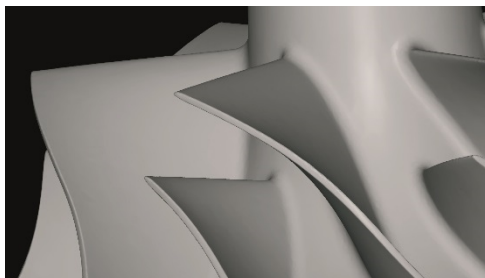




WHAT ARE THE BENEFITS OF INTRODUCING AN OPTICAL MEASUREMENT METHOD?

ADVANTAGES OF OPTICAL METROLOGY



Are you currently using conventional coordinate measuring machines (CMM) and would like to make your work more efficient and sustainable using state-of-the-art technology?

This whitepaper gives you an overview of the possibilities and advantages offered by optical measurement technology and, in particular, by 3D digitizing using white light fringe projection.

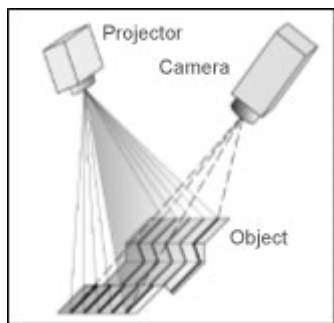
This technology provides new, highly versatile possibilities. Capturing the entire object surface opens up a completely new dimension in the quality and detail of the information you get about your processes. Whether you work with classical nominal-actual comparisons, speed up your form finding process for the capture of design samples, or use reverse engineering to create a parameterizable CAD file allowing the digital representation of “old” components for which no CAD data is available (anymore) – optical measurement technology moves your business forward in many ways.

The non-contact solution also allows measuring easily deformable materials such as foamed objects, which cannot be reliably measured by conventional methods using CMMs. In this way, you can fill any remaining gaps to achieve consistent data availability while improving your position in the market with a technology of the future. Show your employees, customers and partners that you are among those leading the way in your industrial sector, that you act rather than react. By providing your employees with advanced qualification opportunities focused on new technologies, you improve employee retention and increase the level of identification and satisfaction in your company.

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HOW DOES THE WHITE LIGHT FRINGE PROJECTION METHOD WORK?



A projection unit projects a fringe pattern, which is encoded using a special process, onto the object to be measured. The topography of the object causes deformations and deflections in the fringe pattern. These make the object's surface visible in 3D to the camera systems (one or more cameras), which form the second key part of a white light fringe scanner. To determine the individual 3D point coordinates, a triangulation calculation (relationships in the right-angled triangle) is performed from each camera pixel on the basis of beam intersection (projector – camera(s)) and encoding.

Depending on the camera resolution and measurement volume that are used, a coarser or finer 3D point pattern (resolution) is placed over the object. The finer the pattern, the better intricate details (radii, edges, etc.) can be represented. This so-called lateral point spacing typically ranges between 20 μm and 250 μm , depending on the selected system. Please note in this context that a value specified for the resolution is not equivalent to the “accuracy of the system”. Please see the “What quality and accuracy can be expected?” section for further information.

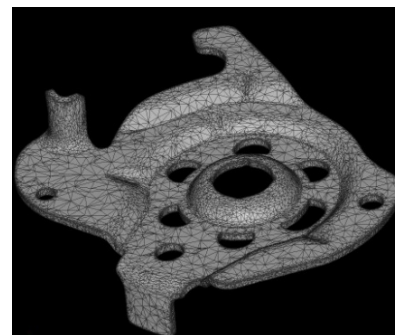
WHAT CHANGES FOR THE USER?

Optical measurement takes a different approach than tactile measurement technology:

First all the areas that are to be measured are scanned, ideally the entire object. For this purpose, the individual images taken are arranged next to each other – similar to a panoramic photo – by using overlap areas (distinctive regions captured in both images). This process is referred to as matching. The individual scans can also be matched using adhesive reference marks (points). This depends on the specific application and on the system used. Some systems will always need reference marks to ensure correct matching, while other don't.

