58th IWK

Ilmenau Scientific Colloquium
Technische Universität Ilmenau

8 – 12 September 2014

»Shaping the Future by Engineering«

Department of
Mechanical Engineering

TECHNISCHE UNIVERSITÄT
ILMENAU

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Dear Conference Participants!

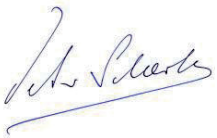
We are delighted to welcome you to Technische Universität Ilmenau for the 58th Ilmenau Scientific Colloquium (58. Ilmenauer Wissenschaftliches Kolloquium, IWK). The IWK looks back on almost 60 years of tradition in exchanging scientific ideas and bridging disciplines. In 2014, the Ilmenau Scientific Colloquium is again organised by the Department of Mechanical Engineering. The title of this year's conference:

"Shaping the Future by Engineering"

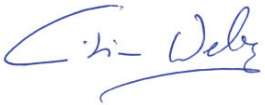
points out that in our modern world technology and its creation by engineering is probably the most dominant driver in shaping the future of mankind – posing a great responsibility on engineers as the main actors. The Colloquium, complemented by workshops, is characterised by the following topics, but not narrowly limited to them:

- Precision Engineering and Precision Measurement Technology
- Mechatronics, Biomechatronics and Mechanism Technology
- Systems Technology.

The topics are those facets of Mechanical Engineering in which our own Department strives to excel, as a centre of both research and teaching. They are also part of the dedicated research strategy which Technische Universität Ilmenau as a whole has successfully defined as a strategic guideline. As always in the long series of IWK conferences, we have invited and encouraged contributions both from academia and industry. We are delighted with the response: After careful international reviewing, more than 200 contributions remain for presentation, representing 15 contributing countries. The range of subjects certainly reflects the interdisciplinary nature of the conference topics and will bring together industrialists and scientists from a variety of disciplines. The discussions during the IWK will doubtless be both wide and deep, both exciting and exhaustive, providing the material, we are sure, for further publications in the various respective subject-related journals. No matter whether you are an experienced professional or a novice in mechanical engineering – we are convinced that the 58th Ilmenau Scientific Colloquium will be of benefit to you. Besides a fruitful and interesting professional exchange of views, we wish you an enjoyable stay in the town of Ilmenau and its surroundings. Among other things, the town has close connections to Johann Wolfgang von Goethe who already 200 years ago appreciated its beauty and came back many times, both on business and for pleasure. Perhaps the 58th IWK will inspire you to follow in his footsteps!



Professor Peter Scharff
President of the Technische Universität Ilmenau



Professor Christian Weber
Dean of the Department of Mechanical Engineering

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Room / Date	010	012	129	HU-HS	202	204	210	211/212	EAZ/ 1341/42 (FASP)	Arrhenius-bau – Room 124	117 (Ward-robe)	Foyer Humboldtbau
Monday, 08.09.14 1:00 p.m.-3:00 p.m.	**Audimax - Opening Ceremony and Plenary Lecture** (Prof. L. Blessing, Université du Luxembourg)											Conference Office Installation Companies
3:00 p.m.-5:30 p.m.	Outside of Humboldtbau: **Welcome Reception for all speakers, participants and guests**											
Tuesday, 09.09.14 9:00 a.m.-12:00 noon		2.3	1.3	3.3	2.1	3.1	1.4	1.1				Conference Office Visits of Expositions
12:00 noon-1:30 p.m.	**Poster Session**											
1:30 p.m-4:30 p.m.			1.3	3.3	2.1	3.1	1.4	1.1				Conference Office Visits of Expositions
8:00 p.m.	Ilmenau's Festival Hall: **Academic Gala Concert**											
Wednesday, 10.09.14 9:00 a.m.-9:45 a.m.	**Audimax - Invited Lecture** (Prof. K.-D. Sommer, PTB Braunschweig)											Conference Office Visits of Expositions
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12:45 p.m.-1:40 p.m.	Start from the Humboldtbau: **Scientific guided tours** (any one time)											
1:45 p.m.	Start from the Mensa (Refectory): **Excursion to Weimar** (World Heritage)											
8:00 p.m.-11:00 p.m.	"Hotel Tanne" Ilmenau: **Banquet**											
Thursday, 11.09.14 9:00 a.m.-12:00 noon			2.2	3.3		WS2		1.2	WS2 (10:40-12:00)	HVG		Conference Office Visits of Expositions
1:30 p.m.-4:30 p.m.			2.2			WS2		1.2		HVG		
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Friday, 12.09.14 9:00 a.m.-12:00 noon			TKM-WS									Conference Office Removal Companies
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Legend	Sessions of the 58th IWK	Accompanying Programme of the 58th IWK									Further Events/Workshops	

- Workshop WS1 – Living Glass Surfaces
- Workshop WS2 – Virtual Engineering throughout the Product Life-Cycle
- Workshop WS3 – Design Science and Biomimetics (Bionics) – State and Perspectives
- Workshop WS4 – Thermal issues in dimensional metrology – the EMRP - project T3D
- HVG - Projektbeirat "Reinigung von Glas"
- Workshop TKM – 13. Ilmenauer Telekommunikations-Manager-Workshop

Registration/Conference Office

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Opening hours/ Registration

Monday, 08.09.14	8:00 p.m. – 3:30 p.m.
Tuesday, 09.09.14	8:00 a.m. – 8:00 p.m.
Wednesday, 10.09.14	8:00 a.m. – 1:00 p.m.
Thursday, 11.09.14	8:00 a.m. – 8:00 p.m.
Friday, 12.09.14	8:00 a.m. – 4:00 p.m.

General Information

Catering/WLAN-Access/Parking

Coffee break Refreshments

At the colloquium, refreshments will be offered during the coffee breaks in the foyer of the conference building.

Meals and Refreshments

All participants may take advantage of the catering service in the Mensa (refectory) of the university. You can get there within a few walking minutes from the conference building.

The cafeteria "MINI" at the Humboldtbau also provides meals and beverages on a limited scale. Opening hours: 8:00 a.m. – 3:00 p.m.

WLAN-Access

Throughout the 58th IWK in all lecture rooms WLAN is available.

SSID: TUI-Guest

You will be redirected to
https://beaker.net.tu-ilmenau.de/login.html

Login: **intcoll2014** Password: **collpass**

Free Parking

On the campus, the signposting system will help you find the way to the conference building (Humboldtbau) easily.

We have reserved for you the parking space right behind the building "Arrhenius" near the conference building. From there, you can reach the Conference building – (Humboldtbau) on foot within a few minutes.

Conference Programme

Opening Ceremony

Monday, 08.09.14, 1:00 p.m. – 3:00 p.m./ Audimax	Musical opening by Gabriel Gatzsche, Member of the Fraunhofer Institute for Digital Media Technnology (IDMT), Ilmenau and Markus Mehnert, CTO of IOSONO GmbH Erfurt.
Moderation:	Professor Stefan Sinzinger, Member of the Organising Committee
1:10 p.m.	**The participants will be welcomed by** - Professor Peter Scharff President, Technische Universität Ilmenau - Professor Christian Weber Dean, Department of Mechanical Engineering - Uwe Höhn Minister of the Thuringian Ministry for Industry, Employment and Technology Musical interlude
ca. 2:00 p.m.	**Plenary Lecture "Transdisciplinary Design"** Professor Lucienne Blessing, Université du Luxembourg, Faculty of Science, Technology and Communication
3:00 p.m.	End of Opening Ceremony and Plenary (Afterwards Welcome Reception)

Invited Lecture

Time: Wednesday, 10.09.2014
Location: Humboldtbau, Audimax

9:00 a.m.	**Invited Lecture** K.-D. Sommer (D-Braunschweig)

Accepting the future measurement challengens

The foreseeable development of measurement and metrology is an indispensible part of the general development of cutting-edge technology. It is strongly like with both, the future development of cyber-based production and process technology, i. e. the implementation of the so-called „Industrie 4.0 Concept“ also named the Internet of Things and on the other hand.

With the reliable responses to the also known as Big-Picture-Issues, which namely include the areas of sustainable energy supply and use, environmental protection, health care, the impact of the global trade, reliable food and nutrition supply, safety and security, developing individual mobility and global trade. The innovation and development of technologies themselves, such as, for example, nanotechnologies, IT and cyber-physical solutions, as well as mastering both complex cyber-physical productions and widely or even globally distributed facilitating systems are both: part of the solution and a great challenge.

Environmental protection as well as the possible automatic care and health care of elder people might require the measurement of completely new measurands exceeding our existing SI System. As an example categories like wellbeing, comfort or the opposite might be mentioned; meaning we have to exceed the SI once day to a set of „soft units“.
There is another point: To an increasing extend, measurement results will be the result of fusing of many individual results. As examples one may state both the weather forecast and civil or military exploring systems.

All these examples may serve for a more secure and more efficient economy and civil society. But on the other hand, measurement has to take care, that measurement as part of information science will not overdo its technological potentials.

The paper will present numerous examples of the potential new world of measurement and metrology.

9:45 - 10:00 a.m. Coffee break and Visits of Expositions

Topic 1:

Precision Engineering and Precision Measurement Technology

Session 1.1 Nanopositioning and Nanomeasuring Machines
Session 1.2 Measurement and Sensor Technology
Session 1.3 Precision Engineering and Optics
Session 1.4 Image Processing and Quality Assurance

Session 1.1 Nanopositioning and Nanomeasuring Technology

Time: Tuesday, 09.09.2014
Location: Humboldtbau, Lecture Room 211/212
Chairman: E. Manske (D-Ilmenau)

9:00 a.m.	**Invited Lecture** H. Bosse, B. Bodermann, G. Dai, J. Flügge, C. G. Frase, W. Häßler-Grohne, P. Köchert, R. Köning, Chr. Weichert (D-Braunschweig)

Challenges in nanometrology: high precision measurement of position and size

The precise measurement of the position of an object to be measured or machined is a basic task in precision engineering and nanotechnology. This contribution describes recent developments of the PTB in high precision position and size metrology as support for different nanotechnology applications. For high precision measurement of the position of line graduations, the PTB has developed the Nanometer Comparator, a 1D displacement comparator based on vacuum interferometry. Examples of the latest measurement performance are given. For instance, measurements of the positions of line graduations on 152 mm (6'') photomasks can be made with an uncertainty of U95% = 2 nm over 140 mm and measurements on high quality 1D incremental length encoders can be performed with an uncertainty of U95% = $[(1\ \text{nm})^2 + (2 \cdot 10\text{-}9 \cdot l)^2]1/2$. The Nanometer comparator has been upgraded by integration of a new object carriage and a special straightness interferometer to also allow straightness measurements e.g. on photomasks carrying cross mark graduations or length encoders carrying additional straightness graduations (1.5D encoders). Details of these developments as well as improvements in the drive system of the Nanometer Comparator will be described. Another application of precision optical interferometry is its use in a combined optical and x-ray interferometer, made of 28Si material in order to calibrate the 28Si lattice parameter with an uncertainty of $2 \cdot 10\text{-}9$. This experiment is part of a set of different precision experiments, which should allow to determine the Avogadro constant NA with an uncertainty below $2 \cdot 10\text{-}8$. The measurement of the size of nanoscale features has additional challenges, because in addition to the length metric, also the location of opposite feature edges has to be precisely determined. These bidirectional measurands, such as the width of a line (critical dimension, CD) need a suitable physical modeling of the sensor signal, which is used for location of the feature edges. A recent development of the PTB to use transmission electron microscopy in the traceability chain of AFM CD measurements will be described. The uncertainty achieved for CD measurements on high quality Si line structures is U95% = 1.6 nm.

9:30 a.m.	Kuang-Chao Fan, Hung-Yu Wang, Shih-Hsin Hsu (TW-Taipei); Hao Zhou (TW-Hefei)

Self-volumetric error compensation of a developed Micro-CMM

With the continuing trend toward device miniaturization in many engineering and scientific fields, the need for highly-precise measurements at the micro- or nanoscale has emerged as a critical concern. The development of micro-CMMs (or called nano-CMM, micro/nano-CMM in different names) has become a trend in the world to measure 3D features of micro objects.

However, the performance of a high-precision micro-CMM is extremely sensitive to the effects of volumetric accuracy. The volumetric error has to be compensated.
The volumetric accuracy of a micro-CMM depends on numerous factors, including geometric errors, motion induced errors, deformations of structural members and thermally induced errors. Therefore, the basic design concept of Micro-CMM is to meet the requirements of high stiffness, force balance, thermal balance, Abbe principle, metrology frame and vibration-free. Based on these criteria, the developed Micro-CMM consists of a bridge frame of pagoda shape for high stiffness and force balance, a co-planar stage with multi-degree-of-freedom measurement system (MDFMS) to conform to the Abbe principle, a Z-ram of coaxial counterweight design and a contact scanning probe.
In the co-planar stage, two long reflection mirrors are mounted on the moving table to reflect the laser beam from each axis. The shape error of the reflection mirror affects the measurement result when nano-scale positioning is demanding. A MDFMS, including one linear and two angular motions measurement, is designed for each axis. The linear measurement is based on the Michelson interferometer, while the angular measurement is based on the dual-axis autocollimator. This 6-DOF capability can measure the positioning error, straightness error, squareness error and angular errors of the X and Y motions. In addition, the shape error of the mirror can also be separated by using two MDFMS. In the Z-stage, the displacement is measured by a developed grating interferometer. The Abbe offset can be found by experimental procedure. Therefore, the volumetric error of the micro-CMM can be analyzed and compensated in real-time during the probe measurement in the working space. Experimental tests show that the accuracy of 3D measured results can be significantly enhanced.

9:50 a.m.	N. Vorbringer-Dorozhovets, R. Füßl, E. Manske (D-Ilmenau)

Application of the metrological SPM for long distance measurements

Current trends in micro-, nanotechnology and precision engineering demand scanning probe microscopy (SPM) measurement at ever larger distances as well as with ever higher resolutions and accuracies. The nanopositioning and nanomeasuring (NPM) machine developed at the Ilmenau University of Technology with a measuring range of 25 mm × 25 mm × 5 mm and subnanometre resolution constitute an excellent scanning stage for such SPM measurements. This research deals with the challenges of scans over a range of several millimeters performed by the NPM machine in combination with the metrological SPM-head. Examples for such long distance measurements are topography scans over several millimeters for investigation of structure transformation or for determination of the nanoscale roughness of surface profile. Whereupon the tip size of the cantilever and its alteration affect the measurement result. Another challenge is the pitch determination of glass scale over a range of 20 mm. Usually the average pitch value can be traceable measured with very high accuracy using optical diffractometry. Besides the mean pitch, the SPM technique allows the determination of local pitch variation and uniformity. The NPM machine and metrological SPM-head were applied before for measurement of pitch standards over a range of 1 mm where excellent results are achieved.

10:10 a.m.	A. Müller, R. Mastylo, N. Vorbringer-Dorozhovets, E. Manske (D-Ilmenau)

Markers for referencing topography measurement data of optical surfaces

Topography measurements of optical systems are done with various methods, each of it using its own data grid, point of origin or even coordinate system. Fitting procedures and interpolations are implicitly needed to enable the comparisons of measurements.
In this paper we describe the development and the production of a series of marker structures for a more direct way of alignment and position reference of optical surfaces measurement data. By implementing the markers, the capabilities of 'scanning lithography' were demonstrated, using the nanopositioning and nanomeasuring machine NMM1 for providing the precise lateral and height position control of the sample, while a focused exposure laser beam was coupled and collimated into the surface scanning focus probe. After having successfully applied markers to the surface, the qualities of the shapes have been inspected.

10:30 - 10:40 a.m. Coffee break and Visits of Expositions

10:40 a.m.	E. Manske, R. Füßl, R. Mastylo, N. Vorbringer-Dorozhovets, O. Birli, G. Jäger (D-Ilmenau)

Ongoing trends in precision metrology, particularly in nanopositioning and nanomeasuring technology

Continuing engineering progress in precision fabrication technologies, especially in the diversified micro- and nanotechnology, stimulates the advance in precision metrology, particularly in nanopositioning and nanomeasuring technology. Structures reach atomic dimensions, thus becoming more and more complex. Consequently, measurements are made – to an increasing extend - of larger surface regions and sidewalls with higher aspect ratios as well as fully 3D micro- and nano-structures. Therefore, the resolution of nanomeasuring machines approaches the picometre level and the frequency stability of the laser sources is increased to the range of 10-10 to provide multiscale accuracy. Area-measuring optical sensors provide fast amount of data (> 5 Tbyte). Lateral highly resolved measurements are only possible by tip-based AFM single point probes but are extremely time consuming. Here, adaptive intelligent algorithms for optimum hierarchical measurement strategies are necessary. Multisenor instrumentation and multiparameter characterization provide additional challenges also in profoundly parallel data processing. Newest achievements at the Competence Centre "Nanopositioning and Nanomeasuring Machine" as the successor of the Collaborative Research Centre SFB 622 are demonstrated, and ongoing research activities are presented.

11:00 a.m.	P. Köchert, C. Weichert, J. Flügge (D-Braunschweig); J. Wurmus, E. Manske (D-Ilmenau)

Digital beat frequency control of an offset-locked laser system

A digital control system for two coupled laser cavities was developed to generate two lasers beams those frequencies differ by an adjustable beat frequency, which is required for heterodyne interferometer applications.

The proposed digital control is supported by a field programmable gate array enabling a high grade of flexibility and requires only a digital input and single analog output channel. Measurement results demonstrated that the beat frequency could be stabilized over an integration time of 1 s with an Allan deviation of 8.6 Hz. In addition, the dynamic behavior of the closed-loop control system was verified by investigating the step response. It was possible to change the beat frequency by a value of 7.5 MHz in about 250 ms.

11:20 a.m.	S. Hesse, C. Schaeffel, S. Zschaeck, C. Amend, A. Müller, E. Manske (D-Ilmenau)

Scan performance of nanopositioning systems with large travel range

This work investigates and compares the scan performance of two different design types of NPM/NMM. Diverse design principles lead to different mechanical setups and thus to completely different requirements for the implemented position control system. The first system is a 2D fine positioning stage which is supported by ball bearing guides in a serial arrangement. It provides a travel range of 200 x 200 mm2 and the axes are driven symmetrically by linear direct drives. The drive system carries a Zerodur corner cube as reflector for the 2D plane mirror laserinterferometer system. On the other hand there is a demonstrator for a 3D planar direct drive with circular travel range of Ø100 mm. The moving slider is supported on 3 air bearings, providing a virtually frictionless planar guiding of the slider. The drive system is an integrated direct drive which actuates the slider in x-, y- and φz. The slider is made of Zerodur and has reflectors for the 3D-laserinterferometer system directly bonded to it.
The scan measurements were carried out in x- and y-direction with velocities from 1 μm/s to 10 mm/s. The results of these investigations show that both systems can provide scanning motions with nanometer precision. For scanning speeds up to 1 mm/s both systems achieve tracking errors of less than 1 nm together with velocity errors of less than 1 μm/s. Significant differences can be seen at velocities from 1 mm/s on. The air guided positioning system shows excellent dynamic behavior which arises from the elimination of disturbances (especially friction effects), the high system stiffness and bandwidth and a corresponding control design. At the roller guided system on the other hand a sophisticated friction modeling and the implementation of the friction model in the advanced control algorithm provide the basis for the superb scanning accuracy.

11:40 a.m.	K. Zimmermann, B. Fiedler, E. Gerlach, I. Husung, I. Zeidis, , R. Füßl, E. Manske, R. Theska (D-Ilmenau), T. Hausotte (D-Erlangen)

Positioning with nanometre precision requires a high tech Nanopositioning and Nanomeasuring Machine (NPMM) and an optimal machine setup

The paper deals with an optimal setup of high precision machines, working in nanometre dimensions. On the example of the Nanopositioning and Nanomeasuring Machine (NPM Machine), developed at the Technische Universität Ilmenau, the problems of active and passive vibro-isolation are discussed.

In the focus of investigations are the vibrations, induced from the environment to the machine, as they may affect the working accuracy of the machine. Thus, an exemplary hook up for a working NPM Machine is presented. The results of measurements of the vibration velocity vs. time are introduced and discussed for selected measuring points from ground to the top of the machine. The opportunity of theoretical analysis, using numerical methods, is shown. Prospects of further estimations are given, including more detailed analysis and analytical analysis.

12:00 noon – 1:30 p.m. Lunch and Visits of Expositions
12:00 noon – 1:30 p.m. Poster Session

Session 1.1 Nanopositioning and Nanomeasuring Technology

Time: Tuesday, 09.09.2014
Location: Humboldtbau, Lecture Room 211/212
Chairman: A. Yacoot (UK-Middlesex)

1:30 p.m.	**Invited Lecture** D. Imkamp (D-Oberkochen); A. Gabbia (D-Düsseldorf)

Challenges and Trends in Manufacturing Metrology – VDI/VDE Roadmap

'Faster, safer, more accurately and more flexibly' is the title of the 'Manufacturing metrology roadmap' issued by the VDI/VDE (The Association of German Engineers and Association for Electrical, Electronic & Information Technologies) Society for Measurement and Automatic Control published in 2011. The document presents a view of the development of metrology for industrial production until 2020 and was drawn up by a German group of experts from research and industry. 3 years after the publication the expert team meets again for reviewing the roadmap and decides to update it. The paper summarizes the content of the roadmap and the scheduled update. Under the impact of global megatrends manufacturing technology is faced with a number of different challenges. The topics of resource efficiency, of mastering new process technologies, of increasing flexibility and of transparency have a special importance in manufacturing today. These topics are not changed significantly within the last years. Nevertheless new slogans appear to describe changes in manufacturing technology. The most important one especially in Germany is 'Industry 4.0'. It is a project of the high-tech strategy of the German government, which promotes the computerization of traditional industries such as manufacturing. Its impact on manufacturing metrology was already a topic of several publications. Information from metrology will be transferred and presented differently. The availability of metrological information within digital networks may increase transparency of manufacturing processes. But the computerized availability requires appropriated techniques to present and process the information data. Metrology itself will not be influenced directly. The challenges and trends in manufacturing metrology caused by trends in manufacturing are described with the terms 'fast', 'accurate', 'safe' and 'flexible' in the original roadmap. Additionally holistic techniques like computer tomography and three-dimensional optical methods become more important and justify a separate term.

2:00 p.m.	C. Weichert, P. Köchert, R. Köning, J. Flügge (D-Braunschweig)

Stability of a fully fibre-coupled interferometer

The long-time stability of interferometer can be increased by separating heat sources using optical fibres. But the use of multimode fibres to transfer the superposed beams to the detectors can also increase the measured phase variations. A Mach-Zehnder setup, which represents a minimized realization of a heterodyne interferometer with spatially separated input beams, was used to analyse the noise limitations of interferometer and the influence of multimode fibres. The resolution was measured and calculated for different beat frequencies and receivers. According to the used beat frequency the noise is dominated by either the shot noise and amplifier noise or the laser intensity noise.

The minimal standard deviation of 4.8 pm over 60 s was achieved both with and without the use of fibres. In case of long-time measurements the position variations were observed to be ±20 pm, which were introduced by the fibres. Their disturbing influence was increased by stimulating mode conversion.

2:20 p.m.	Yung-Cheng Wang, Lih-Horng Shuyu, Chung-Ping Chang (TW-Yunlin); E. Manske (D-Ilmenau)

Signal interpolation method for quadrature phase-shifted Fabry-Perot Interferometer

This manuscript reports about the signal processing method for the quadrature phase-shifted Fabry-Perot interferometer (QFPI). In this research, the analysis and testing of QFPI have been demonstrated. And the signal processing and optimal parameters of different situation are investigated in this paper. By this signal processing and analysis, the interpolation error of QFPI can be reducing by 85%, comparing with conventional signal processing.

2:40 p.m.	S. Strube, G. Molnar, H.-U. Danzebrink (D-Braunschweig)

Field programmable gate array based digital lock-in amplifier for highest resolution heterodyne interferometer

In this work the electronics for a highest resolution heterodyne interferometer is presented. It comprises an analog front-end, a high speed dual channel analog-to-digital converter and a field programmable gate array for high speed, low latency signal processing. The gate array contains a system on chip (formulated in a hardware description language), consisting of the main processing block (lock-in algorithm) combined with a 32 Bit CPU and additional periphery controllers. Output data is streamed over a high speed serial bus, USB2 or a fiber link. For different uses the firmware and the main processing block may be substituted, while the rest of the system (hardware & software) may remain the same. The underlying electronic-platform and evaluation concept is very versatile and can be used for many different interferometric (homodyne and heterodyne alike) concepts or completely different signal acquisition tasks.

3:00 – 3:10 p.m. Coffee break and Visits of Expositions

3:10 p.m.	M. Schake, M. Schulz, P. Lehmann (D-Kassel)

High-resolution fiber-coupled interferometric point sensor for micro- and nanometrology

The determination of surface roughness is a common challenge in industrial quality assurance. Modern industrial processes involving the fabrication of products which feature complex surface geometry and small tolerances require precise, process integrated measurement technology. Examples for the scope of applications of our sensor are optical lenses for use in cameras or smart phones as well as roughness measurements on surfaces of injection valves for efficient combustion engines.

Because tactile techniques like stylus method or atomic force microscopy run the risk of damaging the measurement object, there is a high demand for contact free optical measurement systems. In our contribution we demonstrate the feasibility of a high resolution fiber-coupled interferometric point sensor with periodical path length modulation to determine the surface profile of rough surfaces. A short introduction concerning the sensor principle and the evaluation of roughness measurements according to ISO standards is given. Measurements on two specimens characterized by different roughness parameters Ra=483 nm and Ra=1650 nm are presented. The surface profiles obtained by measurement with our interferometric point sensor are compared to reference profiles obtained by stylus measurements. Also commonly faced measurement errors, specific to our sensor like phase ambiguity, are discussed. Concerning this issue a technique for the correction of phase jumps using the optical signals modulation depth in combination with two light sources of different wavelength is proposed.

3:30 p.m.	D. Dontsov, W. Pöschel, W. Schott (D-Ilmenau); N. Kukowski, T. Jahr, P. Schindler (D-Jena)

Tidal earth crust deformation measurements

Deformation of the earth crust mainly results from the tidal forces of sun and moon acting on the Earth, but also comes from seismic wave propagation or regional and local sources. Strainmeters allow the observation of crustal deformation with a resolution better than 10-9 m. At the Geodynamic Observatory Moxa in Thuringia/Germany an assembly of strainmeters of different types record the deformation. The analysis of the strainmeter data shows the comparability of the data from the different instruments as well as the good data quality connected to the very low noise level at the Geodynamic Observatory Moxa. The strainmeter systems described in this paper are long range laser interferometers of Michelson type. These interferometers with corner cube reflectors are precision length measurement instruments and coupled by optical fibers . They are specially designed for long range operation under difficult environmental conditions. The interferometers are installed in the Geodynamic Observatory in a gallery dug horizontally intro the adjacent slope. The measuring ranges are 26 and 38 meters. The resolution of the systems is about 1 nm. All interferometers are designed for long-term measurements over several weeks. To minimize the influence of temperature and air pressure changes on the interference fringes due to the dependence of the refractivity index of air on these values, the horizontal borehole for the diagonal 38 m strain is sealed at both ends with a special glass and the 26 m strains use the hermetic metal tubes for the laser beam protection. All data are sampled every 10 s. In addition, inside the gallery several sensor measure variations of temperature, air pressure or humidity. At the laser strainmeter, another air pressure sensor is installed and five temperature sensors are placed at different points along the laser beam. Outside the observatory building, a meteorologic station records environmental parameters.

3:50 p.m.	A. Kelm, R. Boerret, D. Wiedemann (D-Aalen)

Detection of subsurface damage in optical transparent materials using short coherence tomography

This presentation describes the use of short coherence interferometry for the detection of subsurface damage (SSD) in optical transparent materials. The method is based on an interferometer using a light source with a short coherence length. A time domain (TD) and a frequency domain (FD) approach are explained. The OCT method allows a nondestructive measurement of the SSD compared to the state of the art SSD metrology, where the sample is destroyed. Compared to previous results a frequency domain (FD) setup is build up which allows SSD measurements under production environment conditions. The results of the FD set are presented and discussed.

End of Session

N. Hofmann, R. Mastylo, E. Manske, R. Theska (D-Ilmenau)

A compact tactile surface profiler for multi-sensor applications in nano measuring machines

A tactile surface profiler was developed for applications in the nano measuring machine NMM-1. To enable its utilization as part of a multi-sensor concept in an automated sensor changer, a compact design was necessary. The profiler uses a flexure guide made from two circular steel membranes as suspension for the stylus and a focus sensor system to measure its deflection. The profiler was integrated into a NMM-1 to prove its function and investigate its metrological properties. Measurements of different samples showed a reproducibility of few nanometers.

A. N. Ivanov, M. D. Nosova (RU-St. Petersburg)

Use of phase inversion points of the light field for angular displacement measurement

It is offered to use points of a phase inversion of the light field formed by diffraction or interference of light for angular measurements. Inversion points can be used as adjustment marks matching with which can be performed with very high accuracy. For determination of position of inversion point it is possible to use slit, as intensity distribution behind it depends on distance between center of a slit and an inversion point of the light field. If a slit intersects inversion points with different orders, then behind a slit the secondary interference pattern is appeared. It allows make measurements with limiting error no more than 1" in the measurement range 1 angular degree.

St. Mühlig, M. Lotz, J. Siepmann, S. Jung (D-Göttingen);
J. Schindler, G. Baer (D-Stuttgart)

Tilted wave interferometer – improved measurement uncertainty

A novel, promising and highly flexible interferometer is introduced to measure aspheres and freeform surfaces of arbitrary shape with high precision. It is based on a Tywman Green interferometer that uses a huge number of light sources which are all tilted to each other. Therefore, the device discussed in this contribution is called Tilted Wave Interferometer (TWI). The availability of manifold light sources in a Twyman Green interferometer allows to measure aspheres and freeform surfaces in a way that is very close to the nulltest setup for spherical surfaces. The idea is that each of the light sources illuminates a part of the surface under test (SUT) close to a nulltest configuration. In other words, the illuminating rays of the light source are almost perpendicular to a local part of the SUT yielding a low line density of the resulting interferogram. In consequence, each light source allows measuring a local part of the SUT. Therefore, the combination of the interferograms of all light sources enables the measuring of the entire SUT.

The proposed concept of the TWI is very flexible and can be adapted to a wide range of different aspheres and freeform surfaces. Otherwise, the TWI constitutes a very complex optical devise and its calibration is, of course, a non-trivial task. Therefore, the calibration of the TWI is treated in a very abstract manner based on a description of the observed wavefronts. The wavefront of the interferometer of every single light source is decomposed into Zernike polynomials. To determine all unknown coefficients of this description it is important to develop a robust calibration scenario for the TWI based on known SUTs, such as high precision spheres. The contribution discusses in detail the abstract calibration of the TWI and introduces two different calibration scenarios. The first one is based on a calibration of the TWI using a single object whereas the second one uses manifold different objects. The achieved performance of the TWI regarding both calibration scenarios is revealed. Based on performed measurements of representative aspheres, the achieved robustness and accuracy of the calibration scenario is presented and discussed in detail.

