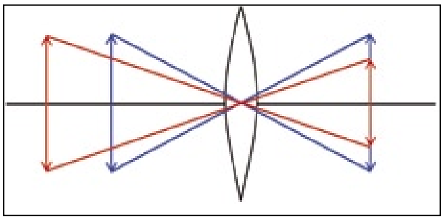


Fig. 3: Imaging with a conventional lens is a central projection

formation is shown for the cone of rays which pass the center of the lens. It is quite evident that the height of the image depends upon the object distance in central projection. Parallel projection would eliminate this effect. We thus need an optical arrangement with image formation by those rays only which enter the system parallel to the optical axis. For a simple thin converging lens, all the rays traveling parallel to the optical axis are focused to the focal point on the optical axis – this is just the basic definition of the focal point. A small aperture, centered in the rear focal plane, will thus block all those rays which did not enter the system parallel to the optical axis, and the image will be formed with the remaining rays. Fig. 4a shows this arrangement: the concept of an object side telecentric lens. It can be shown that the image size for a fixed detector plane remains constant for this system even when the object distance is changed [2]. Since the diameter of the aperture must not be reduced to just a pinhole for reasons of intensity, the telecentricity can only be achieved in approximation. Telecentric lenses are usually designed for a fixed working distance and have a defined telecentric range around this distance. Within this range, the remaining variation of the magnification is specified. For a good telecentric lens, e.g., the image size may vary by just 1 µm over the whole field. When this precision is to be fully exploited for gauging, it makes sense to optimize all the other optical parameters of the lens. The remaining distortion at the image plane is an important source of uncertainty of the measurement. For this reason, telecentric lenses are usually very well corrected and are specified with distortion of much less than 1 percent.

Bilateral Telecentricity

With an object side telecentric lens, the magnification will remain constant for a fixed position of the detector plane perpendicular to the optical axis only. Even a small tilt of the image plane may result in changing image heights for an object moving away from the lens. Since the rays hit the image plane as a divergent or convergent bundle at oblique incidence, the intensity distribution of edges of objects may become asymmetrical. Methods with subpixel-precision are often reasonable in conjunction with telecentric imaging, where the remaining changes of the image size are just fractions of the pixel pitch. Subpixel-algorithms, however, may be quite sensitive to asymmetries in the edge profile. A lens system with two stages can eliminate these disadvantages. For this purpose, the aperture is placed in the front focal plane of a second lens, which projects the aperture to infinity, thus producing rays leaving the system parallel to the optical axis. This concept is illustrated in figure 4b. It can be shown that the image size for this arrangement remains constant even when the detector plane is not fixed; it is insensitive against defocusing [2]. The magnification in this case is the ratio of the focal lengths of the two lenses. Such bilateral telecentric lenses are available with a mechanical means for re-focusing and thus allow for the adjustment of the working distance to the requirements of the application. In general, this concept is quite similar to the Kepler telescope, but with the main difference that the bilateral telecentric lens uses only those rays which enter the system parallel to the optical axis. This directly leads to a very important restriction for applications with telecentric lenses: for imaging in parallel projection, the free diameter of the lens has to be larger than the object itself. For large objects with dimensions of several feet like in web inspection, e.g., a single telecentric lens neither

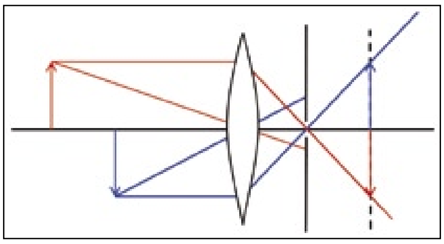


Fig. 4a: An aperture in the focal point results in an object side telecentric lens; for the fixed detector plane the magnification is constant for different object distances

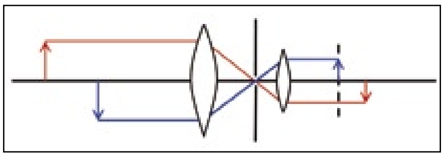


Fig 4b: In the bilateral telecentric system, the image size does not depend upon the position of the detector plane

will be available nor be an economical approach. A phalanx of staggered smaller telecentric lenses with overlapping fields of view usually provides a reasonable alternative. Due to their optical layout, telecentric lenses are longer compared to conventional lenses [3], may have a mass of several kilograms, will usually require high brightness lighting, and are quite expensive. For precision measurements of dimensions in image processing, however, these masterpieces of technical optics are often mandatory.

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INSPECT

Vision

VISION: COMPONENTS AND TECHNOLOGIES

The Vision section of INSPECT deals with new trends in the camera market, changes in frame-grabbers, the wide range of lenses, the rapidly increasing variety of illumination as well as with the increasing use of smart cameras, vision sensors and compact systems. Software, with its facets of algorithms and user guidance as well as data processing and communication has its platform in the Vision section. In addition, the „hidden heroes" such as interfaces, processors and cables are taken out of the shadow and their effect on the success of the equipment as a whole is given appropriate editorial attention. The Vision section is addressed both to readers who plan the in-depth technical details of systems, as well as to users for whom Plug, Play & Forget is the primary aim.

Millions of Mirrors

Technology and Applications of Digital Light Processing

Digital Light Processing (DLP) is the technology, originally developed by Texas Instruments, to have the light of a light source reflected onto the projection area by miniscule square micro mirrors. The micro mirrors, operating as a light switch, are positioned on a DMD (Digital Micromirror Device) chip and are responsible for the projection of a single pixel, each. Depending on the resolution such a DMD chip can consist of millions of mirrors, each of them to be switched several thousand times per second.

For many years, DLP technology is well known for powering digital projectors. Soon after commercial introduction, developers and researchers began to transfer the micro display technology into their innovative developments outside traditional projection displays. This has gained speed especially after the introduction of the DLP Discovery development kits, offering a flexible electronics platform to design products for new applications.

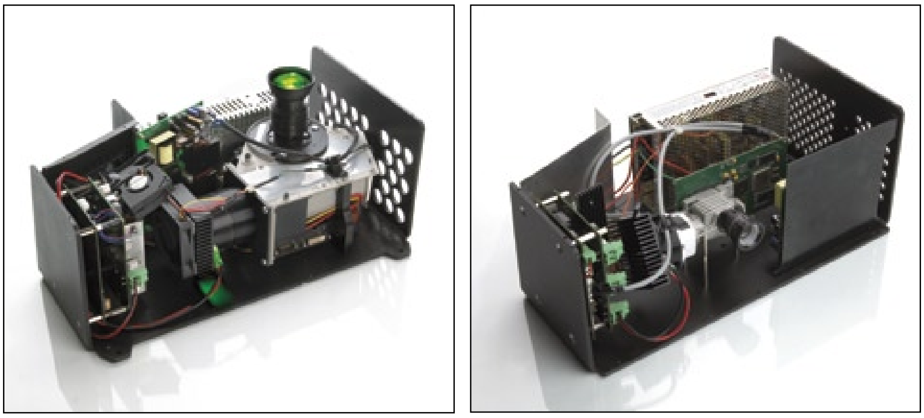
But product development in new applications generally demands much more than access to the basic functionalities of such electronics platforms. Efficient data interfacing hardware and software is required as much as a versatile light engine, providing display illumination from a light source and imaging the micro display to the relevant object or receptor.

Visitech's series of Luxbeam DLP Light Engines provide engineers with a professional light engine development platform already during early stages of their development projects. The fully functional integrated modules include electronics, optics and light source as well as pre-installed Luxware software to control the DLP micro display functionalities. Different optical configurations and a selection of various light sources such as arc lamps and high brightness LEDs enable straight forward integration of the light engine into individual product developments.

Application Example: 3D Optical Metrology Systems

3D optical metrology systems are being implemented across an array of diverse applications that include 3D biometrics, inspection equipment, forensics, engineering design, alignment equipment, dermatology and cosmetics, biomedical applications or product manufacturing. Specific parameters are measured in these applications such as 2D and 3D surface shapes, contours, roughness, and discontinuities.

Structured lighting, i.e. a series of well defined light bands or stripes, is illuminating an object. A high resolution camera, located at some pre-defined angle different from the illumination angle, records these bands or stripes on the object. High level processing of the acquired images using optical triangulation principles and sophisticated phase shifting algorithms then extrapolates the raw data to a multidimensional image.



The fully functional integrated Luxbeam DLP Light Engine modules include the pre-installed software and the light source as well as all electronic and optical components

The measurement accuracy of these systems is a function of accuracy and repeatability of controlling light bands (or stripe width) and gray scale. With high resolution and precise control of individual pixels in the micro display and high fidelity in gray scale bit depth, fringe projection with Luxbeam Light Engines makes it possible to repeatedly project fringe patterns with varying widths, orientations, and phase shift values. This enables engineers to build high accuracy 3D optical measurement systems with measurement accuracy down to 1/10 bandwidth (<1 micron).

Technical Benefits in Industrial Applications

There are a number of features that make the DLP technology specifically interesting for emerging and industrial applications, i.e.

- each pixel is digitally controlled,
- high reflectivity,
- polarization independent, increased light efficiency,
- ability to work with IR, Visible, and UV light,
- proven technology with over 18 million chipsets shipped,
- can use PWM to achieve a very linear gray scale,
- fast switching speed in the microseconds,
- variety of resolutions from XGA to 1,080p and WUXGA (1,920x1,200 pixels).

Combined with these display features, the Luxbeam Light Engines have already demonstrated to be versatile and flexible for research and engineering, enabling product developments in the broad range of industrial DLP micro display applications such as hyper-spectral imaging, 3D security, spectroscopy, medical engineering, augmented reality, rapid prototyping, 3D volumetric display, high performance imaging, and machine vision.

As an independent DLP Design House and Texas Instruments' leading value adding partner, Visitech's engineering team has aggregated in-depth expertise in development and manufacturing of DLP electronics and light engines and supports product developments in many areas of emerging and industrial micro display applications.

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Pixel Highway

Move Large Volumes of Data

The industrial image processing application environment is increasingly developing into something like a "Metropolitan Area". Here millions of commuters present the city's management with almost insoluble tasks in respect of the infrastructure. And what can you do to ensure that the data streams consisting of millions and millions of pixels arrive safe and sound at their destination from the peripheral, so that they can be used productively in your work on the PC? A highway using CameraLink technology is an excellent solution.

The factors bringing us to this conclusion are well-known: the user has at his or her disposal cameras that generate huge volumes of data with their high resolution and high image refresh rates for the purposes of monitoring and controlling production processes, often using image processing systems for quality assurance. A number of criteria define the task of optimizing data transport, and hence the selection of the interface, for the user: speed, security, integration effort, flexibility and costs. A glance at the market reveals how important orientation to the correct application is.

Standards have also been defined for camera interfaces to help in integration with existing architectures. Thus FireWire and Gigabit Ethernet (GigE) can score here, as they bring defined software standards, the former in the shape of DCAM and the latter with GigE Vision. Standardization affects only the hardware with USB2.0, CameraLink and analogue interfaces.

Cable length is also important in the installation of image processing solutions in a production environment. Analog and GigE cameras perform well for lengths of up to 100 m. USB, CameraLink and FireWire are good below the 10 m mark. However, if we keep our focus on the facts outlined at the start, we come back again to the criteria of transmission speed and bandwidth. Clocking, processing speed and assurance of practically zero error rates in production cause us to equate the data volumes generated to the task set. Here the CameraLink interface comes into play now in order not to reduce the „yield" of modern cameras.

Why Choose CameraLink?

CameraLink is specified for rapid image transmission. The technology is based on the three transmission structures, Base, Medium and Full, to allow it to cover a basis of applications as broad as possible. The table below shows the specified maximum data transfer rates as a function of the clock rates. The number of taps indicates the number of channels used for the transmission of the data (table 1).

For comparison, a GigE camera can transfer a maximum of 125 MB/s, FireWire IEEE1394b manages just 100 MB. This shows clearly that CameraLink is fully justified for fast image transmission.

CameraLink uses LVDS (low-voltage differential signaling) which is characterized by high speeds at low voltage levels as its physical layer. Up to 28 TTL signals are transmitted over standardized connectors and cables. One or two plugs must be connected for each camera, depending on the version.

There is progress today on the power supply to the cameras. The introduction of Power Over CameraLink (PoCL) has significantly reduced the gap in respect

Table 1:
Source: [Specifications of Camera Link Interface Standard for Digital Cameras and Frame Grabbers Version 1.1]

Configuration	Ports/taps supported (8 bits/tap)	Number of connectors	Data transfer rate	Maximum clock rate
Base	A,B,C	1	255 MB/s	85 MHz
Medium	A,B,C,D,E,F	2	510 MB/s	85 MHz
Full	A,B,C,D,E,F,G,H	2	680 MB/s	85 MHz

of user friendliness to USB, FireWire and GigE, and "plug and play" is getting closer. Another advantage over these interfaces is external hardware triggering, which has a very low latency.

Bottleneck at PCI Overcome

A fast camera interface is only as useful as the host bus system that passes the data on. Until a few years ago, the established standard for PC-based image processing systems was PCI (Peripheral Component Interconnect). With a bus width of 64 bits and a clock rate of 66 MHz, the maximum transmission rate of 53 MB/s is less than the maximum data transmission rate that can be achieved with a CameraLink camera configured to the Full configuration.

Significantly higher throughput rates are possible with the PCI-X standard that was agreed upon in 1998. PCI-X 1.0 reaches a maximum of 1,066 GB/s with a single subscriber on the bus and is thus capable of transferring the data from a CameraLink camera configured in the Full configuration without problem and, above all, securely.

The PCI Express databus, introduced in 2004 and intended for both copper lines and optical connections, is the solution to the problem. PCI Express has one to 16 lanes, depending on the version, and is run at a clock rate of 1.25 GHz per direction. This bus, characterized by serial point-to-point connections, is full duplex-capable. Maximum data transfer rates of 4 GB/s are achieved with 16 lanes. Using just one lane, the rate of transmission per direction is still 250 MB/s – i.e. 500 MB/s in total. A PCI Express bus should have at least three lanes if it is to be capable of reliably transferring data from a camera with a Full configuration CameraLink interface.

Full Concentration on the Job

The combination of PCI Express and CameraLink means that the user is able to implement applications previously thought to have been impossible. Vision & Control offers CameraLink in conjunction with a powerful vicosys series image processing computer. In the base level, two cameras in Base configuration or one camera in Medium configuration can be operated on the vicosys multiple camera system.

Applications in the stamping and beverages industry with typically high cycle rates also demand software algorithms which can achieve optimum evaluation of image information. Only a finely tuned hardware and software package will be able to cope with the constantly high clock speeds so that, to get back to our analogy, the traffic on the Pixel Highway always flows quickly and safely.

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Green Mobility

Quality Control of Cylinder Wall Surfaces for Engine Optimization

The issues surrounding environmentally friendly transportation and efficient personal mobility remain high on the green agendas of both automotive manufacturers and international governmental groups committed to developing cleaner, low emission, low consumption combustion technologies. New fuel technologies are widely under development, with technologies ranging from hydrogen cells to advanced electrical fuel cells and other hybrid technologies. However, until such time as these novel technologies are both market-ready and commercially proven, automobile manufacturers still see significant potential in the further development of the classical combustion engine, and as such, are assigning high priority to this development in order to further reduce fuel consumption and emissions whilst significantly increasing life times of traditional engines.

Development programs currently underway amongst many combustion engine manufacturers are exploring a diversity of technical optimizations. Of particular interest to quite some of the manufacturers is the potential offered by increased ignition pressures and higher engine revolution speeds. In such developments, significantly increased internal pressures and friction scenarios are created, resulting in the creation of far higher impacts and stresses at the internal cylinder wall surface than those previously experienced. Furthermore, the utilization of such techniques requires detailed analysis of tribological parameters such as enhanced lubricant retention.

It has been demonstrated that the success and effectiveness of such advancements can only be achieved through repeatable precision manufacture and perfect surface finishing of these cylinder walls. Researchers in this area are particularly interested in exploring the possibilities and limits in producing complex micro structures at tolerance limits and in a state of serial production in order to maximize the efficiency potential of the cylinder interface itself. Micro structures on cylinder wall surfaces made by lasers or honing techniques are crucial for the effective performance of the oil film between cylinder and piston which in turn, directly affect the overall performance, efficiency and endurance of the engine. By machining perfectly optimized micro structures, it is possible to create a highly effective vertical 'reservoir' for the lubricant, in which a defined volume of oil can be retained on the cylinder wall after the movement of the piston. Typical micro structures include classical honing 'crosshatch' marks, 'pockets' or 'increasings'.

