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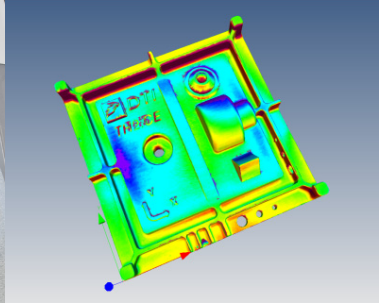
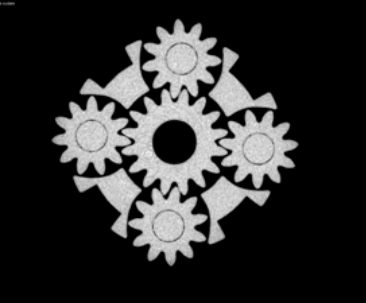
CONFERENCE

Application of CT Scanning in Industry

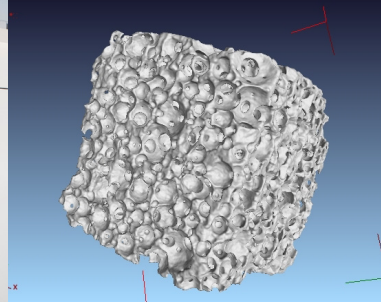
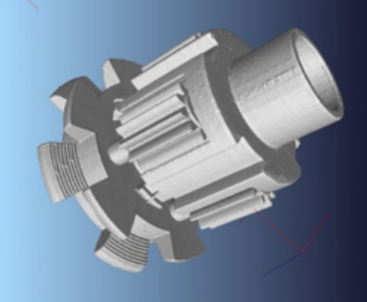
31st May 2011, 08.30-17.00

Danish Technological Institute
Gregersensvej 1, Conference Hall
DK-2630 Taastrup

Danish Technological **Institute**
Measurement and Quality



08.30-09.00	Registration and coffee	
09.00-09.15	Welcome to Danish Technological Institute	Maria Holmberg, DTI, DK
09.15-09.30	Introduction	Prof. Leonardo De Chiffre, DTU, DK
09.30-10.10	Improving the Production using X-Ray Com- puted Tomography - Potentials and Challenges	Prof. Robert Schmitt, RWTH Aachen University, Germany
10.10-10.40	Coffee Break	
10.40-11.00	Measuring micro features with dense point clouds – Scanning with tomography, micro- probes and laser	Detlef Ferger, Werth Messtechnik GmbH, Germany
11.00-11.20	Nano- and Microtomography for materials science	Bart Pauwels, SkyScan, Belgium
11.20-11.40	Industrial Computer Tomography and Precision	Christof Reihart, Volume Graphics GmbH, Germany
11.40-12.00	Automating Analysis	Martin Vester- Christensen / Søren Erbou, Deformalyze ApS, Denmark
12.00-13.00	Lunch	



13.00-13.20	Aspects of traceability of dimensional CT measurements	Dr. Markus Bartscher PTB, Germany
13.20-13.40	International round robin on dimensional computed tomograph	Dr. Simone Carmignato, Padova University, Italy
13.40-14.00	CT Metrology – CT Round Robin	Ph.d. student Jais Angel, DTU, Denmark
14.00-14.30	Coffee break	
14.30-14.50	Image Analysis for Volumetric Industrial Inspection and Interaction	Prof. Ramus Larsen, DTU, Denmark
14.50-15.10	CT scanning strategy: Prediction of image quality	Post Doc Jochen Hiller, DTU, Denmark
15.10-15.40	Influence Parameters in CT scanning	Ph.d. student Pavel Müller, DTU, Denmark
15.40-16.00	Coffee Break	
16.00-16.20	Measurement of micro moulded parts by Computed Tomography	Dr. José A. Y. Fabra, University of Zaragoza, Spain
16.20-16.40	Accuracy in biology	Lars Bager Christensen, DMRI, Denmark
16.40-17.00	Closing and Summary	Maria Holmberg, DTI, Denmark

Published by Teknologisk Institut Måling og Kvalitet Gregersensvej 2630 Taastrup

Editor Maria Holmberg

Layout Susanne Gundlach

Registration for the conference must be done before 12th May 2011 at the link below:

<http://www.dti.dk//30509.1,1>

Everybody is welcome to bring a scientific or technical poster

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TEKNOLOGISK
INSTITUT

"Application of CT Scanning in Industry"

Conference at Danish Technological Institute

31st May 2011, 08.30-17.00

Gregersensvej, Indgang 1

Program

08.30-09.00 Registration (Coffee)