M. Lotz, M. Büchner, U. Nehse (D-Göttingen); G. Uhlrich, P. Kühmstedt, S. Schröder, M. Hauptvogel (D-Jena)

Combined optical sensor for 3D geometry and roughness measurement

Manufacturing of function relevant mechanical parts with high surface quality is time and resource intensive and therefore expansive. Thus the optimization of the manufacturing process as well as its control is crucial. The area of function relevant mechanical parts with high surface quality is wide and they are typically grinded. Their behavior is influenced by the micro structure of form and surface of the functional surfaces. A direct integration of 3D geometry and roughness measurement in the manufacturing process is important because it will improve time, energy and resource efficiency significantly. Optical measurement systems have different well known advantages compared to tactile ones. One major advantage is that optical systems are faster and therefore more information about the object to be measured is generated. 3D geometry measurement can be realized using pattern or fringe projection. But today optical roughness measurement is limited to polished surfaces (rms 0.2…30 nm) and uses only 2D scattering profiles. The paper presents a new combined optical sensor which can be used to measure micro structures in areas of 1 x 1 mm^2 up to 10 x 10 mm^2 with highest resolution. It combines a fringe projection 3D geometry sensor with a 3D surface roughness sensor. The main challenge of the realization of the same measurement position is the mechanic size of the sensors: two sensors cannot be arranged exactly at the same position. So the classical geometries of both systems were redesigned. The main novelty of the development was an interlacing of the scattering light sensor and the 3D surface sensor. A new camera module was developed to realize a new compact sensor design. The field of view of both sensors is combined in the same local position to reduce measurement time. Thus it is possible to measure functional surfaces in one setup. The geometrical information is used to improve the measurement accuracy of the scattering light measurement, especially, on curved metallic surfaces. Therefor an alternative approach is presented. The new compact sensor system can be mounted in different orientations. In a first application the sensor was integrated in an optical measuring machine.

A. Yacoot, J. Mountford, M. Tedaldi (UK-Teddington), B. Reid, S. Levy (UK-Devon)

Performance verification of a dual sensor stage

Y. Khoma, B. I. Stadtnyk (UA-Lviv); Th. Fröhlich (D-Ilmenau)

Improvement of metrological characteristics of portable impedance Analyzers

Impedance spectroscopy is a measuring technique which is widely used in various applications, such as electrochemical and bioelectrical analysis, corrosion monitoring, proximity sensing, nondestructive control etc. The measuring devices used for these purposes are called impedance analyzers. In various applications, especially for measurements in non-laboratory conditions, portable impedance analyzers (small-sized and with low power consumption) are required. Most of the existing portable analyzers on the market have low accuracy and only allow measurements in relatively narrow frequency range. Thus it is a topical task to improve their accuracy and to extend their frequency band. When designing impedance analyzers, the complex issue is to ensure the stable metrological characteristics of the measurement channel across a wide frequency and measuring range. The current investigation allowed to develop a novel concept to improve the metrological characteristics of portable analyzers. This concept is based on minimizing the analog part of the impedance analyzers' measuring channel and on compensating for errors using algorithmic correction and digital signal processing. The research includes an analysis of quadrature conversion (the procedure that returns impedance quadrate components – resistance and reactance) based on the algorithm of single-point Fourier transform. Mathematical models of Fourier transform errors caused by harmonic distortion and spectral leakage have been developed and used to improve quadrature conversion precision. The application of auto-balancing circuits as measuring converters have been proven advantageous. This approach allows to reach high accuracy and resolution, good dynamic characteristics, stable current and voltage conditions on the object under test, as well as simple (one-channel) structure of measuring channel, small dimensions, low weight and low power consumption. Formalized mathematical models of active measuring impedance/admittance-to-voltage convertors were developed and used to synthesize the analytical equations for algorithmic correction of measurement results. Applying algorithmic correction allows to eliminate frequency errors and thus to improve the accuracy and extend the frequency range.

O. Ivakhiv, Y. Hirnyak, M. Nakonechnyi, T. Repetylo (UA-Lviv)

Evaluation of system's with neural controller stability

The controllers which are built using classical methods in the process of system operation do not provide full adequacy with controlled values of nonlinear objects. We consider the features of dynamic neural network and the reference mathematical models construction which carried the review of neurons activation functions and feasibility of using gradient algorithms including the Levenberg-Marquardt algorithm for training of dynamic neural networks. Obviously the control action of such dynamic system is corresponded with the difference between output signals of the non-linear object and the chosen reference. On contrary to a typical structure it was proposed to put these signals on two separate inputs. The comparison of obtained errors in traditional and proposed structures of input circuit of neural controller showed that the last one is the most effective in quality and productivity sense. Also the stability of the system supported by neural controller with two separated inputs is discussed.

Session 1.2 Measurement and Sensor Technology

Time: Wednesday, 10.09.2014
Location: Humboldtbau, Lecture Room 211/212
Chairman: K.-D. Sommer (D-Braunschweig)

10:00 a.m.	K. Bärner, W. Morsakov (D-Göttingen, I.V. Medvedeva (RU-Ekaterinburg), K. Irrgang (D-Martinroda)

The thermopower of nickel

The diffusion thermoelectric power (short TEP) of nickel is calculated via the 3d- phonon conductivities in connection with the Boltzmann-Fermi statistics. One obtains several electronic contributions, two of which relate to the sum and the difference of the spin-polarized density of states functions N^+ and N^-. Under an internal ferromagnetic polarisation, two magnetic TEP-contributions appear, one of which relates to the ferromagnetically ordered regime while the other relates to the paramagnetism of the transition metal sample. The results are compared with the experimental absolute Seebeck coefficient (ASC) of nickel.

10:20 a.m.	K. Irrgang (D-Martinroda)

Theoretical analysis of strain effects on SEEBECK coefficient

The absolute Seebeck coefficient of thermocouple wires change due to mechanical strain effects. If the thermocouple wires is not allowed to change its size when subjected to a temperature change because it is embedded in a second material with smaller coefficient of thermal expansion this will change the apparent Seebeck coefficient. At the atomic scale, a temperature gradient causes the electron gas in the material to diffuse from the hot side to the cold side. On the other hand the diffusion is counteracted by the density gradient along the considered thermocouple wire that is caused by the temperature gradient and the thermal expansion. We will give a detailed model of the diffusion equation, the density gradient and a consolidated model of the strain effects on Seebeck coefficient.

10:40 a.m.	R. Volytskyi, B. I. Stadtnyk (UA-Lviv)

Review of the structure and the principle of work of nuclear – quadrupole resonance thermometer

Nuclear quadrupole resonance which was first described in Dehmelt and Krüger's articles in the middle of XX centuries, formed the basis of the nuclear quadrupole resonance thermometer. The essence of the phenomenon of nuclear quadrupole resonance is that, if a substance is placed in an electromagnetic field with a frequency equal to the frequency of the quantum transition of electrons to another energy level in the nuclei of the substance, it will be observed energy absorption of this electromagnetic field. Since it is known that the frequency of the quantum transition between energy levels is a function of temperature of environment in which a substance take place, that has characteristics of nuclear quadrupole resonance, then this effect can be used to measure temperature. In article present the history of development and the structure, and principle of work of nuclear quadrupole resonance thermometer.

11:00 a.m.	J. Garbers, S. Augustin, T. Fröhlich (D-Ilmenau); S. Gehrmann, (D-Stuttgart); K. Irrgang, L. Lippmann (D-Martinroda)

Metrological optimization of thermocouples for exhaust metering

To improve the measurement of the exhaust gas temperature, the influence of the thermocouple geometry was investigated. Different geometries with a tapered tip and two geometries with a radiation shielding were tested. The numerical calculations and the experimental evaluation showed an improvement in steady state accuracy. The possible improvement in temperature value is 31.6 kelvin comparing the standard and the best working thermocouple geometry. The improvement when comparing the tapered thermocouple to the best working shielded geometry is still 21.4 kelvin. In the experimental evaluation, the time dependent behavior was investigated as well. Here the shielded thermocouple is slightly slower than the tapered thermocouple without shield.

11:20 a.m.	S. Marin, M. Hohmann, M. Schalles, G. Krapf, T. Fröhlich (D-Ilmenau)

Insert with a multiple fixes-point cell for a temperature block calibrator

The calibration of temperature sensors is carried out by different principles, depending on the required uncertainty to reach. In laboratories, temperature sensors are calibrated at fixed-points. These are equilibrium states between the pure materials phases and they are reproducible with small uncertainty. In industry, the temperature sensors are mainly calibrated by means of comparison with internal or external reference sensors in thermostats or temperature block calibrators. The former devices are able to reach a lower calibration uncertainty, but in a limited temperature range. The latter devices do not reach as low uncertainties, due to different factors like the axial temperature gradients due to the stem error, but they are cheaper and transportable and their temperature range exceeds 1000°C. To get a device with a lower uncertainty compared to temperature block calibrators but with their properties of handling and temperature range, a new temperature block calibrator was designed at the Institute for Process Measurement and Sensor Technology of the Technische Universität Ilmenau. It works in a temperature range from ambient temperature up to 600°C. This device includes a copper block with high thermal conductivity split into three parts. By means of heat flux sensors between the parts, the heating zones are controlled in a manner, that the axial heat fluxes through the cooper block are zero. Due to Fourier's law of heat conduction, there are no axial temperature gradients in the copper blocks if there are no heat fluxes. Furthermore the new temperature block calibrator has coaxial alignment of the reference sensor and the sensor under test and an adiabatic shield built with exterior heaters to minimize the radial heat fluxes and to improve the homogeneity of the thermal field. With the aim to implement an in-situ-calibration of the reference sensor and a permanent operation of the new temperature block calibrator, one part of the copper block is substitute by a multiple fixed-point cell. The paper shows the thermal design of this cell which was estimated and optimized by means of thermal simulations. Different geometries of the fixed-point cell and arrangements of the fixed-points materials, melting curves and temperature fields are compared.

11:40 a.m.	M. Hohmann, P. Breitkreutz, M. Schalles, T. Fröhlich (D-Ilmenau)

Calibration of heat flux sensors with small heat fluxes

Heat flux sensors (HFS) for heat flux of conductive origin are usually calibrated at calibration benches using the guarded-hot-plate-method. This method requires a known heat flux through the sensor under test, which is usually provided by measuring the temperature difference over a plate with known geometry and thermal conductivity. A new calibration bench was developed at the Institute for Process Measurement and Sensor Technology of the Technische Universität Ilmenau to calibrate HFS with small heat fluxes around zero. The new calibration bench uses the surface temperatures of the HFS to determine the heat flux. The temperatures are determined using a method known from the calibration of contact surface thermometers. By means of thermocouples inside homogenization blocks the surface temperatures of the homogenization blocks, and thereby the surface temperatures of the HFS, are extrapolated. Two heaters are controlled in a manner, that the surface temperatures change from equal values to certain differences. Using these temperature differences and the sensor signal, the offset and the sensitivity of the HFS can be determined.

12:00 noon – 12:45 p.m. Lunch and Visits of Expositions

12:45 – 1:40 p.m. Start Guided Tours

1:45 p.m. Start Excursion to Weimar

Session 1.2 Measurement and Sensor Technology

Time: Thursday, 11.09.2014
Location: Humboldtbau, Lecture Room 211/212
Chairman: W. Holzapfel (D-Kassel)

9:00 a.m.	A. Klein (D-Braunschweig); V. Ebert (D-Darmstadt)

Dual fiber-coupled laser hygrometer for fast in-situ gas analysis with minimized absorption path length

Direct tunable diode laser absorption spectroscopy offers the possibility for highly selective, fast, calibration-free and sensitive in-situ measurements of individual gas components. Minimally invasive fiber-coupled sensors are especially interesting for numerous applications e.g. process or combustion analysis, where compact sensors for applications with limited optical access are required. Especially the sensor development for the gas analysis in internal combustion engines is challenging as harsh environmental conditions and very confined space have to be considered. A new, high-speed laser hygrometer with a fully fiber-coupled, minimally invasive sensor head was developed for localized absorption measurements in space confined applications like in engine diagnostics. The sensor optics has the dimensions of a typical engine spark plug. To allow species measurements at the location of the ignition spark only a few millimeters absorption path are allowed for in-situ measurements. To achieve a high sensitivity one major step in the spectrometer design is an application-specific absorption line selection in order to determine a target line with minimal spectral interference by other gas species. We isolated a well separated H2O absorption line around the 2.6 μm region. The design and development of the fiber-coupled hygrometer is discussed using customized optical components to realize a minimally invasive sensor for harsh environments with a time resolution down to 100 μs. Laser, detector and electronic components are placed in one transceiver unit to be separated from the measurement point to reduce disturbances caused by vibrations as well as distortions of the results by ambient water vapour. A sensor prototype was fabricated and a validation of the spectroscopic, optical and mechanical concept was successfully conducted. An optical resolution of 3•10-3 absorbance was achieved. The sensor enables calibration-free H2O measurements at 10 kHz with a detection limit of 0.06 Vol.-% with a theoretical dynamic range from 0.1 Vol.-% up to 100 Vol.-% at pressures from 0.1 – 0.5 MPa. Further, the uncertainties for water vapor measurements using the dTDLAS were significantly improved by measuring the required molecular parameter with high accuracy.

9:20 a.m.	M. Silinskas, R. Mikuta, E. P. Burte (D-Magdeburg); R. Bourouis, S. Kloos (D-Baden-Baden)

Characterization of non-dispersive infrared gas concentration sensor system for multi gas detection

In this work, we present a low cost multi gas detection system for a simultaneous measurement of up to four kinds of gases. The main conclusions are based on the investigation of CO2 gas concentration, which are also supported by CH4 gas and H2O vapor.

It was found that the continuous heating of the IR source and the absolute values of thermopile voltages are not suitable parameters for the gas detection because of high sensitivity to the influence of temperature and/or gas flow parameters. The sine like signal is preferential for our measurement system. The amplitude of the sine is very stable and is proportional only to the concentration of particular gas (according to the optical filter) and is not dependent on the concentration of other gases or on temperature. In this way, the CO2 gas concentration can be measured from 50 ppm to 400 000 ppm with the same measurement setup. However, the lower detectable concentration of CH4 was about 500 ppm

9:40 a.m.	B. Goj, U. Brokmann, H. Bartsch, E. Rädlein, J. Müller (D-Ilmenau)

Thin-film capable ceramics for humidity and temperature sensoring applications

In this paper we present methods to achieve thin-film capable substrates made of Low Temperature Co-fired Ceramic (LTCC) without grinding or polishing processes. Two planarization methods are explained and discussed. The first is based on a thin sol-gel layer which is dip coated. The second planarization method utilizes a screen printed glass paste to smoothen the surface of the substrate. The emerging advantage of the modified LTCC surfaces is that thin-films like gold can be deposited and structured with small feature sizes and good electric properties. We will demonstrate the benefit of thin-film capable ceramics utilizing an innovative temperature and humidity sensor. The sensor comprises two interdigital capacitors and two resistors which form an AC bridge circuit. Depended on the external temperature and humidity the bridge is detuned and the amplitude and phase of the output voltage is changed.

10:00 a.m.	N. Rogge, M. Engwicht, S. Welsch, F. Hilbrunner, T. Fröhlich (D-Ilmenau)

Hygrostat based on adsorption processes controlled by a high precision chilled dew point mirror

This work is concerned with the calibration of humidity sensors with a hygrostat. The moist air is produced by a hygrostat and measured with a reference sensor. In this work a chilled mirror dew point hygrometer is used, to achieve the necessary absolute accuracy. The used hygrometer developed by ConSens GmbH forces a thermal gradient on the mirror surface with its average temperature corresponds to the dew point temperature. So when the equilibrium is reached, one half of the mirror is bedewed and the other half is dry. This reduces problems with undercooled vapor, which becomes problematical with a lack of condensation nuclei. Also an interpolation can be used to estimate the temperature at the boundary line between dry and bedewed area. Even when this line moves out of the middle of the mirror, the frontier line between the dry and bedewed area can be estimated due to an optical detection system which allows measuring the dew point accurately and continuously even while it is drifting.

10:20 - 10:40 a.m. Coffee break and Visits of Expositions	
10:40 a.m.	V. Ullmann, M. Kühnel, E. Manske (D-Ilmenau)

Interferometrical determination of concentric run-out errors in rotary tables for optical roundness measurement

For high-accuracy roundness measurements of ring gauges it is necessary to know the uncertainty input of the parasite influences to the recorded data. The experience in roundness measurements showed that one of the largest deviations is caused by the concentric run-out error of the utilized rotary table. A novel optical probe head basing on laser interferometers has a measurement resolution up to 20pm to detect a relative change in length. Hence, it is an interesting experiment to use this optical probe head technology for the concentric run-out detection. It is possible to show the accuracy potential in interferometrical form measurements of ring gauges. Therefore, the institute for process measurement and sensor technology developed an optical principle based on established and adapted measurement methods in concentric run-out error detection. The main goal is to increase the reproducibility of the whole measurement system by using the interferometrical sensor technologies for recording a table specific concentric run-out error. After that it is possible to correct the roundness measurement results in the future by subtraction of the recorded data from the roundness measurement data. This publication presents measurement results for the concentric run-out error of a system-integrated rotary table which includes air bearings. The investigations of this table show a maximal concentric run-out error of 537.51nm. It was possible to determine this error with a reproducibility of 31.31nm in maximum.

11:00 a.m.	T. Widmaier, P. Kuosmanen (FI-Aalto); B. Hemming, V.-P. Esala (FI-Espoo); D. Brabandt (D-Karlsruhe)

New material standards for traceability of roundness measurements of large scale rotors

Large rotors are used in different industrial areas. The rotors in the paper and steel industry are called rolls. They are key elements for the steel and paper production, because they are in direct contact with the produced product. Therefore the roundness of the rolls is important for the operation and for the quality of the end product, i.e., paper and board or steel sheets and strips. The rolls are periodically reground and roundness measurements are made throughout the machining process. During the last decades several measurement systems for large rolls of diameter 500 to 2000 mm were developed. Most of the systems can perform roundness measurements and use multiple sensors during the measurement. These multi-point measurement algorithms of the measurement systems are typically based on the three-point roundness measurement algorithm developed by Yasuo Aoki and Shigeo Ozono in Japan in the 1960', the Ozono method. This method can separate the geometry (roundness) of the measured rotor from its movement, which are both seen in the sensor signals. With reliable roundness measurements it is possible to use the measurement results to correct the tool path of the machine tool. To achieve reliable measurement results from a metrological and quality point of view, every measurement should be traceable and every measurement result should be together with an estimation of the measurement uncertainty.

The sizes of the rotors in the steel and paper industry, and thus the measurement range of the measurement devices is much more than the size of the traditional material standards, which are used for calibration of the roundness measurement devices. Therefore, three different material standards in the form of discs with different roundness profiles will be made during this research: type A will be perfectly round, type B with a harmonic profile with 21 UPR wave and type C with multiple waves. They will be measured at least in the laboratories of two national metrological institutes (NMI): MIKES (Finland) and Metrosert (Estonia). The diameter of the discs will be over 500 mm. In the first tests with the disk type C measurement results made with roll geometry devices were compared with the roundness measurements results from MIKES. The analysis of the results made with the roll geometry devices showed that a deviation of the amplitude of the individual waves from the disk was 2.3 μm or less from results of MIKES. The complete uncertainty assessment is still required, but these first results show that the reliable roundness measurements of the large scale rotors in the industry are possible.

11:20 a.m.	N. Dubovikova, C. Karcher, C. Resagk (D-Ilmenau)

Force measurements by strain gauge sensors as part of time-of-flight flow rate control

Contactless techniques are the most promising methods for liquid metal flow rate control and some of these methods are based on electromagnetic induction of breaking force acting on an electrically conductive fluid which is moving through a static magnetic field. Providing flow analysis in case of aggressive and hot liquids is a complicated task, especially when liquid's composition and, hence, its physical properties, are unknown. One of the techniques is time-of-flight Lorentz force velocimetry (LFV). By using the method one can estimate volumetric flow rate without knowing of electrical conductivity, magnitude of magnetic field or characteristic dimension. The method is an up-to-date contactless technique for control of volumetric flow rates of hot, opaque, and aggressive fluids, where neither contact nor optical method can be applied. Since metal melts are excellent electrical conductors, the employment of electromagnetic flow measurement devices are favorable. LFV is based on the fundamental principles of magentohydro-dynamics (MHD). When an electrically conducting material passes the magnetic field lines stretched by an arrangement of permanent magnets, eddy currents are induced inside the moving material. These eddy currents interact with the applied magnetic field and, as a consequence, Lorentz forces are generated within the material. The generated force opposes liquid's movement and, according to the Newton's third law, the same value of force is acting in the opposite direction on the source of magnetic field - permanent magnet. Because the force depends on velocity, it provides a velocity dependent force signal for flowmeter applications. The flow velocity has a linear influence on the resulting Lorentz force; hence it can be estimated by measuring the force signal. The most important and crucial challenge within the technique is detection of small fluctuations of Lorentz force value. In this article we will focus on special aspects of application of highly sensitive strain gauge force sensors within the framework of time-of-flight LFV.

12:00 noon – 1:30 p.m. Lunch and Visits of Expositions
12:00 noon – 1:30 p.m. Poster Session

Session 1.2 Measurement and Sensor Technology

Time: Thursday, 11.09.2014
Location: Humboldtbau, Lecture Room 211/212
Chairman: T. Fröhlich (D-Ilmenau)

1:30 p.m.	I. Rahneberg, T. Fröhlich (D-Ilmenau)

Contact materials for mass artifacts

The present work deals with the comparison of the properties of different contact materials in combination with a stainless steel mass artifact. Furthermore measurements for typical contact materials in combination with silicon surfaces with different configurations of the surface oxide layers are presented. An experimental setup for reproducible measurements of short to mid-term wear is introduced. The device allows the simulation of 10000 load cycles in less than six hours, while ensuring well defined contact motion. From the theoretical investigation of the contact physics and the measurement results recommendations for the design of contact points will be derived.

1:50 p.m.	F. Hilbrunner, T. Fehling, S. Mühlich (D-Göttingen)

Influence of the air buoyancy correction to the uncertainty of mass Comparisons

This article deals with the essential aspects of calculating the uncertainty budget for the measurement of the conventional mass of weights in compliance with international standards. One uncertainty component results from the air buoyancy correction. If air density is calculated from the ambient conditions temperature, barometric pressure and relative humidity, uncertainty components will result from climate data measurements and from the equation for calculating the air density. In this context an important issue is the permissible uncertainty contribution of the climate data. All models of the Cubis series of mass comparators are equipped with a calibrateable digital module for measuring the ambient conditions. This module allows an exact determination of the air density synchronous to the measurement of mass, in order correct for errors resulting from air buoyancy in a mostly automatic way. Built-in application software for mass determination guides the user in a clearly structured way throughout the individual exactly timed steps of mass comparison. Finally a record is automatically generated that shows all relevant information of the particular mass comparison including a complete uncertainty budget, along with the associated climate data.

2:10 p.m.	C. Diethold, M. Kühnel, T. Fröhlich (D-Ilmenau)

Development of a force-displacement measurement device for the determination of spring constants of AFM cantilever

This paper discusses a measurement device for the determination of force displacement curves or spring constants respectively. Especially the calibration of spring constants of atomic force microscopes (short: AFM) cantilevers is an important field of investigation and concentration of this work.

The spring constant can be measured with two measurement modes. One mode uses separate force and displacement measurement devices which correspond to the state of the art. The second measurement mode is more sophisticated using one sensor which measures force as well as the displacement simultaneously; a separate nanostage is not need. The measured sample is an AFM type cantilever, its determined spring constant is in both measurement modes approximately 50 Nm-1 with a very good repeatability of 0.02 %.

2:30 p.m.	N. Rogge, H. Weiß, I. Gushchina, H. Baumgartl, T. Fröhlich (D-Ilmenau); A. Amthor (D-Erlangen)

Model-based design of digital control concepts for electromagnetic force compensated balances

This contribution deals with the precise physically motivated modelling of an electromagnetic force compensated balance (EMFC) in preparation for a controller design process.
A precise knowledge of the subsystem's dynamic and static characteristics provides the possibility to obtain additional information from the measured physical quantities. Additionally, the system's reaction to different input signals was investigated. Besides the excitation at the voice coil of the EMFC balance, an experimental setup was designed that excites the system at the weighing pan. This enables the modelling of the interrelationship between the lever deflection and the force on the weighing pan. In typical application cases the force on the weighing pan is unknown and hence the knowledge of these characteristics is useful for measuring a mass within short periods of load. Based on these detailed investigations a two-beam model was designed, which is able to describe the balance's behavior. Despite the model's simplicity a good conformity with the measured behavior was achieved. For fast data acquisition a FPGA-based signal processing system was utilized to obtain a high sample frequency in combination with a synchronous measurement and excitation.

2:50 – 3:10 p.m. Coffee break and Visits of Expositions

3:10 p.m.	R. S. Oliveira, H. A. Lepikson, A. C. P. Bitencourt, R. Machado (BR-Rio de Janeiro); S. Winter, R. Theska, T. Fröhlich (D-Ilmenau)

New proposals for the dynamic tests of torque transducers

There is a gap in the metrological traceability chain of the torque quantity. The dynamic use of this kind of sensor is based on traditional static calibration results. Two new systems are proposed in order to test the torque sensors dynamically. An inertial system provides the dynamic torque reference values through the acceleration of well known mass moments of inertia, while the brake torque system provides resistive torque during the application of constant or variable speed to the measuring transducer. The dynamic responses of the generated torque curves and some parameters can be analyzed, such as the peak torque errors, the high torque rates regions, the dynamic stiffness and angle displacement of coupling devices. A first approach of the uncertainty budget is carried out and results seemed satisfactory with an expanded uncertainty of 0.09 % in a 10 N m generated inertial torque.

3:30 p.m.	F. Schwesinger, G. Krapf, T. Fröhlich (D-Ilmenau)

PC-based low latency controller for dynamic mechatronic systems

It can be observed that the digital control of complex dynamic mechatronic systems, like electromagnetic force-compensated (EMFC) balances, gains increasing importance. Common digital controller architectures base on an analog to digital converter (ADC), a digital processing unit and a digital to analog converter (DAC). Usually the processing unit consists of a microcontroller, signal processor (DSP) or field-programmable gate array (FPGA). But also the usage of personal computers (PC) comes to mind as a processing platform in digital control, both during development and productive operation. Especially the "PC-in-the-Loop" concept has various advantages compared to DSP or FPGA solutions, not only concerning prototyping aspects. Limitations regarding available memory resources and computing power are negligible in PC systems. However common PCs equipped with conventional interfaces and multitasking operating systems (OS) show significant discontinuities and latencies in data transfer and processing speed. Though, in terms of the stable control of physical systems, a defined runtime performance as well as fast response times are mandatory for digital controllers. Within this context, a PC system was designed that overcomes the described problems by using a real-time Linux operating system and an FPGA-based interface for data acquisition and data output. During researches the utilization of commercially available standard components and free open-source software tools was prioritized. Using the example of a controlled EMFC balance, the functional capabilities of this system were analysed and optimized. Having regard to these points, the publication deals with the motivation of designing such a digital controller for mechatronic systems. Realized concepts are discussed and used components are described. In addition detailed hard- and software concepts will be introduced. Achieved measurement results are presented concerning system latencies and closed-loop frequencies.

3:50 p.m.	J. Schleichert, M. Carlstedt, R. Marangoni, I. Rahneberg, T. Fröhlich (D-Ilmenau)

Dynamic characterization of a multi-component force transducer using a Lorentz force load changer

Strain gauge based force transducers are often used in applications that require the measurement of static or quasi-static forces. For these measurements a static calibration is sufficient. In dynamic measurements however, the measurement deviation caused by using static calibration coefficients increases when approaching the resonance frequency of the sensor. This paper deals with the dynamic characterization of a multi-component force sensor used in Lorentz force eddy current testing, a measurement principle that is based on the measurement of dynamic force reactions. For the dynamic calibration a system is presented that allows the use of various test signals to determine the system parameters of the force transducer. Measurement results for different test signals are shown and main sources of error are discussed. Based on the estimated parameters, an inverse filter can be designed to calculate the dynamic force from the measured output voltages of the sensor.

4:10 p.m.	D. Hernández, C. Karcher, A. Thess (D-Ilmenau)

Application of a multi-degree-of-freedom sensor in local Lorentz force velocimetry using a small-size permanent magnet system

Lorentz force velocimetry is a contactless flow rate and velocity measurement technique in liquid metals. In this technique, permanent magnets generate magnetic field lines which penetrate the entire cross section of the flow in a determined streamwise volume subset. According to the principles of magneto hydrodynamics, eddy currents are generated inside the fluid giving rise to a secondary magnetic field. The interaction between the secondary and the first magnetic field give rise to Lorentz forces within the fluid but in the direction opposite to the flow ("braking effect"). According to Newton's third law, there is a counter force of the same magnitude in streamwise direction acting on the permanent magnet system which is fixed to a force sensor. Given that the magnetic field lines penetrate the entire cross-section of the flow, the measured force FL is proportional to the flow rate Q, the applied magnetic field B to the power of two and to the electrical conductivity σ of the liquid metal.In the case of local Lorentz force velocimetry where the permanent magnets are significantly small in comparison to the cross section of the flow, we are able to have a qualitative assessment of the local velocity of volume subset of the flow owing to the rapid decay of magnetic fields. A novel arrangement of small-size permanent magnet system attached to a multi-degree-of-freedom is proposed. This enables us to measure all the torque components acting on the magnet system in addition to the Lorentz force components while measuring velocity fields with local gradients. This in turn, allows for the estimation of both the local streamwise velocity component as well as its gradient.

End of Session

A. Kraskovskii (RUS-St. Petersburg)

Probabilistic method for calculating the position of a magnetic marker for 5-dof magnetic systems

The system under consideration consists of magnetic markers. Markers generate a magnetic field. In the magnetic field, several magnetic sensors are placed. Problem is to determine the position of the magnetic marker, using the value of the magnetic filed form sensors. Marker has 6 degree of freedom (DOF), but magnetic field depends only form 5 coordinates. The most obvious solution is to solve the system of equations. Another way is using probably theory to find it. Several conditions are required for the solution of the equation system: Total number of equations matching the unknown variables, Partial derivatives with respect to all degrees of freedom should not be equal to zero, or the equation will have an infinite number of solutions or have no solutions. To exclude an infinite number of solutions you can use more sensors. In this case, there is a problem of choice equations that will be used, or due to errors in the system may not have any solutions. We also mast calculate value of errors of the result because influence of measurement error on the accuracy of the result is not equal, due to the different values of the derivatives of the magnetic field at different positions of the marker. We can calculate the probability that the marker is in position with specific coordinates. To determinate probability in a point of searching area, one must get probability density function of measuring value of magnetic field. One mast calculates value of this function for theoretical value of the magnetic field in this point. We must calculate probability of small area around the point. Probability that marker is in small area will called as "probability for point", referring to a point in the center of this area. We can calculate probability for all points in searching area. When we apply all data from sensor, we can determinate most probable position of the sensor and dispersion of result. This method requires a significant amount of computation. This is evident from the fact that the distribution function should be at least several points. It is necessary to have a pitch size is several times smaller than the magnitude of the standard deviation of the measurement result. We must reduce searching area. It is possible to do with different methods.

B. Stadnyk, S. Yatsyshyn (UA-Lviv)

State standard of electrical resistance on the basis of von Klitzing constant

In this work we investigate the problem of implementation of the high-precision reference standards. We consider the Ukrainian state standard of electrical resistance. This standard is proposed to develop by applying the latest nanotechnology achievements, such as research of electrical conductivity of nanopatterns. The latter are inherent in the inverse of conductance quantum that is equal (12906.4037 ± 0.0020) ohm.