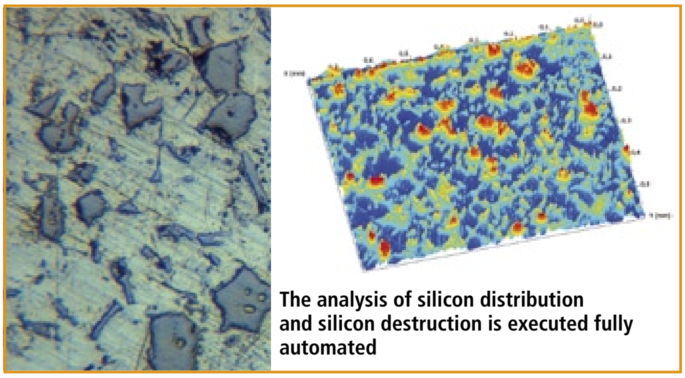
Repeatable precision manufacture and perfect surface finishing of the cylinder walls is of the essence

Optimization of Cylinder Wall Surfaces

The use of weight reducing, light metals for engine castings provides engine designers with another potential source for fuel consumption reductions. The utilization of such light metals also enables the manufacturer to explore special surface treatments or coatings to the cylinder wall surfaces. A favored method is in using the honing process to expose ultra durable silicon crystals which can be cast with the metal. The inclusion of such crystals provides the necessary rigidity and wear resistance required to bear the forces from the movement of the pistons in a running engine. When used in conjunction with other surface hardening procedures, such techniques can prove highly effective.

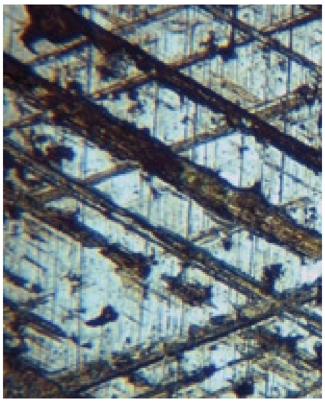
It is clear that further optimization of classical combustion engines remains high on the agenda of automotive manufacturers. Furthermore, it is clear that many of the different techniques under investigation are focused on improvements to the quality and performance of cylinder wall surfaces. However, one key aspect remains common to all these optimization techniques: to acquire the ability to maintain effective control of the quality of the cylinder wall surface during production.

One established solution which has proven its ability by providing the necessary level of quality control is the CylinderInspector, designed and manufactured by the German inspection company, Opto Sonderbedarf GmbH. CylinderInspector is an optical inspection and analysis instrument which has already gained its heritage as the inspection instrument of choice amongst virtually all German automobile manufacturers. This highly



The analysis of silicon distribution and silicon destruction is executed fully automated

versatile, multi functional inspection system is available in three versions: a handheld Quick-test system for spot tests, a manual CylinderInspector for use in quality control and laboratory environments and a fully automated version for high throughput applications with high control density.



Micro structures on cylinder wall surfaces are crucial for the effective performance of the oil film between cylinder and piston which in turn, directly affect the overall performance, efficiency and endurance of the engine

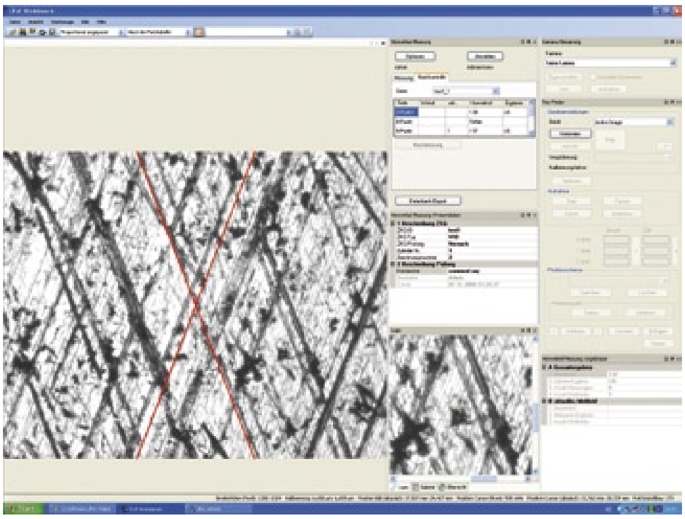
From Manual to Fully Automated Inspection

The basis of each system is a high resolution optical zoom fitted with perfectly optimized illumination, enabling a low magnification overview mode and instantaneous zooming to high magnification mode in order to inspect regions and features of interest (e.g. destroyed silicon crystals) in very high resolution. Using the Quick-test system this can be done by a simple eyepiece or by a simple USB camera in conjunction with the unique measuring software running on a laptop PC. Both manual and motorized CylinderInspectors provide an enhanced suite of software tools for the technical measurement and analysis of many additional critical parameters.

The correct angle of honing into the wall of the cylinder is crucial to its tribological or 'oil retaining' performance. CylinderInspector's comprehensive software suite enables automatic, accurate measurement of this critical angle. The collected data, images and results can be archived in CylinderInspector's image database software which also provides 'one-click' reporting and fast searching for maximum production archiving efficiency.

A key inspection step in the optimization of cylinder wall technology is the ability to detect machining errors. All versions of the CylinderInspector make this a simple task. Honing defects can be detected visually in both in macro and micro magnifications. Once inserted, the system enables easy rotation around the internal walls of the cylinder. This makes analysis of the lower and upper points of piston travel very simple whilst also enabling detailed analysis of honing turning point and other critical points.

The ease of use and very high resolution make CylinderInspector an invaluable tool in the development and manufacture of advanced engine blocks. The simplicity of CylinderInspector translates into a very short learning curve, and thus the system can be integrated quickly and seamlessly into a manufacturing process. CylinderInspector's versatility and convenience enable a skilled user to detect defects to honing tools quickly and effectively, thereby dramatically reducing rejections and scrap whilst increasing overall productivity, and providing very fast return on investment.



A typical task for the CylinderInspector is the automated measurement of honing angles at pre-determined measurement points

Production Control

The motorized version of CylinderInspector offers seamless, automated integration to a manufacturing process. Typical tasks for this system range from automated measurement of honing angles at pre-determined measurement points, all the way to fully automated analysis of silicon distribution and silicon destruction all measured against specification criteria or even to feeding back directly to a production process. Furthermore, this system enables different escalation scenarios to be identified for different grades of defects, for example to check if the crystal destruction rate is occurring locally or distributed across a complete cylinder.

Image stitching is another key feature offered by CylinderInspector, and enables very large areas of a cylinder to be imaged, stitched, and analyzed. Furthermore, a tool for performing automatic analysis of area, size and distribution of pores or graphite fins is also available.

It is clear that a wide range of different parameters are important for the proper function of the engine, many of which rely on a perfectly formed cylinder wall. CylinderInspector combines up-to-date machine vision with a customized programming interface enabling manufacturers to achieve a precise and repeatable measurement of their defined parameters – enabling significantly enhanced control over their cylinder production process and far higher product quality control.

To satisfy the critical needs of this next generation of engine design, Opto has developed its family of CylinderInspector products – combining perfect image quality, flexibility, and a fully customizable software suite giving automotive manufacturers the ability to inspect and quantify the internal finish of their cylinders to unprecedented levels.

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Combined Advantages

Leutron Vision's PicSight Smart GigE is a smart camera with a Gigabit Ethernet interface and a 32 Bit RISC processor. The camera is available with 28 different monochrome and color sensors offering resolutions from VGA up to 5 Mpixel. Application development for the camera is done in ANSI C/C++, which enables developers to easily reuse existing code. A comprehensive development package makes writing and testing applications for the camera a convenient task. Data can be uploaded to the camera over the build-in FTP interface. A web interface allows to change settings through a web browser. The PicSight Smart GigE comes with 64 MB of memory for saving multiple images and program code, and 32 MB of flash memory for application storage. It is fully GigEVision/GenICam compliant.

Leutron Vision GmbH
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Third Generation Vision Sensor

Cognex has added the Checker 3G series to its award-winning Checker vision sensor product line. With simple setup, integrated part detection, lighting, I/O and job change all in a rugged IP67 housing, Checker 3G is the easy, reliable and affordable way to verify all products or parts on the line. With it the user chooses whether to configure the sensor as a presence sensor or measurement sensor. Presence sensors verify that features are present. Measurement sensors verify that features are the correct height, width and/or diameter. In either mode, there is no limit to the number of part features that a single Checker can "check". Checker is also able to detect and track over 6,000 ppm in varying positions along the production line, overcoming imprecise part positioning and delivering consistent, precisely timed pass/fall results. No other sensor, vision sensor, or vision system can do this.

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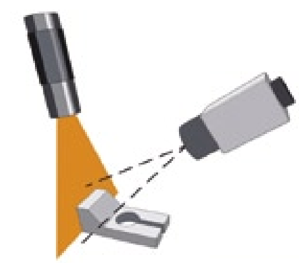
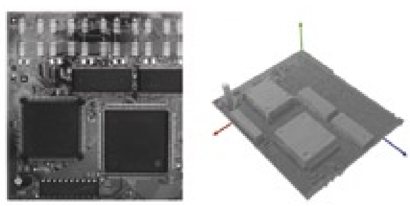
New 3D Vision Technologies

3D vision becomes more and more important, especially for robotics. So far, the machine vision software Halcon by MVTec already provided many 3D technologies. MVTec Software will now showcase further 3D vision technologies of the recently published version 9.0. The descriptor-based matching is a revolutionary new matching technology. This method is able to find perspectively distorted objects. It is based on the detection of interest points where gray values are clearly differentiated from neighboring areas (brightness, curvature, corners, spots). The perspective, deformable matching is also able to match perspectively distorted objects. In contrast to descriptor-based matching, the perspective, deformable matching is edge-based and thus can best be used with objects with clearly distinguishable edges.



The 3D shape of an object is determined by measuring the profile of the object along a projected line of light.



By sheet of light measurement, an elevation model can be determined. Preliminary, this method is suitable for objects without texture, e.g., electronic components.

MVTec Software GmbH
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Code-reading Systems for Industrial Applications

The new stationary 1D/2D code readers from the Siemens Industry Automation Division are characterized by their high reading reliability and speed as well as by diverse communication and connection possibilities. A primary use of the compact Simatic MV440 code-reading systems, which feature high protection rating IP67, is for reading data matrix codes such as direct part marks (DPMs) on objects under difficult ambient conditions in an industrial environment. Thanks to its flexible lighting options, the system can be adapted to the respective application. Typical uses are product tracing, process control and checking the quality of marking in a variety of applications in the automotive, packaging, pharmaceutical, tobacco, cosmetics, electronics and food & beverages industries.

Siemens AG
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12 Megapixels, 25 fps and Global Shutter

Toshiba Teli has announced the CleverDragon CSC12M25BMP19 camera, aimed at the most demanding, uncompromising requirements of industrial image processing. The camera features a monochrome CMOS chip (24,6 mm × 18,5 mm sensor area) offering 4,096 × 3,072 active pixels with a pixel size of 36 µm^2 and the ability to output 25 frames per second. The frame rate can be increased even further by selecting particular regions of interest (ROI) – for instance, up to 48,662 fps are possible when outputting individual scan lines with a bit depth of 10 bits. Furthermore, the highly sensitive sensor enables to take low noise pictures – with a high dynamic range due to the multi-slope exposure method. A global shutter enables distortion-free imaging of fast-moving objects as required for the most machine vision applications.

Framos GmbH
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Four New Fast VGA Camera Models

Basler Vision Technologies is starting series production of four scout camera models that are based on Sony's new ICX618 sensor. The cameras feature a compact 29 mm x 44 mm x 73.7 mm housing and are equipped with a C- or CS-mount lens adapter. They are available in monochrome and color and with a Gigabit Ethernet or IEEE 1394b interface. The EMVA 1288 data for the new scout scA640-120gm camera shows the same total Quantum Efficiency (QE) and the same absolute sensitivity threshold as Sony's bestselling ICX285 sensor. In addition to their superb sensitivity, the new scout models are fast. They offer an acquisition rate of 120 frames per second at full VGA resolution.

Basler AG
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Cost-effective Capability for Solar Cell Inspection

Dalsa announced its entrance into the solar cell inspection market. The company's efficiencies and expertise in area scan, line scan, and embedded processing for inspection in the flat-panel display industry are now being successfully applied to solar cell inspection, resulting in high quality, yet cost-effective inspection capabilities for the solar cell industry. Machine vision is used for three general purposes by solar cell manufacturers: product inspection; identification and tracking; and lastly, product assembly. Dalsa's cameras and hardware are used in the initial part of the quality inspection process to verify patterns and edges, inspect coatings, and to check for micro-cracks. The precision of the image capture and processing technology contributes to the immediate and accurate detection of defects in this critical stage of the manufacturing process.

Dalsa
Tel.: +1 514 333 1301 • kumi.verma@dalsa.com • www.dalsa.com

Full 64 Bit Driver Support

Basler Vision Technologies is launching release 2.1 of its pylon driver package. This release focuses on 64 bit system support for Microsoft Windows. Additional improvements include a DirectShow64 module, multicast support, and reworked installation scripts, even for 64 bit Windows Vista. A free download of the pylon 2.1 release, including the SDK, is available from Basler's website. The 2.1 release is a full new 64 bit version of the IEEE 1394-b, GigE Vision filter, and GigE Vision performance drivers included in the pylon package. In order to address the full installed memory, pylon's C++ API is now also available in a 64 bit version. Because the API itself has not changed, customer applications can easily be converted to 64 bit. The 2.1 release also provides reworked installation scripts that improve the comfort level for Windows Vista installations, even for 64 bit Vista. All six pylon drivers are fully certified by Microsoft, which makes Basler one of the few providers with a full certification.

Basler AG
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Uniform Illumination at Tilted Surface for Inspection and Metrology Tools

Most of the detection tools for analysing surface properties have to be located perpendicular to the inspected surface. Furthermore, it is necessary to illuminate this surface homogenously. Now a new kind of asymmetric homogenizer is introduced. This is a micro-lens array consisting of micro-lenses with different profiles. Free form surface of every individual micro-lens enables a uniform illumination at the tilted surface. Limo's standard illumination tool for tilted homogenization generates 300 x 340 mm^2 field at the angle of 55°, in a working distance of 1.5 m and with inhomogeneity less than 5 %. Compared to traditional methods, the tilted illumination affords obvious advantages for the process. Since only one illumination device is needed instead of two, the cost can almost be reduced half. Furthermore, the efficient signal detection can simplify and accelerate the whole progress.

Limo Mikrooptik GmbH
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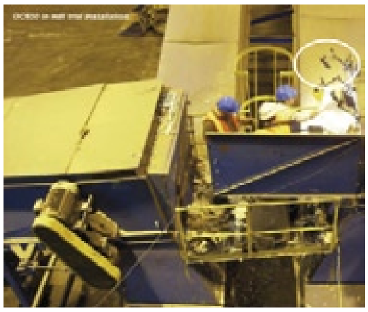
Machine-Vision in Wood Industry



Canada is one of the world's preeminent manufacturers of high quality wood products. Forintek, a leading organization in wood products research started developing an online fines measurement system following high level interest from the OSB industry in 2002. Now the analog camera of the original design was replaced with the Prosilica GC650 monochrome digital camera. The GC650 is a fast, VGA resolution camera with a GigE Vision compliant interface. The 1/3 „ CCD progressive scan Sony ICX424 sensor provides excellent image quality and sensitivity. The GC650 was fitted with a 12 mm lens and set to operate 4 feet away from the target at 1/1,000s exposure and 20 frames per second. In addition, technicians at Forintek used the 2x2 binning function that is part of every Prosilica CCD camera in order to further enhance image sensitivity. Today, over 10 OSB mills in Canada, USA and Europe are using the online fines measurement system originally developed by Forintek. A patent has been filed for this technology.