*Putting up
posters etc.*

09.00-09.15 Welcome to Danish Technological Institute

*Maria Holmberg,
DTI, Denmark*

09.15-09.30 Introduction

*Professor
Leonardo De
Chiffre, DTU,
Denmark*

**09.30-10.10
1 Improving the Production using X-Ray Computed Tomography -
Potentials and Challenges**

*Professor Robert
Schmitt, RWTH
Aachen
University,
Germany*

X-Ray Computed Tomography (CT) is a non-destructive imaging technology. By means of CT an object can be acquired holistically including exterior and interior features, which are inaccessible for tactile or optical sensors without destroying the part. From the images taken at various angles the object can be reconstructed volumetrically at very high point density, i.e. providing a geometric model in 3 spatial dimensions plus the material density. Thus, in the recent years the X-Ray Computed Tomography has become interesting for production metrology. The volumetric model can then be used for dimensional measurement, non-destructive material testing and assembly control making CT a versatile inspection technology. Using a CT scanner as coordinate measuring machine requires that different tasks have to be addressed, e.g. the estimation of an uncertainty in measurement, the traceability to the national standard of length, the capability of the measurement process. To achieve the high accuracy of actual tactile coordinate measuring machines the CT has to be improved regarding the hard- and software of a CT scanner. The presentation outlines the state of the art for CT in industrial application describing potentials and current challenges. Areas in need of improvement are identified and approaches are presented which will enable the CT not only to be a mean for checking the object specification but providing detailed feedback to improve the production process.

10.10-10.40 Coffee Break

**10.40-11.00
2 Measuring micro features with dense point clouds – Scanning with
tomography, microprobes and laser**

*Detlef Ferger,
Werth
Messtechnik
GmbH, Germany*

During the last years modern sensors like computer tomography (CT) and tactile-optical sensors have been integrated into coordinate measuring machines. The presentation gives an overview of the available sensor technology and shows the achievable accuracy of CT by comparing the results to measurements of a traceable tactile-optical sensor. Especially dimensional measurements of multiple points on micro features will be addressed. This includes measurements on teeth implants and scanning of micro gears. Furthermore injection nozzles of common rail systems for automotive applications were analysed.

It will be shown that modern CT systems with highest structural resolution have an immense accuracy. Even better results on micro features will be achieved by raster tomography or region of interest CT, which will also be explained. Due to the physical principle of X-ray computer tomography, methods for the compensation of remaining systematic errors are very important too. Methods to compensate these errors, like Werth AutoCorrection or Helix CT, will also be discussed.



11.00-11.20 **Nano- and Micro-tomography for materials science**

*Bart Pauwels,
SkyScan, Belgien*

3 Micro- and Nano-computed tomography (micro-CT/nano-CT) is a very powerful technique to visualize and measure the internal microstructure of different types of material, both biological as non-biological, in a non-destructive way. This talk will focus on the use of micro-CT and nano-CT in materials science. Some examples, where micro-CT has an added value and gives new insights in materials and processes, will be discussed. These examples range from materials and devices for biomedical applications (e.g. scaffolds, implants ...) over art to the study of sample rocks for oil exploration.

The result of a micro-CT reconstruction is a set of thin, virtual slices through the object and opens a unique possibility for the numerical analysis of the object's internal microstructure. 3D analysis software allows extracting these numerical characteristics, such as internal porosity, size distribution for pores or grains, orientation analysis, surface/volume ratio, etc.

Programs for realistic visualization show the reconstructed microstructure as a realistic 3D object on the screen. Dependent on the task, surface or volume rendering can be used. In both cases realistic visualization includes possibilities for virtual sectioning, viewing to the object from any point including internal positions and creating movies of flights around and inside the object.

Micro-CT doesn't only allow scanning static structures, but can also visualize microstructural changes during loading, tension, cooling, heating, etc. Special object stages can be used for such in-situ experiments. The final information in this case becomes 4-dimensional and reflects the behavior of the object's internal microstructure under the specific external interaction.

11.20-11.40 **Industrial Computer Tomography and Precision**

*Christof Reinhart,
Volume Graphics
GmbH, Germany*

Over the past years Computer Tomography (CT) has become a well recognized tool in metrology. The efforts of national metrology and material research labs, expert committees, the CT manufacturers and software companies have made CT a reliable tool for metrology in many applications. These efforts have made CT these days a technology trusted by a rapidly growing users community.

However often industrial CT - if it is in CT system design or in CT data processing - still does not utilize the know-how generated in CT metrology. In CT data processing e.g. we often experience that binarization by using a global threshold is used as the first step of a complex data processing chain, wasting more precise information actually available in the original CT data.

This presentation will demonstrate how Volume Graphics enhances its CT data analysis tools for different applications by taking advantage of all the information that is available in the original CT image data. It will also show up known limitations of CT imaging that can't be overcome by data processing and therefore limit the "precision" of the analysis results.

11.40-12.00 **Automating Analysis**

*Martin Vester-
Christensen or
Søren Erbou,
Deformalyze
ApS, Denmark*

5 Moving from exploratory to automated analysis of CT-data is a major challenge, especially when dealing with biological tissue. Nonetheless, it is crucial when up scaling to large amounts of data in order to ensure objective measurements as well as for reducing time-consuming manual handling. A complete web-based framework for automated upload, handling, book-keeping and analysis of CT-scanned pig carcasses is presented. The user supplies the raw CT-scans, and after upload production-specific parameters can be set and results for the whole database are returned before finishing the next cup of coffee...

12.00-13.00 **Lunch**

13.00-13.20 **Aspects of traceability of dimensional CT measurements**

*Dr. Markus
Bartscher, PTB,
Germany*

6 Traceability of dimensional measurements is achieved by creating a metrological chain between the SI unit of length - the meter, material standards of different type and specific industrial parts.