Index Terms – State standard of electrical resistance, von Klitzing constant, Hamon network.

H. Lehmann (D-Geraberg)

Calibrating slender thermocouples oneself

A simple method for calibrating slender, fast response temperature sensors like mineral insulated metal sheathed thermocouples (MIMS-TCs), cable-type thermocouples or thermocouples with single- sheet insulation is described. The use of so called fixed-point calibration rods makes it possible to calibrate such sensors at one particularly chosen temperature easily. Due to their slim design (outer diameter 6 mm) fixed-point calibration rods permit a calibration in exactly that situation where the measuring application normally takes place (in-situ calibration). Thus the whole individual measuring circuitry and its specific thermal conditions are involved during calibration process. A second sensor for measuring the calibration temperature (reference sensor) is not necessary. Fixed-point calibration rods are useful for quality management inspections in rough industrial application areas, for outdoor surveying tasks as well as for precision temperature measurements in calibration baths or furnaces. The paper introduces into structure and handling of fixed-point calibration rods. Exemplary calibrations of MIMS-TCs with an outer diameter of 1.5 mm are presented.
Different methods to generate a fixed-point calibration temperature are outlined.
Furthermore, different approaches to determine the fixed-point and to derive a correction value are described. Finally, uncertainty estimations for temperature calibrations at 548.2 °C (m.p. of AlCu eutect.) under laboratory conditions on the one hand and rough industrial conditions on the other are formed. They illustrate the promising potential for improving the reproducibility and reliability of MIMS-TCs by means of fixed-point calibration rods.
Index Terms **-** MIMS thermocouples, slender temperature sensors, temperature calibration, miniature fixed-point cells, reproducibility, measuring uncertainty.

M. Pufke, F. Hilbrunner, C. Diethold, T. Fröhlich (D-Ilmenau)

Capacitive sensor technology based on area variation for precise position detection

For position sensors lots of different measurement systems are well known. In a balance, which depends on the electromagnetic force compensation principle, optical sensors for further control are state of the art. First steps with application of an alternative capacitive measuring arrangement had been made, which had shown that nanometer resolution could be achieved. In this paper, two different types of structures, based on capacitive changes of gap and area between electrodes, are compared and discussed. It can be pointed out, that nanometer resolution is achievable, even with simple electrode structures and materials.
A basic suitability as position detector for use in a balance system can be found, but further steps have to be made for successful adaption.

G. Krapf, F. Schwesinger, T. Fröhlich (D-Ilmenau)

High-precision analog interfaces for low-latency PC-in-the-loop controller

Digital controllers offer enormous advantages regarding the flexibility, adaptability and implementation of complex controller structures. Here, especially PC-in-the-loop concepts are worth to mention, which provide almost infinite computing power, memory resources and prototyping capabilities. However, these systems reveal a specific weakness: Their interfaces to the analog world often have high latencies or insufficient metrological characteristics. That is why analog-to-digital converter (ADC) as well as digital-to-analog converter (DAC) modules were developed, which meet the requirements of high-speed and high-precision control systems. Against this background, basic principles and problems are presented, which relate to the development of corresponding modules. In this connection, the design process and the resulting technical compromises are described. In Addition, first measurements concerning latencies, closed-loop frequencies and metrological characteristics are presented and discussed. Finally, the potential for further improvements is introduced.

M. Rivero, M. Kühnel, T. Fröhlich (D-Ilmenau)

High precision dual axis tilt stage

The necessity for study the effect of tilting in tilt-sensitive devices requires the development of systems that fits to the demands of the experimental setups under investigation. This work addresses the characterization of a high precision dual axis tilt stage developed at the TU Ilmenau. The characterization of the presented stage was done by using as reference device a high precision tiltmeter based on commercial weighing cell developed at the same institution and an autocollimator. The results obtained are in good agreement with the expected theoretical values and have the resolution of the available stages on the market but with a high load and size capacities. The sensitivity of the stage fitted with a linear polynomial is 0.450 mrad/mm and leads to errors of ± 20 μrad on the sensitivity. A third degree polynomial fitting leaded to error smaller than ± 2 μrad. A useful resolution of 1 μrad was obtained for both moving directions, upwards and downwards. When the sliding unit moves downwards, the resolution is better than 0.347 μrad. A repeatability smaller than 0.4 μrad and a backlash smaller than 4 μrad was observed on axis x, while approximately the half of these values for the y axis. The cross sensitivity of the axes was observed to be less than 2μrad or smaller than 1.2e-4, in relative terms over the whole range of ± 17 mrad. Measurements showed that the design used for the stage lead slight differences on the performance of both axes. Modifications on the design can be done to overcome these problems leading to a resolution improvement. Additionally, significant reduction of tilt stage weight can be done by a new design of supporting bases. This would lead to an increase on the useful maximum load. Further research will be done to investigate the effect of the supported load on the tilt stage performance as well as on improvement on the design.

M. Kühnel, M. Rivero, C. Diethold, F. Hilbrunner, T. Fröhlich (D-Ilmenau)

Dual axis tiltmeter with nanorad resolution based on commercial force compensation weigh cells

High precision measurements and monitoring of tilt or inclination are not only essential in the field of geophysics and geodesy but also in ultraprecise force and mass measurements. We present a new concept for high resolving tilt/ inclination measurements. Thereto a commercial electromagnetic force compensation (EMFC) weigh cell is mounted in a hanging position and loaded with a defined weight. Thus the system conforms to a pendulum. By measuring the tilt depended deflection of the pendulum with the position sensor of the weigh cell we achieved a measuring rage of ± 2 mrad. By operating the pendulum like a hanging balance and compensating the pendulum deflection with the balance internal voice coil a tilt dependent lateral force is measured. In this case the measurement range of the Tiltmeter was extended to ± 9 mrad. In both measurement modes a standard deviation of < 10 nrad (1.5 nrad filtered) within a period of 30 minutes was achieved.

Session 1.3 Precision Engineering and Optics

Time: Tuesday, 09.09.2014
Location: Humboldtbau, Lecture Room 129
Chairman: R. Theska (D-Ilmenau)

9:00 a.m.	K. John (D-Ilmenau)

The Influence of Polarisation Changes Introduced by Deflecting Elements to Interferometric Measurements

In a large variety of high precision measurement and positioning applications interferometers play an important role. When the object under test is not accessible in a straight line or such a layout would restrict the design of the device too much, the beam path can be folded. But the deflecting elements (mirrors and prisms) used for this purpose can introduce measurement errors to the system. Errors due to the mere presence of such an element or caused by slight movements of it have to be corrected for reliable measurement results. In this contribution we address changes that deflecting elements inflict on the polarisation of the interferometric measurement beam. We show the impact of these changes on the measurement and discuss a compensation method.

9:20 a.m.	H. Scheibe (D-Jena); R. Theska (D-Ilmenau)

Approaches to Cost-effective Manufacturing of Precision Aspheres

Precision aspheres are used in a wide range of technical applications. Their admissible form deviation typically shows less than 1μm pV which allows a separation to the quality class of mid performance aspheres. Common applications containing precision aspheres are e.g. objectives for SLR cameras and microscopes as well as binoculars. With respect to the required performance of the optical systems, generative manufacturing technologies such as precision molding/bright molding, are not an option due to induced material inhomogeneities and stress birefringence. Thus, cutting manufacturing technologies such as grinding and polishing are used exclusively. The aim of this paper is to gain insight into the process chain for the production of precision aspheres and the manufacturing technologies used. Furthermore, deficiencies of current manufacturing technologies are shown and needs for action are derived. The state-of-the-art manufacturing technology for prepolishing processes is called Bonnet Polishing. It uses a flexible subaperture tool body which provides a (relatively) small contact zone. The removal rate of a polishing tool correlates with the size of its contact zone. Thus, Bonnet Polishing leads to long processing times which turn out to be the cost driver for the manufacturing of precision aspheres. Furthermore, polishing tools with small contact zones are prone to generate mid frequent form deviations in a spatial wavelength range of 0.5 – 2mm. The subsequent smoothing process does not provide an effective way to remove the tool fingerprint. At present, time-consuming fine correction is the only way to eliminate remaining high frequent form deviations. In order to reduce manufacturing costs, this paper provides three considerable approaches to discuss: 1. optimized process parameters for an increased removal rate; 2. a multi-tool setup for simultaneous processing with at least two polishing tools; 3. a full aperture active-adaptive polishing tool.

Every approach shows specific pros and cons with regard to the manufacturing process as well as technical complexity, installation space, etc. Thus, a comparison and evaluation of all three approaches is given. Finally, this paper presents a concept of the preferred approach.

9:40 a.m.	B. Dinh Bao, S. M. Latyev (RUS-Sankt Petersburg); R. Theska (D-Ilmenau)

Speaking about methods of lens' centering

Lens decentering in lens systems, especially in objectives significantly degrades the quality of the image that they create. They most strongly affect the aberration of coma.
In order to avoid or reduce that, lenses are centered whilst manufacturing, gluing and placement in the mounts. Significant decrease in the lenses decentering in the mounts is achieved by using special manufacturing equipment allowing the coincidental adjustment of the optical axis of the lens with the base axis of the mount during the assembly process. Solutions for these alignments based on shifting, tilting and rotation of components are provided in the construction of high-quality objectives (microscope, photolithographic, air camera optics). For the optimization of such adjustment methodes, the influence coefficients of decentering of each optical surface of the lens system to coma must be calculated and taken into account. Automation of assembly and adjustment of lens systems is advantageously carried out on the basis of a virtual simulation of the lens construction, using algorithms that take into account the existing technological errors and their effect on image quality.

10:00 a.m.	F. Wohlfahrt (D-Selb); R. Theska (D-Ilmenau)

The influence of contact force in dilatometry

Exact measurement of dimensional changes is important in modern material research, such as analysis in the field of zero-expansion materials, polymers, foams, sandwich materials and ceramics. The length change of a sample as a function of temperature can be measured with common dilatometers under a small load as defined in national standards. Especially for applications with soft materials, this contact force – generated by the precision-engineered measuring cell – influences dilatation to an extent that can no longer be ignored and is crucial for exact determination of the thermal expansion and CTE (coefficient of thermal expansion). This article presents a new design and construction of a force-controlled measuring cell in dilatometry. The proposed system is designed for measurement and control of the contact force in dilatometer measurements in order to minimize its effect on the length signal. A function integrated construction allows equivalent measurement of the initial sample length and the length change by the same component. The measurement cell's functionality is demonstrated by means of several experimental measurements on different samples which show the influence of the contact force on the initial sample length and on the CTE. With the proposed measuring cell, the application field of dilatometry can be further expanded to the measurement of visco-elastic material properties like creeping effects.

10:20 - 10:40 a.m. Coffee break and Visits of Expositions

10:40 a.m.	A. Grewe, M. Hillenbrand, St. Sinzinger (D-Ilmenau)

Imaging systems with Alvarez-Lohmann lenses

Luiz Alvarez and Adolf Lohmann independently invented specific kinds of varifocal lenses in the late 1960s. The focal length of these lenses is changed by a lateral displacement of two freeform phase plates. This enables compact optical systems with tunable focal length by using well defined surface functions. Due to the rapid development of precision fabrication technologies for freeform optical components in the last 20 years, Alvarez-Lohmann lenses became a current topic of research. Typically the theory behind these lenses is based on an idealized model to describe the optical system. Since not all assumptions of the model are fulfilled in real optical systems, Alvarez-Lohmann lenses induce aberrations that decrease imaging quality. We analyze aberrations typical for Alvarez-Lohmann systems and suggest optical designs to increase the imaging quality of those systems. As an example for optimized Alvarez Lohmann systems a hyperspectral imaging system is presented.

11:00 a.m.	T. Siefke (D-Jena)

Investigation on process induced nano scale shape deviations of DUV tungsten wire grid polarizer

The polarization is an essential feature of electromagnetic radiation and therefore relevant in many areas of optical science and technology. Several analytical methods, such as ellipsometry are basing on the setting and measurement of a particular polarization state or additional information can be obtained as in spectroscopy or microscopy. Furthermore nano patterning methods such as optical lithography can be improved. Especially in the DUV wavelength range tungsten wire grid polarizer overcome the possibilities of conventional devices in terms of large element area, small overall height and a broad acceptance angle. Therefore the interest in such devices grew rapidly in recent years. Wire grid polarizers are nano optical devices consisting of a metallic grating structure with a period below the wavelength, in this case 100 nm. Additionally a high aspect ratio from about 6 to 10 is necessary. This kind of structures can be fabricated by a double patterning process. However material properties as well as geometry deviate from an ideal binary, tungsten grating thus deteriorate the optical performance. To allow for a targeted optimization of the process, we studied the influence of those deviations. For this purpose firstly, the influence of the complex refractive index is evaluated. Subsequent a refined geometry model, containing major shape deviations, is presented and its applicability is shown. Thereby the agreement between simulation and measurement is significantly emended. Afterwards the model is used to assess the influence of particular shape deviations according to their severity. It is found that the extinction ratio is generally more vulnerable to deviations than the transmittance. The most significant influence is the complex refractive index. Changes of some percent cause an impairment of about one order of magnitude. Concerning the shape deviations, the most severe impairment is induced by deviations of the width and tilt of the ridges. A decrease of the ridge width by one nanometer causes 20 % reduction of the extinction ratio and tilt of the ridges by one decree causes a decrease of 10%. Therefore future improvement of tungsten wire gird should focus on material properties as well a proper definition of the ridge width and tilt.

11:20 a.m.	N. Heidler (D-Jena)

Investigations on the damping properties of vacuum-compatible aerostatic journal gas bearing elements

Gas bearing elements with special sealing units can be used to realize high-precise movements within a vacuum environment. During the transmission of the surrounding pressure of the bearing from normal atmosphere to vacuum, the properties of the bearing change.
Within this paper, the changes of the bearings damping parameters are investigated.
An experimental setup is used to excite an aerostatic journal gas bearing and measure the resulting system response of the element. A fitting procedure, based on the equation of motion of free natural damped systems, is used to obtain the damping constant and the eigen angular frequency. For small deflection amplitudes close to the concentric position of bushing and cylinder, the investigated aerostatic journal gas bearing element shows a very strong damping behavior. The transmission of the surrounding pressure from normal atmosphere to vacuum slightly increases the damping of the system. In general, the time based system response for different supply pressures and surrounding pressures shows only narrow differences.

11:40 a.m.	A. Geis, S. Husung, Ch. Weber, E. Manske, R. Füßl (D-Ilmenau)

Vectorial tolerances for the uncertainty analysis of precision measurement devices

Increasing demands on precision measurement devices require a detailed analysis of the existing measurement uncertainty, especially when the required measuring accuracy is in nanometre dimension. Such measuring devices consist of several sensors, drives, guidance, a corner mirror, a metrological frame and other precision elements. For the analysis of uncertainty budgets a vectorial metrological model can be used. Important influencing factors on the measurement uncertainty are the expected form, position and dimension tolerances. Therefore, an important part of the investigation in the uncertainty is a tolerance analysis. It seems obvious that it may be useful to feed an uncertainty analysis based on a vectorial metrological model with tolerances also based on a vectorial model. Thus, a considerable amount of information transfer between, for instance, conventional tolerance parameters and vectorial parameters as required by the uncertainty analysis could be avoided.

12:00 noon – 1:30 p.m. Lunch and Visits of Expositions
12:00 noon – 1:30 p.m. Poster Session

Session 1.3 Precision Engineering and Optics
Time: Tuesday, 09.09.2014
Location: Humboldtbau, Lecture Room 129
Chairman: St. Sinzinger (D-Ilmenau)

1:30 p.m.	N. Pavlycheva (RUS-Sankt Petersburg)

Development of spectral devices at the Department of Optical Electronic Systems KNRTU-KAI

The report presents the results of research in the field of spectral devices, performed at the Department of Optical Electronic Systems of Kazan National Research Technical University in recent years. Among them are the spectrograph on a Rowland circle with the diffraction gratings recorded by the aspheric wavefronts; portable spectrographs for investigating nanomaterials; some new spectrograph schemes based on transmission concave holographic gratings. Designed spectrographs provide high-quality spectra with the use of few optical components. The educational complex "Fundamentals of diffractive optics and holography" for pre-university, undergraduate and postgraduate levels of training is also represented.

1:50 p.m.	K. Meiners-Hagen (D-Braunschweig)

Refractivity compensated tracking interferometer for precision engineering

As part of a European joint research program (JRP IND53), PTB and SIOS develop a refractive index compensated tracking interferometer. In a first step a prototype interferometer using standard optomechanical components was set up for testing and optimizing the system. A frequency doubled Nd:YAG laser with a frequency stabilization on a Doppler free absorption line of iodine serves as light source. Both wavelengths of 532 nm and 1064 nm are used in the heterodyne interferometer. Due to the dispersion the optical path lengths of both wavelengths are different. The air refractive index can be compensated for by this optical path difference, if the partial pressure of water vapor is known. If the air pressure is known, the effective temperature in the beam path can be calculated as well. The prototype has no tracking capabilities and turned out to be mechanically not very stable. The interferometer was compared to a HeNe reference interferometer for distances ranging between 4 m and 6 m. At each position 8192 length samples were taken with an averaging time of 12 microseconds for each sample. Since the refractive index compensation method increases the uncertainty by a large factor (65.5 in our case), an averaging procedure not over the length values but over the calculated temperature was applied. From each length sample a temperature was derived and a moving average over 1024 samples (12.3 ms) considerably reduced the scatter. With the averaged temperature, the measured air pressure and humidity, the refractive index compensation can be achieved with a standard deviation of 3.5 nm on a short time scale compared to a standard deviation of 90 nm without averaging. The averaged temperatures differ from directly measured values by less than 0.15 K. However, due to mechanical drifts of the prototype, the length values differ by up to 0.7 micrometer from the reference values.

2:10 p.m.	J. Bischoff (D-Ilmenau)

Development of mirror cells for a satellite born solar telescope

The development of a mirror telescope for the ESA/NASA Solar Orbiter mission is presented. This mission is dedicated to solar and heliospheric physics and was selected as the first medium-class mission of ESA's Cosmic Vision 2015-2025 Programme. The space craft will carry a scientific payload of various instruments. One of the imaging remote-sensing instruments onboard will be the Polarimetric and Helioseismic Imager (PHI). The PHI instrument will provide high-resolution and full-disc measurements of the photospheric vector magnetic field and line-of-sight (LOS) velocity in the visible wavelength range. The LOS velocity maps will allow detailed helioseismic investigations of the solar interior, in particular of the solar convection zone. PHI will address and resolve Basic questions in solar physics by studying the Sun at high resolution from close up and from high latitudes up to 35°. It will be composed of two telescopes. The off-axis Ritchey-Chrétien High Resolution Telescope (HRT) will image a fraction of the solar disk at a resolution reaching 150 km at perihelion. The refractor Full Disk Telescope (FDT) will be able to image the full solar disk at all phases of the orbit. Each telescope will have its own Polarization Modulation Package (PMP) located early in the optical path in order to minimize polarisation cross-talk effects. Polarimetry at a high signal to noise level is baselined for PHI. The HRT and the FDT will sequentially send light to a Fabry-Perot filtergraph system ($\sim$ 100 mÅ spectral resolution) and on to a 2048 $\times$ 2048 pixel CMOS sensor. The main focus of this paper is on the optical and opto-mechanical development of the PHI-HRT. The telescope is formed by a primary concave and a secondary convex mirror. The entrance aperture of the system is 140 mm. The primary is almost parabolic while the secondary is hyperbolic. Optical Performance is discussed by means of simulations in combination with measured interferograms. Moreover, surface roughness requirements are derived from theory and compared to experimental results. Last but not least, the robustness of the mechanical design is verified with FE-Analysis, environmental and vibration tests.

2:30 p.m.	N. Smirnov, S. M. Latyev (RUS-St.Petersburg); R. Theska (D-Ilmenau)

Adjustment and evaluation of incremental optical rotary encoders

The subjects of this paper are incremental optical rotary encoders and methods for a minimizing of measured errors of the controlled process of rotary encoders. This paper presents centering methods for incremental optical rotary encoders. In general, there are two methods to adjust optical rotary encoders. The first method deals with a centering mark and the second method bases on analogue signals from oscilloscope. In addition, the paper describes measuring methods and equipment for the automated accuracy control of optical rotary encoders and a method for compensation of measured errors. The paper presents a novel special coupling device for control encoders. The design of the novel coupling device provides an unrestrained connection between controlled and reference encoders. The elaborated experimental setup increases the calibration accuracy of rotary encoders considerably.

2:50 – 3:10 p.m. Coffee break and Visits of Expositions

3:10 p.m.	C. Hahm (D-Ilmenau)

Concrete – Future Material for High Precision Machines

In previous studies it has been shown that machine parts for high precision applications made of Self Compacting Concrete (SCC) are a promising alternative to those conventionally made of natural stone. Parts with comparable functional surface finish and mechanical properties can be done in shorter time and at lower cost starting from small lot sizes. The developed "ready to use" primary shaping process offers vast freedom of design compared to machined natural stone. In the current studies the concrete mixture, the moulding and post moulding processes have been continuously optimised. Now long term stable machine parts can be made with a geometrical deviation / fluctuation in the same range as parts made of natural stone. This article shows major improvements of the properties that have been achieved based on solid concrete beams. An overview will be given for future research of lightweight concrete parts.

3:30 p.m.	M. Hillenbrand (D-Ilmenau)

Miniaturized AMD vision aids: principles and realization

In this paper we discuss two kinds of adapted vision aids for people suffering from Age-Related Macular Degeneration (AMD). Both aim at redirecting the central visual information which cannot be seen by AMD patients to the outer, unimpaired parts of the retina. The first kind of vision aid redirects the central field of view using prismatic elements and magnifies it homogeneously with Galilean telescopes. The second variant is based on anamorphic prism pairs and leads to a one dimensional magnification of the full field of view. In both cases we apply segmented optics to realize the complex optical functions with low-weight components suitable for all day use. Replication in PDMS is discussed as an efficient fabrication process for segmented elements which can be attached to the glasses of AMD patients. First replicated elements are shown.

3:50 p.m.	M. Lotz, J. Siepmann, St. Mühlig, S. Jung, G. Baer (D-Jena)

Tilted Wave Interferometer - Design and Test

Requirements on optical systems raise – they need to be more compact with better optical performance. Therefore spherical lenses are more and more replaced by aspheres and freeforms. Both elements can improve the optical performance significantly by more degrees of freedom in optical design. But their manufacturing is complex and needs metrology in the manufacturing process chain. State of the art measurement systems have different disadvantages which limits their usage for aspheres and freeforms. A new interferometric method called Tilted Wave Interferometry can overcome existing limitations. In the paper design and test of an interferometer realizing the new method are described. The Tilted Wave Interferometer is a complex measurement sensor. Its complexity is caused by the need to connect software, mechanics, electronics, mechatronics and optics. A model based approach is the base for the measurement sensor and its design.

Thus the design process differs from well-known ones. At first the software model which is strongly connected to the optic design need to be developed. After this step the following design stages like embodiment design can start. The paper describes these differences and presents results of the development. Two expansion stages of the described Tilted Wave Interferometer are realized. A horizontal setup is used for fundamental research and tests and a vertical setup is realized to meet customer needs for metrology in the manufacturing process chain. The vertical setup consists of an additional positioning unit and is used for measurements on aspheres and freeforms. Assembly and adjustment of both setups are explained. Test results regarding mechanical properties and measurements on a demonstrator asphere show the function of the Tilted Wave Interferometer. One conclusion of the paper is the need to integrate aspects of complex systems of today in the well-known design process and its methods. The outlook of the paper shows which further development steps are planned to measure freeform surfaces in their manufacturing process chain.

End of Session

R. Akhmetgaleeva (RUS-Kazan); E. Muslimov (RUS-St.Petersburg)

Development of a spectrometer for fluorescence analysis in cancer diagnostics

In the present paper an optical scheme of compact two-element spectrometer for cancer fluorescence diagnostics is presented. It consists of a concave holographic grating and a spherical projection mirror. The working spectral range is 500-1000 nm and the obtained spectral resolution reaches 0.91 nm. The scheme is extremely compact and has f-number equal to 2.4.The design algorithm is described in details with special emphasis on stray light suppression. All the listed features allow to use the developed scheme in a small-sized affordable diagnostic device. A comparison with a similar single grating scheme was carried and revealed obvious advantages of the proposed design.

Session 1.4 Image Processing and Quality Assurance

Time: Tuesday, 09.09.2014

Location: Humboldtbau, Lecture Room 210

Chairmen: G. Linß (D-Ilmenau), D. Hofmann (D-Jena)

9:00 a.m.	M. Rosenberger, A. Grewe, E. Manske, M. Hillenbrand, Th. Fröhlich, St. Sinzinger, G. Linß, R. Fütterer, M. Correns (D-Ilmenau)

Hyper- and Multispectral Imaging Systems– a Survey of Different Approaches at the Technische Universität Ilmenau

Hyperspectral imaging technologies and multispectral imaging technologies became more and more important for industrial measurement techniques, quality control and automation technologies. One unsolved problem is the fast and simultaneous image capturing of different spectral channels. The best approach up-to-date is known as push-broom scanner. On the Ilmenau University of Technology different methodologies are objective of the recent research as well as for the research in the future. The paper gives a survey about the different approaches. The paper starts with a system which deals with the principle of FTIR Spectroscopy, which needs a mathematic transformation to deliver spectral image data. In the following two chapters a confocal approach using tunable optical elements based on Alvarez Lohmann lenses will be presented. The paper ends with a multispectral system operating with different color filters.

9:20 a.m.	T. Beier (D-Jena)

A self-optimizing framework for developing metrology software on massive parallel processor architectures

The precise measurement of optical surfaces requires not only high performance measurement instruments but also extreme compute intensive algorithms. Production constrains often dictate that measurement tasks should be finished as fast as possible. In the last years the increase in computation-power of processors has been achieved by increasing the number of cores and the development of massive parallel hardware architectures. Today nearly every standard PC not only contains a multicore processor, but also a massive parallel GPU which can be used for general purpose computations. At a first view it seems quite reasonable to exploit the parallel computing power of GPUs for computation intensive tasks. At closer look development of software that runs on GPUs and other massive parallel hardware is a very demanding and time consuming task. A framework for programming parallel hardware is OpenCL. It provides portability of code between different hardware architectures, but it cannot ensure portability of performance. This paper introduces the concept of a new developed self-optimizing parallel programming framework that addresses the issue of performance portability. This framework provides a set of algorithm building blocks. With the help of these building blocks a wide range of algorithms can be described, that work on one- or two-dimensional objects like images, vectors and matrices. The separation into building blocks enables a wide range of possible optimization and parallelization strategies. From a given description of an algorithm and using a set of heuristics, the framework is able to synthesize a number of different OpenCL kernels.

Those kernels, that all serve the same purpose, differ in parallelization and optimization strategies. In a benchmark process the best performing kernel on the used hardware platform and a given problem size is determined. This approach enables the development of flexible metrology software, which can run complex algorithms on different parallel hardware architectures while achieving considerable performance. Finally this paper shows the achieved performance of this framework, demonstrated on different standard computer hardware platforms on the basis of algorithms in the field of interferometry.

9:40 a.m.	H.-Chr. Schwannecke, R. Fütterer, M. Rosenberger, G. Linß (D-Ilmenau)

SICALT-Spectral Image Correction and analysis Tool

Enhancing, displaying and analyzing multi and hyper spectral data is the key aspect of this paper. For this purpose the "Spectral Image Correction an Analysis Tool" – SICALT was developed in our department under the use of the MatLab language and the model view presenter software design pattern. With SICALT we want to have a tool at hand that can transform data from multi or hyper spectral imagers into a form, usable by standard quality assurance image processing tools. We demonstrate the functionality on a printed circuit board by the segmentation of different materials.

10:00 a.m.	P.-G. Dittrich, D. Hofmann, D. Kraus, D. Höfner (D-Jena)

Quality assurance with calibration tools for mobile smart photonic dimensional, color and spectral measurement systems

Mobile smart photonic measurement systems are convenient, reliable and affordable. Microsoft have been released their Windows 8 operating system in 2012. Windows 8 opens new possibilities for the development of innovative measurement systems. Touchscreens on smartpads and standardized USB-Interfaces ease the application of consumerized smartpads also for commercial tasks. Innovative mobile photonic measurement systems are the combination of miniaturized dimensional, color and spectral sensor modules with smartphones and smartpads under Microsoft Windows 8 operating systems and commercial available software packages for industrial and non-industrial applications. One of the big challenges is their mobile and task specific calibration in field. Smartphones and smartpads are becoming significant game changers not in consumerized applications only. Aim of the paper is to show selected examples for the application of smartphones and smartpads directly in field measurements. Significant influence on the accuracy of field measurements have available tools for mobile calibrations. Selected mobile calibration tools for mobile smart photonic dimensional, color and spectral measurement systems will be represented and explained.

10:20 - 10:40 a.m. Coffee break and Visits of Expositions

10:40 a.m.	D. Kraus (D-Jena)

Quality assurance with spectrometer hardware apps or mobile smart photonic spectral measurements

An important key factor for the spectral revolution in smart instrumentations for mobile spectral measurement technologies in diagnostics is the entry of Microsoft into the

smartphone and smartpad market. The Microsoft Surface smartpad with its standardized PC architecture and Windows 8 operating system can easily be applied for many proven spectral measurement applications without re-inventing or re-adjusting available approved software. Most industrial and laboratory software packages are designed for Microsoft Windows operating systems. They are running directly on Windows smartcomps or indirect virtually or remotely on Apple and Google smartcomps. Another key factor is the reduction of the mass, size and price of the measurement modules. Aim of the paper is the demonstration of a paradigm shift in measurement engineering and quality assurance. Smartpads, smartphones and smart wearables (smartcomps) in combination with hardware apps (hwapps) and software apps (swapps) are fundamental enablers for the transformation from stationary working places towards innovative mobile working places with in-field measurements and point-of-care (POC) diagnostics for process control and quality assurance. Practical examples for the application of innovative mobile smart photonic spectral measurement systems will be given.

11:00 a.m.	Th. Lemazyk, P. Brückner, A. Schlegel, G. Weber (D-Ilmenau)

Multichannel Sorting of Food

For quality control and price determination of natural products like for example wheat in mills or in grain storage units, it is necessary to evaluate the current state of the product. In the case of wheat this is done by lab assistants through a manually held sight check of a sample of the delivered product. The wheat is examined on different types of damage for example special types of mould, fractions, stones or insects which is generally called Besatz. Those different classes of Besatz are sorted afterwards and weighed to determine the mass percentage of each class in the amount of wheat. Because of the inconstancy and exertion of the manual Besatz analysis, the goal is to develop an automatic detection and sorting process which is reliable and fast and can be applied for different natural products. With the rising demand on quality and security of food, the automatic and fast analysis of natural products, particularly through the application of image processing, gains increasing importance. The extraction and analysis of control samples of grain in mills and silo plants serves the avoidance of storing contaminated deliveries and to determine their composition. As criteria of refund to the manual Besatz analysis, the automatic Besatz analysis offers a higher reliability with a faster process speed on the base of image processing. For the acceptance by the German and accordingly the European administration and for the comparability with the results of previous methods, the per cents by weight of the single fractions of material have to be determined. Therefore a sorting of the recognized objects in separate classes is necessary.