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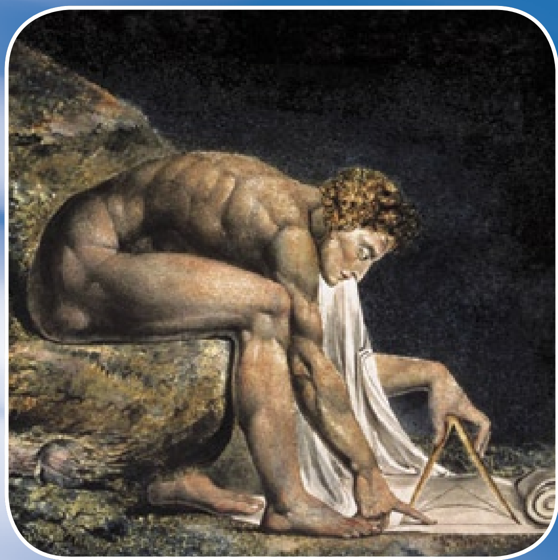
INSPECT

Automation



AUTOMATION: MEASUREMENT – INSPECTION – IDENTIFICATION – GUIDANCE

The Automation section features turn-key systems and applications. 3D robot guidance in automotive assembly lines is a topic which is just as important as the quality control of wine bottles in Napa Valley. Surface inspection of webbed material in glass, plastic, metal and paper production, inspection of print quality in the printing industry or on cans of tuna, inline dimensional checks of entire car bodies – these are all topics you will find in the Automation section. Success stories with testimonials from users show not only the performance of technology in various fields, but also guide you to suitable suppliers for your application.

Precision out of Gold City

Methods for High-precision Optical Measurement

A combination of a high-resolution sensor system and precision mechanics is required for high-precision measurement of large, complex geometries. Depending on the task at hand, the optical properties of the measured objects, part handling and machine set-up, different measurement technologies need to be chosen. EHR, out of the "gold city" Pforzheim, is specialized in customized multi-sensor solutions for precision measurement machines.

The most important component in a precision-measurement machine is the sensor for data acquisition. Coordinate measurement machines (CMMs) generally use tactile i.e. contacting sensors or so-called test probes. However, non-contacting optical sensors are being used ever more frequently. The most commonly applied measurement principle in this case is laser triangulation. Tool presetters on the other hand are primarily based on telecentric measurement principles. Both processes are camera-based – images are captured and then analyzed. Therefore, the term used is image analysis or machine vision.

General view of the precision measurement machine for semi-automatic measurement of synchronizer rings

Other machine vision measurement methods are white light interferometry, stripe light projection, laser micrometers and confocal chromatic distance measurement sensors. With the EHR precision measurement machines, all these methods can be combined to create an overall solution.

Capturing Large Measurement Ranges

The disadvantage of all high-resolution measurement methods is their small measurement fields. Standard tool setting devices feature a telecentric measurement setup with measurement fields in the order of 1 cm². Laser line triangulation devices, which can achieve approx. 10 µm in resolution, have a measurement range of around 2 cm. Much the same applies to other sensors.

This means that it is possible to measure indexable inserts, drill bits, milling cutters and other tools with similarly small dimensions, but not components or tools that are a few decimeters in size. In order to capture large measurement ranges, mechanisms that can move the small measurement field of a high-precision sensor system to a sensing point are required. Since the positioning accuracy of mechanics alone is much too imprecise, this must be determined by an incremental travel measurement system. Only this combination can facilitate a comprehensive high-precision measurement system over large distances.

Control and Evaluation

The central element of any measurement system is the software that controls the various components. EHR generally uses one or more IPCs instead of a PLC. The basis for the control software is EHR's own system nucleus TIVIS, which is responsible for the following tasks:

- capturing the measurement values of various sensors or cameras,
- evaluating and interpreting the data,
- controlling the mechanics, incl. reading out the incremental position measurement,
- synchronization of all measurement data,
- machine vision,
- communication with superordinate control systems,
- communication with and/or control of robots or other mechanisms,

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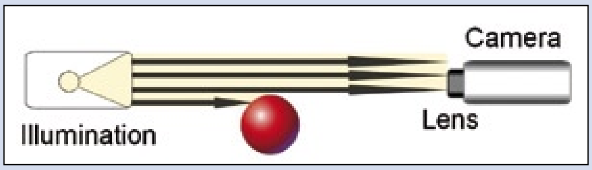
COGNEX

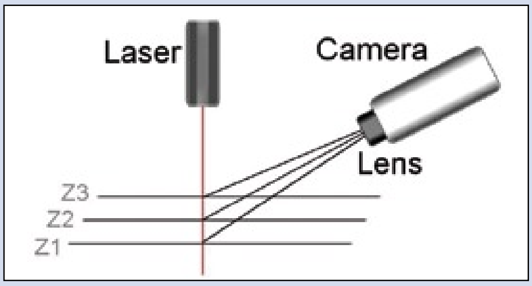
Optical Measurement Methods: Measurement Principles and Accuracies

Telecentricity



Telecentricity is taken to mean the direction of the principal ray parallel to the axis, i.e. an aperture angle of 0°, of lenses and illumination in general. The advantage of telecentric lenses is that the size of the objects in the telecentric range (this is roughly the depth of field range of the lens) does not change. Therefore, these lenses are freely used as measuring lenses, e.g. for tool pre-setters. In this case, telecentric illumination shines directly into a telecentric lens (with a common optical axis) and the object being measured is located between the two. The great advantage of this arrangement is that specular objects can also be measured because reflected rays are no longer imaged on the object. The disadvantage is that, firstly, only outer contours can be captured and, secondly , that the lens diameter is approx. twice as large as the image field or measurement range. The measurement accuracy largely depends on the size of the field of view, the resolution of the camera and the software-related sub-pixel interpolation. Typical tool pre-setters with a field of view of just 1 cm² and a 1 megapixel camera can achieve measurement accuracies of a few µm.

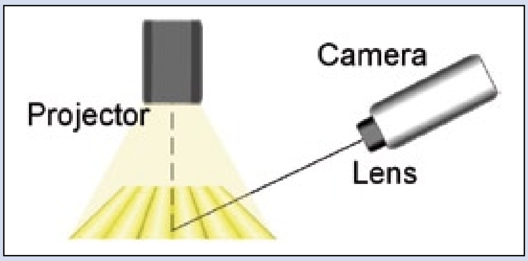
Laser Triangulation



Laser triangulation refers to light section methods where, for example, a straight laser line is projected onto an object and captured at a particular angle (triangulation angle), by a camera. The deviation of the straightness of the laser line in the camera image provides a dimension for the object height along the line. A scan of several lines produces a depth image (surface profile) in X, Y and Z. The measurement accuracy largely depends on the length of the line and the camera resolution. With a line length of approx. 20 mm and a VGA resolution camera, the measurement accuracy is in the order of 10 µm. With the right software interpolation, the measurement repeatability achieved is then approx. 1 µm. Laser triangulation is a well-established method of measurement that is both robust and cost-effective. However, it is a scanning method so that either the sensor or the object being measured must be moved. Specular or semi-transparent surfaces can prove difficult (not „equable" in optical terms).

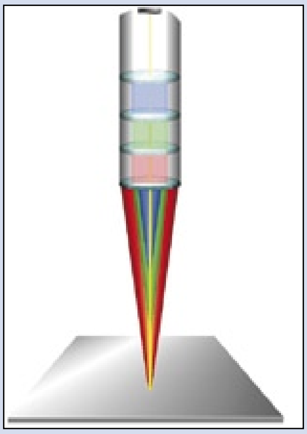
Stripe Light Projection

The stripe light projection is a triangulation method as well. Here many parallel lines are projected onto the object which are then captured at a particular angle by a camera and analyzed. A distinction is drawn between the Coded Light Approach (CLA: discrete light-dark lines that come closer together image by image; Gray code sequence) and the phase shift method (stripes with sinusoidal intensity modulation shifted late-



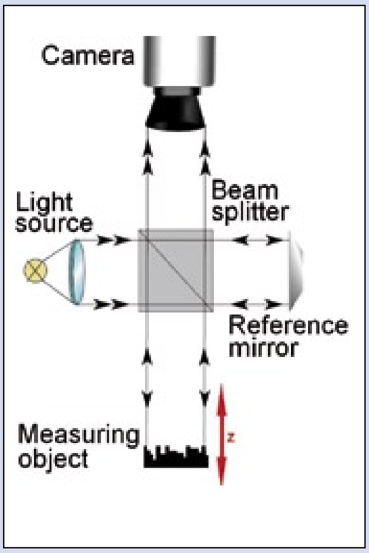
rally by quarter periods). In order to compute a depth image on the basis of this, several images must be taken with the changed stripe pattern. This method produces 3D data directly without a scanning device although a stripe projector is required. In this case too, the measurement accuracy largely depends on the size of the field of view and the camera resolution. With a FOV of approx. 1 cm² and a 1 megapixel camera, measurement accuracies of approx. 10 µm are typical.

Confocal Chromatic Distance Measurement Sensors



With confocal chromatic distance measurement sensors the color error of lenses (chromatic aberration) is used by splitting white light when focusing on the measured object in such a way that in order to obtain a distance, only one color is imaged sharply. The color of the light scattered by the measuring point (diameter approx. 10–100 µm) is measured and assigned to a distance. This measurement method is extremely precise and produces measurement accuracies in the sub-micrometer range even with specular and transparent surfaces. As a result of the confocal arrangement of light source and detection optics, there is no shadowing as with triangulation measurement systems. One disadvantage is that so far this method of measurement can only be used selectively.

White Light Interferometer



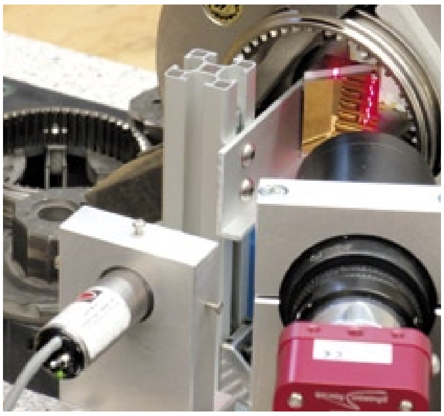
White light is guided to the object being measured through two channels. With certain heights, there are light superposition effects (interferences) which are captured by a camera. The distance is predetermined for these heights. All the heights of the object being measured are obtained as it is moved up and one image is registered each time. A depth image is then compiled from all the images. In the case of measurement fields of up to 25 cm², the measurement accuracy is in the sub-micrometer range. This is a scanning method with which several images are captured. One disadvantage is the rather large and cumbersome setup which is not particularly robust either.

- archiving of measured values or other data,
- password management,
- customer-specific tasks.

In order to evaluate the measured data, the company's in-house machine vision library has been integrated into TIVIS. The machine vision tools of the powerful Halcon library are also available.

Application-specific Choice of Measurement Technologies

Using the hardware and software basis described, various combinations have been compiled at EHR to create customer solutions. Crankshaft mills in particular provide a graphic illustration of precise µm measurement of large objects. Here the position of dozens of small indexable inserts must be measured and, where necessary, realigned. To do this, a stable arm was fitted to the z-axis of a tool presetter in such a way that the laser scanner is positioned centrally in the tool so that the individual indexable inserts can be moved precisely into position from there.



Prototype for internal measurement of a gear change sleeve with laser triangulation penetration optics

EHR also specializes in the measurement of internal part characteristics. The teeth of gear wheels, for example, are frequently measured tactile by „dislocation" (over-pin dimension). Here, the penetration depth of a ball is measured between the tooth flanks. This process is costly because it is very time consuming. With the EHR algorithms, the gear wheels are „digitally dislocated": A laser scanner captures its 3D contour into which balls of the same radius are then mathematically fitted. In this way, both measurement methods are directly comparable but with the great advantage that the latter measurement method can be automated and performed without the risk of human error.

Further measured values can also be obtained with the same measured data, e.g. parallelism and axial run-out of areas, heights, angles, diameters, roundness and other special component-related characteristics. This ensures fast, comprehensive quality assurance. Internal areas that are difficult to reach or which cannot be accessed using standard triangulation sensors are acquired with reflector (or prism) designs and separate camera-laser components.

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Wrap Up

Precise 3D Stereo Measurement at 900°

Thyssenkrupp Steel AG is producing stainless flat steel and other high quality steel at a modern hot strip mill in Bochum, Germany. The sheet steel quality of coiling is monitored by an automated optical inspection system. The 3D measurement is carried out contact free and without any interruption of the production process. Measurement results are important data to control the current condition of the production line and the impact of different steel qualities to the rolling process. In the future, measurement results shall be used to define objective criteria for the optimization of the whole process with the aim to achieve effective enhancement of product quality and productivity.

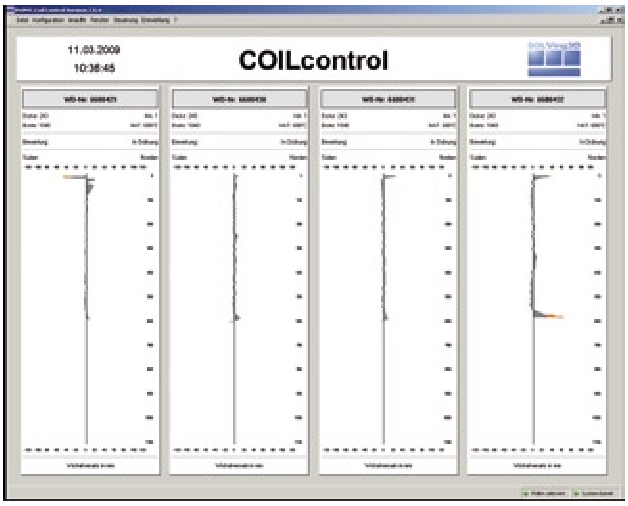
The quality control is executed with the Coilcontrol system of Germany based Solving3D. Coilcontrol is a non-contact and fully automated 3D measurement system for the measurement of coiling quality at the head side of the coil. There are five types of bad shapes which are classified by the software. Even red glowing steel coils with diameter up to 2 m are measured with an accuracy of 0.5 mm. The system consists of a freely configurable sensor head and a separate PC for data evaluation. The sensor heads, set up with a minimum of two cameras and one lighting device, can be placed quite close to the hot coil. Maneuverable mechanical components are not necessary and it is not hard to guard the cameras against radiant heat emitted from the hot coils. Usually this is done with water-cooled mountings.

Profile Measurement

In order to measure the coiling quality a laser line is projected onto the head of the coil. This leads to so called profile points marked with lighting. The line is captured with a high resolution stereo camera system. The sensor head captures the whole line with one shot and can reconstruct up to 1,000 3D points with a depth resolution

Transportation of coils at hotstrip mill (ThyssenKrupp Steel AG, WBW Bochum, Germany)

During measurement a laser line illuminates the head site of a coil



Display of the measurement results in the control office

of 1 to 5,000 in relation to the length of the profile. The maximum depth range for the detection of coil beginnings and coil ends is about 1,000 mm. Thus Coilcontrol can measure coils with a width of up to 2,000 mm without any movement of the sensor head.

Fiber optics cable is used to connect the camera with the PC. This allows very long distances between sensor head and computer without any loss of signal quality. Operation terminal and display are securely placed in the control office. Forceful defect avoidance with Coilcontrol is strongly assisted by the software. Clearly arranged graphical views and integrated classification of the coil shape are immediately available to the operator in the control office. NOK coils are marked in the dataset and can be sorted out early on in order to avoid consequential costs, for example from transportation. In the case of defect recurrence counteractive steps can be taken immediately. Furthermore Coilcontrol is able to handle datagrams with additional product information. For example the individual number, the coil's width and temperature as well as the thickness of rolling stock can be displayed and as the case may be used in the measurement process.

Cost Reduction and Quality Enhancement

All measurement values and even the original images are stored in a relational database with a capacity of one year of production data. Coilcontrol implements a SQL interface to all established database systems. This data stock is used for long-run analysis. Measurement results from Coilcontrol can be used not only for the analysis of the coil´s shape but also for deducing indirect information about the state of the production line. Early detection of defects avoids the delivery of products with poor quality to the customer but also reduces transportation cost in the coil storage. One has to keep in mind, that re-organization of coils is not that simple because of their weight. Coilcontrol measurements in the data stock enable the plant operator to monitor the long-term condition of the production line and provide a basis for informed decisions regarding maintenance and service planning. The high expectations for the system regarding return of investment and quality improvement have been met.

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Perfect Interaction

3D Robot Guidance, In-line Measurement and Data Analysis Secure Quality in Body-in-White Production

More and more automotive manufacturers secure highest precision results, maximum availability and even cost benefits: 3D robot guidance combined with highly accurate in-line measurement technology from one source leads to optimal fitting accuracy of automotive bodies. Using the best-fit method the dimensions of the car body are measured, the components geometry determined and their optimum position calculated. Temperature-compensated sensor technology is used for in-line quality inspection and gauging and consistent quality management of the measured process data guarantees the fastest possible means to maximize quality results.