Once all the regions to be tested have been acquired, the resulting point cloud is used to calculate a triangle mesh (STL). This format is the simplest surface format. It is not to be confused with a modeled CAD data set that has been parameterized. This STL model can be used subsequently for the nominal-actual comparison based on the CAD file.

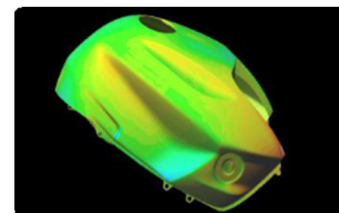
The next step then is the metrological evaluation of the scanned data set. In this process, STL and CAD are aligned with each other according to drawing or customer specifications. The desired features (such as holes, surface areas, edges, cones, etc.) are evaluated based on form and location, and a report is created in PDF format.



WHAT ARE THE CONCRETE ADVANTAGES OF THIS 3D MEASUREMENT TECHNOLOGY?

1. Quick, integrated object and process assessment

It takes just a few mouse clicks to immediately get a first impression of the entire object thanks to the lookup table. Even less experienced users can quickly get an overview and determine a tendency for the object to be tested.



2. Measurement information also in previously not tested areas

By fully capturing all the areas that are visible to the camera(s), users now also obtain information on sections for which no data was acquired using conventional tactile measurements. In this way, latent critical areas are included in the evaluation already in advance.

3. Subsequent additional evaluations are easy to do

If the tested objects have already been delivered to the customer and you receive a complaint, you will be able to additionally and reliably evaluate every single feature any time later, because you do not have to re-scan and re-align the object. All these subsequent examinations can be performed without the object even being there physically.

4. Different levels of automation are available

A first level of semi-automation is achieved by the use of a rotary table, which provides easy and efficient handling especially for objects that completely fit into the respective measurement volume (object size approx. up to a component volume of 200 mm x 200 mm x 200 mm). The rotary table is controlled by the scan software and automatically moves to the angular positions defined by the user.

Full automation is implemented by adapting the scanner to an industrial robot that acts as the positioning system. In this case, the measured object is digitized fully automatically: Once the positions have been programmed, the robot traverses them one after the other and initiates a measurement at each position. Offline programming is also possible here.

5. Site-independent measurements without costly clamping systems

As the measuring systems are highly portable, the test equipment will go to the object, if necessary. They are usually not restricted to a measuring room so that you can use the system wherever you need it and thus act independently of site or department.

If your objects have sufficient inherent stability, you need no clamping equipment.

HOW QUICKLY ARE THE MEASUREMENT RESULTS TYPICALLY AVAILABLE?

As the computers available today are very powerful, the scan data can usually be acquired very quickly. The scan time itself depends largely on the object and on the object features you want to evaluate later. In other words, how many single scans are necessary to digitize the object? A single scan takes between 2 and 5 seconds, depending on the contrast of the surface. Provided that the measurement sequence on the evaluation side has been programmed once, the evaluation of the features and the generation of the report are completed in a matter of minutes.

WHAT QUALITY AND ACCURACY CAN BE EXPECTED?

The results delivered by high-quality digitizing systems today are definitely comparable with those of conventional CMMs. Digitizing systems are thus the ideal complement to classical tactile measuring machines. For optical measurement systems, accuracies are determined using a standardized VDI Test (VDI 2634 Sheet 3), which basically follows the acceptance routines applied in tactile measurement technology. Here the sphere distance deviation and other characteristics are determined. High-end systems may well achieve values in the single-digit μ range.

WHAT APPLICATION POSSIBILITIES ARE THERE?

The application possibilities are very versatile. The classical use case is the nominal-actual comparison via CAD in quality assurance. However, after the introduction of these systems, it often happens that very soon completely new use cases arise, which may be highly company-specific, but involve a very high specific benefit and result in an extremely rapid ROI.