11:20 a.m.	S. Holder, G. Linß (D-Ilmenau)

Acceleration of image restoration algorithms for dynamic mesurements in coordinate metrology by graphic processing units

This paper presents an approach for decreasing the processing time of dynamic image restoration for metrological applications. An extension of the Richardson-Lucy deconvolution algorithm for an optimal breaking of the restoration with respect to the change of the sub pixel-precise edge position is proposed.

An extension of the Richardson-Lucy deconvolution algorithm for an optimal breaking of the restoration with respect to the change of the sub pixel-precise edge position is proposed. Therefore a powerful parallelization of the restoration algorithms was tested on graphics processing unit (GPU) by using OpenCV C++ framework. A comparison to a processing on multi-core central processing unit (CPU) with a variation of input data size and restoration calculation amount is performed. The experimental results reveal the optimal break-even point for an time efficient processing of the algorithms on GPU.

11:40 a.m.	W. Nordhoff (D-Überlingen)

Secret aspects of future engineering

Supplying foreign markets with localized, or even locally manufactured products is regular business for big corporations. However small and mid-size businesses in particular manufacturers of scientific equipment or R&D centers can not rely on a large local sales force. They don´t have the manpower and financial resources to satisfy foreign customers easily. Fortunately the KMUs (SMEs) experience an increasing demand from overseas.

KEY FACTORS FOR SUCCESS

1. Point of View

Try to put yourself in the shoes of your customer/try to see your project thru the eyes of your customer.

2. Planning

Plan additional time/manpower to clarify, acquire, process, deliver and support your project.

3. Communication

a) (Get to) know your customer during frequent visits and by staff exchange!
b) Does the culture of my customer allow him to communicate freely and clearly?
c) Does my customer really have the (technical) knowledge to understand me clearly?
d) Explain, confirm and get agreements on important matters in writing
e) Do I really understand my customer? Because we like to hear, what we want or assume to hear!
f) Repeat technical specifications exactly the same way
g) Clarify your customers chain of command early
h) Observe your customers feelings
I) What is the understanding of "time/timing" for my customer?

4. Technical standards

a) DIN/ISO is not almighty; other standards e.g. JIS may apply
b) Study common local practices, e.g. symbols, abbreviations

5. Money matters

a) Increased financial risk
b) Varying exchange rate
c) Export limitations
d) Import limitations or fees

6. Legal

a) Chances for a successful claim at reasonable cost are slim
b) Break down your project into "milestones"/project steps: after your delivery & acceptance of each milestone your customer shall make the payment for this milestone
c) Protect your know-how

12:00 noon – 1:30 p.m. Lunch and Visits of Expositions
12:00 noon – 1:30 p.m. Poster Session

Session 1.4 Image Processing and Quality Assurance

Time: Tuesday, 09.09.2014
Location: Humboldtbau, Lecture Room 210
Chairman: D. Hofmann (D-Jena)

1:30 p.m.	D. Höfner, P.-G. Dittrich, D. Kraus, D. Hofmann (D-Jena)

Quality assurance with digital learning equipment for mobile smart photonic dimensional, color and spectral measurements

Aim of the paper is a demonstration of the paradigm shift in education and training with digital equipment for mobile smart photonic dimensional, color and spectral measurements. Due to the major changes in computational devices by their transition from stationary desktop computers to consumerized mobile smartphones and smartpads - in short smartcomps - new possibilities in education and training for mobile smart photonic dimensional, color and spectral measurements are given. Manufacturers and system integrators of hardware apps and software apps for photonic image sensors and digital image processing software are trying to reduce the significant qualification deficits of potential users of modern equipment by special activities in education and training. Two efficient methods are promising:

1. Sensors & imaging specific multilingual digital text books (mbooks) and videos for end users on smartcomps,
2. Sensors & imaging specific hands-on trainings in industry and/or shared be tween universities and industry.

1:50 p.m.	A. Mitsiukhin (BY-Minsk)

Extraction of the motion indications in the sequence of images

The problem of extraction of the motion indications, i.e. coordinates and parameters of the motion in the sequence of images is considered. The analysis of the images under consideration is based on the use of a cyclic group with the operation of dyadic shift on the finite intervals. The majority sequences on the dyadic group are formed with the help of the dyadic-shift operations. The whole set of sequences is obtained by specifying the coordinates of vectors. The class of these sequences can be obtained by the majority addition of the Walsh functions. Detection and extraction of the dynamic object is implemented through intermediate calculations of the majority sequences describing the moving object. The correlation method for extracting the motion indications in the sequence of images using the majority sequences determined on the dyadic group has been considered.
The value of the coefficient of the correlation function depends on the position of the moving object on the image and shift τ. The determination of the shift comes to the comparison of the sequence with each sequence of the set and selection of the nearest of them as regards the Hamming distance.

Should the frame rate, inter-pixel distance and value τ corresponding to the maximum coefficient correlation be known, the motion direction and component of the velocity can be determined. The sufficiently reliable extraction of indications of the motion of hardly distinguishable objects can be provided by increasing the time of observation and length of the majority functions. Such an approach makes it possible to obtain the precision characteristics of the processing which are near to the optimum ones. Here the scope of necessary calculation would be considerably reduces, should the distinctive structural properties of the applied transforms and signals be used. The problem of finding the dynamic object was solved when masking the latter with pulsed unipolar noise ("salt-and-pepper").

2:50 – 3:10 p.m. Coffee break and Visits of Expositions

End of Session

K. Andig, K. Trambitckii, G. Polte (D-Ilmenau); D. Garten (D-Schmalkalden)

Elimination of out-of-focus region for surface analysis in 2-d colour images

Modern industrial cameras give possibilities to get quality images of objects. To be sure, that an output image is suitable for image processing it is necessary to keep all regions of the image in sharp details. When area of interest is a part of a surface of a complex shape, some regions of the object in the image can be out-of-focus. In that case, it is necessary to segment and remove out-of-focus regions from the image. Focus features are used to get an overall image sharpness rate. Texture features use spatial, frequency, histogram and other information of an image. In our project, we applied these features to detect blurred regions of images of metal surfaces. An image of a surface is divided on equal regions, and different focus features are calculated for each region. In that project, 34 different algorithms were tested on a sample image with an out of focus region. Results were analysed and, consider computation time and application of obtained results for segmentation, only 7 features remained. They were used for the further investigation. These features were tested using the whole set of sample images of a surface to check the reliability of each feature in application to our task. Only 2 of them showed robust result: mean of grey levels and spatial frequency. In our project an initial image of a metal surface obtained from a CCD camera has an RGB colour space. For the next calculations the image is converted to a greyscale image. In the next step of our algorithm, the image is divided into equal regions with size of K×K pixels. In our project K is equal to 25 pixels. Further, an image feature is calculated for each region. Calculated values are stored in a matrix. The obtained matrix is used as a map for the next segmentation step. If an element of the matrix is greater than a threshold, then a corresponding region of an image is marked as in-focus region, and vice versa. These methods can be successfully applied for segmentation of in-focus regions of metal surface images. The research project, which forms the basis of this paper, is funded by the Thuringian Ministry of Economics, Technology and Work and the European Social Fund (ESF). The responsibility for the content of this paper lies on the author.

M. Schellhorn, M. Preißler, R. Hoffmann, G. Linß (D-Ilmenau)

Imaging sensor system with wireless data transmission for in-process measurements in the machining area of milling centers

In the course of progressive rationalization and automation of production it becomes increasingly clear that the traditional spatial and temporal separation of production and metrology is unable to cope the increasing demands of the quality assurance. In addition to the actual measurement time the time for the whole quality circle, starting with the machining of a workpiece through to its metrological determination and finally the use of this information in the production is crucial. Machine-integrated sensor systems which are fully integrated in the flow of information enable early defect detection and thus a reduction of this time.

This paper discusses the challenges of the development process at the example of an integrated image processing system for milling machines, which can be loaded via the HSK (hollow shank taper) interface from the tool magazine. The use of optical technology in the work environment is associated with certain obstacles. Since constantly coolant and chips are distributed in the machining area, the sensor system must be protected from pollution. Another major field of research exists in the power supply of the sensor system and the data transfer. Since milling machines already have tool changing devices, it is necessary to adapt these devices to meet the requirements of an additional measurement system.

M. Rosenberger, G. Linß, R. Fütterer, J. Rilk, M. Lawin (D-Ilmenau)

Energy Efficient Light Modulation for Multispectral Imaging

In the following paper an approach for cost-effective multispectral imaging system is given. For the spectral separation the special characteristic of LEDs were used in combination of an optical band-pass filter. Therefore standard LEDs were evaluated in order to wavelength distribution, availability on standard distributors. For the use of this LED setup a special 24 channel light controller were developed and evaluated. The second major part was the efficiency of the controller, especially in the state of low light requirement. In this case normally a lot of electric power will be lost in the electronic. The developed control unit uses a special combination between analog and digital electronics which leads to high system efficiency. The complete setup was tested and optimized using a reflection normal. The paper ends with a multispectral application detecting safety features of a bank note.

P. Costa (BR-Duque de Caxias)

Study of Optimal Algorithm for Distance Measurements in Computer Vision

This paper has the purpose of presenting a study to determine the accuracy of a method for image measurement called Null Detector. In this new method, instead of determining the distance between two borders by counting pixels or by using subpixel approximations, the image itself is shifted and the border of the object to be measured is acquired in different points of the image. By using numerical adjustments for a specific point of the image, the real location for the border is found. The advantage of this method is that the pixel length does not need to be calibrated since it does not involve counting pixels.

Topic 2:

Mechatronics, Biomechatronics and Mechanism Technology

Session 2.1 Mechatronic Systems
Session 2.2 Assistance Systems
Session 2.3 Mechanism Technology

Session 2.1 Mechatronic Systems

Time: Tuesday, 09.09.2014

Location: Humboldtbau, Lecture Room 202

Chairmen: H. Rothe (D-Hamburg), T. Ströhla (D-Ilmenau)

9:00 a.m.	Li Li (D-Zittau)

Adaptive Kalman filter for active magnetic bearings using softcomputing

Magnetic bearings can not only solve the bearing wear and life problems but also reduce the loss and noise of bearing. However, the strong disturbance and noise from the system affects the control behavior. Based on the Kalman filter the influence of noise will be reduced. But the strong nonlinear and uncertainty of parameter of the magnetic bearings make it difficult to establish the estimation / prediction equation in Kalman filter. This paper presents a design method of system estimation / prediction for Kalman filter with using soft computing, including linear local model for overall system, intelligence function as system identification and adaptive kalman filter.

9:20 a.m.	K. Röbenack, J. Winkler, M. Franke (D-Dresden)

Nonlinear Control of Complex Systems Using Algorithmic Differentiation

In mechatronics and robotics one often encounters highly complex nonlinear systems, whose dynamics are described by a system of nonlinear ordinary differential equations. In simulation, one can use very sophisticated models, whereas controllers are typically designed on strongly simplified models. Quite often, this results in linear controllers which are unsuitable for the original nonlinear system. We suggest an approach allowing nonlinear controller design even for very complicated models. Normally, nonlinear control laws are computed symbolically. If the controller design is based on differential-geometric concepts, one often encounters symbolically computed Lie derivatives. Our approach is based on an alternative differentiation method called algorithmic or automatic differentiation. With this computation method we can circumvent problems that may arise in symbolic computation. The feasibility of our approach is verified on the well-known benchmark problem of an continuous-stirred tank reactor model.

9:40 a.m.	P. C. Sanjuan Szklarz, E. Jarzębowska (PL-Warsaw)

Symbolic derivation of control models for nonholonomic mechanical systems

A systematic approach for a definition and derivation of control models for mechanical systems with nonholonomic constraints is presented. A mechanical structure of a system is translated to the geometric definition of local coordinate transformations. Further, mathematical equations of a control model can be matched to the geometric definition. Finally, numerical algorithms for numerical simulations are built as translations of an underlying structure to code procedures.

10:00 a.m.	A. Bulgakov, G. Tokmakov (RUS-Kursk)

Mechatronic System for Bulldozer's Intellectual Control

The most important task for bulldozer's traction mode control is to use its traction capacity in full by means of its end-effectors control. To keep traction mode at maximum or at a given resistance value applied to end-effectors automatically is difficult due to a great number of stochastic factors affecting the bulldozer. Thus, it is a must for the automatic control system to have self-tuning features [1]. The given paper presents a decomposition of a bulldozer's workflow model using analytical modeling method and neural networking technologies. Bulldozer is taken as a mechatronic system [2, 3]. The study presents analytic dependences for the sub-processes where analytic modeling based on bulldozer's parameters correlation knowledge is applicable. Models of the sub-processes are included into the general structure of bulldozer's workflow simulation model. They are intended to be used to study bulldozer's separate units applying analytic dependences of between their workflow parameters and to simulate bulldozer's workflow in general. Technique of identification and modeling of bulldozer's workflow based on neural networking technologies is described.

10:20 - 10:40 a.m. Coffee break and Visits of Expositions

10:40 a.m.	F. Schale, M. Braunschweig, S. Frank (D-Ilmenau)

Complexity of mechatronic systems on example of mobile robots

Mobile robots do not only get a greater importance in industrial applications but also in the private sector. In the near future assistance and care robots will also arrive at everyday life. In addition to their actual tasks the mobility of the robots is always the basic requirement. To meet this requirement of mobile robots a great variety of basic tasks has to be solved, e.g.: electrical power supply, energy control, orientation and navigation, obstacle detection, position- and drive control, communication between subsystems and with the environment These tasks are typical for mechatronic systems (mechanics, electronics and computer science). This paper is supposed to represent the complexity and the resulting subtasks of mobile robot systems.

11:00 a.m.	N. Bolotnik (RUS-Moskau); I. Zeidis, K. Zimmermann (D-Ilmenau)

Dynamics of a Two-Module Vibration Driven Robot

A two-body system excited by a periodic change in the distance between the bodies is a simple model of bioinspired limbless worm-like locomotors. Such systems can move progressively in nonlinear resistive environments. This principle of motion can be used for biomimetic mobile robots. The paper is a continuation of studies in the literature and by the authors themselves, in which the motion of a two-body system in a dry friction environment was considered. Now, we investigate a two-body system excited by a periodic change in the distance between the bodies and moving in an isotropic Coulomb friction environment for the case of low friction.

The system consists of two bodies coupled by a prismatic joint that allows the bodies to move translationally relative to each other along a rectilinear guide. The joint is actuated by a drive that periodically increases or decreases the distance between the bodies according to a prescribed law. The bodies of the system interact with an environment that resists their motion with forces depending on the velocities of the bodies relative to the environment. These forces are external with respect to the system. The forces generated by the drive change the velocities of the system's bodies relative to each other and relative to the environment, which causes change in the environmental forces acting on the system. Thus, by controlling the relative motion of the system's components we can change the external forces acting on the system, controlling thereby the motion of the entire system in the environment. The system under consideration can move progressively, if the bodies have different masses and the times of increase and decrease in the distance between them during the period do not coincide. The motion changes in direction if the bodies of the system change in place or the difference between the times of increase and decrease in the distance between the bodies changes in sign. A prototype based on the principles described above was built and the experiments demonstrated an acceptable agreement with the theoretical predictions.

Acknowledgement: This study was partly supported by the German Research Foundation (DFG) (projects Zi 540-12/1) and the Russian Foundation for Basic Research (RFBR) (project 14-01-00061).

11:20 a.m.	St. Gorges (D-Ilmenau); Ch. Riehs (D-Stuttgart); K. Zimmermann, T. Kästner (D-Ilmenau)

A cascaded worm-like locomotion system – constructive design, software and experimental environment

The earthworm utilizes a special type of locomotion. Robots which reproduce this way of movement could have very versatile applications in the future. The Ilmenau University of Technology is actively researching in this field. Now a robot has been developed to apply the theoretical results. This paper describes shortly the basic principle and the development of the robot. Furthermore a platform is presented, which has was created to demonstrate and test the abilities of this robot. The platform allows to alter some environmental parameters to display the effect on the motion. On a laboratory computer runs a software which generates the gait and transmits it to the control system of the robot. This software can also the visualization the generated gait, so the user has a direct feedback.

11:40 a.m.	S. Köhring, St. Lutherdt, M. Fremery, H. Witte (D-Ilmenau)

A wheg-axle-tracking mechanism for passenger transport purposes

Within the project Silver Mobility it was ascertained that the market does provide technical assistance for supporting near-field mobility of the age group 50+, but it is rarely optimally adapted to the needs of the user. In particular the ability to overcome obstacles is in need of improvement.

For this using whegs, known from mobile robotics, seems to be promising. But in order to use them for passenger transport purposes, the dynamic height offset occurring in wheg-driven mechanisms, called alternation, strictly has to be eliminated. For that purpose a mechanical solution published in a patent specification was taken up and developed. In result there are optimized gearboxes which are capable of reducing the alternation to 8.4 %, respectively 3.3 % assuming an additional electronic speed control of the drive.

12:00 noon – 1:30 p.m. Lunch and Visits of Expositions
12:00 noon – 1:30 p.m. Poster Session

Session 2.1 Mechatronic Systems

Time: Tuesday, 09.09.2014
Location: Humboldtbau, Lecture Room 202
Chairmen: Th. Sattel, M. Weiß (D-Ilmenau)

1:30 p.m.	Xin Zhao, S. Petkun, (D-Hallstadt); I. Zeidis, K. Zimmermann (D-Ilmenau)

Dynamical Behavior of Window Regulator Systems

Modern electrical power window regulator for vehicle door is made of electrical drive, mechanism, electronic hardware and controlling software. Due to the increasing system complexity, method is being searched to analyze system behavior and influencing factors. In this article, a mechanical model is introduced to simplify window regulator systems. In the model, glass mass and moment of inertia of electrical drive armature are essential components, because they possess the most kinetic energy of system during moving. To build up model, moment of inertia is firstly converted into effective mass. With it, mechanical model, with two degrees of freedom, is formed in the way that tow masses are connected by spring and damper. One mass is pushed by a driving force, which is a composite of constant and periodic force. This driving force is a representative of the torque from electrical drive. The other mass, simulating weight of window glass is applied by a Coulomb's friction force, the direction of which depends only on the velocity of glass. Both driving force and friction force are assumed to be small in comparison with elastic force. In one case, the system is analyzed when periodic component of driving force is zero. The stable state of system can be achieved, when the constant driving force is equal to the amplitude of friction force. In another case, the periodic driving force is non-zero. The system is then investigated with method of averaging. As verification, the stationary amplitude of system is compared between analytical calculation and numerical solutions of the system equations. The two special cases of comparison are that constant component and periodic component of driving force each is equal zero. A more general case is that the two components are both non-zero. The cause of periodic driving force is the irregular rotation of electrical drive. In worst case, it could lead to failure of safety function of window regulator systems. In a highly abstracted manner, the model in the paper provides a perspective to understand the dynamic behaviors of window regulator systems.

1:50 p.m.	K. Röbenack, A. Danish, Ch. Gottlöber (D-Dresden)

Active trajectory tracking of cutting edge in peripheral milling

Peripheral milling is one of the most widely used and important method for shaping wooden work pieces. Unfortunately, there are some surface quality issues related to peripheral milling, especially when the feed speed is high. The wavy structure that is obtained is called a cutter-mark and is inherent in the kinematic process of peripheral milling. Reduction or removal of this wavy structure requires sanding or other operations afterwards. This obviously leads to extra time and costs. The authors presented a new mechatronic approach which can be used to eliminate the cycloid motion of the cutting-edge.

The machine spindle position is moved periodically in one dimension to generate a linear motion of the cutting edge parallel to the work piece surface. In this paper the approach is used for the complex case when there are multiple cutting edges.

2:10 p.m.	S. Börner, F. Becker, E. James, K. Zimmermann (D-Ilmenau); V. Minchenya (BY-Minsk)

Low-cost Piezoelectric Unimorph Actuators – Analytical, Numerical and Experimental Studies with a Focus on Mobile Robotics

In this paper we discuss the static and dynamic behaviour of low-cost piezoelectric circular unimorph actuators with the aim to use them as a vibration motor for miniaturized mobile robots. The discussed example consists of two layers: a brass plate and a piezoelectric ceramic layer. For the analytical description, the actuation system is modelled as a thin elastic plate, which can be described with the help of the Kirchhoff hypothesis of plates and laminates. For the numerical analysis, a finite element model was created and solved using the program package ANSYS®. The results are compared with measurements using a scanning laser vibrometer. It can be concluded that the studied piezoelectric low-cost unimorphs can be used as vibration actuators in the considered frequency range, but that the static and dynamic behaviour of individual unimorphs differs considerably due to manufacturing tolerances.

2:30 p.m.	St. Hanitsch, J. Hampl, R.Fischer, J. Tobola, M. Stubenrauch, A. Schober, H. Witte, M. Hoffmann (D-Ilmenau)

Integration of Hydrogels into BioMEMS

Hydrogels are an interesting group of materials for the utilization in miniaturized bioreactors as well as BioMEMS. They can be implemented in fluidic systems or applied as a surface coating. Most hydrogels are fully biocompatible, their properties can be chemically tuned over a wide range thus making them a perfect interface between the world of solid state materials and the living world with biomolecules, cells and organisms. Within the research network "WK Basis" we focus on three main application areas for hydrogels: sensor coatings, tailored surfaces for cell cultivation and 3D patterning of hydrogels in BioMEMS.

2:50 – 3:10 p.m. Coffee break and Visits of Expositions	
3:10 p.m.	A. Bulgakov (RUS-Kursk))

Automatisation the 3D Reconstruction of the Building Model using 2D Images

This paper studies photogrammetry procedure performed by miniature unmanned rotorcraft, a quadrocopter. As a solution to build up 3D model for buildings facades, UAV can be a real asset as it can reach difficult corners of the building and take repeated captures. The high maneuverability of the quadrocopter permits us to take diagonal pictures containing information about the depth of the building, which is very critical factor while generating the 3D model.

The limitations of the terrestrial scanning procedure in terms of mobility, climatic and ground condition dependency and the non-cost-effective factor of manned aerial photogrammetry lies behind choosing UAV to automate photogrammetry procedures. In this paper we offer to study the quadrocopter as nonlinear object, to design an optimal controller based on modular concept in order achieve the necessary tilting stability. The suggested control algorithm has proved its efficiency in controlling different poses of the quadrocopter in comparison to other control techniques. The aim of the paper is to have the best quality of 2D captured pictures in order to superpose them to generate 3D model of the building. The generated trajectory takes into consideration the deviation factor of the ultrasonic altitude sensor and GPS module. Tracking the desired coordinates allows us to automate the photogrammetry procedure and wisely use manpower to generate the 3D model. The automation cycle consists of several overlapping algorithms [1] that are discussed in details in the paper.

3:30 p.m.	D. Kupriyanov, V. Musalimov (RUS-St.Petersburg); D. Shvarts, M. Tamre (EST-Tallinn)

Global descriptors application in object recognition

Nowadays problem of group robot interaction is as actual as it never was before. SLAM technology is a step forward in solving it. You can create large map with the help of the group of mobile robots by merging pieces of navigational data that robots collected. It would be nice to make robots also able to help each other determine precise size and position of object. By determining the size and relative place of the object with the help of dynamic measurement method, it will be possible to merge this data with the 3d map of the environment and add special descriptor to the object, so all the robots in the group will recognize it. 3D maps built by SLAM are usually made with the help of local descriptors. Such systems collect and store data about the environment. If object recognition is added here, it becomes important to not only create and store separate object database, but also create a method capable of retrieving and comparing information about objects. The global descriptors have less discriminative power and not so common for solving such a kind of problem. However, the global descriptors have a number of advantages. They are more compact and cheaper in computation sense. They have successfully used in place recognition application and for solving loop closing problem. Therefore, the main goal of this work is investigation of possibilities of global descriptor usage in object recognition. The work deals with series of experiments, which include creation of image model, based on training images, image recognition and retrieval of corresponding object from database and so on. Local descriptors approach are compared to global one, so usage of SIFT (Scale-invariant feature transform), SURF (Speeded Up Robust Features), GLOH (Gradient Location and Orientation Histogram), HOG (Histogram of Oriented Gradients), LESH (Local Energy based Shape Histogram), GIST descriptors are researched.

End of Session

H. Kirchner, M. Rehm, J. Quellmalz, H. Schlegel (D-Chemnitz)

Energy efficiency measures for drive cooling system of a machine tool by use of physical simulation models

Due to global resource scarcity, the energy-efficient production constitutes an important measure for future-oriented operation of the manufacturing industry. The machine tool as a central operational unit of production processes therefore offers a wide range of technical and technological capabilities for economization and optimization. Improved drive dynamics decisively boost productivity and accuracy of cutting machine tools but need thermal stability to ensure the process stability. Therefore the servo motors should be able to follow the enhanced dynamics without overheating. For that purpose selected motors are cooled by a customized ancillary unit. Since the amount of consumed electrical energy of the ancillary components is significant, compared to the total energy consumption of the machining center, a high potential for energy savings arises in this field of research. The cooling unit solely accounts for about 20 to 30 % to this power consumption. The paper shows an approach for a continuous theoretical and practical process of generating a physical simulation model for the cooling circuit of a machining center for turning and milling. With the help of divers experiments and mathematical calculations different sub-simulation models could be created, evaluated and improved. The hydraulic model showed good correlation with the coolant system. The analysis of the thermal behavior of the machining center revealed a lot of heat sinks and sources. Therefore, the thermal model should be created successively for each servo motor. Finally an accuracy up to 5 % for the hydraulic submodel and up to 15 % for the thermal submodel could be achieved. Using simulation and reference experiments, various diverging constellations of the cooling circuit, realized by manipulating its physical parameters, could be investigated. As a result, three consecutive energy saving concepts for the cooling ancillary system can be stated. A first approach is the coolant supply on demand. Secondly, the deactivation of partial circuits of the cooling unit could lead to additional energy savings. As a third concept, the substitution of the constant feed pump of the chiller by a frequency converter-controlled pump improves the overall energy efficiency.

A. Noll, C. Behn (D-Ilmenau)

Fuzzy-adapted Lane Assist of Vehicles with Uncertainties

Inspired by the motivation to find new possibilities for creating adaptive mechanical motion systems, this work is a contribution to the research on fuzzy adaptive control concepts. An already existing high-gain adaptive control strategy is extended by a fuzzy-adaptation law using various fuzzy logics. In succession, several strategies are developed, analyzed and simulated when they are firstly applied to control a biologically inspired sensor system (fast-adapting receptor cells). The controllers are more effective than other ones from literature. In a next step, the best working fuzzy-adaptation strategy is used to adaptively control a lane assist of vehicles based on a single-track model in state space. To find an optimal solution, the classic control theory and fuzzy logic are combined. In order to assess the effectiveness of the fuzzy-adaptation model, other lane assists which are already known from literature are compared to show the Pros and Cons and to find out which efficiency the attempt has.

R. R. Marangoni (D-Ilmenau); R. Baron (BR-São Paulo)

Pipeline inspection robot

The design and construction of a remote-operated pipeline video inspection robot and the development of a software for its remote control were addressed in this work. Based on the analysis of existent solutions, a robot with the following characteristics was built: wheel based movement mechanism, energy supply through embedded batteries and communication through a category 5 Ethernet cable. The embedded controller is a Raspberry Pi board (32 bit ARM processor), coupled with an Arduino (ATmega328 microcontroller) and a driver circuit to power the motors. An USB video camera and its pan and tilt control systems are connected to the Raspberry Pi and driver circuit respectively. The camera images are digitally sent to the operator, and are encapsulated in IP-packets, in such a way that it is possible to take advantage of the reliability and efficiency of the preexisting protocols and infrastructure. Through the developed remote control software, it is possible to visualize the captured images and the batteries' state, as well as control the robot's speed, camera orientation and illumination. The operational capabilities of the robot were evaluated by means of field tests. The robot is capable of inspecting dry pipelines with a minimal diameter of 400 mm and with up to 25 m of length. The maximal operating time is 4 hours.

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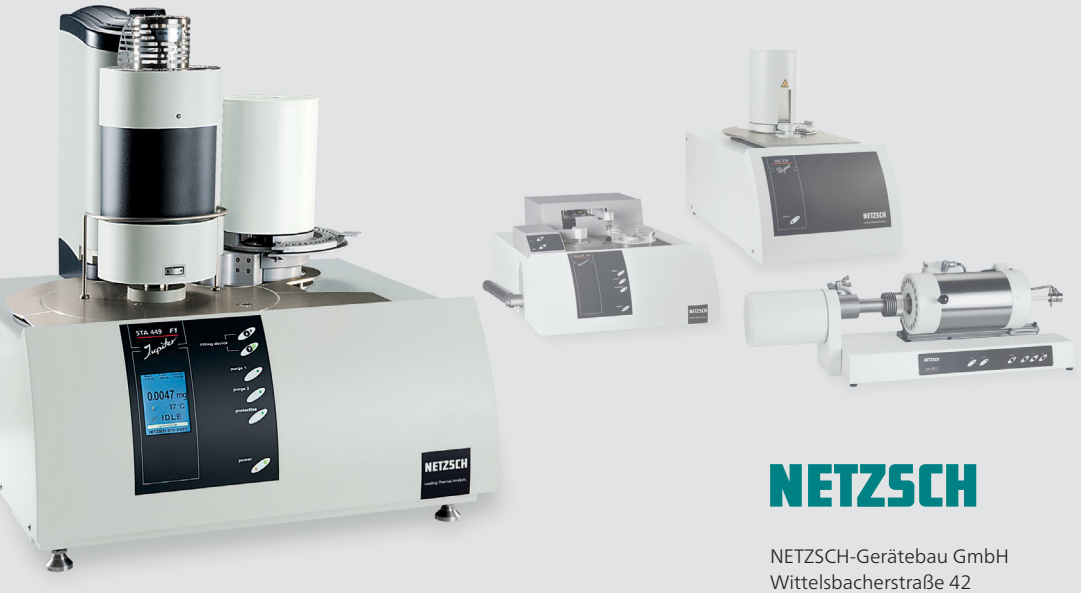

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Session 2.2 Assistance Systems

Time: Wednesday, 10.09.2014

Location: Humboldtbau, Lecture Room 129

Chairmen: K. Zimmermann, H. Witte (D-Ilmenau)

10:00 a.m.	I. Rottc, V. Musalimov (RUS-St. Petersburg)

Regularity of dynamic visual acuity change in the training results

Dynamic visual acuity (DVA) – the ability to perceive and distinguish details of moving objects, determine the speed and direction of object's movement. Development of methods for the estimation of DVA is necessary to assess the suitability (productivity and quality) of work of persons associated with the perception of moving objects, the reaction rate and adaptation abilities of human, optimization of visual work. The measuring unit include: template for non-contact measurement, high-speed videocamera, control and data processing device, frame grabber, side monitors. Subjects performed the task: to fix gaze on the camera objective, after the start signal to move the gaze on the optotype which is shown on the screen of one of the two monitors synchronously with the start signal, to recognize the optotype as quickly as possible and move the gaze to starting position. DVA – the time corresponding to the return of gaze on the original position. Average DVA for healthy adult subjects aged 23-35 years: 272 ms. In accordance with the Kolmogorov criterion the Weibull distribution (A=9,221; B=1,044;) optimally fit for experimental data approximation. Critical significance level for it equal 0,847. For regression analysis [1] of one-dimensional simulation models (linear regression models) by the Ordinary Least Squares method, the dependence DVA level from training is selected: $Y = \beta_0 + \beta_1 x_1 + \varepsilon(\mu,\sigma)$

here Y – the simulated value of DVA, x – influencing factor, ε – random component, σ – standard deviation and μ – the average of distribution of the simulated noise which calculated over the experimental data. The regression coefficients: β_0=281,86 и β_1=-1,99. Verification that the regression coefficients are not contradict output data carried out on the basis of Student's t-test. Calculated and graphically constructed confidence intervals cover estimators of coefficients, so the evaluation considered significant at level 10% [2].