Fast assembly processes in automotive manufacturing need to be executed reliably, including those of alternating vehicle types. Examples include the assembly process of doors, front, rear and side windows, the installation of glass modules in the vehicle‘s roof or assembling a panorama glass roof. During these assembly steps, flexible best-fit manufacturing methods are being used more and more often.

The goal of this process is to actively control and regulate the robot in each of its movements, i.e. to guide it. This reduces the need for rework of the car body parts to a minimum. Quality measurement is also integrated into the process directly after assembly. Both tasks are performed by the field-proven robot guidance sensors (RGS) of Isra Vision and their smart "brothers" in the SGS^{3D} series. Both can either be used at a stationary location or mobile by being integrated directly into the robot gripper. These rugged sensors are so compact that they can even perform reliably in hard to reach places, as well as irrespective of surface types and color of the body part.

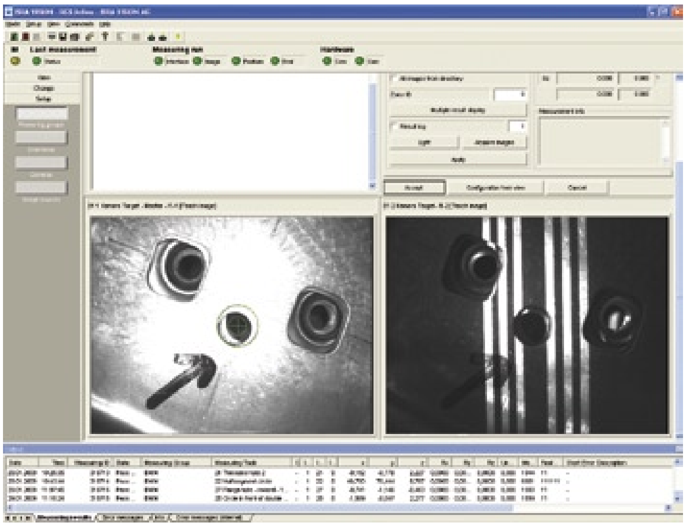
Combination of Multi-line and LED Surface Projection Technology

The sensors offer the highest possible flexibility because of the combination of multi-line and LED surface projection technology. It is even possible to perform measuring tasks in motion. The multi-line projection based on 3D form matching and the LED technology guarantee the highest possible precision in 2D/3D quality and coordinate measurement technology. This is why the sensors can also be utilized when placing especially demanding visible seams, for example near the door seam, in the trunk area or the engine hood. They achieve tolerances of +/- 0.1 mm or better and combine the exact determination of a position of any free-form surface with the possibilities of gauging with 3D technology. With this technology, the final assembly position can be inspected three-dimensionally for quality during a production run. Because the use of an image processing sensor makes it possible to realize both 3D robot vision as well as inspection functions at the same time, this intelligent combination provides the customer with added cost benefits.

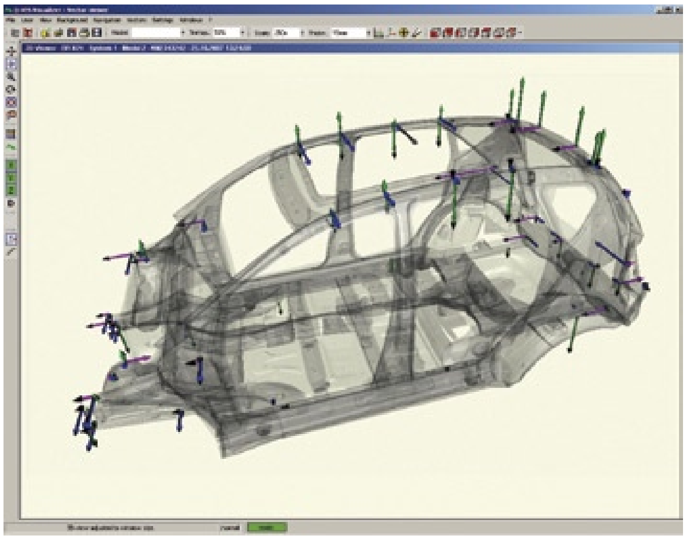
The image acquisition and analysis with the optical gauging systems is performed very quickly. The teaching process is simple. Interfaces are available for all established robot control systems.

In-line Gauging Technology: Maximum Reliability

Measurement technology packages consisting of the measurement cell computer, geometry gauging sensors (GGS) and temperature compensation technology represent a significant enhancement and complement the best-fit systems. They offer maximum reliability at lowest possible defect tolerance levels. Six LED lines and the 3D form matching option ensure highly precise results. The perfectly matched in-line gauging systems are also very well suited for measuring large sub-assemblies such as car bodies. One of these systems, for example, is integrated directly in the Fiesta body-in-white assembly line at the Ford plant in Cologne,



Clearly defined quality characteristics: Visualization at a measurement cell computer



Detecting interrelationships: Spatial presentation of all measurement deviations in the CAD model

Germany and is used there for demanding measuring tasks. The reason: These systems score in comparison at speed, ease-of-use and accuracy. The high robustness reduces the number of downtimes.

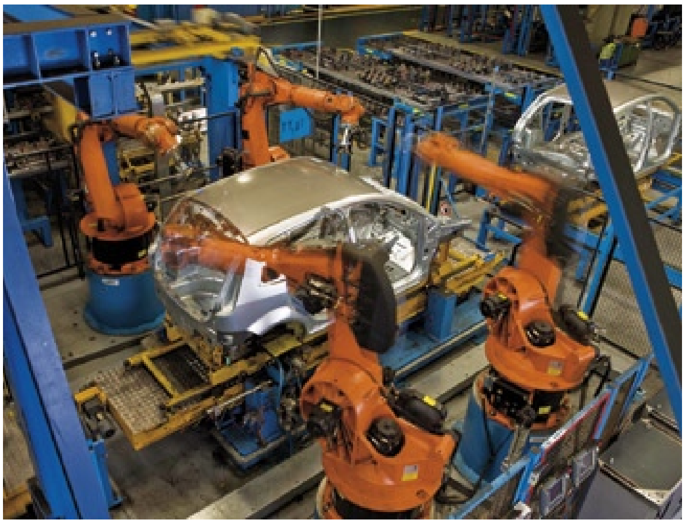
The gauging system provides results immediately after installation and excels, as does the best-fit system, in system stability and linearity. Even the most difficult to access areas in the engine compartment, the dashboard area and the car interior can be reached. Even larger features can be measured efficiently and accurately by having the robot approach several measuring points and then analyzing the measurement data intelligently. In summary: a highly reliable system for best possible quality in every application.

The systems take on a variety of different gauging tasks: They range from 3D bolt inspection and the inspection of door lock holes to determining the center of a circle of large openings, for example in the assembly access for the fuel level sensor or the opening for the longitudinal column. Thanks to the most accurate measuring results, the quality of car bodies can be increased dramatically.

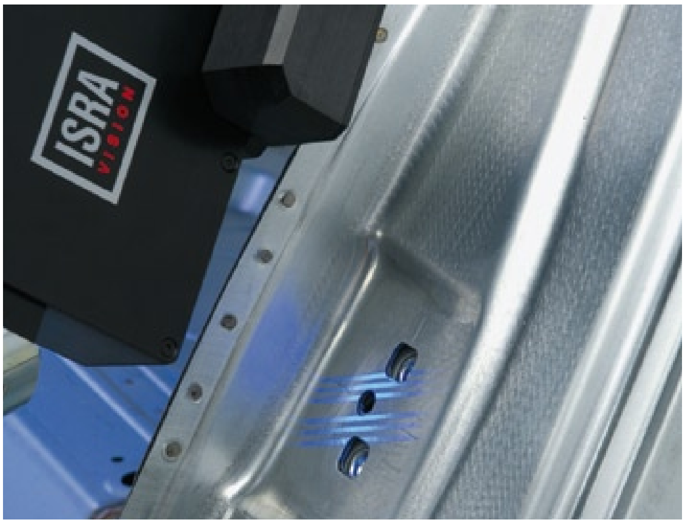
From Gauging Technology to Optimized Production Processes

The overall potential of this in-line measurement technology is unlocked as soon as the amount of measuring data generated from the individual stations (cells) is combined to create valuable knowledge that can be used to optimize production processes. This function is performed by the intelligent, cross-process quality management software Q-Vis, offered either as a stand-alone solution or in combination with the in-line gauging technology package.

The production quality database is installed separately from the sensor and robot technology on a central server to be used for various different in-line gauging stations. The client programs of the modular database system can be run on any office computer. The modular system monitors seamlessly, it visualizes, analyzes and optimizes – from the local measurement cell



The path to more quality: Fully automated gauging cell for inspecting even the hardest to reach measuring points



Quick, flexible and highly accurate: Exact measurements of holes and sheets at various positions

throughout all production lines in each plant around the world with both local as well as global access options. Among the separate modules are a control station, an analysis, a visualization, a reporting and a management module. The control station module presents the most recent quality status and aggregates the various measured data: At one glance, the operator can determine whether or not the measured object complies entirely with the specified tolerances. With only three mouse clicks, the operator is able to navigate from the visualized overall status to the individual measurement results. The operator can quickly determine whether the defect is a single outlier or if a certain trend can be established. The analysis module performs the task of processing the 2D and 3D data, rapidly displaying the characteristic parameters for a given day, and is equally capable of providing an accurate analysis of longer-term variations. Complex mathematical calculations and process analyses assist in production optimization. The reporting module provides informative statistics. The management module allows the preparation of high quality documents as a basis for decision making.

Proven Standard System in Automotive Production

Q-Vis is already being used as a standard system at Mercedes production plants in Rastatt, Sindelfingen and Bremen, Germany and also in East London, South Africa, and with great success. A typical application involves the measured results generated using the visualization module that can then be compared with the car body's CAD model and any deviations determined in this manner are used directly for optimization measures used in the welding systems. Audi in Ingolstadt also benefits from the advantages offered by the analysis system. The intuitive GUI is widely accepted among users. In addition, Ford is now also considering expanding its measurement cell network and introducing the Q-Vis analysis system, and by doing so taking advantage of the particular strength of the combined in-line measuring technology and quality management opportunities. The combination of the in-line measuring technology and production decision intelligence makes it possible to immediately implement routine quality processes that react quickly and can be well documented. The benefits of the in-line gauging technology are increased many times over. Along with the many technical advantages of the 3D robot vision, the in-line measuring systems and the analysis software, the user benefits from the Isra Vision expertise in designing solutions, which ensures that an investment in these systems is quickly amortized.

Compact and smart: 3D sensor technology for in-line gauging and robot vision

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Outsourcing

Contract Measurements with Image Processing

The quality and cost benefits of employing machine vision technology in production are without controversy today. However, the decision to invest into this technology is as well based on additional criteria as time available for research and learned selection of the right system, the means available for the invest, the suitability of existent staff, the feasibility to integrate the equipment into the production process and the logistics and material handling required.

As a developer and manufacturer of inspection systems, Visimation GmbH knows this situation and can offer not only the design and construction of customized systems but also a „contract measurement" service.

In addition to the purely dimensional measurement of geometries such as length, diameter and angle, the inspection criteria of a product may also include its surface quality, presence, position and form of impressions or even functions such as the thread quality. Features that go beyond the versatile possibilities offered by image processing will ideally be adaptively integrated in the inspection plan.

solution / requisition	slip system	glass plate	linear stroke	rotund stroke	measuring roboter	workpiece-carrier system	adaption	measurement services
	GS	GT	LT	RT	MRO	WT	AN	LMZ
assembled parts	X	X	X	X	X	X	X	X
stamping parts		X	X	X		X	X	X
plastic parts		X	X	X	X	X	X	X
assembly technique				X	X	X	X	
bulk goods	X	X	X	X	X		X	X
tray goods		X	X	X	X			X
tape feed			X	X	X	X	X	
manual mounting			X	X	X	X	X	
optical	X	X	X	X	X	X	X	X
tactile			X	X	X	X	X	X
pneumatical			X	X	X	X	X	X

Visimation currently manufactures five different basic types of inspection machines

Measurement Methods

The classical method to optically measure a part very precisely is transmitted light imaging. The outline of the part can be measured to an accuracy of +/-2–3 µm depending on the optical resolution. Even higher resolutions with acceptable frame rates have recently become possible with cameras such as the JAI BM500. However, the fluctuating surface roughness of the inspected part, which cannot usually be resolved in the overall image, often marks the limits of measuring accuracy for optical area methods. If measurement accuracies are required below this limit, these are possible with tactile or pneumatic methods – though these are 10 times slower.

The much more complex incident light method can be used to inspect the surface of a part for damages, flaws and scratches or the correct location of an impression, for example.

Apart from these methods for individual, two-dimensional features, the possibility of a 3D recording of objects are constantly improving thanks to the laser light section method. Deformations in even complex geometries can be detected with the resulting spatial profile.

System Concepts

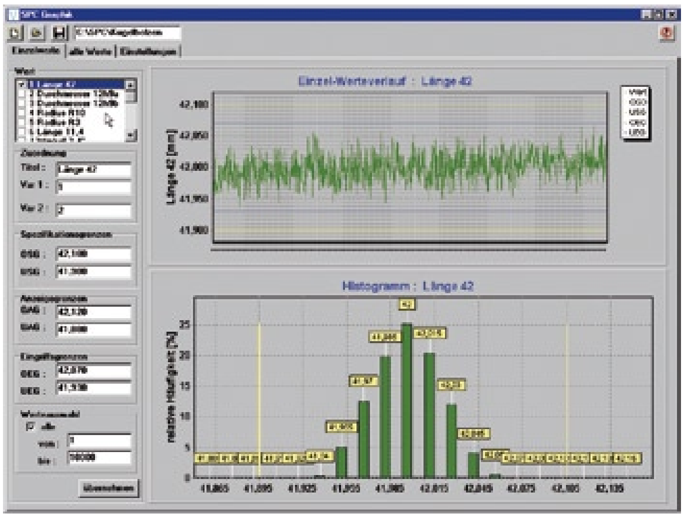
The main criterion for the part throughput on one hand and the variety of inspection methods on the other is the way in which the test pieces are passed by the measurement stations. Visimation currently manufactures five different basic models. In sliding systems (GS) the parts glide by the cameras on glass or rail guides and are measured in motion, thus allowing frequencies of up to six parts per second. The glass plate system (GT) also performs inspections in motion and with the same clock rates. The parts lie flat on the plate with no further guidance and are passed by the cameras like on a carousel. Linear cycle systems (LT) or circular cycle systems (RT) are ideal if the parts have to be rotated around their own axis or have to undergo an additional tactile inspection, for example. The parts are stopped after every cycle. A number of further test methods can be realized along with the fast optical inspections.

High-end flexibility is offered by the measuring robot (MRO). The six-axes robot can flexibly feed (almost) anything that can be picked up mechanically or by suction to the individual measuring stations. It can remove items for individual positioning from a tray or pick up loose bulk material thanks to an intelligent camera guidance system.

System Invest or Outsourcing?

Do relatively small or medium-sized series have to be mechanically inspected? Are the medium-term release orders

A number of test criteria can be checked by optical, tactile, pneumatic or other methods on sliding system, glass plate, linear cycle or measuring robot systems



At the end of the inspection, the customer receives measured, sorted and if necessary already packed parts with corresponding test reports and statistical evaluations

still uncertain? Is the strategic focus on manufacturing? Is a short-term reaction to production problems needed? Does a large series start-up have to be tackled at short notice? In these and other cases, commissioning mechanical inspections as a service in the form of contract measurements might be considered.

A number of test criteria can be checked by optical, tactile, pneumatic or other methods on sliding systems, glass plate, linear cycle or measuring robot systems, as contract work too. The set-up and inspection costs can be calculated following a definition of the criteria, requirements and feasibility.

If this proves economically profitable and the matching tests system can be prepared, the desired inspection of the parts can begin. At the end of the inspection, the customer receives measured, sorted and if necessary already packed parts with corresponding test reports and statistical evaluations.

The performance of single orders – or a permanent outsourcing of inspection tasks - or an interim solution with a subsequent investment in one's own inspection system – this strategic/economic decision is left up to the customer.