This unbroken chain is ideally accomplished by measurements with a known and valid measurement uncertainty. But achieving traceability of dimensional measurements is a challenging topic for a complex measurement technique like computed tomography (CT). It requires the - at least empirical - knowledge about all relevant influence factors, about definitions of e.g. reference methods and about processes to assess all these items. The talk will highlight and discuss some aspects of the traceability of dimensional CT measurements. One focus is the reference measurement of the part under study for the case of freeform shapes. Attention has to be directed to the correct probing of these surfaces in the case of tactile measurements and to the correct software processing (actual nominal value comparison) for the reference and the CT data sets. A second topic is the analysis of measurements of a dismountable reference standard with inner geometries and the discussion



of the recent approach of the VDI/VDE draft 2630-2.1 . Finally, the talk will give a short outlook to reference standards for micro CT measurements and their potential benefit for a better traceability of CT measurements.

13.20-13.40 International round robin on dimensional computed tomography

- 7** This work reports the preliminary results obtained from the first international intercomparison of CT systems for dimensional metrology. This comparison, called "CT Audit", has been organized by University of Padova and involves important institutions and companies in Europe, America and Asia, including national metrology institutes, CT systems manufacturers, research institutes, and industrial users. Further information on the intercomparison can be found on the project's website: www.gest.unipd.it/ct-audit.

*Dr. Simone
Carmignato,
Padova University,
Italy*

13.40-14.00 CT Metrology – CT Round Robin

- 8** Inter laboratory comparison of industrial CT scanners for dimensional metrology, organized by DTU Department of Mechanical Engineering and involving 4 institutions and companies in Denmark. The presentation focuses on motivations, objectives and first results.

*Ph.d. student Jais
Angel, DTU,
Denmark*

14.00-14.30 Coffee Break

14.30-14.50 Image Analysis for Volumetric Industrial Inspection and Interaction

- 9** X-ray computed Tomography (CT) allows for industrial inspection of 3D solids. In this presentation I will give examples on how model based image analysis can be used to derive relevant properties of the 3D solid from recorded CT scans. We will be concerned both with fixed and deformable geometry objects. Moreover, we will touch upon how these images can be used in a image guide interaction with the solid.

*Professor Rasmus
Larsen, DTU,
Denmark*

14.50-15.10 CT scanning strategy: Prediction of image quality

- 10** The range of objects inspected by means of industrial computed tomography (CT) scanners usually much differ in size, form, and material. In comparison to medical CT in industrial CT it is often difficult to assure the optimal scanning parameters to achieve the highest performance level of the system for a given set of boundary conditions (physical and technical limits of the CT system, magnification factor, scanning time etc.).

As a consequence the influence of the operator on the result is very high. In this talk, a semi-empirical method for optimal object-specific CT scanning is discussed.

*Post Doc Jochen
Hiller, DTU,
Denmark*

15.10-15.30 Influence Parameters in CT scanning

- 11** This presentation focuses on CT scanning applications for industrial and metrological purposes, where attention is on the current challenges in CT scanning, i.e. identification of influence factors and their elimination. State of the art of influence factors in CT scanning, a theoretical analysis and an experimental investigation will be presented. In particular, experimental investigations concern methods and techniques to correct and reduce errors and artefacts due to a defined parameter, both as they are realized in literature and performed by the authors.

*Ph.d. student
Pavel Müller, DTU,
Denmark*

15.30-16.00 Coffee Break



16.00-16.20 **Measurement of micro-moulded parts by Computed Tomography**

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Accuracy and time exigencies are getting tighter and tighter in the field of manufacturing engineering and smaller mechanical parts are characterized by smaller tolerances to be verified. The evolution of dimensional metrology has to be capable of meeting these demands. Thereby, apart from the optimization of traditional metrology equipment, new technologies based on new measuring concepts are being developed. One of them is Computed Tomography (CT) metrology using X-rays. This talk focuses on dimensional verification of two micro-injection moulded components, selected from actual industrial productions, using CT metrological tools. In addition to CT scanning, other Coordinate Measuring systems allowing fast measurements suitable for in-line quality control were employed as validation instruments. The experimental work carried out and the analysis of the results provide valuable conclusions about the advantages and drawbacks of using CT metrology in comparison with conventional Coordinate Measuring Systems when these techniques are employed for quality control of micro moulded parts.

*Dr, José A. Yagüe
Fabra, University of
Zaragoza, Spain*

16.20-16.40 **Accuracy in biology**

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Determination of spatial features in biological specimens often suffers from lack of a proper reference. As many features includes assessment of tissue and many tissues are elastic by nature measurements in tissues as meat and fat differ highly from many other industrial materials. The talk will touch upon important topics of some CT-based applications within the meat industry as experienced by DMRI. These topics include mixed voxels, validation with no true reference, thickness of elastic layers and objectivity in assessment of meat, fat and bone.

*Lars Bager
Christensen, DMRI,
Denmark*

16.40-17.00 **Closing and Summary**

*Maria Holmberg,
DTI, Denmark*