References

1.V. Mescherjakov "Problem in statistics and regression analysis with MATLAB", M.: Dialog-MIFI, 448 p, 2009.

2.Yu. Rotts, V. Musalimov "Dynamic visual acuity experimental determination", Scientific and technical journal of information technologies, mechanics and optics, № 5 (87), pp. 49–53, 2013.

10:20 a.m.	E. Bances (D-Ilmenau)

A ear-pinna acoustic pressure analysis coupled with an ear-canal emulator 711

Simulations of the pressure on the pinna are significant contributions to the continuous improvement of hearing aids devices, i.e. they helps to improve the sound reception coming from different directions. Other interesting results are those that arise of the ear canal, leading to the implementation of ear-canal emulators, which mirror the acoustic behavior of the human ear.

Analyses of the distribution of instantaneous pressure in the pinna and the ear canal allows better understanding, how the human auditory system behaves under sounds from various directions. In the present work, we present an ear pinna model coupled with an ear canal emulator, to understand how the pressure is distributed in the model covering the human hearing range of (20Hz - 20 kHz). The model is based on an artificial human head called Neumann KU80 and the ear-pinna is coupled with an ear-canal emulator regarding the international standard specifications IEC 60318-4. The simulation considered an ear-pinna box of cubic shape which approximates the free space, providing an absorbing volume and using the walls of the box as external sound sources from different directions. The simulation of the complete model was done in Comsol Mutiphysics 4.3 and the frequency simulation range covers 20Hz to 20 kHz, the human hearing range. Comsol and its acoustic module in the frequency domain were used to analyze two different cases: when the sound source comes from the lateral plane of the pinna and when it comes from the dorsal plane. In each case the eardrum sound perception (pressure distribution) at different frequencies was studied. Index Terms - Acoustic, Ear Canal, Pinna Simulation, Emulator 711 coupler.

10:40 a.m. | A. Paessler, Th. Nagel (D-Dresden)

Innovative Cooling and Compression System to Decrease Swellings on Fractures at Extremities

If there is a break in a bone, the surrounding tissue swells due to protein influx, bleeding and lymphatic influx. A chirurgical operation in the area of the fracture cannot be carried out in this time. This leads to high treatment costs, long delay times and persistent pain periods. It is necessary to develop a mobile cooling and compression system, which enables the surgeon to significantly earlier execute a necessary intervention. Hence, the patient has to suffer less pain and overall costs of the treatment can be reduced significantly. To support the process of the swelling reduction active, it should be tried to exploit the principles in the occurrence of a chemical reaction, in this case an inflammatory reaction. By the use of a concerted, regulated cooling influence to the tissue, the metabolism at the fracture area should be slowed down. It results in a decrease of the posttraumatic swelling because of the inhibition of the local inflammatory response. To carry away the heat from the inflammation area of the fracture, U-shaped polyethylene tubes are used. The cooling of the water in this tubes is carried out in a re-usable device console by the use of Peltier elements. With the help of an innovative textile temperature sensor mat it is not only possible to measure the temperature two-dimensional at the fracture area, but also to adapt it flexible to the individual human anatomy. It allows an increased mobility compared to conventional cast. At the same time the excess accumulation of fluid can be removed from the fracture area by simulating a technical lymphatic drainage. Some suitable shaped pressure chambers made of polyamide will be fit to the human anatomy of the patient. The pressure chambers are used to maintain a constant pressure on the tissue around the fracture area. Moreover, higher pressures are applied to the pressure chambers in a specific frequency, so-called pressure pulses. This supports of the venous activity and thus removes the liquid of the swelling. By these extrinsic compressions of the vessels, the blood is actively transported back into the cardiovascular system to the heart and the swelling is decreased. Both systems should be connected with each other depending on the activity of the patient by a fuzzy logic algorithm.

11:00 a.m.	N. Omar, M. Fremery, H. Witte (D-Ilmenau); M. M. Abdelhameed, F. A. Tolbah (EG-Kairo)

A wheg-module with electromagnetic spokes

Based on the mechatronics design methodology a new approach for a wheg-driven robot is introduced. The wheg module with electromagnetic spokes is a wheg appendage with actively controlled spokes, to enhance the whegs performance by decreasing the vibration of the robot during motion over smooth terrains (alternation in the direction perpendicular to the direction of motion), increasing its ability to overcome obstacles without the need to change the design. The wheg was studied using a mathematical model. Simulations using the multi-body simulation tool ADAMS View® were done to help improving the concept. Based on the results from the mathematical model and simulations a prototype for the wheg module with electromagnetic spokes was manufactured, and experiments were done to evaluate the concept.

11:20 a.m.	T. Kaufhold, V. Böhm, I. Zeidis, K. Zimmermann (D-Ilmenau)

An approach to Magnetically Actuated Miniaturized Compliant Locomotion Systems

This paper describes two biologically inspired locomotion systems. The first system implements the main advantages of amoeboid movement and is able to move in the plane. The second one is an advanced version of the first system. It uses a magneto-sensitive-elastomeric structure in combination with a periodic magnetic actuation and is vibration driven. Furthermore, an asymmetric configuration of the body is used to generate planar locomotion. The working principle of this system is discussed with the help of modal, transient dynamic and magneto static analyses. Based on the numerical simulations, a prototype was developed, built and verified with experimental tests. Also further results of magneto static analyses and investigations on the first system are presented.

11:40 a.m.	S. Orujgoli (D-Ilmenau)

Bio-inspired: Self-organization in Cooperative Robots

12:00 noon – 12:45 p.m. Lunch and Visits of Expositions

12:45 – 1:40 p.m. Start Guided Tours

1:45 p.m. Start Excursion to Weimar

Session 2.2 Assistance Systems

Time: Thursday, 11.09.2014

Location: Humboldtbau, Lecture Room 129

Chairmen: Ch. Ament, H. Witte (D-Ilmenau)

9:00 a.m.	St. Lutherdt, A. Michaelis, F. Becker, St. Köhring, N. Fränzel, F. Weichert, S. Holder, M. Brandl, M. Fremery, H. Witte (D-Ilmenau); B. Faenger (D-Jena)

SilverMobility – near field mobility concepts for the age group 50+

The research group "Silver-Mobility - near-field mobility concepts for the age group 50plus" develops concepts to support elder people with beginning or advanced loss of their personal key mobility. Also the improvements of existing systems to substitute loosen abilities like wheel-chairs are in focus of the research group. The paper gives an overview about the approaches and some resulting concepts, mainly for overcoming of obstacles with wheel-based mobility aids, for energy storing solutions and for different assistance systems for mobility aids. The main principle for all these concepts was to get know and analyze the future users, their requirements and needs and then derive solutions from these analyses. The results show the necessity to develop adaptable, individualisable and re-configurable systems.

9:40 a.m.	A. Michaelis, K. Pezoldt (D-Ilmenau)

Risk Perception of the Elderly – Analyzing the Adoption of Innovative Mobility Systems

As a result of the demographic change, firms focus on the elderly as new potential target group. Hence, elderly-specific innovations, especially in the area of mobility systems, are developed. With increasing age the physical performance of the elderly decreases which affects crucial everyday activities. That is why innovative mobility systems covering short distances are of particular importance in order to maintain the mobile independence of the elderly in their everyday life and to ensure their social integration. When a mobility aid becomes vital, the elderly tend to use traditional and familiar mobility systems. However, they often associate a high perceived risk when it comes to innovative mobility systems because nowadays they are characterized by a high technological level. This may result in the rejection of the innovative mobility aid. The perceived risk can be of a functional, financial, social, physical, psychological or time-wise nature Firms need to consider and reduce the perceived risk serving as potential adoption barrier in order to ensure the product's success. Existing studies are segmenting the elderly trying to characterize a heterogeneous group and investigating their purchase behavior as well as their innovativeness. However, up to date, no study has investigated the adoption behavior of the elderly in terms of the perceived risk. Against this background this study aims at analyzing the risk perceived by the elderly during the adoption of an innovative mobility aid system. Thereby, all risk dimensions are considered in order to identify the risk dimensions which are relevant in the adoption process of the innovative mobility system. Subsequently, implications are made for practitioners how to reduce the perceived risk in order to market their innovative mobility aid successfully. This study contributes and broadens existing research on the successful adoption of innovations by the elderly. Furthermore, the results can be transferred to related research areas like innovative assistance systems.

10:00 a.m.	O. Bondarew, K. Zimmermann, F. Becker, I. Zeidis, B. Admamov, M. Abdelrahman (D-Ilmenau)

A description of the dynamics of a four-wheel Mecanum mobile system as a basis for a platform concept for special purpose vehicles for disabled persons

A four wheeled Mecanum vehicle has been analyzed kinematically and dynamically in this paper, that to understand and to determine the influence of the vehicle parameters and model them analytically. The principle of the nonholonomic mechanics has been used to introduce an exact dynamic model. The major focus in the work, presented in this paper, is on the 4WD 100mm Mecanum Wheel robot kit 10011 - Nexus Robot. Also, a set of simple and complex motion trajectories have been presented. The simulation results for the analytical models of the four wheeled Mecanum vehicle are presented and discussed briefly. A future view on the modern research trend lines in the field of omnidirectional mobile robots, in the next few years, is presented at the end of the paper.

10:20 - 10:40 a.m. Coffee break and Visits of Expositions

10:40 a.m.	N. Fränzel, Th. Schroeder, Chr. Ament, F. Weichert, A. Wenzel (D-Ilmenau)

Range Estimation System for Powered Wheelchairs

In this paper, we present a method to estimate a wheelchair's power consumption and therefore its battery autonomy. The wheelchair powertrain is modeled to enable a virtual driving simulation. The use of a white box model enables an adaption to other systems and configurations. This model outputs the actual battery and motor currents within a simulation for a given route and speed profile. These currents affect the battery's SoC, whose total charge depends on its temperature. To account changes of the available charge, a simplistic model of the battery's temperature dependence is introduced, that has been acquired via discharge cycles within a climate chamber. Furthermore, an *a priori* simulation uses the model to estimate the SoC after the virtual completion of a route with a corresponding height and velocity profile. Finally, the paper compares the results of the simulation result with real measurements using the recorded tracks and the generated virtual routes. Since the input for the *a priori* estimation relies on virtual routes, their quality is assessed as well.

11:00 a.m.	Ch. Iida, R. Suzuki (J-Ougigaoka)

Control and Evaluation on Powered Assistive Systems for Standing-up Motion

Standing-up motion is one of important actions in daily life. Physically weak or elderly people often require support for standing-up motions. The purpose of this study is to develop a new powered assistive system for standing-up motion. The positions of the vertical / horizontal axes of the assistive system have been controlled by using the internal model control based controller.

The validity of the proposed system has been confirmed through experiments. The proposed assistive system has been able to control the vertical / horizontal axes by using the IMC-based controller, and has been able to generate an appropriate trajectory for standing-up motions. Muscle activities have been observed by using a surface electromyography (EMG) for evaluating effectiveness of the assistive system. The system has been assisted muscle of tibialis anterior on standing-up motions. The proposed assistive system will be able to support for standing-up motions at home or hospitals as a rehabilitation machine.

11:20 a.m.	N. Suzaly, T. Nowack, S. Sprenger, P. Kurtz (D-Ilmenau)

An attempt to objectively determine part of the key indicator method using the Kinect® camera

It is important to evaluate the risk of musculoskeletal disorders related to repetitive or heavy lifting tasks. Thus, a method known as the key indicator method is recommended by the Federal Institute for Occupational Safety and Health (BAuA). The key indicator method (KIM) is used to assess manual material handling operations of employees in various fields. Through manual observation and assessment, certain key indicator parameters differ from one observer to the other. To help avoid variations in the results obtained, an objective method of assessment is here proposed using a motion-sensing input device from Microsoft, Kinect(TM). Using the Kinect(TM) camera, person recognition as well as a pseudo-skeleton model recognition is made possible. Data obtained from the pseudo-skeleton model can be used to objectively evaluate and classify the body posture. In this paper, we introduce the attempt to assess the body posture during manual work processes using the Kinect(TM) camera.

11:40 a.m.	Ch. Döbel (D-Rudolstadt)

Combining Learning Classifier Systems with the Decision Theory for creating a Smart Home

An adaptive, optimizing device management system for households called ENKOS is described that is basing on learning classifier systems (LCS) as well as methods of the decision theory to solve specific generalization and adoption problems. The two aims of ENKOS are firstly to minimize the electrical energy consumption inside the household by interpreting the user's wishes (controlling the devices), and secondly to enhance the consumer comfort by predicting the wishes of them by learning. This paper shows the feasibility to meet the aims by using learning classifier systems with extensions of the decision making theory, and the influence of several parameters towards the value of the learning rate of the objective function.

12:00 noon – 1:30 p.m. Lunch and Visits of Expositions
12:00 noon – 1:30 p.m. Poster Session

Session 2.2 Assistance Systems

Time: Thursday, 11.09.2014
Location: Humboldtbau, Lecture Room 129
Chairmen: C. Behn, H. Witte (D-Ilmenau)

1:30 p.m.	Th. Helbig, D. Voges, I. Husung, T. Volkova, Chr. Will, C. Behn, J. Steigenberger, K. Zimmermann, H. Witte (D-Ilmenau); S. Niederdschuh, M. Schmidt (D-Jena); G. Klauer (D-Frankfurt/M.)

Technical, non-visual characterization of substrate contact using carpal vibrissae as a biological model

During the flow of evolution, animals have developed specific sensory systems for the interaction with their environment. One example are tactile hairs – so called sinus hairs or vibrissae – on the body surfaces of mammals. These sinus hairs provide inspiration for technical development, since the variability of the biological sensors is due to mechanical structure. The aim of our research is to provide a technical, non-visual characterization of substrate contacts based on the biological model of carpal sinus hairs of rats. Rats live in a tactile world, they have poor visual acuity and lack binocular fusion, making their tactile senses crucial in very different occasions, regarding orientation, locomotion, grasping and more. Carpal sinus hairs may be found at the distal end of the lower arm near the carpal bones in arboreal mammals as well as in mammals with high grasping abilities. In this contribution, we present methods and first results from motion studies with living rats are introduced, which shall help to clarify the functionality and role of carpal sinus hairs in the detection of substrate disturbances, which investigate the influence of mystacial and carpal sinus hairs on different walking parameters, analyses of geometrical, structural and mechanical properties of carpal sinus hairs and the transfer of these into mechanical models, and at last a macroscopic model of a sinus hair. Mathematico-mechanical models at various levels of abstraction (rigid body models, continuum mechanics), based on experiments (movement studies, biomechanical measurements), and analyses of the results serve as an augmentation in basic research as well as a foundation for biomimetic (more exactly: bionic) transfer.

1:50 p.m.	Ch. Will, J. Steigenberger, C. Behn (D-Ilmenau)

Quasi-static object scanning using technical vibrissae

Biological observations have shown that rodents use their vibrissae to estimate obstacle contact within a few contacts of the tactile hair. Based on this observation, a mechanical model of an animal vibrissa is developed, resulting in a long slim beam with a clamp as support at one end. A sweep of the beam along a profile, with its boundary describable by a strictly convex function, exhibits two phases. A phase in which the beam contacts the profile at its tip and a phase in which the beam contacts the profile tangentially (between the tip and the base). An analysis of the problem results in a decision criterion for the reconstruction and in a formula for the contact point of the beam with the profile. This is new in literature. Based only on forces and moments at the support it is possible to reconstruct the profile.

2:10 p.m.	D. Baldeweg, Ch. Will, C. Behn (D-Ilmenau)

Transversal Vibrations of Beams in Context of Vibrissae with Foundations, discrete Supports and various Sections

In this paper, we deal with the transversal vibration analysis of beams. Based on mechanical models which are inspired by the vibrissae of rats and mice, a contribution to the distance detection using these mechanical sensors is made. Already existing models from literature are improved and designed more realistic: the elasticity of the follicle-sine-complex (FSC, support of the vibrissa), of the skin, and the conical shape of the vibrissa are taken into account, and their impact on the dynamic analysis is determined. The FSC is modeled by a viscoelastic-foundation, the skin by a discrete spring-damper-combination, the conical shape by three different diameters, and the object contact point by a (fixed) bearing. Furthermore, different types of supports (clamping, bearing and free end) are considered. Due to the complexity of the models, we firstly focus on conservative systems in this paper (three models are studied). As mentioned, these models differ from each other only by the type of support. For the obstacle distance detection, we set up two algorithms to unambiguously determine the object distance with the help of some eigenvalues (later measured in experiments) of the boundary-value system (i.e., partial differential equation with boundary conditions). This is firstly done in deriving the context of the transition points between the natural frequencies, and secondly in establishing the functions of the displacements with the help of the relationship between the eigenvalues and the natural frequencies. Finally, the influence of the discrete spring on the behavior of the eigenvalues is presented, and the algorithms are tested to be valid for the developed models.

2:50 – 3:10 p.m. Coffee break and Visits of Expositions

3:10 p.m.	M. Fremery, H. Witte (D-Ilmenau)

A joint with tunable compliance for changing locomotion patterns

This paper introduces a joint with active tunable compliance in order to change locomotion patterns of mobile, bio-inspired robots. Using a spring off the shelf with linear stiffness coefficient, a change in joint compliance is realized by changing relevant lever lengths inside the joint. Thereby the design follows VDI 2206, the design guideline for mechatronic products. Based on a mathematical calculation as well as on a multi-body-simulation inside SOLIDWORKS MOTION a first prototype was manufactured and tested. Comparison of measured data with those values theoretically predicted entails the design and production of the JWTC 2.0. By implementing the mechanism inside the underactuated swimming robot URMELE the authors intend to change locomotion patterns in a defined and reproducible manner.

3:30 p.m.	L. Heinz, M. Krüger, C. Behn (D-Ilmenau)

Kinematics and Dynamics of various Models for Snake-like Locomotion Systems

Worms and snakes are living paragons for the development of biological inspired crawling rescue robots.

The investigations on worm-like locomotion systems (WLLS) has a long and outstanding tradition at the Department of Technical Mechanics at TU Ilmenau. Because the investigated models (up to friciton exploration and adaptive control of certain gaits) can only operate in a straight line, actual analysis is devoted to snake-like locomotion systems (SLLS). In contrast to various works from literature which are focusing only on the development of prototypes, we try to follow an analytical framework. The global goal is not to construct prototypes with one-toone properties of snakes, rather the models shall exhibit its main features. At first, we set up various models of SLLS consisting of mass points. Each mass point is equipped with a rotatable skid (realizing no-side-slip) having ideal spikes as a ground contact realizing non-negative velocities in skid direction. We investigate these models in a kinematical and dynamical way, where we firstly assume that the link lengths are constant. The skids are controlled off-line via various mechanisms. Then, we switch to time-varying link lengths (the entirety of all link functions is called gait). In dynamics, actuator forces have to adjust these link lengths. Since it is rather impossible to calculate the necessary actuator force a-priori, we apply an adaptive controller which adjusts these force outputs on its own and λ-tracks a certain gait to achieve movement of the whole system –- undulatory locomotion.

3:50 p.m.	F. Becker, S. Börner, T. Kästner, I. Zeidis, K. Zimmermann (D-Ilmenau); V. Lysenko (BY-Minsk)

Spy Bristle Bot – A Vibration-driven Robot for the Inspection of Pipelines

In this paper, a bristle bot for spying and inspection purposes is presented. It consists of the main body with integrated power supply, vibration motor and inspection technology. It is surrounded by a cylindrical chassis with evenly distributed bristles. The robot is designed for pipelines and tubes with a diameter of 25 mm, but the chassis can be exchanged to adapt the robot for different pipeline sizes. Furthermore a mechanical model of a bristle robot is studied numerically. The locomotion velocity is obtained for different parameter combinations and resistance forces.

End of Session

D. Sayfeddine, A. Bulgakov (RUS-Novocherkassk)

Performing indoor radiation leakage test using quadrotor

Mechatronic and robotic technologies have infiltrated into in different industrial and transport applications. This success has stimulated new tendencies in biomedical machinery designs. For instance, systems like DaVinci surgical robots, Karl Storz exhauscopes providing 3D previews, Philips advanced medical imaging with position automation and assisting TRUMOF VIKI vocal systems have pushed the health service to a new benchmark. In the same time executing hybrid projects in biomedical sphere requires new quality assurance. This has lead to new technical standards for the designs known as "medical grade designs". Nowadays, we have plenty of medical grade monitors, integration with fiber optic connectivity ruling out even the utilization of normal cat-6 cables. In a related matter, medical imaging has a supplementary quality check: the radiation check. Systems like CathLabs, MRI and CT scan has to generate radiation into the limit to be accepted. Radiation check is usually done by experts who track the excess in radiation around the LEAD glass, entrance and exit doors and in the nearest halls. This test is usually done manually what will expose the operators to a "unknown" circumstances with regards to the amount of radiation being generated. Replacing the human being in routinely and dangerous tasks is the main aim as of mechatronic and robotic products. Thus we see to offer a solution to replace the radiation operators during the quality check. An aerial miniature robot, a quadrotor, equipped with necessary radiation sensors to scan all the identified areas while the operators are behind LEAD protection glass. This paper offers a simulation on the state control of the UAV due to the restrictions to access recently installed radiology sites for "outsiders". The duty of the robot is to identify the edges of the doors based on which will be generated 2D trajectory coordinates to move along with pre-defined speed and conservation of the safety distance to the edges.

Session 2.3 Mechanism Technology

Time: Tuesday, 09.09.2014
Location: Humboldtbau, Lecture Room 012
Chair: L. Zentner (D-Ilmenau)

9:00 a.m.	S. Linß, L. Zentner (D-Ilmenau); A. Milojević (RS- Niš)

Considering the Design of the Flexure Hinge Contour for the Synthesis of Compliant Linkage Mechanisms

Due to their advantages, compliant linkage mechanisms are state of the art in high precise motion systems for guiding and transfer tasks. Therefore, especially prismatic flexure hinges with basic cut-out geometries are used as revolute joints. In this contribution, with the help of the finite elements method (FEM) it is shown that the possible motion precision of compliant straight-line mechanisms and compliant grippers is determined by the dimensions and particularly by the notch contour of the flexure hinges. For this reason, both aspects are newly considered as free parameters regarding the multi-criteria synthesis of compliant linkage mechanisms. It can be shown that 4th order polynomial contours are suitable to realize both highly precise guiding and a large motion range.

9:20 a.m.	L. A. Gonçalves Junior, A. C. P. Bitencourt, H. A. Lepikson (BR-Salvador); R. Theska (D-Ilmenau)

Characterization of the Elasto-Kinematic Behavior of Asymmetric Cross Spring Bearing

Cross-spring bearings are widely used in precision engineering applications due to the high repeatability of motion and systematic characteristic of the main errors. Thus, this work is focused in the characterization of the elasto-kinematic behavior of such bearings. Firstly, an analytical approached is proposed to model load-rotation relationship of cross-spring bearings. Then, a numeric-iterative technique is used to obtain the solution of the resulting nonlinear system of equations. The obtained results are used to determine the major systematic error of the bearing; the rotary axis deviation. Furthermore, they are also applied to perform the geometric optimization, stress analyzes and to investigate the stiffness characteristics in order to provide useful insights to help in design stage of such a bearing. Finally, the results provided by the mathematic model are verified by finite element analyzes (FEA).

9:40 a.m.	St. Griebel, M. Feierabend, L. Zentner (D-Ilmenau); A. Bojtos (H-Budapest)

Characteristics of a Compliant Fluid-Mechanical Actuator for Creating a Screw Motion - Comparison of Simulation and Measurement Results

In this paper a compliant fluid-mechanical actuator which provides a screw motion for adduction of dry electrodes on the surface of the head is investigated. The simulated and measured characteristics with and without a load torque are compared.

The compliant fluidmechanical actuator is one piece, hollow on the inside and consists of a helical twisted lateral area. Its height and diameter are 50 mm. It consists of silicone Elastosil® M 4644 and can be used in a pressure range from 0 to 1 bar. Advantageously, the actuator reaches a rotational angle of approximately 100° and a stroke of about 29 mm. These values can be increased by load torque. In the pressure range of $0 \leq p \leq 500$ mbar, the actuator operates mainly on the principle of folding. In addition, it generates a nearly linear screw curve. In the pressure range of $500 < p \leq 1000$ mbar, it operates mainly on the principle of strain. Hence, the actuator generates a stroke that is almost independent of the load torque. Furthermore, the deviations of rotation angle and stroke of the Ansys® FEM simulation model and of the functional model are in the pressure range of $p \geq 200$ mbar without load torque, in consideration of an experimentally determined friction torque that is less than 10 %. The simulation models can be used in addition to the development and investigation of fluid-mechanical actuators.

10:00 a.m.	A. Milojević, N. D. Pavlović, N. T. Pavlović (RS-Niš)

Adaptive Compliant Gripper Finger with Embedded Extending Actuators

Developing a gripper that can grasp irregular and unpredictably shaped objects represents a challenging task. Grasping objects of widely varying shapes and surfaces essentially requires adaptability for safe and reliable gripping performance especially when fragile objects of different stiffness are manipulated. Many researchers have thus developed different kind of universal flexible grippers. Most of these grippers require external drive (compressed air or electrical motor) and assembling. Moreover, there is no unique synthesis methodology.
Compliant mechanisms with embedded actuators are one way to obtain the gripper which could accommodate its grasping surface to any irregular and sensitive grasping object. This paper presents the new solution of adaptive compliant gripper (in this paper only one gripper finger) with embedded actuators. By embedding actuators within a compliant gripper structure, gripper may be capable of producing many complex deformations of the grasping surface i.e. gripper would be adaptive. The algorithmic framework for distributed actuation within a compliant active structure has been already developed by others, but the proposed method often produces compliant mechanism with lot of intersections between elements as well as elements and actuators, which are very difficult (or nearly impossible) to manufacture. Beside this, intersection between elements often increases complexity and stiffness of the structure which can significantly lower the system functionality. This paper also presents an improved design methodology for the simultaneous synthesis of compliant mechanism and actuator placement. The design methodology is improved so that compliant systems (compliant mechanism with embedded actuators) without intersecting elements are obtained (unlike solutions obtained by using existing methodology). This represents one novel approach to the synthesis of compliant systems and it is applied to developed adaptive compliant gripper. It will be demonstrate that adaptive compliant gripper with embedded actuators (in this paper extending actuators are used) may be capable of achieving many different grasping patterns and can adapt its shape to the grasped objects, thus having many advantages over existing grippers.

10:20 - 10:40 a.m. Coffee break and Visits of Expositions

10:40 a.m.	L. Hartmann, R. Reich, U. Kletzin, L. Zentner (D-Ilmenau)

Approaches on Material Analysis and Modeling of Bouncing Putty

In this contribution the mechanical properties of Bouncing Putty are investigated and the material parameters are determined by a rheological model. The Bouncing Putty is a silicone polymer, which shows viscoelastic behavior and it is characterized as a non-Newtonian fluid with dilatancy. If it is thrown on a surface, it bounces back like a spring. But it flows like a viscous fluid, if it is simply put on a desk. The reason why it behaves either like an elastic material or like a viscous liquid is the speed of the deformation. For dilatant also named shear-thickening materials the viscosity increases, if the strain rate (speed of the deformation) rises. Because of the non-linear stiffness and damping behavior, this material is very interesting as a smart material in modern engineering, especially to handle disturbing vibrations and dynamic effects. Hence, to use this material for applications in engineering the non-linear spring-damping behavior has to be assessed by the functional relations of the mechanical parameters. But, determining stiffness and damping is not trivial, because the non-constant values are based on experiments and they depend on the theoretical model, which is applied. Due to this, an appropriate rheological model to map the effect of shear-thickening is developed and a testing method, based on a deformation test under constant strain rate using a servo-hydraulic testing machine, is presented. The recorded testing data is fitted to the rheological model and this yields the values of the material parameters according to the model. As a result, the stiffness and damping parameters of the dilatant Bouncing Putty are quantified for different strain rates.

11:00 a.m.	R. Lichtenheldt, B. Schäfer, O. Krömer (D-Weßling)

Hammering Beneath the Surface of Mars – Modeling and Simulation of the Impact-Driven Locomotion of the HP3-Mole Using Enhanced Multi-Body Dynamics

As the formation of the rocky planets in our inner solar system has always been a major subject of scientific interest, NASA's discovery mission InSight (Interior Seismic Investigations, Geodesy and Heat Transport) intends to gain further knowledge about the interior structure of Mars. In order to understand the processes that lead to planetary evolution, Mars' seismic as well as thermal properties will be measured. DLR's HP3-Mole (Heat Flow and Physical Properties Package), an innovative self impelling nail, will hammer itself into the red planet deeper than any other instrument before, in order to measure the heat flux and thermal gradient in a final depth of 5 m. To achieve this challenging goal, high fidelity simulation models have been used throughout the whole development process. To meet the demands on accuracy, two detailed models were created based on enhanced multi-body dynamics and discrete element techniques. For the most detailed analysis both methods are coupled to enable further understanding of the interaction between mechanism and soil dynamics. Validation has been carried out for every existing prototype stage of the mechanism and has shown very good correlation between measurement and simulation. Additionally the soil model is compared to penetration tests in real soil as well as cone penetrometer measurements.

Using these simulation models various influences can be evaluated by virtual prototypes in the actual environmental conditions of Mars, which would not be achieved in reality before the start of the mission. By supporting the design with detailed simulations, it was possible to increase the locomotion performance while reducing the consumed power remarkably, i.e. by less than 5W of input power.

11:20 a.m.	A. Bendahhou (D-München); L. Zentner (D-Ilmenau)

Measurement Tools and Strategies to Improve Stability in Metal Cutting

The conducted measurements show slight differences in the prediction of stability lobes due to the variation of tool-holder mass and length. It is show that even though the 380 mm configuration is stiffer, it reaches lower depth of cut over the available spindle speed spectrum. An experimental validation of the predicted cutting parameters has to be done with respect to trade-offs in terms of output loss, cost per part and Quality reduction in series production.

12:00 noon – 1:30 p.m. Lunch and Visits of Expositions
12:00 noon – 1:30 p.m. Poster Session

L. Hartmann, L. Zentner (D-Ilmenau)

Modeling and Investigation of Spring Clip Mechanisms and Applications in Precision Engineering

In many technological fields spring clip mechanisms are used as a kind of compliant mechanism, especially as clamping and securing elements. A specially formed wire bracket is supported by two parallel arranged revolute joints with shifted axes. Due to the special support of the compliant mechanism element (spring clip) in a fixed frame, the mechanism is preloaded and so the force-displacement behavior is influenced. The size of the mechanical preload is determined by the distance between the two shifted axes. In this contribution we investigate examples of the effect of a mechanical preload on the deflection of one asymmetric spring clip mechanism using numerical and analytical methods and we suggest applications of spring clip mechanisms in precision engineering devices.