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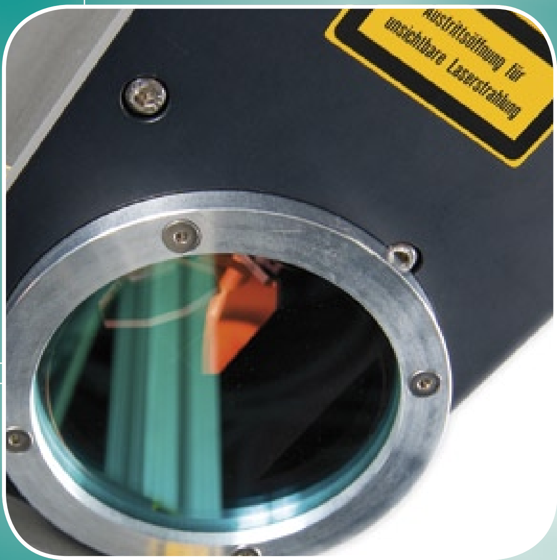



DEFECT DETECTION AND CHARACTERIZATION

Heat flux thermography is a powerful and versatile procedure of non-destructive material and component testing. The photos show a system section and system components: Powerful infrared cameras and stimulation technology optimized for the task (LED array and laser stimulation). The interaction with high-performance software allows recording IR image sequences and their conversion into output images with specific algorithms. These output images allow defects to be detected and characterized, either by operator decision or automatic analysis.

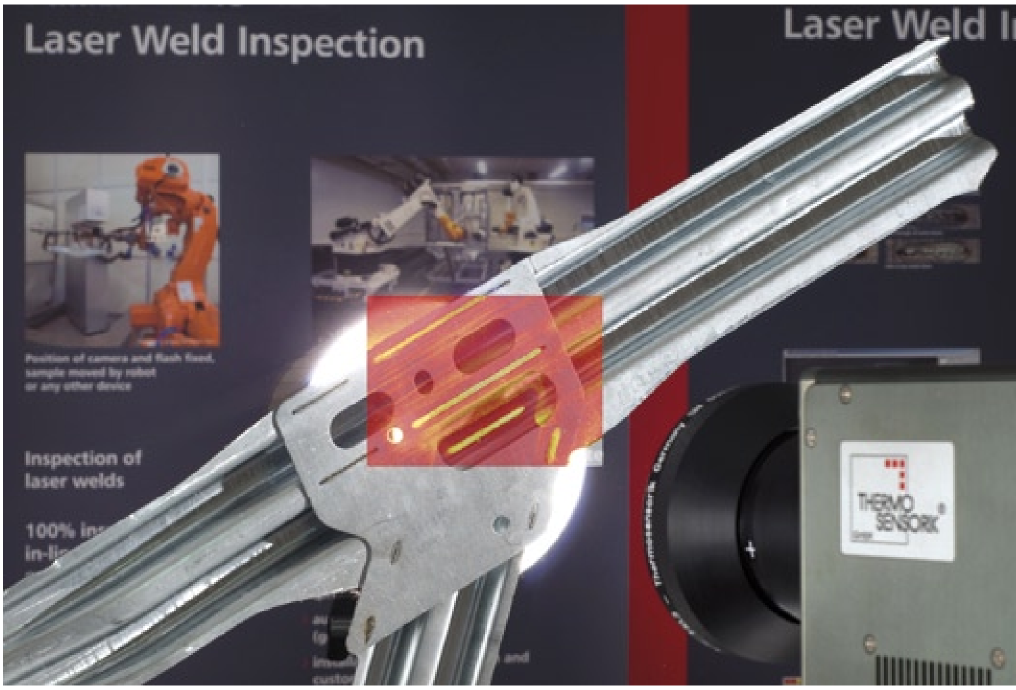
THERMO SENSORIK GmbH

More on Page 50

Heat Flux Thermography

From Laboratory System to Industrial Application

Heat flux thermography – or also "active thermography" – is based on the three-dimensional heat flow within a part to be tested. A number of different stimulation technologies can generate this heat flow over the area to be tested by the inhomogeneous warming of the component. The heat flow is disturbed if defects are enclosed in the material.



Literally at lighting speed, i.e. in less than one second, the heat wave stimulated by a flash travels through the automotive body part. At the same time, an infrared video of the opposite components surface is taken. The Thermosensorik software controls the recording of the raw data and their further processing into various output images (compare fade-over in the photo). They provide information on the quality of the weld. But how does this method work?

An infrared camera maps the changes of the heat radiation on the component surface with fast times and high thermal resolution (normally in the range of milliseconds and millikelvin). The infrared video permits conclusions to be drawn – in part also by the comparison with mathematic models of heat dissipation – about the three-dimensional heat flow and thus flaws hidden in a part. Typical components are: Car body structures, solar modules, turbine blades, steel strips, painted sheet metal, micro-electronic circuits, carbon fiber compound materials… the list could be continued almost indefinitely.

By contrast, with "passive thermography" only the heat radiation emitted from all objects is captured. This also permits a defect detection in some cases – but only of defects on the component surface.

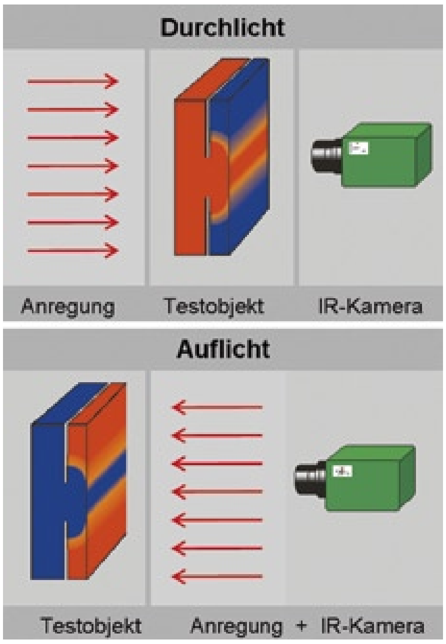
Heat Flux Thermography – a Non Destructive Test Method

Heat flux thermography, apart from the known methods of non-destructive testing (NDT) such as x-ray, ultrasound and eddy-current testing, has also become established during recent years as an independent NDT method in the industrial field. This is especially due to the availability of a wide range of high-output infrared cameras and application-optimized infrared lens attachments (e.g. microscope lenses). Furthermore, the available stimulation methods were developed further or adapted and optimized to the demands of heat flux thermography. However, the key step toward broad industrial employment was the development of automated systems, suitable for production runs, for specific applications. The benefits of heat flux thermography (touchless, non-destructive, imaging, etc.) for a technically and economically successful application were demonstrated hereby. Heat flux thermography can partly replace destructive test methods (e.g. "hammer and chisel test" of welding joints) and, to an extent, a suitable test method only became available with heat flux thermography.

Infrared Cameras and Lenses

The main components of measuring technology are high-resolution infrared cameras and infrared lenses with high luminous intensity. Both components must be adapted to the same wavelength range: For example, infrared cameras are supplied for the short, medium and long-wave infrared range (SWIR, MWIR and LWIR). Furthermore, there are special cameras covering two adjacent wavelength ranges: S/MWIR and so-called dual band for the medium and long-wave infrared. To be able to crisply map a fast process or, in general, to utilize high frame rates, sensitive detectors and imaging systems with high luminous intensity are needed. For this reason, cameras and lenses from Thermosensorik GmbH are designed for large apertures (F/2.0 or F/1.5).

When choosing the right camera, the following must be considered as well: The number of pixels required for the geometric resolution, the image frame rate (at specified image size) required for the time-specific resolution and, closely related to this, the achievable integration time (exposure time). Last but not least, mapping scale and the distance between camera and object must be accommodated: Are telephoto lenses or microscopic lenses with spatial resolutions below 3 µm required or is a standard lens the right choice? But even smaller scenarios can be achieved: Apart from the unique range of microscope lenses, solid immersion lenses



Principle illustration Heat Flux Thermography
(Graphics: Thermosensorik GmbH)

and the heat flow spreading to all sides ensure that heat sources even in the nanometer range can be determined.

Stimulation Technology

The choice of the right stimulation method is especially important in heat flux thermography: What requirements do the test specimen and the test environment present? Material properties such as electric conductivity, heat capacity and conductivity as well as the absorption capability need to be considered here just as much as accessibility, work safety or operating costs and fatigue properties. The choice encompasses not only flashlamps, halogen lamps, LED arrays and lasers but also heating under operation voltage, eddy-current stimulation, ultrasound, hot and cold air as well as mechanical stimulation. Induction or eddy-current stimulation belongs to the touchless stimulation methods and is to be preferred over illumination stimulation, especially with strongly reflecting metallic test specimens.

The example below shows how a brass tube clad in plastic and having holes passes through the induction stimulation. In this case only the conducting brass tube is heated from which the heat wave travels through the plastic jacket to the surface. The output image is created by adding many line images taken during the passage time and it also shows the holes below the plastic jacket.

The optical stimulation methods are primarily recommended for electrically non-conducting materials: Halogen lamps, flashlamps, lasers, LED arrays. Stimulation via halogen lamps is especially suited for lock-in thermography with modulation frequencies up to 1 Hz. The surface stimulation with flashlamps is probably the most common method also because systems designed for three-shift operation have been available for quite some time. Flashlamps are able to generate a sufficient heat gradient – and thus an adequate heat flow – with high energy and in a pulsating manner, even in materials with good heat conductivity. Lasers and LED arrays allow both for the fast modulation of the stimulation output and for the smart choice of the stimulation wavelength, adapted to the specimen material and the sensitivity range of the IR camera. Furthermore, laser stimulation permits introducing heat focused on a single point or over a large surface (broadened or scanning).

Induction stimulation of a demonstration probe; metal tube with plastic jacket and measuring result

Laboratory and System Software

Market demands have specified two development directions for the software: A versatile laboratory software product ("Multi-purpose software" MPS), software for periodically stimulated measurements (lock-in suite) and add-on options (script language, software development environment, ...) are used primarily in research settings with constantly changing application areas.

Apart from this, the Thermosensorik System Software SCS was developed especially for use in industrial production. It is equipped with a fieldbus interface, customary in the industry, and two operating modes: Operator mode and expert mode. This prevents faulty operation in production, on the one hand, and, on the other hand, the expert is able to optimize or redefine parameters for additional components at any time. Professional advice and feasibility studies in the application laboratory of Thermosensorik help find the optimal combination of camera, lenses, stimulation method and analysis software.

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Automatic Focus Adjustment

Piezo Drives for Microscopy

It is difficult to imagine microscopy in biotechnology or clinical and pharmaceutical research without automation technology. Many applications in industrial surface inspection also require appropriate solutions for sample handling and sample positioning because of the large amount of data and the desired throughput. Conventional stepper motors achieve the required speeds and have resolutions in the micron range, making them adequate as drives for sample scanning in the XY-direction. Motion along the optical axis, on the other hand, requires much higher resolutions and, at the same time, long settling times must be avoided. Piezo drives are thus able to offer far better fine adjustment for the focus. Moreover, they can be comparatively easily integrated into the application and a retrofit is also unproblematic in most cases.

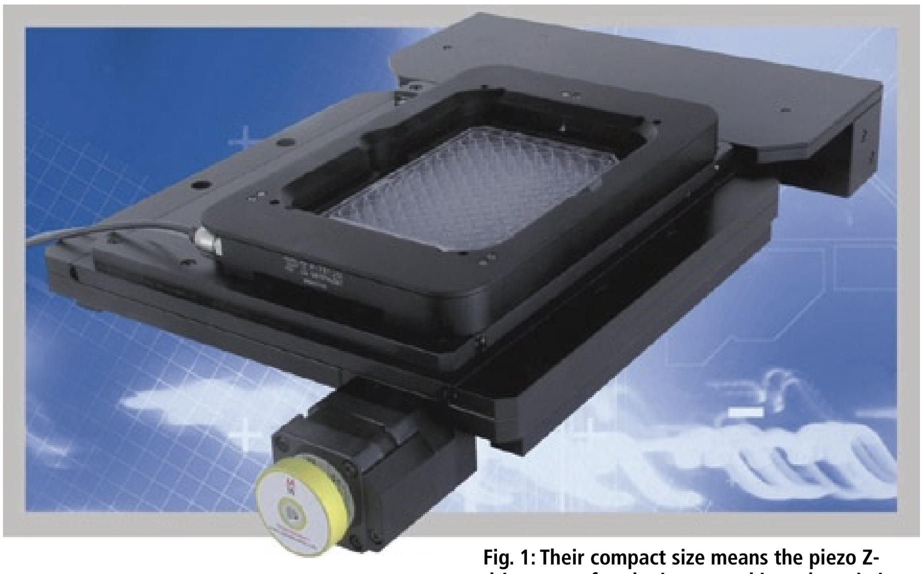


Fig. 1: Their compact size means the piezo Z-drives can often be integrated into the existing XY sample scanner (shown here, a Märzhäuser stage) (Photo: PI)

There are now many applications in microscopy which require precise, dynamic adjustment of the sample along the optical axis. These include auto-focusing onto the topography of the surface, or data acquisition in different focal planes for the computer-aided representation of a three-dimensional structure. In all these cases, the important issue is to focus as quickly as possible with the maximum possible accuracy.

Advantage of Speed for Screening

Screening covers a broad spectrum of applications in microscopy. It denotes a systematic testing method used to identify samples with certain properties in pre-defined test ranges, and it usually involves a large number of samples. Typical applications can be found in biotechnology, medical diagnostics and pharmaceuticals. In screening, tissue or cell samples are exposed to an active substance and the changes are investigated as a function of the dosage applied and the exposure time. Speed is important not only for high throughput, but also to avoid sample deterioration during examination, such as when fluorescent tracers need to be irradiated. Furthermore, the handling process also requires high sample throughputs. This is another reason why it is desirable to focus as quickly as possible.

Physik Instrumente (PI) from Karlsruhe, Germany, offers a range of piezo drives especially for these applications (see text box); the drives can be flexibly and easily mounted on a microscope, either in addition to, or in place of, a conventional Z-axis motor-usually a stepper motor (fig. 2). The devices work by moving either the objective, the objective turret or the sample along the optical axis. Even if the first sample is in focus, the focal planes of the subsequent samples can be different from the first, either because of differences in fill level or because the respective sample holders are uneven. The focus must thus be readjusted for every sample, with minimal settling time,

Properties and Advantages of Piezo Drives

Piezoelectric materials convert electrical energy directly into mechanical energy and vice versa. This piezoelectric effect was discovered in 1880 by the Curie brothers. For positioning, it is the motion which occurs when an electric voltage is applied to a piezoelectric material which is important. Drives based on the piezoelectric effect move in the sub-nanometer range with excellent dynamics. Using classical methods, travel ranges up to 1 mm can be achieved with high resolutions in the nanometer range and high dynamics for scan frequencies up to several kilohertz. The motion is based on crystalline effects, so there are no rotating parts or friction; piezo drives are therefore practically maintenance-free and not subject to wear. They can move large loads up to several tonnes. Electrically they act as capacitive loads and require no power in static operation.

Fig. 2: Piezo drives can be flexibly and easily mounted on a microscope to allow rapid fine tuning of the focus. It is thus possible to travel several hundred microns in only a few microseconds and with an accuracy of a few nanometers (Photo: PI)

in order to guarantee the quality of the analysis. This task is performed by the piezo drive. The auto-focusing procedures for readjustment therefore no longer employ the slower stepper motor (if present at all) but only the piezo drive. With a maximum travel range of up to 500 µm, it adjusts the position to within a few nanometers in milliseconds.

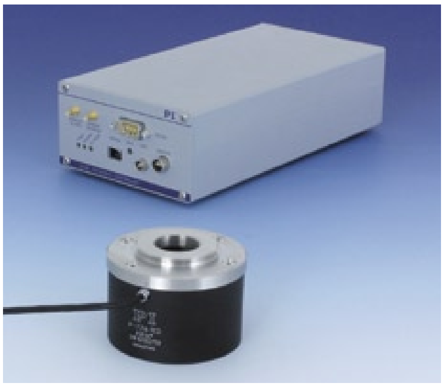
Three-dimensional Imaging

These advantages of piezo drives can also be used for three-dimensional imaging. In confocal microscopy, virtual cross-sections through a tissue sample are made, elucidating its structure. This is accomplished by displacement of the focal plane, and also requires very precise movement of the imaging optics along the optical axis. Alternatively, the sample can be moved accordingly. Both methods have their advantages.