Overview of the application areas:

- **Quality testing / inspection:**
 - Actual-nominal comparison of the measured data to the CAD data set
 - Measurement of dimensions and edges/boundaries (e.g. when measuring sheet metal parts)
 - Serial testing in production (manually/automated)
- **Mould and tool making:**
 - Tool reconstruction
 - Creation of scan data for generating milling paths
 - Acquisition of actual status after release of the tool
 - Wear test after “x” cycles
- **Design:**
 - Scanning of design models in the form finding process as interface to CAD
 - Generation of milling paths for the creation of scaled models, for example
 - Documentation of the design steps
- **Rapid Manufacturing:**
 - 3D data acquisition for Rapid Prototyping
 - Actual/nominal data comparison
- **Reverse Engineering**
 - Generation of CAD data from scanned STL models
- **Other Applications**
 - Scanning of art/historical objects
 - Archaeology
 - Medical-technical applications, e.g. skin scanning

WHERE ARE THE LIMITS OF THE SYSTEMS AND HOW CAN THEY BE AVOIDED?

Fringe projection is a contrast-based measurement method. This principle will only work if the surface of the measured object “cooperates”. This means that it has to be possible to represent the fringe pattern on the surface in such a way that it is visible to the camera(s) (light fringe - dark fringe - and so on). You come up against the limits whenever the object surface does not support this, e.g. reflecting (polished steel) or transparent surfaces (glass). Very dark (and slightly glossy) surfaces also tend to make the digitizing process a bit more difficult. If the adjustment functionality provided by the system's settings is not sufficient any longer, you can solve the problem by applying an artificial, ideal contrast: white chalk spray.

There are different kinds of suitable sprays that are applied in coating thicknesses of a few μm . Once the measurement is complete, you simply blow or wipe off the spray.

Volatile sprays have meanwhile also become widely used. They dissolve without residues after about 24 hours. If the specified measuring tolerance permits (the measurement is performed on the sprayed coat!), it is a proved means allowing the optical measurement even of uncooperative surfaces.

A second limitation is shadowing. Wherever the fringes cannot be projected due to the specific geometry of the object (strong undercuts, etc.), no scans can be performed. The following rule of thumb will work in most cases: Everything the eye can see can normally be digitized.

WHAT DOES A REAL-WORLD EXAMPLE FROM ZEISS OPTOTECHNIK LOOK LIKE?

Application: Reverse Engineering

Industry: Consumer Goods

TASK:

The company has a long tradition in the manufacture of hunting rifles and is committed to providing products of the highest quality and precision. For the 3D inspection of handmade stocks featuring complex free-form surfaces, the company was looking for a high-accuracy optical measuring system for digitizing and reverse engineering to a CAD model.

SOLUTION:

Using a suitable optical sensor in combination with a rotary table for the automatic positioning of the stock, 3D digitizing takes only a few work steps. The subsequent quality control using suitable software allows a quick and accurate comparison of the complex 3D free-form surfaces with the nominal data. New handmade stocks are digitized and a CAD model of each stock is created using reverse engineering software. This model is then used as the basis for the new production.

CUSTOMER BENEFITS:

The tactile 3D coordinate measuring machines previously used by the customer could no longer satisfy the increasing requirements that resulted, in particular, from the growing complexity of free-form surfaces in the new stock models. As the company is committed to offering its customers highest quality and precision, the custom solution was exactly what they had in mind. Added value was also created by the fact that, despite the high performance of the system, the hardware and software were very easy to learn and use.

The complete expertise from 3D scanning to reverse engineering is now in-house, which substantially increases flexibility and reduces response times in quality management and in design.

“With this measuring system, we are faster, more flexible and more efficient than ever before,” says the company’s head of quality management and quality assurance. “Whether it’s reverse engineering or the 3D inspection of complex components, this system offers the optimum solution for us, and allows quick, easy and high-precision quality control.”

Not only the technical aspects were a key factor in the positive purchase decision, but also the ease of learning and use as well as the excellent price-performance ratio.

The company anticipates realizing ROI within three years.

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