L. Hartmann, R. Opfermann, L. Zentner (D-Ilmenau)

Analysis of Supports of a Three-legged Compliant Snap-Through Structure for Application in an Excess Flow Valve

Installing excess flow valves in gas pipelines is an active protection to avoid accidents successfully. In case of damage or destruction of gas pipelines the gas flow is automatically shut off, when a predefined flow rate is reached. Current research work is focused on novel closing devices with a compliant three-legged snap-through structure instead of spring-loaded and guided closing disc. Contrary to the conventional valve design the new approach realizes a valve with a bistable switching behavior without any intermediate position, meaning that the valve is either completely open or completely closed. Additionally to the shape and the geometric parameters of the three-legged snap-through structure, the mounting of this structure in the valve housing also influences the switching behavior of the valve. In this contribution the influence of the kind of support to the force-displacement behavior especially the switching force of the excess flow valves using the finite element method (FEM) is analyzed.

M. Issa, L. Zentner (D-Ilmenau); S. Hügl, Th. S. Rau, O. Majdani (D-Hannover)

Specific Curvature Behavior of Compliant Mechanism with Hydraulic Activation Used for Medical Instruments or Implants

In recent years, there are ever increasing demands on the accuracy of surgical procedures besides the gentle, minimally-invasive surgery. Due to the complexity of patient-specific anatomy and the need to preserve crucial structures that may lie on the linear pathway from the access to the target area, analyzing of non-linear access paths is preferred.

This method requires specific design of the instruments (e.g. flexible endoscopes) or the implants (e.g. Cochlea implant). The existing systems used in this field are developed using smaller dimensions, increased operative possibilities, easier and faster handling resulting in a reduction of potential trauma. In this paper, a new compliant mechanism, which allows for a specific curvature by external activation, is presented. The curvature behavior of the compliant mechanism by hydraulic actuation is considered. The curvature behavior of the compliant mechanism by hydraulic actuation is of interest to facilitate the insertion of the implant or the instrument used in the non-linear access paths to the target area, and to avoid any damage, which could occur during the surgical procedure. With the help of the simulations, a specific curvature behavior of the compliant mechanism executed by hydraulic actuation is demonstrated in this paper. For simulation purposes the Finite Element (FE) model was used.

M. Issa, L. Zentner (D-Ilmenau)

Sensor Elements Made of Conductive Silicone Rubber for a Compliant Gripper

The purpose of this paper is to create the foundation for the use of conductive silicone rubber (Powersil 466 A/B VP) [1] as sensor elements. Therefore, several investigations of the characteristics of conductive silicone rubber are carried out depending on different loads. The sensor element made of conductive silicone rubber changes its electrical properties under the influence of the loads. This paper presents an application of this material as sensor elements for a new compliant gripper. The sensor elements of the gripper have two functions; they are parts of the gripper structure and they give rough information about the gripping process. The production technology of the sensorized gripper and the experimental measurements are discussed in this paper.

A. Chaykina, St. Griebel, L. Zentner (D-Ilmenau)

Compliant Shear Force Sensor

This paper presents a novel compliant sensor for detecting the magnitude and direction of applied shear force or distribution of shear forces on a surface. The operating principle of the sensor is based on the large deformation capacity of silicone elastomers. The magnitude of the shear force is determined by measuring the internal pressure in the moment of electrical contact closing or opening. The sensor is particularly suitable for human-machine interfaces, such as robotics and medical technology. The functionality of the proposed shape is tested using the finite elements method (FEM). Subsequently, the sensor is constructed and the selected principle for detecting the magnitude and direction of shear force is verified by metrological test.

A. Milojević, N. T. Pavlović, T. Petrović, M. Milošević, M. Tomić (RS-Niš);
S. Linß, L. Zentner (D-Ilmenau)

Optimal Design of Adaptive Compliant Mechanisms with Inherent Actuators Comparing Discrete Structures with Continuum Structures Incorporating Flexure Hinges

A compliant mechanism represents a single piece flexible structure which uses elastic deformation of its flexible members to achieve force and motion transmission. There are many advantages of using compliant mechanisms compared with rigid body mechanisms: Absence of wear and backlash, reduced noise, no assembly, easier maintenance and manufacturing. Previous studies of adaptive compliant mechanisms use a design process where actuators and sensors are added after the compliant mechanism is developed. This includes the determination of actuator and sensor type, orientation, size and location.

In this paper a novel methodology for the optimal design of adaptive compliant mechanisms and their actuation in only one structure is represented. Hence, the structural topology of the compliant mechanism and the placement of multiple inherent actuators are simultaneously synthesized. Two different approaches during the novel design methodology are used for exemplary developing two topology optimized adaptive compliant grippers with same topology but different shape: A discrete beam like structure and a continuum structure incorporating optimal designed flexure hinges with polynomial contours. The improvement of performance of both grippers is compared regarding the adaptability, the stroke and the controllability. The resulting adaptive grippers can grasp objects of widely varying shapes and could have possible application in many fields, e.g. in medicine and robotics.

M. Feierabend, L. Zentner (D-Ilmenau)

Conception of the Mechanical Part for a Hand Rehabilitation Device for Use in Medical Training Therapy

The hands are regarded as the most intensively used parts of the human body. They are used to perform very different activities, and to carry out necessary daily needs. Due to their exposed location and frequent use, hands have a high risk of injury. By the natural way in which humans use their hands, their major importance only becomes apparent after they are injured. Permanent damage is not limited to physical performance, but can also have psychological effects on the patient. Therefore, the fullest possible rehabilitation of the hand is desirable. To achieve this goal, active repetitive movements are important. These increase strength, accuracy and functional use when applied to patients. Robotic technology is one approach to provide such a therapy. Mechanical devices can provide therapy for long time periods, in a constant and accurate way, without fatigue. They also can perform different functions, as well as record a wide range of parameters. Mechanical rehabilitation devices can improve short and long-term motor control of the patient. The restoration of motoric control appears greater after robotic/mechanical-aided therapy in comparison to conventional therapy. This paper presents the design of the mechanical part of a novel, portable device for the handrehabilitation in medical training therapy. The device will be used for the continuous passive motion (CPM) and continuous active motion (CAM) handrehabilitation. It is designed for patients recovering from hand surgery or strokes. The device is capable of flexing/extending the metacarpophalangeal (MCP), proximal interphalangeal (PIP) and distal interphalangeal (DIP) joints. All joints can be moved independently through a motion range from 0° to 80° for the PIP and DIP joint and up to 70° for the MCP joint. The rigid frame structure simplifies the mounting of actuators and sensors. It is also possible to integrate a size adjustment for different hand sizes. By padding the inside of the frame structure, an individual adaptation to various hand forms (finger diameter, deformation) is possible.

Topic 3:

Systems Technology

Session 3.1 Components, Systems and Processes
Session 3.2 Sustainable Mobility
Session 3.3 Production and Processing Technologies

3.1 Components, Systems and Processes

Time: Tuesday, 09.09.2014
Location: Humboldtbau, Lecture Room 204
Chairman: Ch. Weber (D-Ilmenau)

9:00 a.m.	Th. Lasch (D-Aspach)

Competition of innovation – realization by „Consistent R&D"

We live in a global market with globally acting competitors and global cost structures. Therefore, the creation of innovative products is and will be more and more the most important task for companies. This innovative process must cover the whole chain – from the first idea to the competitive product. There are many known methods for the optimization of product design and the design process itself. All these methods are only sufficient for single aspects. Using the experience of many design projects it is proposed a new integrating procedure with much more influence on the requirements of product development. This is called „Consistant R&D" (consistent research & development), standing for completness, consistency, consequence.

1. All divisions give active input regarding creation of innovations

All departments have to be involved in the screening of possibilities for innovations.

2. Requirements of product development and production control the company equally

If the quantity of new products have to be increased, than they should be considered as really existing products in the planning. Consequently, the resources for future products must have the same weight regarding decisions. To achieve this, some procedures must be modified.

3. Product development process and production process merge to one value creation process

We have a strong trend to more individualized products. So the task for the future is to develop „ready" products without prototyping but at the cost of mass products.

4. Bundling of competence and mandate in autonomous teams

Small competent units can handle the increasing amount of tasks much better than a centrally controlled company. However, they need clear rules and figures given by the management.

Than the project leader will be an entrepreneur.

9:20 a.m.	A. Crostack, H. Binz, D. Roth (D-Stuttgart)

Concept of modelling the Failure Mode Effects Analysis (FMEA) on the base of Characteristics-Properties Modelling (CPM)

The contribution describes the comparison of the Failure-Mode and Effects-Analysis (FMEA) and the Characteristics-Properties Modelling (CPM) in order to define the results of a FMEA (failures, their effects and causes and their rating) which can be modelled by using the CPM. Additionally, the possibility in order to support the procedure of the FMEA based on existing CPM models is examined. For this purpose, in a first step, the basics of CPM and FMEA are analysed. Based on this, the steps of the FMEA are identified, which results can be directly modelled by CPM.

This theoretical concept will be explained using different examples and performed in a first application scenario by using the example of a sandwich element. It is shown that most aspects of a System FMEA or design FMEA can be directly modelled by the basic elements of CPM. Due to the fields of application of CPM it is not possible to model the results of Process FMEA which examines for example, manufacturing or assembly processes. For the modelling and support of the organisational aspects of the FMEA, the combination of the functionalities of CPM and of the common project management would be necessary.

9:40 a.m.	R. Arunachalam, Z. Qamar (OM-Muscat)

Design for Quality in the Concept Generation Phase of the Product Design Process

The design process with the quality in mind especially the customer requirement is the focus of this research. Quality may refer to many attributes of a product, predominantly originating from the customer requirements. Among the several techniques available for understanding and ranking the customer requirements, Quality Function Deployment (QFD) is perhaps the most popular. Although several engineering design textbooks deal with the product design process, they do not clearly point out how to use the information developed in the QFD in developing the concepts for the design. The proposed methodology provides a clear link between QFD and concept generation, at the same time ensuring that most important customer requirements are addressed and a quality product is developed.
A QFD was developed for the redesign of the squeeze casting attachment. The last column of the QFD shows the relative weight that can be used to identify the most important customer requirements. This information provides the missing link to the concept generation phase. Redesign can of course not be attempted for improvement of all customer requirements listed in the QFD. The highest 4 relative weight values translate into the most important functions for which redesign should be attempted. The customer requirements could be considered as the major sub functions that need to be fulfilled in order to satisfy those selected customer requirements. Using the morphological method, three concepts were generated. A basic decision matrix was utilized to select the best concept from the three generated. The selected concept was developed into a detail product. The design process focused on how to transfer the important customer requirements identified in the QFD and incorporate it when generating the concepts. This has been demonstrated through the example of developing a concept for a squeeze casting attachment through which the link between the QFD and concept generation has been clearly established.

10:00 a.m.	Chr. Muggeo (D-Kaiserslautern)

An Approach for a Model Based Development Process of Cybertronic Systems

Modeling today's products means modeling interdisciplinary 'product systems' integrating various authoring systems with the technical-administrative product structure and the related processes. This paper introduces System Lifecycle Management as key concept to cope with risen requirements in the development process for so called Cybertronic Systems. Along with an approach based on methods of Model Based Systems Engineering the outlined challenges are studied in the research project mecPro^2.

The overall concept considers engineering processes as well as engineering data. Within the project a framework for modeling a product system in the early development phases (left wing of the V-model) will be defined which guarantees traceability and also manageability of such complex Cybertronic systems.

10:20 - 10:40 a.m. Coffee break and Visits of Expositions

10:40 a.m.	B. Posner, H. Binz, D. Roth (D-Stuttgart)

Development of working structures with a focus on Lightweight Design

This paper presents a method for developing a variety of solutions for working principles and working structures with a focus on their lightweight design potential. Furthermore, an existing procedure and criteria are transferred, implemented and complemented in order to reduce the developed variety of solutions to focus on the selection of solutions with greater lightweight design potential. The procedure is demonstrated using the development of a vacuum shredder as an example, to assist understanding the method's application.

11:00 a.m.	N. Pitatzis (GR-Thessaloniki)

Design and FE Calculations of a Lightweight Civil Unmanned Air Vehicle

This script refers to the strategic design steps followed towards the scope of the structural optimization of an unmanned air vehicle (UAV). In order to attain the aforementioned aim, the strategy of parameterization has been followed, given the capabilities that modern computer aided design and engineering (CAD and CAE) programs provide to the aeronautical engineer. Accordingly, both the external shell structure and the internal structural parts of the aircraft have been interactively parameterized. The capability to parametrically amend the geometry and material properties of major and/or non-essential structural parts of the aircraft, allowed for several loop-like structural and aerodynamic analyses that led to significant airframe weight reduction of more than 30% between the initial-coarse and final-optimized structural configurations in a time effective manner. The outcome is a structurally integral aircraft according to the relevant Certification Specifications for Very Light Aeroplanes (CS-VLA) of the European Aviation Safety Agency (EASA).

11:20 a.m.	A. Wodtke, K. Augsburg (D-Ilmenau)

Geometry- and functional principle improvements of high-temperature thermocouples for in-engine measuring points from the viewpoint of the flow and life optimization

The reduction of emission limits and the efficiency enhancement of internal combustion engine commonly lead to an increase of exhaust gas temperatures. With the aim of making statements about motor function and component critical thermal conditions, the temperatures of the exhaust gas in particular are detected by highly dynamic high-temperature thermocouples with a thermowell.

This measuring equipment is exposed to a very harmful environment and must be resistant and sensitive at the same time. For this reason a novel test concept has been developed and implemented, which allows variable mechanical loads on a thermocouple with thermowell under realistic operating conditions, i.e. exhaust gas temperatures up to 1050°C. Numerous high load measurements have been carried out with this test rig resulting in a variety of sample failures, which were subsequently analyzed and discussed in details. This information can be used to develop the next generation of high temperature thermocouples with a better resistance despite dynamic measurement characteristics.

11:40 a.m.	A. Baltrusaitis, A. Bargelis (LT-Kaunas)

Virtual Engineering Application for Modeling the Flexible Machine Station at the Order Handled Manufacturing System

The paper deals with the virtual engineering application for modeling the flexible machine station (FMS) at the order handled manufacturing system (OHMS). The FMS virtual model is crated as alternative to decrease the manufacturing cost in OHMS companies where non-productive time is dominated. Two types of FMS as "In line layout" and "Loop layout" have been used examining parts' and their work pieces 3D CAD models. The modeling is based on created mechanical parts' design features (DF) classifier, DFMA method and mathematical dependences for machining time versus removed material volume from the part's work piece during machining operation. This methodology for FMS operations forecasting of the manufacturing time has been applied. Developed virtual FMS model has been tested applying piloting procedure in Lithuanian OHMS Company X.

12:00 noon – 1:30 p.m. Lunch and Visits of Expositions
12:00 noon – 1:30 p.m. Poster Session

3.1 Components, Systems and Processes

Time: Tuesday, 09.09.2014
Location: Humboldtbau, Lecture Room 204
Chairman: U. Kletzin (D-Ilmenau)

1:30 p.m.	Th. Münzing, H. Binz (D-Stuttgart)

Challenges of the sizing of ballscrews for their use in the primary flight control system of a helicopter

Aligned with the advancing electrification in aircrafts and helicopters, the substitution of hydraulic pistons by electromechanical actuators is gathering increased attention. Depending on the application, current sizing approaches for the intended rolling contact drivetrain elements are not able to consider all aspects of the present operation conditions. These are in particular high frequent dynamic axial loads in combination with small motions. Aerospace applications furthermore are faced with wide ranges of operating temperatures and strict requirements regarding failure safety. State of the art sizing approaches only allow a service life calculation regarding the failure mode of fatigue. Since other failure mechanisms, especially tribo-chemical ones, become more likely during the presented operating conditions a new sizing method must be determined that allows the avoidance of wear and therefor enables a modified fatigue life calculation.

1:50 p.m.	J. Lungevics, O. Linins (LV-Riga)

Wear, Friction Coefficient and Slip Property Estimation of Sliding Friction Parts

The key purpose of this work is to propose a methodology for lifetime prediction of wear parts using 3D surface roughness parameters defined in the standard ISO 25178 part 2 for wear rate determination. In this research the random surface model is used, where the height of surface asperities h(x, y) has a normal probability distribution. As a result of research the equations for estimation of the fatigue wear rate and friction coefficient were derived. Also it was revealed that 3D surface roughness parameters are more influential on linear wear rate. In experimental part authors test practical method for static sliding friction coefficient and slip property estimation for different nanostructured coatings. Method is based on inclined plane and it is usable for wide variations of materials. 5 different titanium-containing nanocoated experimental samples were tested. In addition dynamic sliding friction coefficient and 3D surface texture parameters were measured for all samples using CSM tribometer and Taylor Hobson Forms Talysurf Intra 50 profilometer.

2:10 p.m.	V. Gevorgyan, U. Kletzin (D-Ilmenau)

Tribological Behaviour and Tribological Model of Shot Peened Helical Spring Wires

Springs are to be found in technical products in Mechanical Engineering, Precision and Electrical Engineering, Automotive Engineering and many other branches in very different embodiments.

Units with helical compression springs and connected components or guidance elements (plate, bushing, pivot, etc.) can also fail when the spring and the surrounding components touch during spring compression or extension, resulting in wear. These occurrences of contact cause mechanical stresses with secondary thermal, tribotechnical, tribophysical and tribochemical reactions between the coils and between coils and surrounding components. Inherent stresses and micro geometry of surfaces play a significant role in friction and wear behaviour. This is particularly true for springs with shot peened surfaces. One subgoal of this project is to optimise shot peening as an essential step of the manufacturing process to increase the durability of dynamically loaded helical compression springs while taking into account the effect of surface geometry on wear. Oscillation wear often starts with adhesion and abrasion wear processes. These processes lead to fretting corrosion and to the break-down of the inherent compressive stresses, brought about by shot peening, in near surface areas, inevitably causing the failure of the spring and the components and thus of the entire unit. The results of the experimental simulation tests (tribometer tests) were systematised and arranged to create a tribological model, with the objective of offering means which implement the results found so that the designer can easily use them. The most important precondition for developing a mathematical model for wear is predicting the factors of influence to be investigated. All information was gathered and organised to determine the most important factors of influence and, eventually, to mathematically express wear as a function of the factors of influence.
The goal of this paper is

- to determine the influence of surface roughness on wear through tribological analyses of wires with selected surface roughness due to special shot peening procedures.
- to create a tribological model for improving the function and durability of these frequent ly applied components and the units fitted with them.

2:30 p.m.	V. Geinitz, U. Kletzin (D-Ilmenau)

Properties of Torsion Springs before and after Heat Treatment

Actual the members of the research group „Wire and Springs" research the heat treatment on cold-formed springs made from spring steel wire. Torsion springs e.g. are one investigation object. The heat treatment after the cold shaping is used to decrease the internal stresses of torsion springs, but the mechanical characteristics of the spring steel wires alters, too. 8 batches of different test torsion springs are produced. Parameters varied are torsion spring fabrication (coiled around a mandrel or wounded with coil pins), spring index (w = 5/10) and the sequence of the production steps: heat treatment (250°C/30min) before or after cold-shaping. The spring and wire properties (mechanical characteristics, geometry, residual stresses, yield stress 0.01%) are measured before and after heat treatment. The tensile strength Rm and yield strength Rp0,2 rise because of heat treatment up to 200°C (strain aging), but decrease after heat treatments with temperatures more than 200°C. The spring diameter is reduced because of the heat treatment of the torsion springs. A heat treatment period of 5minutes only changes the geometry clearly. The residual stresses in a torsion spring as a result of the cold forming are directly beneficial, if the spring is used in closing direction.

The residual stresses concur with the half difference of yield stresses in opening and closing operation of these torsion springs. Heat treatment after cold forming leads to a higher yield stress of torsion springs operated in closing direction in spite of beneficial directed residual stresses. The strain aging (age hardening) and the reduction of the residual stresses are two contrary processes. Because of the beneficial effect of the residual stresses the reduction of it leads to a decrease of yield stress of the torsion springs in closing operation.

2:50 – 3:10 p.m. Coffee break and Visits of Expositions

3:10 p.m.	R. Lux, U. Kletzin, P. Beyer (D-Ilmenau)

Long-Term Stability Of Patented Cold Drawn Steel Wires

The last two years have seen the "Wire and Spring" research group at Technische Universität Ilmenau cooperating with wire and spring manufacturers (in the form of the Eisendraht- und Stahldrahtvereinigung and the VDFI – the German spring manufacturers' association) in a research project entitled "Long-term stability of mechanical parameters of patented drawn steel wire". Natural ageing effects on (i.e. the long-term behaviour of) the mechanical parameters of patented drawn spring steel and rope wires were investigated in relation to a large number of initial and process parameter variables. For the purpose, two types of Stelmor air-cooled rolled wire with 0.6 % or 0.8 % carbon and a diameter of d = 5.5 mm were produced from steel made with two different forms of steel smelting technology (electric-furnace and converter). As preparation for drawing, one portion of the rolled wires was simply pickled in a standing bath, the other was additionally patented in a lead bath. The wires patented in the lead bath where then subdivided and either pickled in a standing bath or a continuous pickling plant. The 12 rolled wires thus derived were shared between two wire drawing machines and there drawn in either 8 or 11 stages to a diameter of d = 2 mm. There were two drawing speeds, either 6 m/s or 12 m/s. The process resulted in 48 experimental wires of which the long-term stability was to be investigated.
The paper gives an overview of:

- The changes of characteristic values for the mechanical properties determined by i.e. torsion and tensile tests during storage and depending on heat treatments
- An automated detection of cracks along the wire-length which is based on the torsion-testing-curve
- And the correlation between the variation of wire strength parameters and the variation of geometry of springs and other components

End of Session

K. Hoffmeier (D-Jena)

A first inherently pulsation free peristaltic pump

All peristaltic pumps that are currently available produce a pulsed flow. In this work we describe the principle and the development of a pulsation-free peristaltic pump. In this pump the tube is placed flat on a platen and sequentially compressed by a peristaltic mechanism consisting of five linearly arranged plungers. For pulsation-free pumping the plungers are actuated according to a specially developed schedule describing the required flow in the pumping chambers. In order to get the required flow, the compression rate of the tube is modulated over time in an appropriate manner. Because the inner cross section of the tube does not change linearly during compression, the compression-flow characteristic of the tube was measured first. Based on that characteristic the compression rate was described as a function of the flow, allowing the plungers to actuate properly according to a required flow rate. To further optimize the actuation of the tube and to fine tune the interaction of the plungers a prototype was equipped with five linear actuators controlling each plunger separately. After optimization the linear actuators were replaced by a camshaft containing the optimized stroke characteristics of the plungers. The resulting prototype shows a remaining pulsation of only 11% of the mean flow rate which can be further reduced when paying attention to a trade-off between manufacturing expenses and attainable flow-consistency.

Session 3.2 Sustainable Mobility

Time: Wednesday, 10.09.2014
Location: Humboldtbau, Lecture Room 204
Chairman: K. Augsburg (D-Ilmenau)

10:00 a.m.	Ch. Lämmle, Ch. Karcher (D-Ilmenau)

Experimental and theoretical study on high-temperature connection techniques of thermoelectric materials

This paper deals with the structure and the connection techniques of thermoelectric materials for a thermoelectric generator for high-temperature range. The efficiency of combustion engines can be improved by using the waste-gas with the help of thermoelectric generators. After a short introduction into the fundamentals of thermoelectric the function and structure of a thermoelectric generator will be discussed. The calculation of the thermo-diffusion voltage in dependence of the different thermoelectric materials and their physical properties will be elaborated. With the help of these values the expected performance of a thermoelectric generator can be calculated. After this, the structure of existing thermoelectric modules will be critically analyzed and their weaknesses will be examined. These include materials used, the connection techniques, temperature resistance, cyclabillity and the efficiency of selected thermoelectric modules. In conclusion the innovative structure of a thermoelectric module for high-temperature use will be discussed.

10:20 a.m.	K. Höpping, K. Augsburg (D-Ilmenau)

Dynamic Tire Pressure Control System - Analysis of the effect to longitudinal vehicle dynamics and fuel consumption

The choice of the optimal tire pressure is always a conflict of aims. The tire pressure has a significant influence on safety, comfort and environmental behavior. The development of a dynamic Tire Pressure Control System (TPCS) can reduce the conflict of minimal rolling resistance and maximal traction. The first part of the paper discusses the evaluation of tire pressure influence on fuel consumption and vehicle dynamics. The relevant study has been performed using the numerical simulation tool IPG CarMaker. For this purpose a vehicle model was created and validated. To analyze the influence of the tire pressure on tire characteristics a tire model was developed using MATLAB Simulink. Tire parameters were analyzed on a tire test rig and implemented in the tire model. Using synthetic and real driving cycles as well as driving manoevres, the simulation results confirm a high potential in reducing fuel consumption and simultaneously increasing traction forces by adapting the optimal tire pressure. Moreover, control strategies were developed to adapt the optimal tire pressure depending on the actual driving conditions. The strategies were implemented in MATLAB Simulink and connected to the IPG CarMaker simulation. Since the potential of a TPCS is particularly high for light-duty commercial vehicles (with different loading conditions, a high curb weight, and available space for pneumatic system), a Mercedes Sprinter was equipped as a test vehicle.

A pneumatic system was developed that allows changing the inflation pressure of each tire independently and highly dynamically with a rate of 2.5 bar per second. In addition to the powerful hardware, rule based control strategies were implemented to reduce fuel consumption and improve vehicle dynamics. To demonstrate function and efficiency of the TCPS and to validate the developed simulation model, driving tests were performed on a test area. Results of numeric and experimental analyses point out, that an intelligent and dynamic Tire Pressure Control System has a significant potential to increase safety and efficiency for future mobility.

10:40 a.m.	V. Schreiber, K. Augsburg (D-Ilmenau)

Range prediction of electric vehicles

This work presents a model-based approach for a high precision prediction of residual range of electric vehicle. Therefore an energy storage and energy consumption model was established. Its general property allows an easy plug-n-play adaptation on different vehicle. In particular, a methodology for classification of driver behavior has been created, which is independent of the vehicle types. In extension to the vehicle energy model it was advanced to involve the driving performance for accurately prediction. For the reason that the calculation performance and accuracy are more important there was no need to physical modeling of parameters. To perform the parameter identification of the mentioned models, a factor weighted filter was evolved and modified online capable. For calculate the residual range two methods are presented. The first procedure estimates with high probability selected track and their topology. The second procedure proposes a recursive estimation technique. However, in exchange also GPS-data are required. The impact of the recommended process evaluates a very small deviation a smaller amount than 4 km.

11:00 a.m.	H. Sachse, K. Augsburg, V. Ivanov, C. Trautmann, F. Egenhofer (D-Ilmenau)

An approach to lower the particle emission of friction brakes on vehicles

Brake particle emissions are gaining attention since it becomes clear that these emissions rise above the level of modern cars exhaust emissions. The measurement systems can be adapted from exhaust gas monitoring but the testing facilities and the setup is very different and a novel field for research. It was shown that measurement on the dynamometer under laboratory conditions and real driving emission measurement in combination is needed to verify changes on the brake system. Possible ways to reduce the emissions from the brake can relate all assembly parts of the wheel hub and the brake. Pad formulation or disc composition can be optimized but this is a complicated conflict of aims with other demands on the brake system. Collectors are very effective but an additional cost factor which also needs building space inside the wheel rim. Surface machined discs do not solve the initial problem of the produced amount of particles but makes them less harmful.

12:00 noon – 12:45 p.m. Lunch and Visits of Expositions

12:45 – 1:40 p.m. Start Guided Tours

1:45 p.m. Start Excursion to Weimar

Session 3.3 Production and Processing Technologies

Time: Tuesday, 09.09.2014
Location: Humboldtbau, Humboldt Lecture Hall (HS-HU)
Chairman: M. Koch (D-Ilmenau)

9:00 a.m.	M. Pohl, A. Wibbeke, V. Schöppner (D-Paderborn)

Stretching of Polycarbonate

By monoaxial stretching, a self-reinforcing effect can be generated in an amorphous PC-film. This self-reinforcement appears in an increase of strength and stiffness as well in stretching as in transverse direction. The mechanical properties depend on the stretching temperature, the stretching rate and the stretching ratio. The forces during stretching can be described by the Poynting-Thomson-Model. Here, the parameter identification depends of the stretching temperature and the stretching rate. In a benchmark, the mechanical, optical and thermal properties as well the raw material prices of conventionally available biaxial oriented films made of PP, PE and PA were compared to monoaxial oriented films made of PC. It was found that monoaxial stretched PC has both excellent properties concerning the mechanical proteries as well as optical properties, haze and gloss.

9:20 a.m.	J. Rudloff, M. Lang, K. Kretschmer, P. Heidemeyer, M. Bastian (D-Würzburg); M. Koch (D-Ilmenau)

Analysis of the process behavior for planetary roller extruders

In the last few years process models for the planetary roller extruders were developed. These models are allowing an estimation of the processes in the extruder for the first time. However, because of the simplifications that were used for modeling, there can be considerable differences between simulated and experimental results. In this paper, a dimensionless approach for modeling the planetary roller extrusion process is proposed to improve the model quality. Therefore experimental trials with a variation of extruder configuration, material type, throughput and screw speed had been conducted. At these experiments the pressure build up was determined. Based on the results drag flow rate and pressure flow rate were expressed as dimensionless operating numbers to show the influence of power law index and geometry on the pressure building capacity of the extruder. This can help to find more precise assumptions for the process models.

9:40 a.m.	St. Schneidmadel, M. Koch, F. Woyan (D-Ilmenau)

Influences with regard to the processing of conductive polymers

Technical plastics products offer a high potential for light-weight construction techniques. The research activities for functionalized plastics components increasingly become focused. In complex plastics parts, the integration of materials with different properties plays a key role. Especially, conductive polymers offer the possibility to produce low cost complex plastic components in injection molding processes. Beside the functionalization of parts, conductive polymers are also interesting for the housing of electromagnetic compliance (EMC) devices.

The conductivity of these plastics components strongly depends on its processing conditions. On consideration of each step of processing, such as the compounding of the plastic with fibers and a subsequent injection-molding, the main influences on the conductivity are carved out.

10:00 a.m.	M. Langlotz, M. Koch (D-Ilmenau)

Simulation and comparison of the pressure profile of fumigated and non-fumigated polymer melts

The production of various polymer foams is widely used for several years. In the automo-tive and packaging industries, these are more and more applications. There are various methods for preparing plastic foams. The properties of the foam may be achieved by using different influencing parameters, such as the manufacturing process conditions or the choice of the plastic material grade. The processing and design of a single screw extruder screw can be simulated by a simulation program based on fundamental analytical models or by FEM calculation methods for a particular purpose. In order to obtain meaningful results, assumptions have to be made for process parameters and screw geometry, however most importantly; the rheological properties of the material are a prerequisite. However, the rheological properties of a fumigated melt during the extrusion are unknown and have to be evaluated in appropriate experiments. For the solution of the problem pressure profiles are recorded during the process in a screw from the point of gas inlet to extruder outlet thus representing the complete foaming process. These pressure profiles will be used for the validation of a simulation, which describes a fumigated melt. A comparison between fumigated and regular melt is executed and will be discussed in this paper. The objective is to describe the rheological properties of the material using a pressure profile of a fumigated melt flow process.