Pifoc objective Z-drives can be made very small and stiff. They thus exhibit short response times, and their precision guiding system achieves very accurate positioning, even when travel ranges are relatively large. Furthermore, when the objective is moved, motion-related disturbances of the sample can be ruled out. Appropriately designed, Pifoc Z-drives can move either individual objectives or the whole turret (fig. 3) depending upon the application requirements.

There are sometimes reasons for moving the sample rather than the objective, however. The most important is that in phase-contrast microscopy this method does not degrade the image quality. The compact size of piezo drives means they can often be integrated into the existing XY sample scanner (fig. 1). Models with vertical travel ranges from 0.1–0.5 mm fit, for example, onto Märzhäuser XY scanners (microscope accessories) without adaptors. It is therefore still possible to use all the usual sample holders for

Fig. 3: Pifoc Z-drives can adjust not only individual objectives but the complete turret as well (Photo: PI)



specimen slides right down to the multiwell plate. The complete XYZ system retains a low overall height, allowing it to be used with all current models of microscope. Integration and control of the piezo Z-stage is as simple as that of any classical positioner.

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New Possibilities

Laser Tracker Simplifies the Inspection of Large Castings

Otto Junker simplifies measuring processes at its stainless steel foundry with a Leica Geosystems Laser Tracker. The high quality of the machined parts speaks for itself due to the measuring accuracies achieved.

When viewed from the outside, the interior of the stainless steel foundry at Otto Junker GmbH appears to be pitch-black. „Therefore the lads have to be as bright as buttons," quips Ulrich Tigges with a smile alluding to the extremely difficult conditions in the foundry which are so demanding on his colleagues. Tigges is Fabrication Shop Manager for Otto Junker GmbH in Simmerath-Lammersdorf, an Eifel township in southwest North Rhine-Westphalia, only a stone's throw from the Belgian border.

Otto Junker, the company, has been in existence since 1924. Originally Otto Junker just built foundries. However, from providing furnaces for his customers over the years, he developed a new, separate side to his business, which operated independently of the heavy production engineering division.

Ownership of the corporate group today lies with the Otto-Junker-Stiftung, a trust dedicated to the promotion of engineering training. „It is certainly something special to work for a trust," declares Ulrich Tigges. „The close cooperation between Otto Junker and its customers is based on adopting a reasonable, calm manner of addressing one another, mutual understanding and open communication."

Turned Components up to 6 m Diameter

As time went by customer requirements changed. New processes led to requests for more and more machined castings. The Otto Junker foundry, a specialist in stainless steel and special materials, is in the position to offer the customer a complete package. The core business produces components for the chemical, pharmaceutical and food production industries. „Turned components are in great demand," explains Ulrich Tigges. „We use turning mills capable of machining castings up to 6.30 m diameter."

Until 2007 Otto Junker GmbH used conventional measuring instruments, such as calipers or micrometer screw gauges. But handling 6 m diameter castings when using these tools is an extremely complex task: the measuring equipment requires continuous attention and its accuracy must be maintained. Furthermore, some shapes just cannot be measured by conventional means, for example radii and sloping surfaces that run into one another. In these cases diameters are theoretical dimensions of sections which do not in fact exist on the casting and must be construed during measurement. Faced with this situation, the management at Otto Junker decided to carry out measurements directly on the machine using state-of-the-art, software-controlled coordinate metrology, without the need for extra production operations – with immense time savings. The machined castings that leave the fabrication shop have to comply with the tightest of tolerances. Ulrich Tigges: „The ranges of accuracy we are dealing with here are quite incredible. Formed parts with a diameter of 4 m have to be accurate to 3/100 mm. In a very tough environment, this simply cannot be done using conventional methods."

A Short Time Window for Measuring

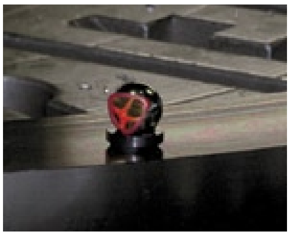
The search for the right measuring solution then took Junker along a very specific path. One customer had been using a measuring arm for a long time. Components with diameters of 6 m soon pushed this type of systems to its limits. Ulrich Tigges was already familiar with laser measuring techniques: as a previous employee of the Geodetic Institute of the Rheinisch-Westfälische Technische Hochschule Aachen (RWTH) he had come across the procedure and had been surprised at the accuracies that Laser Trackers could actually achieve. Several manufacturers demonstrated their trackers. Staff at Otto Junker were skeptical because there was one requirement of the new system that could not be fulfilled: all components, including future components, had to be covered by the new measuring equipment. Up stepped a solution from Leica Geosystems into the limelight: the ability of the wireless probe, the Leica T-Probe, to measure even hidden points, captured the imagination of the foundry staff. „Operating comparable systems demanded a lot of patience. A time window of about 30 minutes per measurement was not long enough for the other systems," noted Tigges. The much greater user acceptance by the foundry staff was the crucial factor for adopting the solution from Leica Geosystems. Otto Junker then purchased a Laser Tracker, which was preconfigured for 6 DOF solutions. A Leica T-Probe is due to be added at some time in the future: Tigges and his colleagues prefer to add to their metrology systems in stages.

Shortly after delivery of the system an acceptance measurement was carried out. For the first time, the new system had to prove its capabilities. „Our craftsmen are accustomed to battling with tenths or hundreds of a millimeter and are very experienced. They were suitably curious – in their view the Tracker had first to prove itself," recalled Ulrich Tigges. The acceptance measurements showed that the new Tracker had fully achieved all the required accuracies.

The training offered by Hexagon Metrology and undertaken by the department heads began with the theory behind the metrology equipment and the PC-DMIS software. There followed some intensive practical simulations. Each step was practiced in a peaceful assembly room: how do you measure a circle, a cone or a single point? A trainer from Hexagon Metrology showed them how. Now we have six employees who can operate the system. They will pass on their knowledge of how the system works to their colleagues. The greatest challenge for users is to verify their own measurements. „Small cones with diameters of 2.5 m and a height of 15 mm at an angle of 10° are very hard to capture. But with a ½" reflector sphere we can also achieve very reliable results. The graphical display in the software is a huge help."

Measurement Process Follows Production

The measurement process at Otto Junker follows the production sequence for the castings in the fabrication shop. The parts emerge from the foundry and are taken out of the mould after two or three days. It is one or a maximum of two weeks until a part is ready for further processing. First of all it is roughly measured using a tape and inspected for casting defects to exclude undersizes. The part is then moved, for example using a crane, on to the turning mill. Every part is stressed differently and orientated to take into account of incipient cracks. The first coarse machining is carried out to within 3 mm of the final shape. After this 20–50 hour long process, the crane lowers the cast part down from the turning mill. The part then rests for several days to allow the strains in the material to be released: the component changes shape during this time – it must „relax". As soon as the next stage of processing begins, the Laser Tracker from Leica Geosystems comes into continuous use. Thin-walled castings with wall thicknesses of only 20 mm move on the turning mill. Therefore they have to be machined more than once and measurements have to be taken from both sides in relation to one another. It is remeasured in 0.5 mm steps until the specified dimensions are achieved. When the part comes within 1.5 mm of the finished dimensions, it must be measured in cycles of three to four hours until the final dimensions are achieved. „In this way we can and will in the future work increasingly faster with the help of the Leica T-Probe," says Ulrich Tigges. „We have also discovered that we can only measure with great difficulty near the machine. The better option is to do it while the component is still mounted. We have so many crane and lorry movements in the shop – therefore it is better if the Tracker remains near the machine. Around the machine the floor plates are more stable and thicker." Deviations are kept within a very small range. It soon became accepted that the new measuring system was operating reliably.



Measuring directly on the turning mill: Michael Gerards, Precision Mechanics Foreman, checks about 30 points on the casting using a reflector

The measurement results supplied by Leica Geosystems Laser Tracker are completely reliable. Michael Gerards and Ulrich Tigges (right) from Otto Junker meticulously check the tolerances.

The Leica Geosystems Laser Tracker also alerted the team to further possible applications. The tracker was a great help when assembling a new turning mill. Ulrich Tigges recalled: „We measured the base for the machine where the table runs on an oil carpet. These tracks have to be parallel to one another and are bedded by hand. Using the Laser Tracker, within a week and a half we had surveyed the tracks – and what we learned from the measurements led to significant savings in time and costs. The 63 t table was quickly installed in the machine." The Leica Geosystems Laser Tracker was also useful in checking the machine. Compensation must be made for wear on the cutting tools. Precise measurement results can tell you the tolerances within which a machine is operating.

„Our highest priority is to keep production running," concludes Tigges. „As we always have a component being processed, it is essential that the metrology system works 100 %. We were well advised by Hexagon Metrology. The precision of the Leica Geosystems solution and the PC-DMIS software was exactly what we needed. The system makes our everyday work much easier."

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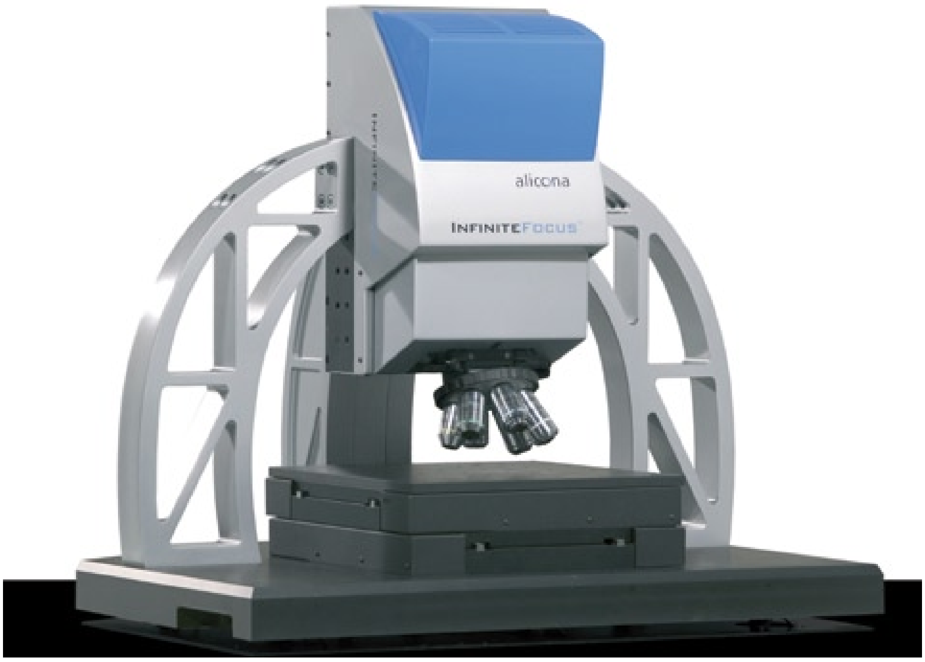
For Highest Surface Grade

All-round Quality Assurance of Drill and Milling Tools

About 60 surface parameters, with the smallest tolerances, determine the geometry, and thus the lifetime, of drills, milling cutters and thread-cutting tools. Quality assurance depends in a crucial way on the full form measurement of the tool in a high vertical resolution. The use of InfiniteFocus, an optical 3D measuring system, guarantees a high grade cutting edge geometry.



High resolution optical 3D surface measuring system InfiniteFocus for measuring form and roughness in the laboratory and in production. Cutting edges are measured with a radius from 2 µm upwards, angles with a minimum of 20°.

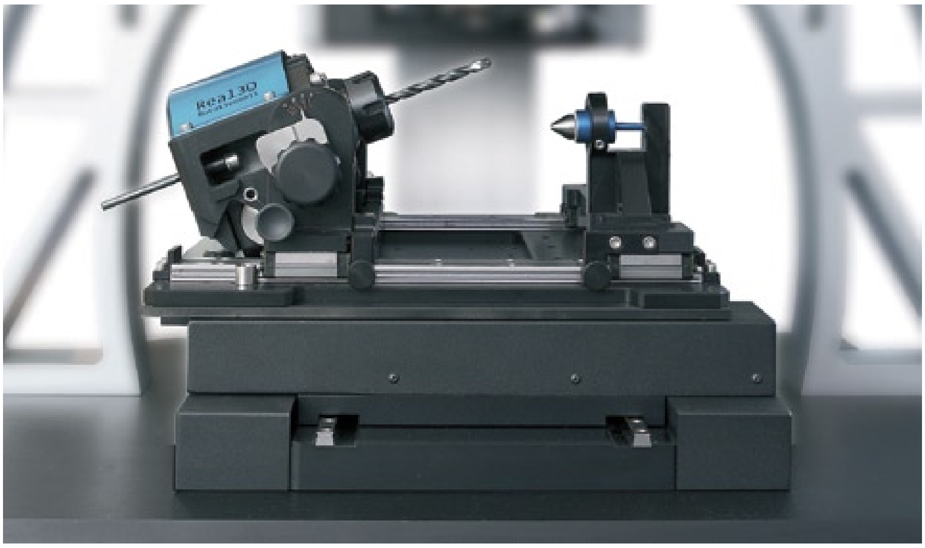
That it's the cutting edge that makes the money is an adage well known to manufacturers as well as users of drills, milling and thread-cutting tools. Manufacturers of cutting and shaft tools have to meet two decisive requirements. First, they have to guarantee their customers a long lifetime combined with excellent machining results of their tools. Then there is considerable pressure to guarantee repeatable quality at the highest possible process reliability and at low production cost. Production faces the strict requirement of machining a given geometry with steady precision whereas quality assurance needs to make sure that the machined tool shows the right geometry before, during and after the manufacturing process. The finished work piece has to correspond to the pertinent CAD data set. In increasing numbers, this applies to extremely small parts with very narrow tolerances, and thus said requirements can only be met by high resolution surface measurement processes.

Any user of drills and milling tools is well aware about the relevance of a timely change of tools. If a shaft or some other cutting tool, as for example a cutting insert, is replaced too late, the surface quality of the material machined will suffer.

Alicona, a leading supplier of optical 3D measurement and inspection systems, offers with InfiniteFocus a measurement solution that serves both, manufacturers as well as users of cutting and shaft tools. The 3D measurement device is used for full form and roughness measurement as well as wear analysis in the lab and in production. Both parties benefit from the technology of Focus-Variation as it enables the optimization of quality assurance and process reliability.

Optical Measuring System Assuring Geometry

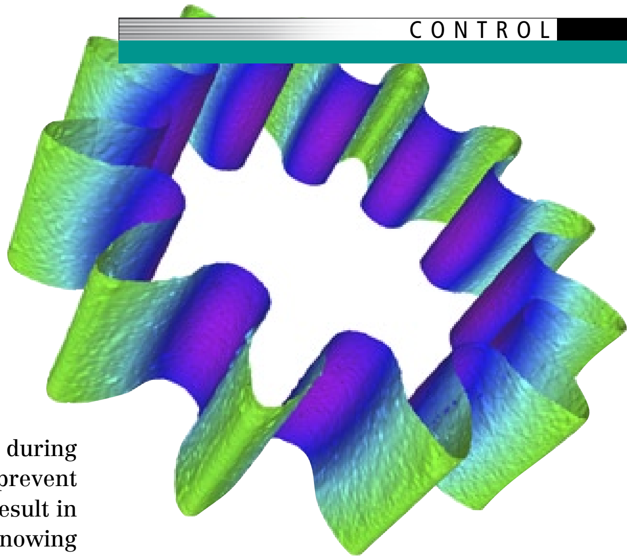
InfiniteFocus is a high resolution optical 3D measurement device for the measurement of critical parameters such as radii and angles of a cutting edge.



InfiniteFocus with rotation unit for rotating drills, milling and threading tools by 360°, thereby measuring completely the form of the tool. This way, the user also measures geometries like roundness or tap point of his tools.

With a correct geometry, manufacturer guarantee pertaining lifetimes and machining results of their drills and milling tools. Even when measuring a complex form like those of threads, this measuring system will achieve a vertical resolution of down to 10 nm. The particular advantage of InfiniteFocus is that one single system will cover all functions of both a conventional surface measuring device and of a coordinate measuring machine. Instead of employing several systems the user measures with only one system both – roughness and form of his tools. The high resolution is also present at large scan heights, rendering this 3D measuring device ideal not only for the measuring of miniaturized components, like micro tools, but also of larger components. Even with topographies showing flanks of more than 80° will the high vertical resolution be achieved, thus making possible the measuring of sharp edges. Also, ground and mirror-finished surfaces, or a combination of matt, glossy and mirror topographies will be measured in the high resolution.