10:20 - 10:40 a.m. Coffee break and Visits of Expositions

10:40 a.m.	M. Bruchmüller, M. Koch (D-Ilmenau)

Improvement of tribological properties of plastic compounds

Nearly every physical movement is associated with friction, which implies a loss of kinetic energy. Tribology helps to reduce friction losses and improves the energy balance of movement. The main influencing parameters on friction are the material properties and the contact surface. Increased surface properties are needed for insufficient tribological partners to keep friction and wear down. Sand, typically known as wear intensive material, is a poor friction partner. Thus sand is used as the reference tribology partner to examine plastic materials and their surface properties to friction and wear. To find the best material for tribological use on sand, measurement devices need to achieve the environmental and dynamic requirements. Then, the measurement results are correlated to selected properties to formulate connections between both, to turn the tribological measurement to a needless procedure. Thus, the calculated formula should simplify the choice of fillers for a tribological improved compound on sand.

11:00 a.m.	M.-E. Steffen, M. Koch (D-Ilmenau)

Manufacturing hybrid lightweight-compounds of closed-cell aluminium-foam and thermosoftening plastics in injection moulding processes

Towards the background of rising energy cost and the shortage of resources, lightweight materials become more important in industrial and automotive applications. Nowadays, vehicle designers try to reduce the weight by substituting high-density materials with low-density compounds of similar mechanical properties. This work deals with the development of a new hybrid-material combination consisting of aluminum foam and thermoplastic. As a result of the porous cell structure, aluminum foams show a low weight with a comparatively high stiffness. In combination with a thermoplastic material the distinctive features of both materials can be combined to obtain a new composite material, which unifies their remarkable characteristics. After primary co-processing, strength and stiffness characteristics of such structural components have not been tested yet and will be examined.

11:20 a.m.	M. Schwind (D-Chemnitz)

Interface Properties of Injection Moulded Biopolymers

Rising prices for crude oil and the continuous trend of high complex technical products are good requirements to establish biopolymers in complex multicomponent applications. Currently a variety of industrial produced biopolymers are available such as the bio-based polymers Polylactide (PLA); Polyhydroxyalkanoate (PHA) and cellulosic plastic. Also "Drop In"-polymers are accessible e.g. Bio-Polyethylene (Bio-PE). To make the biopolymers available to more complex applications the material behavior regarding weld lines and binding behavior has to be investigated because the opportunity of weld lines rises with a more complex geometry of parts or more complex manufacturing processes. In case of multi component injection molding it is essential to know about the bond strength between the different materials. This work compares different thermoplastic biopolymers concerning the strength of hot-hot weld lines and the strength of hot-cold weld lines even in case of different material combinations. Whereas the variation of process parameters (melt temperature, mold temperature) does not show a significant influence of the generally high hot-hot weld line strength the influence on the hot-cold weld line strength is obvious. In case of a bio-obased PA 10.10 the tensile strength could be increased from 22 to 38 MPa. To purify the look and feel of plastics or to increase the resistance against scratches and other environmental impacts hard and/or self-healing PU-coatings are applied on the surface of a basic body. To minimize costs of production and reduce process time in-line surface coating is a valid method. Within these work the bonding strength between biobased thermoplastics and a PU-layer is investigated too.

11:40 a.m.	T. Hartmann, S. Bürgermeister, R. Ringberg, L. Kroll (D-Chemnitz)

TPE-Modification for Advanced Rheological and Impact Properties of Wood Plastic Compounds

In this study a styrenic thermoplastic elastomer (TPE) lubricant mix for enhancing impact strength and rheological processing behavior of wood fiber-reinforced polypropylene (PP/WF) will be introduced.

All PP/WF composites within this investigation consist of a constant matter of 40 wt% WF in combination with 3 wt% of maleated polypropylene (PP-g-MA) and were compounded by a co-rotating twin screw extruder. Four types of dry-blended (DB) TPE-oil-mixes with different TPE/oil ratios were added in amounts of 10 and 20 wt%. The DBs affect a dramatical increase of Charpy impact strength. In addition the elastic modulus was reduced by acceptable degrees. These strong mechanical characteristics are accompanied by an improvement of rheological behavior in processing. All gathered data is analyzed in dependence of used DB composition with respect to mechanical properties and rheological flow behavior by processing parameters and practice oriented flow spiral tests.

The results will be shown in tables:
- Composition of the various PP/WF composites
- Compositions of dry-blends
- Mechanical properties of PP/WF samples (± values are standard deviations)
- Processing parameters during compounding and MFR
- Flow spiral tests with injection molding conditions

The results will be discussed by following figures:
- Percentage changes in mechanical properties for addition of 10 wt% DB related to unmodified sample
- Percentage changes in mechanical properties for addition of 20 wt% DB related to unmodified sample
- Change of tensile and impact properties related to SEBS content
- Change of tensile and impact properties related to oil content
- MFR related to different composite compositions

12:00 noon – 1:30 p.m. Lunch and Visits of Expositions
12:00 noon – 1:30 p.m. Poster Session

Session 3.3 Production and Processing Technologies

Time: Tuesday, 09.09.2014
Location: Humboldtbau, Humboldt Lecture Hall (HU-HS)
Chairman: M. Koch (D-Ilmenau)

1:30 p.m.	N. Laufer, H. Hansmann (D-Wismar); M. Koch (D-Ilmenau)

High Pressure Capillary Rheometry on Wood Plastic Composites with Variation of Wood Content and Matrix Polymer

Wood Plastic Composite (WPC) is a composite material made from wood fibers (fine chip, wood shavings or wood flour) and a thermoplastic matrix polymer. Matrix polymers are mainly polyethylene (PE), polypropylene (PP) and polyvinyl chloride (PVC). The wood content of WPC varies, depending on the applied method of processing, between 50 and 75 wt%. The flow behaviour of WPC melts is of decisive importance for their processability. Understanding rheological behaviour shall help to increase the efficiency of processing of WPC products due to increased material throughput. Furthermore it helps to simplify the development of new WPC products and extrusion tools respectively. This paper describes how various WPC formulations were examined on the basis of high pressure capillary rheometry (HKR). The flow functions of all investigated WPC formulations are shifted to higher values in comparison to the flow function of the unfilled polymer matrix. In general, the extent of displacement of flow functions of suspensions on the condition of negligible particle interactions can be well described by the concept of shear-stress-equivalent inner shear rate according to W. Gleißle and M. K. Baloch. In this work, this concept has been modified by a mathematical implementation of an interaction exponent (defined as the ratio between flow exponent of WPC and flow exponent of polymer matrix). It could be shown that the interaction exponent and the consistency factor of the power law correlate with volumetric wood concentration. On the basis of these relationships interparticular interaction effects can be taken into account, thus the extent of displacement of flow functions of WPC compared to the flow function of the polymer matrix can now be described mathematically.
Furthermore, a functional correlation was found between the consistency factor and the interaction exponent. On the basis of this relationship the flow behaviour of WPC melts can be estimated as a function of the filler content in a simple manner. To demonstrate this, the flow curves for two different PP-based WPC formulations have been estimated. The estimated flow curves show a good consistency with the measured flow characteristics.

1:50 p.m.	F. Heinzler, J. Wortberg (D-Duisburg)

Adaptive process control in injection molding

Today's machine capability in injection molding is at a high standard and the variation of material properties are within a small range. Nevertheless variation in material properties and conditions influences the process- and product-quality. Examples are residual moisture or drying conditions by different material handling. With respect to surface properties especially the injection-phase has a large influence on the part quality. By a recently developed process-adapted-pressure-control during the injection phase combined with control of the switch-over point and packing-pressure, the quality of the process can be improved.

Process variations by, for example, varying residual moisture content of the material are compensated by this new control strategy.

2:10 p.m.	Chr. Simon (D-Ilmenau)

Oxygen and water vapor permeability and required layer thickness for barrier packaging

In the packaging industry container applications appear with increased barrier requirements. In order to protect food and medical products against oxygen and water vapor it is necessary to use at least two barrier materials in 2 or 3 layers, whereas one could also be the main packaging material. Materials with low oxygen permeability are tending to absorb water vapor. Studies have shown that the oxygen and vapor permeability strongly depends on its layer thickness. Based on this, the layer structure of multilayer containers can be defined. With measurements of oxygen and water vapor permeability the configuration of the layer can be improved to extend the shelf life of the package and to minimize the use of material. With the knowledge the required layer thicknesses in a container package can be determined. These layer structures can be simulated with the help of the flow sheet analyzes the injection blow molding process.

2:30 p.m.	F. Woyan, M. Koch, St. Schneidmadel (D-Ilmenau)

Process Parameters Affecting the Quality of Functionalized In-Mold Decoration Injection Molded Composites

This report studies the fundamental parameters affecting the wash-off and the warpage of parts manufactured in in-mold decoration process (IMD). The purpose is to derive a process model for describing the wash-off and the warpage of the parts as a function of the main influencing parameters based on a dimensional analysis. In order to investigate the influence of the materials and various processing conditions, a test mold was created for experiments and simulations were carried out. First of all the main influencing factors have been identified. To quantify the influence of each factor, a full factorial design was used. A DOE of process parameters including injection speed, injection pressure, melt temperature, mold temperature, post-injection pressure and the material were designed and executed. Based on the DOE specimens with a 250 μm and 375 μm thick PC film and a part thickness of 2 mm and 3 mm made from different thermoplastics were produced. In addition, the results of the experiment were compared with the simulation.

2:50 – 3:10 p.m. Coffee break and Visits of Expositions	
3:10 p.m.	S. Vasilkov, A. Pirogov, E. Yablochnikov, Y. Andreev (RUS-St.Petersburg); I. Barvinsky (RUS-Moskau)

Studies of design and technology influence on optical properties of injection molding parts by simulation

The methodology of obtaining a factors rating of the runner system design and technology process influencing on optical properties of the plano-concave lens of polycarbonate has been examined, using Taguchi method for injection molding simulation.

The biggest influence on the refraction index (n) and the difference of the refraction index (Δn) among part areas characterizing its optical heterogeneity is made by the runner system design whilst the principal factor influenced on birefringence is melt temperature. Different type of the refraction index and birefringence dependence from the packing pressure (in the last case is being observed a minimum value under the packing pressure 60 MPa) can be explained when considering the combinations of phenomena. These phenomena take place in a mold cavity in the process of melt filling, packing and shrinkage processes determining strain-stress state of molding in an injection mold and after ejecting from the mold.

3:30 p.m.	G. Schwalme (D-Würzburg)

Inline infrared thermography applied for quality gates and for mould temperature control in the injection moulding process

In injection molding processes, the precise control of the mold temperature distribution often is a crucial prerequisite for the quality of the final products. The demolding temperatures of molded parts are depending, among others, on the cooling time, the temperature distribution of the mold and injection process parameters like melt temperature and injection pressure. For the control loop of the mold temperatures, established technologies use either the coolant-flow and -temperatures in the recirculation pipes or the mold temperatures, measured by sensors in the mold, as reference variables. Thus, only the average temperatures or some, by the selected position of the sensors predefined, spot temperatures can precisely be controlled. A new approach to overcome those limitations is the use of infrared images of demolded parts to realize a closed loop temperature control. For complex technical parts with segmented mold-cooling systems, running at optimized cycle times and within small process windows, the inline use of surface temperature control can help to improve the product quality and increase the process stability. Additionally the principle of measuring the part surface temperatures at the end of every molding-cycle and comparing them to the temperatures of e.g. approved parts enables the precise detection of thermal deviations and thus, applying temperature limits, the automatized rejection of faulty pieces. Without the necessity for changes in the mold, the inline thermography can help to improve the quality, to keep cycle times short and to avoid scrap. In the scope of a public funded research project, the application of inline thermography for the mold-temperature-control and for automatic quality gates in the injection molding processes was successfully developed and investigated.

3:50 p.m.	G. Heiderich, E. Moritzer (D-Paderborn)

Experimental investigations on injection molded parts of mechanically recycled offcuts from the production of continuous fiber-reinforced thermoplastic sheets

This paper describes investigations of the recycling and re-use of remnants from semi-finished part preparation of continuous-fiber reinforced plastic sheets. The polymer sheets consist of a Polyamide 6 matrix with glass-fiber fabric. The sheets are produced as a fiber reinforced band in a continuous process, which is then machined in a following process using a water-jet cutting unit.

Material remnants are produced during this stage; the possibility examined here is whether these remnants can be entirely recycled and re-used in an injection-molding process. To do so, the material remnants must be shredded to recyclate. Following that, the recyclate is processed on a twin-screw extruder in order to produce fiber-reinforced plastic granule, which should replace standard fiber reinforced plastic granules used in the injection molding process. The primary focus of the investigations described here is a characterization of the mechanical properties which it is possible to achieve after completing both the twin-screw extrusion and the injection molding. Over the course of these experiments, the granule is used to produce test specimens while varying the injection molding parameters. Tensile strengths of 187 MPa, elasticity moduli of 21 GPa, and impact strength of 56 kJ/m2 are determined in mechanical testing after production.

4:10 p.m.	J. Tröltzsch, F. Helbig, L. Kroll (D-Chemnitz)

Glass fiber multilayer construction for textile reinforced injection molded structures

Plastic components can be locally reinforced in a load-appropriate manner by integrating textile reinforcement structures into injection molds. However, thermoplastic prepregs are expensive because they are subjected to costly preliminary impregnating processes, so they have hardly gained general acceptance. Also, in the injection molding process a strong matrix-matrix bonding of the prepreg matrix with the injected melt is required in terms of short injection times. This is a critical fact due to residual stresses resulting from shrinkage effects during melt solidification. A new kind of non-crimp fabric in a multilayer design, based on OLU-Preg®-technology (SKM GmbH, Germany), is considered particularly advantageous, whose outer fiber layer impregnation will be completed in the injection molding process. Apart from lower manufacturing costs of this kind of prepreg, the impregnation process with the injected melt leads to an anchoring between the textile structure and thermoplastic melt as observed in in-mould decoration processes.

End of Session

Session 3.3 Production and Processing Technologies

Time: Wednesday, 10.09.2014
Location: Humboldtbau, Humboldt Lecture Hall (HU-HS)
Chairman: M. Koch (D-Ilmenau)

10:00 a.m.	E. Soemer, B. Engel, J. Böcking (D-Siegen)

Bending of unidirectional reinforced thermoplastics

Due to their high specific strength and stiffness compared to metals, thermoplastic composites are suitable for lightweight design. In comparison to metal forming, few processes for thermoplastic composites exist and prediction methods are very specific, requiring additional experiments and/or several try-out loops. Deviations between tool geometry and work piece geometry are observed as springback/spring-in. Residual thermal stresses due to thermal shrinkages are known to cause distortion, as well as structural changes during forming e.g. fibre wrinkling, composite thickness deviations and fibre distribution changes. Bending is known as a flexible forming process of structural and lightweight parts. But, bending parameters of fibre-reinforced thermoplastics need to be evaluated, yet. Bending tests on thin (0,26 mm) unidirectional reinforced tape used in tube winding show high springback, that may not be explained by thermal shrinkages. For bending being a sequential forming process it is suggested, that internal stresses due to elastic-energy-storage in the fibres cannot be neglected. Therefore, an analytical approach to model these stresses is presented in this paper. Furthermore, a bending process is set-up to analyse the influence of bending velocity and forming temperature on the resulting spring-back, experimentally. The rotary draw bending is chosen as process to counteract on fibre wrinkling by applying tension force. Polypropylene glass-fibre-reinforced tapes are bent under variation of initial temperature and bending velocity. The counter force, the forming temperature and the resulting bending radius are measured. The measurement of the forming temperature is done using infrared sensors to avoid changes due to heat capacity of measurement equipment or contact problems on the molten matrix material. Therefore, the emission coefficient of the tape, which is temperature dependent, is identified experimentally.
As result, the influence of forming speed and forming temperature are stated. For the given parameters spring-back reduces with increasing temperatures. In contrast to forming processes with fully heated specimen spring-in does not occur.

10:20 a.m.	J. Brühmann, B. Engel (D-Siegen)

Mechanisms and sources of spring-in and spring-back of fiber reinforced thermoplastics

Fiber reinforced thermoplastics (frt) have a complex spring-in and spring-back behavior due to residual stresses due to manufacturing process. It depends on several parameters such as velocity, pressure and temperature, as well as part geometry. These shape distortions can lead to problems during assembly and its understanding is important in order to optimize the forming process. Several authors refer to anisotropic coefficients of thermal expansion leading to spring-in due to anisotropic contraction during cooling.

Several authors refer to anisotropic coefficients of thermal expansion leading to spring-in due to anisotropic contraction during cooling. They suggest increasing the bending angle of about 2° to compare it. In prior studies, the spring-in behavior of a formed V-shape has been analyzed under variation of named process parameters. Discussions of the results, that also show spring-back, are pure phenomenological. It is supposed that low forming temperatures and high cooling rates lead to spring-back due to suppressing of interply-slip. Interply-slip is the primary deformation mode for bending of multilayered sheets. The individual plies have to slide over each other to avoid wrinkling. In this work, photomicrographs of formed multilayered frts will be analyzed to show sources of spring-back or spring-in. Some test specimens with spring-back angles show similar values of interply-slip compared to test specimens with spring-in angles. For this, the theoretical relations are not valid for all combinations of process parameters. Therefore, there has to be more mechanisms that lead to spring-back than just the suppressing of interply-slip due to low forming temperatures. One reason could be the crystallization of the polymer matrix influenced by the cooling rate. Due to inhomogeneous cooling of the test specimen, there are areas with more or less crystallinity which cause different relative densities. Lower cooling rates lead to more crystallization and thus more contraction. To eliminate the influence of interply-slip in a first step and anisotropic coefficients of thermal expansions in a second step, sheets made of one layer and sheets made of polyamide 6 without any reinforcement will be formed. The unreinforced specimens shall also show the relationship between inhomogeneous cooling and contraction due to different crystallinity.

10:40 a.m.	St. Caba, M. Koch (D-Ilmenau)

Simulation of the Resin Transfer Moulding Process (RTM) by Analysis of the Process Fundamentals

Fiber reinforces plastics (FRP) technologies enable the production of lightweight components. The RTM technique is attractive to obtain vehicle parts with little post-processing in industrial scales. The closed mold process provides a desired freedom in part-design combined with high and reproducible production rates compared to other FRP processes. However, the shorter the mold-closed time the higher the risk to run into quality consistency issues resulting from air entrapments. The acceleration of the process can only be achieved by the knowledge of the fundamental process parameters. The effects of void formation and process speed can be managed to reach progresses in both cycle time and void content. The major mechanism of void formation is the entrapment of air due to flow front inconsistencies. These are generated by the differences of the flow front as a result of advancing forces, viscosity and flow resistances. A faster flow front advancement in the fiber tows results in spherical voids, because air in the flow channel between the tows can be entrapped. On the other hand a faster advance in the flow channels results in cylindrical voids in the tows. Only a balanced flow front could enable a process with low void rates.

The resin flow in the channels is primarily driven by the inlet pressure. The flow resistance is low in comparison to the fiber tows where the channel radius has a smaller order of magnitude. In the tows the resin flow is additively caused by the capillary pressure that occurs in the small channels between the fibers in the tow. So the flow behavior of the flow front depends on different factors. The established factors for influencing the RTM cycle are mold temperature, inlet pressure, application of vacuum, resin and fiber volume content. However, the impact of the capillary effect has not been examined sufficiently. Possible factors influencing the wicking are finish of the fiber, weave of the reinforcements and the radius of the tows. In addition all factors may have interdependencies on each other. Process trials were conducted using a DOE-approach under consideration of material and process parameters for simple 2D parts. The analysis shows the impact of principle process parameters on the achievable part quality.

11:00 a.m.	E. Oberlaender (D-Rudolstadt)

Noval honeycomb sandwich-structures with fiber reinforced face sheets

Sandwich structures are very lightweight and stiff constructions. Concerning fiber reinforced face sheets the majority of applications are built with thermoset materials. Next to the thermosetting material polyurethane (PUR) current investigations in the TITK have been carried out with thermoplastic polypropylene (PP) to embed the fibers and bond them to the honeycomb core. Within the face sheets nonwoven fabrics made of glass fibers, natural fibers and (recycled) carbon fibers have been utilized. As core material the investigations involved honeycombs made of paperboard/cardboard and polypropylene. Concerning established sandwich structures, consisting of fiber reinforced polyurethane face sheets, the substitution of glass fibers with recycled carbon fibers leads to a significant increase of the bending stiffness. In order to gain the same stiffness value a thinner face sheet can be used thus making the sandwich panel much lighter. (However other properties like pressure resistance usually have to be considered as well.) The anisotropy of nonwoven fabrics can be used to generate a specifically high stiffness in one direction. The examined bending stiffness of natural fiber reinforced sandwich panels is about half as high as for sandwich panels with glass fiber reinforcement. Therefore sandwich structures made of natural fibers are suitable for less stressed parts. The usage of polypropylene (PP) leads to decreased stiffness values compared to sandwich panels with polyurethane (PUR) matrix. The influence of coupling agents has to be investigated in order to make the novel sandwich structures competitive. A better crash behavior and recyclability are potential benefits. Sandwich-structures are a highly adjustable construction. Next to geometrical parameters like sandwich height and face sheet thickness, the honeycomb type and especially the kind of fiber and matrix material of the face sheet determine the mechanical properties. In order to compare different sandwich compositions the use of the bending stiffness D seems to be appropriate due to its independence on the testing parameters load and sandwich span. In general the investigations show that the sandwich design theory is applicable for sandwich constructions with fiber reinforced face sheets.

11:20 a.m.	Ch. Fiebig, M. Koch (D-Ilmenau)

The influence of fiber undulation on the mechanical properties of FRP-laminates

It is shown, that the undulation of the roving influences the performance of the laminates. It can be seen that the properties of the laminate depend on the number of fiber crossings using the same type of fibers. Since it is unknown how big this difference is, it is recommended to use an existing analytical model which is extended by correction factors. In this paper, two factors, $\chi 1$ and $\chi 2$, are developed. These factors emerged from a comparison of the theoretical and practical determined values of the tensile stiffness E1. It is to be assumed that the laminate with 0°/90° unidirectional (UD) fabric has a higher young's modules due to the missing fiber crossings. In order to prove this hypothesis, a simple model is developed to describe the influence of the fiber's undulation on the stiffness of the laminate. The properties of the chosen fabrics are compared to those of the undulation-free UD fabric. The selected fibers are made out of glass and have similar properties, e.g. the surface weight of about 400 g/m² and the fiber direction of 0°/90°.An experimental design helps to determine the material characteristics. The laminates are produced by using the RTM-process. Consequently, the influence of the manufacturing process on the mechanical properties is constant. After the laminates are prepared, the fiber-volume-content and the tensile stiffness of the test samples are measured. The values obtained are compared to the calculation model. In order to equalize the values, the factors $\chi 1$ and $\chi 2$ need to be varied. $\chi 1$ describes the difference between the calculation model and the values of the UD fabric. To obtain $\chi 2$, the properties of the 0°/90° UD fabric are compared to the values of the laminates with the woven fabrics. It is shown that the undulation has an impact on stiffness and strength of the laminate due to the fact that the fibers both support and damage each other. Depending on the characteristics of the undulation, deviating patterns are identified. In summary, it is demonstrated that achievable component properties are a function of the undulation of the fibers. Corrective factors are applied to increase the accuracy of a pre-calculation of the mechanical performance, thus to increase the reliability of design and further support the reduction of weight.

11:40 a.m.	R. Hartmann, M. Koch (D-Ilmenau)

CFRP and aluminium foam hybrid composites

One way to minimize the energy consumption of production processes is to reduce moving masses in machinery. This reduction of mass can be carried out through the exchange of solid material, like steel or aluminum, with hybrid materials. These hybrid materials combine application-oriented different type of materials and their properties. This paper deals with the RTM manufacturing process and FEM simulation of such a hybrid material. By using the sandwich design method two tensile-stiff carbon fiber reinforced plastic (CFRP) layers are connected to a low-density aluminum foam (AF) core in order to produce hereafter parts with high weight-specific bending stiffness. At the beginning of this paper an analytical calculation method on the basis of the beam theory is developed, which allows an estimation of the achievable mechanical properties of the composite. The bending stiffness of such a composite is mainly determined by the outer layer modulus and the gravity axis distance of the outer layers.

These findings are incorporated into the development of a FEM model, which allows the simulation of various load cases with selectable composite structure. The challenge in developing this model is the implementation of the material-specific peculiarities. These include the anisotropy of the CFRP layers and the core structure of the AF. An experimental plan is developed by using the DoE method. It allows the determination of the RTM process parameters, which will lead to components with the highest weight-specific bending stiffness. On this account preliminary tests are carried out to identify the usable range of injection pressure, mold temperature and compression pressure of the press. This paper can demonstrate, that the production of CFRP/ AF hybrid material by means of the RTM process is feasible. The first manufactured specimens exhibit no displacement of the fibers and almost no air inclusions. The simulation of CFRP/ AF hybrid material could be implemented. The anisotropy of the CFRP layers can be simulated with the ANSYS fiber fracture software ACP. The structure of the AS core can be mapped with great computational effort. The next step is the execution of the developed experimental plan with an especially designed RTM mold for sandwich composites.

12:00 noon – 12:45 p.m. Lunch and Visits of Expositions

12:45 – 1:40 p.m. Start Guided Tours

1:45 p.m. Start Excursion to Weimar

Session 3.3 Production and Processing Technologies

Time: Thursday, 11.09.2014
Location: Humboldtbau, Humboldt Lecture Hall (HU-HS)
Chairman: J. P. Bergmann (D-Ilmenau)

9:00 a.m.	T. Schade, R. M. Ramsayer (D-Schwieberdingen); J. P. Bergmann (D-Ilmenau)

Electrical steel stacks for traction motors – fundamental investigations on the weldability

Key components in electrical machines are the stacks made out of electrical steel. They conduct and force the magnetic flux and reduce the eddy current losses due to their laminated construction. For new innovative electrical machine concepts, the joining technologies have to fulfill enhanced requirements concerning reliability and reproducibility. Laser welding enables new prospects for the design of the elements guiding the magnetic flux. However, the stacked design of these machine elements represents a challenging factor regarding the development of a robust laser welding process. This paper presents a simulative approach of both the temperature field and the distortion of electrical steel due to laser welding. Modeling techniques for the welding process of a stacked electrical steel configuration are established using finite element methods Furthermore welding experiments were carried out to investigate the weldability of the electrical steel stack. The influences of the compressive stress and the feed rate on the pore formation in the weld seam during the welding of lamination stacks were examined. Two models for the description of the influences were developed. They were validated by experiments, afterwards. In addition, the influence of different feed rate regimes for welding lamination stacks is shown. These results enhance the understanding of a welding process on a stacked workpiece. With these fundamental findings the weldability of electrical steel stacks can be improved.

9:20 a.m.	A. Boaron, W. Lindolfo-Weingaertner (BR-Florianópolis); E. Uhlmann (D-Berlin)

A Quick-Test Method based on Acoustic Emission for the On-line Characterization of Conventional Grinding Wheels

A quick-test method for the in-process characterization of a conventional grinding wheel is proposed based on the acoustic emission technology. For implementing the method, a specific experimental rig and a particular software application have been developed. Both the experimental rig and the software application permit to recognize interferences between the grinding wheel and a dressing tool in a range of 1 μm. The acquired AERAW signals derived from such interferences (elastic deformation range) are used as input data for a specific developed signal processing technique, which allows extracting in-process quantified information from the grinding wheel´s topography features. The quantified information associated with the grinding wheel´s topography is based on both a time domain and a frequency domain in-process analysis.

The quick-test method is validated by correlating the obtained quantified information from the grinding wheel´s topography with both the post-process measurement of the grinding force, (components Ft and Fn) and the post-process measurements of the effective roughness of the grinding wheel (parameter Rts). Index Terms – Cylindrical External Plunge Grinding, Grinding Wheel Topography, Process Monitoring, Acoustic Emission

9:40 a.m.	S. Jahn (D-Jena)

Water-cooled small volume light weight motors

Electric drives become more and more popular for vehicles, beginning with small cars up to high load trucks. To use the stored energy efficient, electro motors with small volume and low weight are required. Because of the specified short time overload capability an adapted cooling system has to be integrated. The heat sinks should add only less weight to the whole system and aluminium-alloys are the materials of choice. In the paper the motor concept with integrated heat sinks as well as the joining process is presented. During the development of new motors for electric driven two decisive criteria vehicles are the reduction in size and weight. To achieve this, it is necessary to optimize the heat transfer inside the motor in order to avoid failures or damaging. With a laminated design of heat sinks, which have to be integrated into the motor housing, it is possible to get the heat out. In the following figure, a heat sink is shown as well as on complete motor. The heat sink is made out of four different cut Al-sheet layers. After cutting, the layers are joined together by diffusion bonding. Diffusion bonding is a solid state joining process, which allows small as well as large scale planar joints. Materials of the same type or multi-material designs can be bonded below the melting respectively solidus temperature. Because of the possibility to join large areas, it is in competition with brazing, especially furnace brazing. For diffusion bonding the parts have to be stacked and then heated to the elevated joining temperature. An applied load is necessary to get the faying surfaces in close contact. Temperature and pressure driven, diffusion across the faying surfaces occurs as well as plastic deformation of surface roughness and creep. At the end of the process, the bond line is not visible any more in the case of similar material joining. With diffusion bonding heat sinks can made out of cut Al-sheet layers. It is no further filler material necessary, which can influence the bond strength in terms of long time stability (e.g. loss of strength due to corrosion of filler materials). The integrated aluminum heat sinks allow a fast heat transfer out of the motor. Because of this, the motor can be overloaded up to 300% for a short time.

10:00 a.m.	F. Lissek, M. Kaufeld (D-Ulm); J. P. Bergmann (D-Ilmenau)

Machining of CFRP: Drilling and milling of unstable work pieces

The usage of lightweight materials, especially of carbon fiber reinforced polymers (CFRP), has significantly gained in importance in the past decades. Particularly the automobile and aerospace industry benefits from the advantages of these materials. Despite competing technologies, like water jet or laser cutting, the machining of near net shape composite material work pieces is still an important step in the process chain.

Concerning this matter, the drilling operation as a preparation for screw or rivet joints and the contour milling are two of the most significant machining procedures. The quality requirements on work piece cutting edges are demanding, but meanwhile they can be met. Especially degradations like delamination, fiber projections and frayings are generally not accepted and should be avoided. Therefore, the implementation of the cutting process requires very complex and cost-intensive clamping techniques. Classic holding devices like mechanical and hydraulic systems are used as well as modular vacuum clamping systems. Especially clamping systems used in industry offer potential to reduce costs by gripping the work pieces partial and not fully supported. Therefore, this paper deals with the machining of unstable carbon fiber reinforced (CFRP) structures. For that reason, the characteristic machining processes like drilling and contour milling of unsupported work pieces are investigated. In practical experiments the unstable work piece was modeled as a one-side fastened bending beam. The flexibility of the work piece was influenced by varying the material thickness or the unsupported length. In particular the delamination mechanism is decisive for the parameters, which enable these production methods. As an unstable behavior of the work piece promotes the formation of damages, it is necessary to develop a limiting criterion for choosing suitable machining conditions. One approach for the drilling process is the use of an energy balance taking into account the elastic energy stored in an unstable work piece. In the following article this possibility is explored and evaluated experimentally by means of tool wear investigations with unsupported work pieces.