Users of shaft tools employ InfiniteFocus for wear control, amongst others. By defining the ideal point in time during production for a tool change they prevent dull, worn-out edges that would result in faulty machining and waste. Knowing after how many revolutions a drill or a milling tool needs to be replaced will be preceded by comparative examinations of the cutting edge. InfiniteFocus measures tool geometry before and after its use in manufacture. In doing this, the measuring system registers both 3D sets of data and automatically calculates a model of difference, independently of manual adjustment. The worn material is calculated automatically and, in addition, visualized in color. By numerically verifying the material removed after a certain time, it will be calculated exactly at what time and at what degree of wear the tool needs to be changed to achieve constant machining results.



Complete 3D survey of a micro gear. Using the high resolution technology of Focus-Variation will help guarantee adherence to of ever smaller tolerances for position, shape, spatial orientation and diameter.

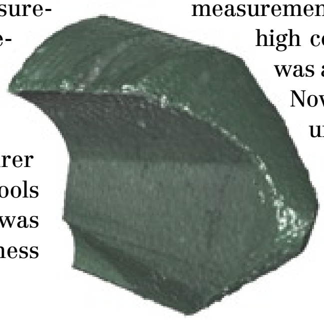
InfiniteFocus measures the radii of cutting tools from 2µm upwards and to minimum angles of 20°. These data make Focus-Variation a technology much sought-after, as no other process, be it optical or tactile, will offer measurements at this high vertical resolution of down to 10 nm with the given features. High resolution numerical verification of form, spatial orientation and surface roughness of cutting tools guarantees meeting ever decreasing tolerances for position, shape, spatial orientation and diameter. Customarily, at least two systems are required to measure these components in a complete and reliable way. With InfiniteFocus, however, the user has a system at his disposal with which he may measure roughness and form, i.e. length, diameter, angles, inclinations, roundness etc., with one and the same system.

Shaft Tools Measured 360°

There are about 60 surface parameters defining the geometry of shaft tools, and with them their lifetimes and machining results. Meaningful measurement demands the full form measurement in a three-dimensional way. Alicona realizes this demand with their optional rotation unit, which rotates the work piece by 360°. Employing InfiniteFocus Real3D the user will also measure geometric values like the undercut on thread flanks which cannot be measured by conventional means. Decisive angles like the front rake or flank angle are measured, as well as different diameters and the concentricity of the shaft. Deviations of shape with respect to a reference body are also automatically established. Due to the direct linkage to a CAD set of data, the user measures and visualizes deviations from the pre-defined CAD model. Measurements of two geometries or free-form surfaces bring to light wear and monitor compliance with tolerances. Says Martin Zeller, CEO of Bass, a manufacturer of high-precision threading tools about InfiniteFocus Real3D: "It was the possibility to measure roughness and form of our tools in high resolution with only one device that convinced us. We have been employing InfiniteFocus with Real3D since last year in our Research and Development." This medium-sized company relies on innovative partners: "What pleases us about Alicona is their high innovative power, a trait with which we ourselves move within the market and which we expect of our partners. So, we're happy to use Alicona's products not only in R&D, but also in our production," says Zeller.

Roughness Determines Surface Quality, Chip Flow and Mechanical Load Capacity

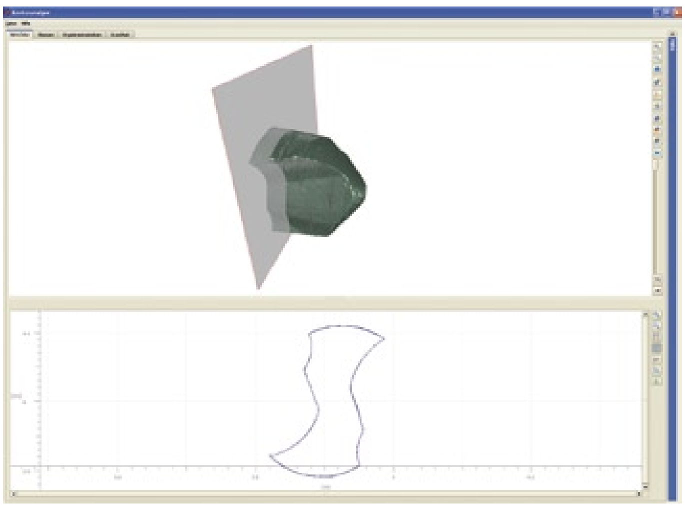
"Finally, we are able to measure the roughness of finely ground or polished surfaces." With these words Thomas Kogler explains one of the numerous advantages that have surfaced since the introduction of InfiniteFocus for quality assurance. Kogler, a machinery technician with Amada, a leading manufacturer of band saw tools, saw machines and edging tools, is dealing with, amongst others, the optimization of band saw tools. Surface roughness is of prime importance here, being a decisive factor for adhesion, toughness and mechanical load capacity and in governing wear resistance. Kogler: "We used to outsource our roughness measurements. This always meant high cost and took time, and was a source of uncertainty. Now we do our own measuring with InfiniteFocus and gain certainty by the high repeatability of the measurements."



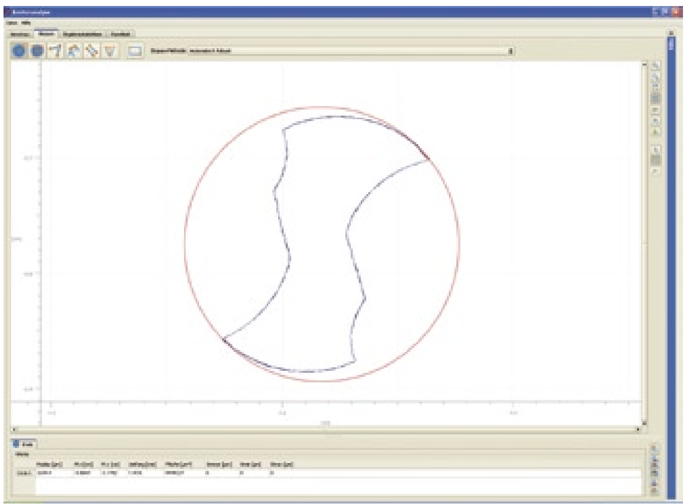
Surface roughness plays an important role for other features of quality, too. The smoother the surface, the better is the chip flow. This way, heating of the chips is reduced, which in turn means higher cutting performance. A high surface quality also minimizes the risk of fusing which, in the worst case, would lead to severely damaging of the tool and even rupture of the tool. Special micro treatment has the purpose of minimizing edge nicks and the danger of edge cracks. Surface roughness also governs layer adhesion in coating processes. Methods of surface smoothing are also used to level out unevenness and excess in roughness of a carrier substrate. Thus, a fast, precision-repeatable measurement of roughness with the possibility of leveling out is as governing a factor in quality assurance as roughness itself. By measuring the depth of roughness one can verify the effect and cost-efficiency of the different methods for surface smoothing, and judge processes of optimizing the surface. Amada appreciates yet another aspect in their daily work with the 3D measuring system: "InfiniteFocus is very easy to operate. For us, this is one of the important criteria, as there are several people working the system. Getting good results quickly and simply and without the necessity of prolonged training is a prerequisite," Kogler says about operating the 3D measuring system.

Measuring Roughness Optically

To gain the highest surface quality with even the smallest component geometries requires high resolution measuring methods. This is why optical technologies are replacing more and more conven-



Contour analysis – tap point section 2 – section



Contour analysis – tap point section 2 – undercut

tional methods like tactile measuring. The Focus-Variation technology for form and roughness measuring is increasingly sought after not only in the machining industry, due to its high vertical resolution and the vast field of application in a laboratory and in production. This method delivers more precise results at a shorter measuring time and thus enhances the efficiency of quality assurance. The user is able to measure the entire surface with up to 100 millions of measuring points, instead of only the profile of one single track. Also, measuring is done without any wear. The principle of optical, non-tactile form and roughness measuring prevents several types of inaccuracy which may occur with tactile measurements, where shape and size of the contact stylus tip largely influence the measuring result. Beside the 3D measuring results, InfiniteFocus will also give a true-color information for the surface, which, in turn, is of great advantage in wear analysis. The present draft of ISO 25178, for the first time standardizing optical measuring technologies, includes Focus-Variation.

Control, the Better Part of Confidence

Quality control is becoming a cost saving factor not only on the home turf. In goods receiving control, too, 3D surface control of the raw material is playing an important role. If, for example, the required roughness value of carbide metal should be known before processing, the product supplied can be checked by a suitable measurement of roughness quickly, simply and automatically. Easy automation of measuring allows efficient and reliable goods receiving control without much personnel involved. The user may also define several parameters, like elevations and depressions, which are then detected, measured and quantified automatically by InfiniteFocus. He thus checks the surface for faults or other deficiencies.

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Perfect Surfaces

Automated Objective Surface Inspection Station with High Flexibility at Daimler AG

The automotive industry is putting great effort into surface quality assurance of body components and bodies-in-white. Experienced inspectors find defects on the surfaces, like dents, bumps, sink marks, waviness, constrictions and cracks using their eyes, hands or a whetstone, and classify these according to their relevance for the paint. Problems are posed by those defects in particular that are hardly recognizable on the sheet metal surface and, after further work steps like cathode immersion coating and painting, become visible and thus customer relevant. Also, any judgment of a surface is subjective, the auditing grade varying with each auditor. There is a potential cost reduction, if relevant surface defects are identified as early as possible and objectively. Daimler AG at their Sindelfingen plant are using the ABIS II surface inspection system as a central auditing station.

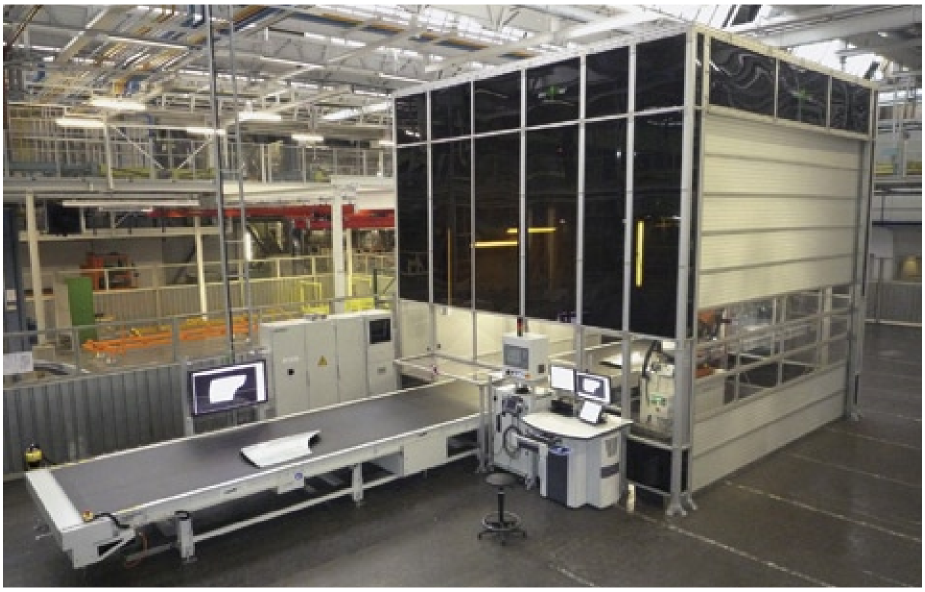

Fig. 1: Complete Installation

Fig. 2: Examining sequence.
1: Feeding parts onto entry conveyor belt,
2: Inspection cell with ABIS II,
3: Exit conveyor belt with indication of inspection results

Having become operational in November 2008 in the press plant of Daimler Mercedes-Benz Cars (Sindelfingen), the optical surface inspection system ABIS II has been used (fig. 1), which shows the highest degree of automation and the greatest component flow, compared to other plants at other automobile manufacturers. During the inspection sequence (see fig. 2), a component is placed on the conveyor belt (1), enters the inspection cell (2), and, after its orientation being captured by the single camera above the belt and after the adjustment of the robot path, is inspected by the ABIS II surface inspection system, to be transported out the inspection cell on the exit belt. Near the exit belt, the surface inspection result is shown on a large visualizing screen (fig. 3) Whether the sheet metal part is okay, or needs re-working, or is waste, is shown to the person taking the sheet metal parts off the exit belt by the report on the visualizing screen. With the classic manual auditing, it takes at least 15 minutes to inspect a complete side frame; using the ABIS II system, this task will be finished in less than two minutes.

The core of the system is the ABIS II optical surface inspection system. ABIS stands for Automatic Body Inspection System, being a system specifically developed to meet the requirements of an industrial environment. The sensor concept is based on the so-called projected-fringes technology, projecting a periodic grid onto the object, and the stripe pattern being registered by a camera placed perpendicularly to the surface. Applying the one-frame technology, with an extremely short exposure time of 0.1 ms, guarantees negligibility of vibration and the surrounding light typically encountered during manufacturing in factory buildings (e.g. press and body plant). Also, there are no moving parts in the sensor, ensuring high acceleration without loss of calibration stability. Integrated classification of surface defects is a decisive part of the data processing, to allow the application of quality criteria during the subsequent decision processes. Analysis system software of ABIS allows defining defect features with their resulting auditing values, which can be set by the

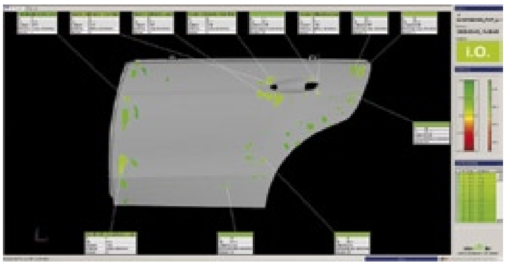

Fig. 3: Indication on visualizing screen

Fig. 4: First 3D cell layout

auditors according to the customer-specific product quality. This, as not every surface defect found is customer-relevant and needs to be reworked.

The user of the ABIS II automated surface inspection system at the press plant in the Sindelfingen plant of Daimler use it for several types of tasks:

- Imaging the agreed-upon surface limit patterns, thereby installing a central control station with objective criteria.
- In case of discussions about problematic spots on a component, there can be found an objective assessment of the quality by individual checks.
- When operating the system automatically, grading of individual press lots can be carried out in an economic way. Lots can be between 100 and 2,000 parts. There is sufficient space around the plant for load carriers and fork lift traffic.
- The surface inspection system, used in random sampling, is integrated into the press plant quality control circuits and thus will facilitate feed-back on the surface quality after a tool change.

The concept of the system, as now operating with Daimler at Sindelfingen, was created in close co-operation between the planners and operators at Daimler and specialists of Steinbichler Optotechnik. The first layout plans (fig. 4) included an overhead door, while at a later stage a sectional gate was decided on, in order to simplify servicing of the orientation capturing camera above the conveyor belt. Using robot simulation the optimal robot position, i.e. distance to conveyor belt and pillar height, was established, so that the sensor could be positioned for capturing even the largest possible parts (side frames) in all positions on the belt.

A special feature of the system at Daimler is an optional extension to inspect parts of complete bodies. For this purpose, the gate will be opened, the body-in-white will be positioned in front of the robot, and the ABIS II sensor, in a secure mode, will be positioned by the robot near the parts to be inspected. This additional mode facilitates inspecting those surfaces that cannot be placed onto the belt as a component after assembly. Side frames, fenders and roofs can, in an assembled state only be inspected on the complete body. The reason for this is the requirement to examine and follow-up surface quality even after the individual process steps, i.e. component, assembled state, cathode immersion coating. Experience has shown that defects appearing to necessitate re-working on a component, sometimes lose their relevance during subsequent processes. But the opposite (particularly in later visible areas) has also been known: surface defects, initially not rework-relevant, have become clearly visible after cathode immersion coating.

The ABIS II surface inspection system installed in the press plant of Daimler at Sindelfingen presently offers the highest degree of automation, the greatest flexibility and work-flow capacity. The requests made by and requirements of Messrs. Dr. Frank Weber, Center Press Plant Manager, and Christoph Schlott, Manager Press Plant Quality Assurance, were implemented in both design and construction of the machine. For Steinbichler Optotechnik GmbH at Neubeuern, supplier (and general contractor) of the machine installation, the customer's satisfaction is a welcome confirmation. As expressed in Schlott's words, "The concept of the machine installation offers exactly what we wished for."