10:20 - 10:40 a.m. Coffee break and Visits of Expositions

10:40 a.m.	R. H. Hassan, B. Engel (D-Siegen)

The Influence of Material Properties on Rotary Draw Bending Process

Rotary draw bending is a method that is used in tube forming. In the tube bending process, the wall thickness distribution changes for the tube's cross section because the neutral axis moves towards the inner arc. Thinning takes place in the outer arc of the tube due to the stretching of the material, whereas thickening occurs in the inner arc of the tube due to the compression of the material. This paper investigates in the rotary draw bending process with different material properties (steel alloy 1.0036 and stainless steel alloy 1.4301). FE-simulation and experimental tests are employed to calculate the variable characteristics such as wall thinning / thickening, neutral axis shifting and strain distribution. The research is compared with the theoretical calculations. The theoretical model is based on a geometrical model that was presented in a previous work. This study helped us to identify the influence of the material properties on rotary draw bending.

11:00 a.m.	M. Röder, M. Koch (D-Ilmenau)

Integration of connecting elements in hybrid-composite components

The design and construction of lightweight components in automotive applications is nowadays a major challenge for engineers. The weight reduction of machine parts implies decreasing energy consumption and an increasing resonant frequency of machine parts.

To achieve lighter parts with similar mechanical properties, fiber composites are particularly suitable. To implement such aspects of lightweight, it is an approach to substitute massive metal components by a sandwich element. In this structure, the composite fibre elements are used to absorb accruing loads. The objective of this design is to reduce the weight of the whole component by using a core consisting of aluminum foam surrounded by thin layers of carbon-fibre elements. These layers have high specific stiffness and strength so that a low wall thickness for the outside layer of the hybrid component can be applied. To obtain a required component thickness, the aluminum foam functions as structural sandwich and filling material. The difference of density between carbon-fibre composite and light aluminum foam is 1.5 g/cm³ to 0.35 g/cm³, which illustrates the degree of weight reduction. Technically, it does not appear to be reasonable to cut mounting-threads in that kind of a sandwich element. To enable the mountability of these parts, assembly elements are desired to allow an integration by means for screws or other standard components. These inserts can connect peripheral parts in practical applications. In order to avoid a destruction of the low duty aluminum foam design, the insert-geometry must ensure that the stress is being transitioned to the carbon-fibre layers. This paper deals with the design of different component geometries, strength calculations, an FEM analysis and the production and review of test specimen. Strength calculations of the developed concepts focus on the stress level in the material and contact pressure. Afterwards, FEM simulations determine the theoretical existing stresses with which the selection of material is conducted. As a result of the insert design, test specimens are produced which installed in demonstrator plate made out of carbon fibre-aluminum foam sandwich. The required pull-out force is examined by pull-out tests and compared to previous theoretical analysis.

12:00 noon – 1:30 p.m. Lunch and Visits of Expositions
End of Session

R. Svidler (D-Chemnitz)

Extruded films of bio-based for packaging applications

To contribute to a robust information base, in this work, the chemical composition and processability in the extrusion process of market-relevant bio-based plastics as well as mechanical properties and surface tension of extruded films were investigated. In the advance, the rheology was determined by measuring melt flow index (MFI). The thermal behavior was analyzed by thermal gravimetric analysis (TGA) and dynamic differential calorimetry (DSC). In the context of structure determination, the infrared spectroscopy (IR) and nuclear magnetic resonance spectroscopy (NMR) are used. The extrudet films were evaluated qualitatively by elaborated methodology. The evaluation criteria include the processability of bioplastic, reproducibility of film quality and organoleptic film properties. To characterize the mechanical properties, tensile test DIN ISO 527-3 was selected. The surface free energy, which can be used to evaluate the printability, compatibility with other polymers and the glueability of plastic films, was determined according to DIN ISO 55660-1/2 by means of a video-based optical contact angle measuring instrument.

D. Sanne (D-Bornheim)

Energy saving potentials in the single screw extrusion through the cooling of the feed zone

Extrusion of polyolefins by means of single screw extruders has been a successfully growing business during the last 50 years. Compared to the conventional extruders with a smooth feed zone, grooved feed extruders are increasing in importance. When they ensure back pressure independency and primarily higher throughput rates. Axial grooves in the feed zone are increase the solid friction on the inside surface of the extruder and prevent the rotation of granulate around the screw. A higher and more constant throughput is ensured because of a forced conveying of blocked granulate which is generated. Due to the resulting friction and compression of the plastic pellets, high pressure and heat are produced. If generated heat is not given off and the melting temperature of the semicrystalline thermoplastic or slumping temperature of the amorphous thermoplastic are exceeded, partial melt film friction in the grooves arises and the conveying efficiency breaks down. The melting film begins to occur at the end of the feed zone because the pressure is the highest in their area. To maintain the solid friction and to avoid melting film friction with increasing screw speed and pressure, a cooling of the grooved bushing is necessary. The heat that is transferred to the cooling agent, usually water can only be regained partially. Therefore the necessity of cooling the grooved feed zone to maintain a high conveying efficiency is an additional loss in the overall energy demand.

First investigations which were performed on a 60 mm extruder driven by the power of a 36 kW motor have shown that by controlled reduction of the cooling power in the feed zone, a large energy saving potential can be represented to reduce the drive power. On the other hand, it is necessary to limit the temperature raise of the feed bush to avoid a breaking down of conveying efficiency due to the melting of plastic pellets in the grooves and a bridging of the adjacent zone.
On the basis of these results, additional energy can be saved and running costs can be reduced. A reduction of the drive power by up to 9% as well as an increase in throughput can also be obtained. Further investigation on the optimization potential of other extruder sizes will be done in the near future.

Workshops:

WS 1 Living Glass Surfaces
WS 2 Virtual Engineering throughout the Product Life-Cycle
WS 3 Design Science and Biomimetics (Bionics) – State and Perspectives
WS 4 Thermal issues in dimensional metrology – the EMRP-project T3D

WS 1 – Living Glass Surfaces

Time: Wednesday, 10.09.2014
Location: Humboldtbau, Lecture Room 012
Chair: E. Rädlein (D-Ilmenau)

10:00 a.m.	E. Rädlein (D-Ilmenau)

Introduction to „Living Glass Surfaces"

10:15 a.m.	E. Rädlein (D-Ilmenau)

Droplets – Ringlets – Precipitates: Reasons for early lateral segregation

10:50 a.m.	M. Junghähnel (D-Dresden)

Advanced Thin Film Coatings on Flexible Glass

11:25 a.m.	A. Gans (D-Jena)

topic: Cleaning requirements and pretreatment before bonding

12:00 noon – 13:00 p.m. Lunch and Visits of Expositions

13:00 p.m.	R. Pahl (D-Berlin)

Reusable bottles in the brewing and beverage industry – cleaning and inspection technologies

13:35 p.m.	D. Werner (D-Weiden)

Glass corrosion effects from dishwashing and their technical solution

Glass corrosion from automatic dishwashing has been investigated by atomic force microscopy (AFM) and other surface sensitive methods. The results show completely different basic causes of glass attack. Local clouding at the mouth rim or line corrosion can be traced back to the production process of the glass. Components of cleaning agents were found to be responsible for iridescence and clouding all over. The comprehensive knowledge of the corrosion mechanism was used to establish one possible technical solution to avoid glass corrosion. Using the so called Protector Dual Protection, the cleanness and brilliance of glass can be conserved even if the glass passed many cycles in automatic dishwashing. The mechanism to prevent the glass surface and enamels are described below.

14:10 a.m.	M. Emonds (D-Mönchengladbach)

Washing of float glass

Der Reinigungsprozess ist ein wichtiger Verfahrensschritt bei der Bearbeitung von Glas, insbesondere bei Veredlungsverfahren. Verunreinigungen, die nach einem unzureichenden Waschprozess auf der Glasoberfläche verbleiben, können zum Ausschuss führen. Flachglas wird in der Regel auf Bürstenwaschmaschinen gereinigt. Diese sind in mindestens 2 Zonen aufgeteilt (Vorwaschzone und Hauptwaschzone), die jeweils einen eigenen Wasserkreislauf haben müssen.

Die Hauptwaschzone sollte mind. 3 Abschnitte aufweisen. Abhängig vom Grad der nötigen Reinigung sind diesen 2 Zonen noch eine Polierstation und/oder eine Sprühreinigung vorgeschaltet. Waschmittel werden in der Sprühreinigung und in der Vorwaschzone eingesetzt. Vier Faktoren beeinflussen den Glaswaschprozess: Temperatur, Mechanik, Zeit und Chemie. Durch das richtige Zusammenspiel dieser Faktoren erreicht man eine gute Reinigung. Verringerung eines Parameters bedeutet, dass man andere Parameter erhöhen muss, um ein vergleichbares Resultat zu erhalten. Möchte man z.B. die Waschzeit verkürzen, um einen höheren Durchsatz zu erzielen, kann man dies durch Erhöhung der Temperatur oder durch Erhöhung der Waschmittelkonzentration erreichen. Da der Erhöhung der Temperatur und der Mechanik anlagenbedingt Grenzen gesetzt sind, ist oft der Einsatz eines geeigneten Waschmittels die einzige Chance, das Reinigungsergebnis entscheidend zu verbessern.
Ein Waschmittel für Glas hat viele Funktionen:

- Verbesserung des Benetzungsverhalten (Verminderung der Oberflächenspannung)
- Verbesserung der Schmutzanlösung
- Schmutzdispergierung/emulgierung
- Verhinderung der Redeposition (Wiederablagerung des Schmutzes auf Glas oder Anlage)

Durch Verringerung der Oberflächenspannung können viele Anschmutzungen (z.B. Fett und Öl) vom Wasser benetzt und abgelöst werden. Ist die Verunreinigung in die Reinigungslösung gelangt, ist es wichtig, dass sie sich nicht wieder auf dem Glas oder auf Anlagenteilen (z.B. Bürsten, Rohrleitungen, Vorratsbecken) absetzt. Ist dies nicht der Fall, so reichern sich Schmutzpartikel an und können nach Erreichen einer bestimmten Konzentration schlagartig „durchbrechen", d.h. in großen Mengen in die Nachspülzone gelangen.

14:45 a.m.	Ch. Gilles (D-Westerburg)

features about water treatment in the glass-industry

15:20 - 15:45 p.m. Coffee break and Visits of Expositions

15:45 p.m.	R. Kirner (D-Ilmenau)

On the influence of directed flows in a wet chemical etching process on the surface roughness of photostructured glasses

16:20 p.m.	N.N.

topic: inspection

16:50 p.m.	E. Rädlein (D-Ilmenau)

Final words

17:00 p.m. Possibility to visit the Institute for Material Engineering

WS 1 – Living Glass Surfaces
Time: Thursday, 11.09.2014
Location: Arrheniusbau, Room 124
Chair: E. Rädlein (D-Ilmenau)

8:15 a.m.	**Start:** Humboldtbau
Excursion to IL Metronic Sensortechnik Ilmenau	
11:00 a.m. - 5:00 p.m.	
HVG-Projektbeirat „Reinigung von Halbzeugen und Produkten aus Glas“(IGF/AiF Research Project No. 17881 BG)	

WS2 – Virtual Engineering throughout the Product Life-Cycle

Time: Thursday, 11.09.2014
Location: Humboldtbau, Lecture Room 204
Chairmen: C. Weber, S. Husung (D-Ilmenau)

9:00 a.m.	S. Pöschl, A.-D. Tudor, N. Doering (D-Ilmenau)

Human factors in ive development – a case study for virtual fear of public speaking training

Virtual Reality (VR) training applications are a success story for research and development. However, in order to firstly, fully understand human-computer interaction in 3D environments and secondly, designing and implementing effective applications, system as well as user characteristics should be acknowledged. In this paper, we present a case study of a virtual fear of public speaking training. The first aim in our project was to implement realistic audience behavior, as findings show that higher simulation realism does not only lead to higher presence and subsequently to higher user performance, but also to better transfer of gained skills into practice. In order to obtain data on realistic audience behavior, three cross-sectional non-participant overt observation studies (total n=91) have been conducted. Results show that audiences seem to be rather positive, frequently showing friendly and neutral face expressions. Additionally, combined and even synchronized behavioral patterns between participants who sit next to each other (like turning to the neighbor and start talking) were registered. Further, participants showed up to 800 different individual patterns of attentive and inattentive behaviors, which offer an extremely broad choice for behavior simulation in VR. Concerning interactivity, participants spent more time paying attention to the speakers when they looked directly at them and spoke in high voice compared to low voice deliveries. They stayed attentive when voice was high, even if speakers' eye gaze drifted. These findings have been used to design and develop a virtual audience for a 3D prototype application. The second aim was to examine the effect of simulation fidelity on user experience, namely perceived realism, fear experienced during a talk, and presence (the feeling of "being there"). An experimental cross-sectional within-subject laboratory user study (n=40) was conducted to evaluate the prototype. Contrary to state of research, no influence was shown on virtual presence and perceived realism, but an animated audience led to significantly higher effects in fear. Our findings highlight the importance of high simulation fidelity for designing and implementing effective (fear triggering) virtual fear of public speaking applications.

9:20 a.m.	A. Siegel, St. Husung, Chr. Weber (D-Ilmenau); A. Albers, D. Landes, M. Behrendt (D-Karlsruhe)

Simulation of acoustical properties of technical systems using a network-based sound-server

Today, the development of new industrial products is often a time-consuming and cost-intensive process. Therefore, the demand for novel methods, which help to make product development more efficient, is increasing. In this regard virtual engineering can open up new possibilities.

For instance, the simulation of product properties and the interactive presentation in a Virtual Reality (VR) environment allow verifying and discussing product requirements at an early stage of the development process. The focus of this paper is on acoustical reproduction of virtual sound sources via a real-time capable, network-based sound-server. A main task of the sound-server is to reproduce the state-dependent properties of different sound sources. For this purpose the sound propagation chain of each sound source has to be reproduced. The transmission of both structure-borne noise and airborne noise has to be considered. The developed methods are explained in the paper using an automotive example. The aim of the example application is to simulate a car passing test (according to DIN ISO 362) in a VR environment. For this purpose the auditory impression along a virtual test track is recreated. Different sound sources which cause the sound of the car (for example the wheels, the engine and the exhaust system) are described by digital filters. The filters are based on measurements carried out beforehand on an acoustical roller test bench.

9:40 a.m.	D. Landes, A. Albers, M. Behrendt (D-Karlsruhe); Chr. Weber, A. Siegel, St. Husung (D-Ilmenau)

Determination of the Near-Field-Acoustics of Primary Vehicle Sound Sources in Relation to Indoor Pass-by Noise Testing for the Verification of a Virtual Acoustic Vehicle Model

The exterior sound emission of a vehicle is an increasingly important criterion for the homologation of road vehicles. The latest limit value of 74 dB(A) is already a major challenge for car manufacturers and the EU is planning an even lower limit of 68 dB(A) in the near future. According to DIN ISO 362, the vehicle exterior noise is determined by a standardized procedure – the outdoor vehicle pass-by. In this contribution, a new approach for determining the vehicle exterior noise in an early stage of product development is presented. The aim is to transfer the measurements from outdoor testing facilities to acoustic roller test benches and furthermore into an entirely virtual environment. Therefore, a virtual acoustic vehicle prototype is verified and validated by measurements on a roller test bench and on a real test track. In a first step, a pass-by test series, using a linear microphone array and considering the vehicle as a point source is performed on the acoustic roller test bench of IPEK – Institute of Product Engineering at Karlsruhe Institute of Technology. In order to substantiate the virtual acoustic vehicle model, the contributions of the primary sound sources of the vehicle to the exterior noise have to be investigated, with the objective of a modular approach for the virtual acoustic prototype. For this purpose, the airborne transfer paths between the primary sources and the far-field of the vehicle are determined by reciprocal measurements. Therefore, a dodecahedral speaker applied with white noise is used. Furthermore, the sound pressure levels are measured in the near-field of the primary sound sources – the engine, all four wheels, the exhaust pipe as well as the frontal intake. Using the reciprocally determined airborne transfer paths, the contribution of the sound sources to the sound pressure in far field can be calculated. Based on the reciprocally determined transfer functions digital filters are computed. The digital filters are convolved with the audio signals which result from the near-field component measurements. Thus the acoustical properties of the vehicle can be reproduced. The processed audio data can be presented by a flexible audio-visual stereo projection system (FASP) at the Technische Universität Ilmenau.

10:00 a.m.	K. Wall, W. Tomaszek-Staude (D-Wolfsburg); S. Poeschl, N. Doering (D-Ilmenau)

State of the art barriers in evaluation of digital mock-ups in immersive virtual environments

Virtual Reality (VR) technology has become popular for the validation of digital mock-ups (DMU). Nevertheless there are still caveats in reliability and usability of immersive validation of digital mock-ups (IVDMU). Most research in this field has been done in laboratory conditions focusing on isolated aspects. The purpose of this study was to explore factors that play a role in the validation of virtual and physical mock-ups (PMU), the perception of DMUs in immersive virtual environments (IVE) with the focus on the user's point of view and daily operation conditions. Further current problem areas of IVDMU should be identified. Therefore a one-shot case study was conducted with users (n=12 vehicle experts) of an IVDMU at Volkswagen. In addition to DMU, a PMU and real cars were used in the validation process. An explorative qualitative approach was chosen, because little is known about the user's needs and expectations of IVDMU in relation to recent VR technology. Data collection was performed by means of semi-structured interviews, which were recorded, transcribed and analyzed by method of Mühlfeld et al. (1981).Results show that rising data complexity and poor usability of VR devices keeps IVDMU far from being mature in daily operation. Several users reported symptoms of cybesickness caused by poor system performance or usability. Rather surprising was the self-assessment of the experts within the validation process. Experts were asked to validate "from an end-customer's point of view". Though, they frequently resumed their expert role shortly after the start. Another result showed a disparity in perception of DMU and PMU. Users have adjusted the PMU like a real car (seat, steering-wheel, mirrors). However, a minority of users has done this with the DMU. Insights were provided into needs and expectations of IVDMU users. Thus more applied research should be done for example to understand effects of perception disparities of PMUs and DMUs (e.g. treated like a real car vs. treated like a visual presentation) under the aspect of validation reliability. The self-assessment of the expert's role in IVDMU should be further examined. Also research should be conducted on factors contributing to cybersickness in order to raise user acceptance of IVDMU.

10:20 - 10:40 a.m. Coffee break and Visits of Expositions

10:40 a.m.	

Demonstration Virtual Reality Lab, Ernst-Abbe-Center (EAZ), Room 1341/42)

12:00 noon – 1:30 p.m. Lunch and Visits of Expositions

WS2 – Virtual Engineering throughout the Product Life-Cycle
Time: Thursday, 11.09.2014
Location: Humboldtbau, Lecture Room 204
Chairmen: C. Weber, S. Husung (D-Ilmenau)

1:30 p.m.	C. Weber, S. Husung (D-Ilmenau)
Workshop and Discussion	
2:50 – 3:10 p.m. Coffee break and Visits of Expositions	
3:10 p.m.	C. Weber, S. Husung (D-Ilmenau)
Workshop and Discussion	
End of Workshop	

WS3 – Design Science and Biomimetics (Bionics) – State and Perspectives
Time: Wednesday, 10.09.2014
Location: Humboldtbau, Lecture Room 202
Chairmen: Ch. Weber / H. Witte (D-Ilmenau)

10:00 a.m.	N. Kizilova (UA-Kharkov)

Optimal reinforcement in nature: from plants and animals to engineered systems

10:20 a.m.	C. Schilling (D-Ilmenau)

Biological structures and technical design – a bio-mimetic approach
Development and improvement of technical devices occur in a synectic manner by transferring principles of living systems, like organisms including the human body, reactions of biomolecules or even supra-organismic phenomena, into technical design. Besides this, the process can have also the aim to pattern technical processes on organismic systems. This paper is a digest of the theoretical work on this topic, according to the tasks on different technical developments and their didactics. It includes citations of the main communications concerning the results of the application in design of micromechanical systems, the research of biocompatible materials and bio-inspired motion systems.

10:40 a.m.	M. Fremery, S. Köhring, O. Nassar, K. Weinmeister, M. Schöne, H. Witte (D-Ilmenau); G. Djordjevic (XS-Nis)

Presentation:
A Phase-Shifting Double-Wheg-Module for locomotion purposes
Following mechatronic design methodology this paper introduces a phase-shifting double-wheg-module which forms an alternative approach for wheg-driven robots. During construction focus was placed on a smooth locomotion of the wheg-mechanism over flat terrain (low alternation of the CoM in vertical y-direction) as well as the ability to overcome obstacles. Simulations using the multi-body simulation tool ADAMS View® were executed in order to prove estimations done. Using the results of simulation and calculation a first prototype was designed, manufactured and tested by experiment.

11:00 a.m.	D. Voges, M. Fremerey, D. Hörnschemeyer, M. Krekeler, C. Schilling, H. Witte, (D-Ilmenau); K. Schomburg (D-Freiberg,i.Br.)

Presentation:
The Cilia Field as a Paragon for Technical Macro Transport
As a part of a student design project of the biomedical engineering studies the movement of cilia (small, flexible hair like rods), and their possible function as an alternative to the transport belt (conveyor) was considered in more detail. As a result, a macro model of a single cilium was designed and a modular cilia field containing 3 x 3 = 9 of those technical cilia manufactured. A proof of transport function could be established.

11:10 a.m.	Th. Helbig, D. Voges, H. Witte (D-Ilmenau); S. Niederschuh, M. Schmidt (D-Jena)

Presentation:

The mechanics of carpal vibrissae of Rattus norvegicus during substrate contact

Sinus hairs are tactile hairs of mammals, commonly also known as vibrissae or whiskers. The term "whisker" contemplates to the mystacial sinus hairs (mSH) in specific, which are situated around the snout of the animal. These mystacial sinus hairs can be moved actively to support and control sensing [1, 29]. The cyclic motion (whisking) of the mystacial sinus hairs was eponymous. In many species not only mSH can be found. Studies have demonstrated a variety of sinus hairs at multiple locations on the body surfaces of mammals [13, 27]. This contribution deals with carpal sinus hairs (cSH) at the forelimbs of rats. Although known for over 120 years – cSH first were discovered in some lemurs at the end of the 19th century [2, 5] – the knowledge of structure and function of cSH in mammals is very sparse in comparison to mSH. Carpal sinus hairs gain increasing interest since there is evidence on influences on the kinematics of the segmental chains of legs. One hypothesis is that cSH signals serve to adjust the stiffness of legs and to prepare them for the contact with different substrates or irregularities in the substrate – a function interesting for robotic locomotion. Studies on the locomotion of animals allow examining the influence of tactile information on walking parameters when mystacial and/or carpal sinus hairs are absent. Due to their small size it is very difficult to visualize the mechanical behavior of cSH during natural movement of a living rat with conventional methods. Therefore, we are proposing the use of a so called pedipulator – a mechanical gearing device which guides a dissected forelimb of a rat artificially on a natural trajectory. This approach shall help to understand the functionality of cSH and to interpret results from previous motions studies with living rats.

11:20 a.m.	Ch. Weber, H. Witte (D-Ilmenau)

Discussion:

"Biomimetics: Future challenges for engineering methods"

12:00 noon – 12:45 p.m. Lunch and Visits of Expositions

12:45 – 1:40 p.m. Start Guided Tours

1:45 p.m. Start Excursion to Weimar

WS 4 Thermal issues in dimensional metrology – the EMRP – project T3D

Time: Wednesday, 10.09.2014

Location: Humboldtbau, Lecture Room 010

Chairman: J. Flügge (D-Braunschweig)

10:00 a.m.	T. Maxwell (UK-Middlesex)

Traceable indentation measurements

10:20 a.m.	H. Lorenz (D-Braunschweig)

Absolute Interferometric measurement of the dimensional and thermal stability of joining techniques

We show how absolute length measurements by interferometry can be applied to measure the dimensional and thermal stability of joints. In order to investigate joining techniques, representative joints were fabricated by a number of methods including screwing and gluing. By using gauge blocks as joining parts parallelism and flatness were achieved which are needed for precision interferometric measurements. We were able to examine the dimensional behavior (i.e. change of length or orientation) of the sample joints on an accuracy level of about one nanometer. Stability has been investigated longitudinally and laterally to the connection interface, also mutual tilting of the parts was detected by analysis of the phase topographies. Measurement results of about one year show that screwed joints do not exhibit significant changes of length, orientation or response to temperature variation. This is different for adhesive joints where dimensional changes of up to 100 nm were observed.

10:40 a.m.	A. van der Nes, D. Voigt (NL-Delft)

Picometer resolution heterodyne interferometry for short to medium term dimensional stability measurements

A thorough understanding of dimensional drift phenomena at the picometer range, stemming from ageing, temperature changes or mechanical stresses in instrumentation or the object to be measured, is essential for high-end precision engineering and accurate measurements. For that purpose, a balanced double-sided heterodyne interferometer is developed to perform traceable measurements of dimensional drift with an uncertainty of less than 10 pm at the short-term (seconds to minutes), and 100 pm at the medium-term (hours to days). The performance of the instrument is presented by means of a 66 hour long double dead-path difference measurement, demonstrating the desired uncertainty levels during a selected period of 19 hours, while operating in ambient air conditions. The residual pressure related path length difference fluctuations form the current limitation to the measurement uncertainty.

11:00 a.m.	K. Bouderbala (FR-Paris)

Reduced thermal model for temperature control and compensation

11:20 a.m.	M. Schalles (D-Ilmenau); J. Flügge, R. König (D-Braunschweig)

Reduction of thermal effects on precise dimensional measurements

Inhomogeneous temperature fields are a source of error in precision dimensional measurements. To reduce these dimensional measurement errors, among other approaches, the complex measurement instrumentation can be thermally stabilized or cooled. At the example of the Measuring Microscope of the Nanometer Comparator at Physikalisch Technische Bundesanstalt, active and passive cooling strategies are shown and advantages and drawbacks of the approaches are discussed. Concluding from those general ideas, a new passive thermal cooling approach which uses the latent heat of the melting process of a Gallium-Tin eutectic alloy is presented for thermal stabilisation of the measuring instrumentation. The design and development of the cooling element are explained and validating measurements which demonstrate a thermal stable time span of 6 h are shown.

11:40 a.m.	S. Rudtsch (D-Braunschweig)

Thermometry fixed points based on binary eutectic alloys

In this work investigations on binary eutectic alloys of gallium with aluminum, with zinc and with tin are presented. It was found that the gallium tin system with a phase-transition temperature of (20,477±0,004) °C is the most suitable fixed point. The definition of the phase transition temperature was based on the maximum of a histogram that shows percentage of time spent in consecutive temperature intervals for equilibrium melting curves. The results show that non-equilibrium effects are the most important influencing quantities. This requires slow freezing of these alloys to minimize the range and slope of the subsequent melting curves.

12:00 noon	J. Flügge, M. Voigt (D-Braunschweig); D. Drung (D-Berlin)

Thermo couples for temperature measurement and control near room temperature

Because thermocouples are measuring inherently temperature differences between two connection points of different metal wires, they are tailored for measuring and control of small temperature gradients in precision engineering equipment without calibration of two resistance thermometers. Despite of this advantage they are rarely used for this application due to the low thermal sensitivity. A multi channel measurement system based on mechanical relays and a newly developed high sensitive voltage amplifier is presented, which allows for a noise level of 0.2 mKp-p using type T thermocouples for average times of a few seconds. For the test of the zero point stability of thermo couples near room temperature a set of 32 thermocouples of different types with wires from various manufacturers and with different wire dimensions and connection techniques were placed in good thermal contact between the two measurement points of each thermo couple at a copper block in a well isolated oil bath for many month.

During this time additionally the effect of stress and temperature gradients on the wires outside of the box were investigated. For a test period of six month all thermocouples which have been directly soldered to the circuit board of the relay box were stable in a range of +/-0.3 mK. These measurement shows that it is possible to use thermocouples in an environment with small temperature variations and an electrically clean environment without the need for individual calibration down to sub-mK accuracy.
12:20 – 12:45 p.m. Lunch and Visits of Expositions
12:45 – 1:40 p.m. Start Guided Tours
1:45 p.m. Start Excursion to Weimar

Welcome Reception

Monday, 08.09.14, 3:00 p.m. – 5:30 p.m.

It is our pleasure to welcome you at Technische Universität Ilmenau. All lecturers, participants and guests are kindly invited to the reception.
Please enjoy Thuringia's hospitableness.

Weather permitting, the welcome reception will be given on the square in front of the Humboldt Building. Otherwise, our guests are kindly asked to go inside. The reception will be held immediately after the Opening Ceremony.

Music provided by: Michael Grübler & Swinging fun

Enjoy yourselves!

Social Events

Academic Gala Concert

Tuesday, 09.09.14, 8:00 p.m. Ilmenau's Festival Hall

All lecturers, participants and guests are kindly welcome to the Academic Gala Concert.

Programme

Philharmonic Orchestra Jena

Ludwig van Beethoven
Coriolan-Overture

Ludwig van Beethoven
Concert Nr. 3 for pianist

Hector Berlioz
Symphony fantastique

Pianist Varvara Nepomnyashchaya (RUS)

Conductor Marc Tardue (USA)

Admission for tickets

Rank 1 to 9 = 18.00 euro/ticket
Rank 10 to 18 = 15.00 euro/ticket

Scientific Guided Tours

Wednesday, 10.09.14, 12:45 – 13:40 p.m.

All participants are kindly invited to visit a selection of scientific research centers of our university.

Meeting place:
Entrance to the Humboldtbau

The following tours will be held:
(each tour starts at the same time)

- Competence Center Virtual Reality
  (Max. Participants: 20)
- Center for Micro- and Nanotechnologies
  (Max. Participants: 15)
- Competence Center Nanopositioning and Nanomeasuring Machines
  (Max. Participants: 20)
- Quality Assurance and Image Processing
  (Max. Participants: 30)
- Automotive Engineering
  (Max. Participants: 25)

Admission: Free of charge

Social Events

Excursion and Banquet

Wednesday, 10.09.14, 1:45 p.m.	Buses depart from the Mensa (Refectory) for the Excursion to Weimar (World Heritage).
2:50 p.m. (approx.)	Arrival in Weimar (Welcome Center)
3:00 – 4:45 p.m.	City tour by Belvedere Express
3:00 – 4:30 p.m.	Sightseeing walk "The historical Weimar"
4:45 – 6:30 p.m.	Individual free time for sightseeing in Weimar
6:30 p.m.	All participants leave Weimar for the Hotel "Tanne" in Ilmenau.
8:00 p.m.	Welcome to the Banquet in Hotel "Tanne" Ilmenau (www.hotel-tanne-thueringen.de) Enjoy Thüringen's cuisine in an informal atmosphere with cultural explanations by JANNA
11:00 p.m. (approx.)	End of the Banquet
Admissions	**for Participation in the Excursion:** **€ 29.75 EUR** (The price includes 25.00 euro net and 19% VAT – 4.75 euro) **for Participation in the Banquet:** **€ 29.75 EUR** (The price includes 25.00 euro net and 19% VAT – 4.75 euro)
Notice	*Please collect your admission ticket in the Conference Office. It must be shown when you get on the bus and when you join the banquet.*

List of Main Authors / Chairmen

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