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High-precision and Non-contact

Circularity and Radial Run-out Measurement with Multi Sensor Monitoring

Novel products are designed nowadays with increasing high standards in production and resource efficiency. In many industrial fields such as automotive, aerospace and medical engineering, some new product features are created which can only be manufactured by means of micro and nano production technologies. With it grows the demand on metrology solutions which are able to detect and diagnose the overall quality, geometry and functionality of those products and features.

In the special case of surface measurement, tactile sensors have been until now the measurement state of the art. These sensors conditionally meet certain requirements on precision and sensing force from high-tech products, as the ones with micro and nano features. In addition to that. these sensors are not able to generate as high measurement frequencies as optical sensors.

For this reason, the importance of optical metrology has been increasing regularly in the last decade, as this technology provides special features like high precision and non-contact measuring. An example is the inspection of circularity and radial run-out. (fig. 1).

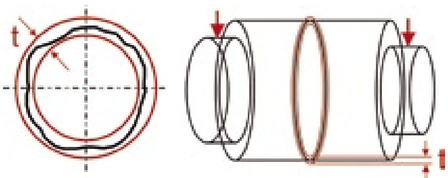

Fig. 1: Inspection of circularity and radial run-out

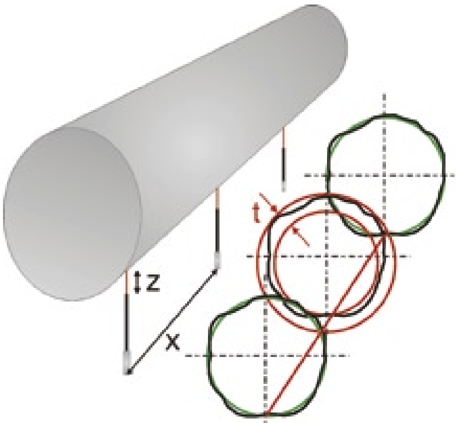

Fig. 3: Probes are calibrated relative its X and Z position

Fiber-based Measurement System

Seeing this demand, the Fraunhofer Institute for Production Technology in Aachen, Germany, developed a fiber-based measurement system for the high-precision measurement of shafts, rollers and machine guides.

The system is based on the measuring principle of low coherent interferometry, and is composed of two main units. The first one is a Fizeau interferometer, which is connected to the second unit, a Michelson interferometer (fig. 2).

The Fizeau interferometer consists of one optical fiber, and its end face is used as the reference surface. At this surface a fraction of the transmitted light beam is reflected and forms the reference wave package. The remaining fraction is then reflected by the object. The optical path difference between both reflected beams encodes the distance between optical fiber and object. The Michelson interferometer grabs these signals and equals the optical path difference by means of a tilted mirror. The resultant interferogram is captured by a CCD camera and processed with computer software.

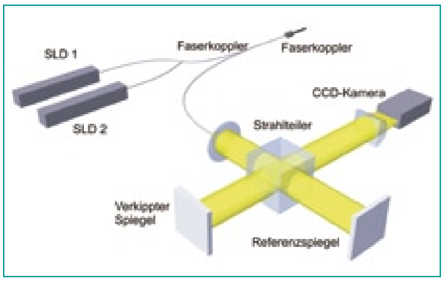

Fig. 2: Measuring principle of the fiber optic distance measuring system

The Probes (Fizeau interferometer) are constructed with optical fibers, and, in order to increase their stiffness, carbon fiber and nitinol tubes are used as protection [1].

Measurement Set-up

The Fraunhofer Institute for Production Technology presents at the Control 2009 in Stuttgart, Germany, a high-precision circularity and radial run-out measurement system with non-contact multi sensor monitoring. This set-up demonstrates a solution for the inspection of assembly elements, which have high geometry requirements, as well as for elements with sensible surfaces parameters.

The set-up is constructed in a flat base rack design, where a spindle delivers the torque using a DC motor. For guaranteeing the assessment of a large range of object diameters and rotational symmetric objects, a coupling fixture was used.

The synchronization between the rotation of the measurement object and the measurement frequency is achieved through an encoder. This encoder features a resolution of 0,1° per revolution and generates a TTL trigger signal. The CCD image acquisition process is controlled by this trigger signal and this way sets the measurement frequency as well as the measurement point cloud.

Three fiber-based probes are used in the set-up for the measurement and are switched by means of a fiber optic switcher. Through that the system software is able to change the measurement position. The probes relative Z positioning is calibrated with a certified test body, and so has a defined relation (fig. 3). With this procedure the system is able of fitting a cylinder in the measurement data.

Analysis

The set-up can assess the circularity of an object (every captured circle) and the radial run-out at the same time. The captured circle contains information about the object's form, waviness and roughness, as well as a possible modulation, which comes from a misalignment of the assessed object. This information is evaluated based on the DIN/ISO 12181-2 and 11562 Standards for circularity, and its results are reported (fig. 4).

Another feature of the system is the possibility of a 3D presentation of the measured element, as well as the evaluation of cylinder parameters according to the mentioned DIN/ISO standards.

The radial run-out assessment is based on the system's rotation axis, which is calculated using two captured circles (fig. 5).

Perspectives

For increasing the robustness of the whole system as well as of the probes, further developments at the Fraunhofer Institute are planned. At addition to further research of possible materials for the fiber optical protection tubes, the development of fiber probes adapted for the roughness measurement is also planned, as well as the miniaturization of the probe diameter.

Another research goal is the improvement of the fiber optical switcher, i.e. the increasing of the maximal switch frequency. This way an elevation of the maximal executable measuring frequency would be achieved, as well as an increment of the maximal number of applicable probes in the radial run-out assessment system.

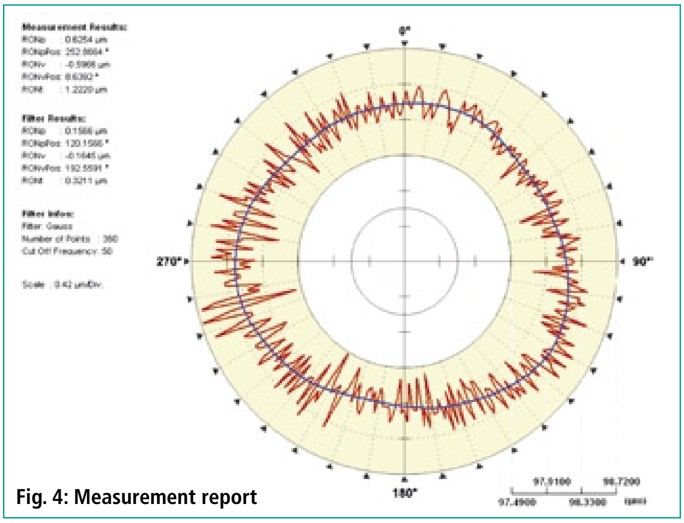

Fig. 4: Measurement report

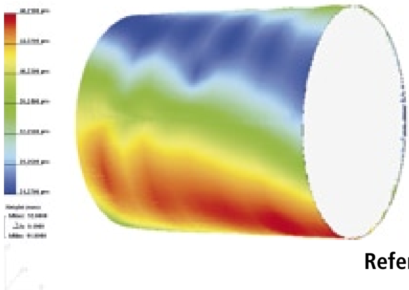

Fig. 5: The radial run-out is evaluated based on the rotation axis, which is calculated using the two outer right and left probes

Another application of fiber optics in the metrology is in structure monitoring, using Fiber Bragg Gratings (FBG), which are used in buildings, aerofoils from wind energy plants, pipelines and oil fields [3]. In the field of medical diagnose, fiber optics are applied in optical coherence tomography, for the minimally invasive measurement of biological tissues [4].

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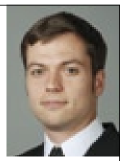

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Thumb Sized Miniature Spectrometer

With its extremely small package size of 28 mm x 17 mm x 13 mm and a weight of only about 9 g the C10988MA suits especially for integration into compact optical sensing equipment. Based on a high level of integration, the number of optical components is kept to a minimum – and thus, costs are minimized as well. Only a concave grating with very short focal length which is replicated onto the top of convex glass lens using nanoimprint technology and a dedicated CMOS image sensor build the complete spectrometer. The C10988MA covers a spectral range from 340 nm to 750 nm.

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New Module for the Dimensional Analysis

The Mountains Surface Analysis Business Unit of Digital Surf, the surface metrology solutions provider, announced the release of a new software module, Advanced Contour, which is part of the Mountains surface analysis software suite. The Advanced Contour module is a complete solution for controlling the dimensions of profiles measured on component surfaces. With an intuitive icon-based user interface, full set of metrological functions, graphical display of form deviations, automatic quality report generation, and the ability to export results to quality management systems, it ensures that contour analysis is not only accurate but also as straightforward and fast as possible.

Digital Surf
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Confocal Sensors in Hybrid Technology

The new optoNCDT confocal chromatic sensor from Micro-Epsilon combines the benefits of two successful confocal design concepts. With an external diameter of 8 mm, the sensor is compact and slim, similar to the optoNCDT 2402 range of miniature sensors. However, due to its larger digital aperture, the sensor can receive significantly more reflected light than the smaller, 4 mm diameter version. In the new sensor an ancillary lens is positioned in the light path before the thin gradient index lens with its exactly adapted refractive index profile. Due to its greater divergence, the so-called relay lens enables significantly more reflected light from the target to be detected. This is particularly beneficial if the sensor has to be tilted or if the target is non-planar, so that the reflected light is only reflected back by an angular deviation in the sensor.

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Dynamic Measurements

Aicon's optical measuring system MoveInspect captures dynamic processes three dimensionally and analyses them with regard to geometric changes. Thanks to a new climate control concept, MoveInspect is now also ready for analyzing movements and deformations under extreme climatic conditions, for example in environmental chambers. Here, the optical system replaces mechanical travel sensors because it reduces the setup work significantly. The system is based on a camera bar that is equipped with digital cameras and offered in different versions. The high-end version is able to conduct tests at a frequency of 1,000 Hz. The system can also be applied for endurance testing as it records the data without any time limit. The results of the dynamic measurements are displayed in a clear and descriptive manner.

Aicon 3D Systems GmbH
Tel.: +49 531 58 000 75 • info@aicon.de • www.aicon.de

Real 3D Measurement through Multi-laser Technology

Metris launches the multi-laser XC65D scanner that captures all 3D details of features, edges, pockets, ribs and freeform surfaces in a single scan. The Cross Scanner's entirely digital operation boosts scanning frequency and drives intelligent laser intensity adaptation to scan any surface without user interaction. The superior performance of XC65D further accelerates the Digital Inspection Process, providing better insight, more flexibility and much higher productivity. Incorporating three lasers in a cross pattern, the XC65D obtains a full 3D view that accurately captures the bore of a hole or the flanges of a notch. In this way geometric features can be extracted from the acquired point cloud with higher confidence and accuracy. The XC65D avoids taking multiple scans of the same feature using different scanner paths and orientations, eliminating time-consuming probe head indexing and drastically reducing overall inspection time. With laser stripes being projected from three sides, the XC65D also provides maximum coverage of complex surfaces with many ribs and pockets.

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New Water Immersion Objective

Olympus has introduced a new 25x water immersion objective specifically designed for multiphoton imaging. It offers researchers outstanding deep-imaging and high resolution performance with the Olympus FluoView FV1000MPE multiphoton laser-scanning microscope system. The new Olympus XLPlan N 25x objective has been designed with a numerical aperture (NA) of 1.05 for high-resolution multiphoton microscopy. It can be used for tissue samples with cover slips and for investigations, such as patch clamping, where the sample cannot be covered. As a result, higher z-resolution and significantly increased brightness is achieved for all deep imaging applications, compared to similar objectives already on the market. With a working distance of 2 mm and a large 35-degree access angle available for patch clamping, this objective is excellent for neurophysiology and related applications.

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Interview with Dr. Rainer Ohnheiser, CEO, Carl Zeiss Industrielle Messtechnik GmbH

INSPECT: Success at Carl Zeiss IMT began with the first CNC-guided 3D coordinate measuring machine which evolved from the 2D measuring microscope. It came out on the market in 1973. How many of these are still in use?

R. Ohnheiser: There are still about 10 machines from this first generation in use today, the majority in Asia and India.

The tactile 3D coordinate measuring machines dominated the dimensional measuring technique market for a long time. When and with which goal was the decision made to develop and apply optical systems – scanners and sensors?

R. Ohnheiser: Purely tactile coordinate measuring machines still dominate the industry. With tolerances in the single-digit micrometer range, there are no alternatives to tactile measurement in the cutting industry, in particular.

Approximately 10 % of the systems sold around the world every year are equipped with only optical sensors. There is also a line of multisensor machines that can measure both optically and tactile. However, the majority of measuring machines purchased every year are used solely for tactile metrology.

In 1990 the triangulation laser was introduced. Which new applications were made possible by this?

R. Ohnheiser: As before, the triangulation laser is still used for the measurement and digitization of freeform surfaces. The measuring accuracies of a hundredth or tenth of a millimeter required for these applications are perfectly adequate.

The increasing amount of data resulting from high-performance sensors is permanently increasing the requirements on computers and software. On the other hand, state-of-the-art computers and software make it possible to achieve far more accurate and informative measuring results. All you have to do is look back on past plan/actual comparisons of intersection lines and curves. Today you have statements about the surface, and colored evaluations of the results are standard.

Precision in coordinate measuring technique creates ever higher demands upon machines and their producers. With the Umess expert system you speak of a "precision-guided scanning method". What exactly does this imply?

R. Ohnheiser: With most precision measurements, the measuring speed of a machine still influences the measuring accuracy. This means that a technician must be very familiar with the dynamic properties of his machine and sensors to achieve the ideal measuring accuracy.

The operator knows precisely which production tolerances are available. However, he does not necessarily know the dynamic influencing variables of a measuring machine. We however know our measuring machines inside – out.

We therefore eliminate the user's doubts about being able to achieve optimal measuring results with the selected parameters such as speed, point density, etc. The user says how accurately he wants or has to measure. Our system of experts does the rest. The system controls the speed, probe deflection and the distance between the points so that the tolerances specified by the user can be reliably complied with.

Your special offer at the moment is the combined application of the measuring instrument DuraMax with the surfact measuring machine Handysurf. What are the resulting strengths?

R. Ohnheiser: DuraMax and Handysurf complement each other regarding the demands of the user and those responsible for production. In addition to measuring the traditional geometries of a prismatic workpiece, the form and surface quality of the parts is also very important.

A measuring machine can measure forms and display trends, but cannot achieve the accuracy of special form and surface measuring machines. This is what led to the combination of these two applications. Our O-Inspect is tailored to the needs of the plastics industry and offers both optical and tactile measuring. It is a traditional optical measuring machine for transmitted light/incident light measurements in an optimally adapted combination with tactile scanning using our Vast XXT scanning sensor.

The lenses, software components and measuring methods from our microscopy division combined with our know-how in tactile metrology created an ideal symbiosis of the skills of the Carl Zeiss Group.

Which ideas do the visionaries at Carl Zeiss IMT wish to realize in the next few years?

R. Ohnheiser: Adding new, initiated technologies to systems is on our agenda. An example is computer tomography with the Metronom 1500 and microsystem technology with the F25.

The enhancement of existing measuring technology is also a top priority in our development plans. Our metrology is similar to the combustion engine which has not yet been fully developed.

You can always achieve considerable improvements such as our new designed bridge-type CMM that will be introduced at the 2009 Control show.

The expansion of services beyond traditional technical service is another focal point. "Customer closeness" is more than just a phrase. Our measuring houses around the world for contract measurements and our three production sites in the most important industrial nations show how important we take this subject.

Software development is always in focus. The rapid development of computer performance opens up outstanding opportunities, but also demands a fast and targeted approach.

True to our policy of developing and producing all system relevant components such as air bearings, drives, controllers, sensors and the software ourselves, unlike the majority of our competitors, we possess outstanding integration skills.

Among the many undisputed achievements of Carl Zeiss are the advancement of optics, science and technology in many fields – often with truly revolutionary ideas – and the ability to open up new fields of application.

In 2009, Carl Zeiss will celebrate the 90th anniversary of its Industrial Metrology business group. However, the cornerstone for measuring technology in industry was laid by Ernst Abbe in 1890 with the formulation of the comparator principle named after him.

Almost 30,000 installations of measuring machines around the world testify to the trust placed in our problem-solving products and services. And we will do everything in our power to continue earning this trust.

Dr. Ohnheiser, we thank you for this interesting discussion.

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