

A blue-tinted wireframe image of a car chassis, showing the engine, transmission, and rear wheel, positioned in the top left corner of the cover.

Proceedings

Michael Bargende · Hans-Christian Reuss
Jochen Wiedemann *Hrsg.*

14. Internationales Stuttgarter Symposium

Automobil- und Motorentechnik



The logo for Springer Vieweg, featuring a stylized white chess knight piece on a black pedestal to the left of the text 'Springer Vieweg' in a white, serif font.

Springer Vieweg

Proceedings

Ein stetig steigender Fundus an Informationen ist heute notwendig, um die immer komplexer werdende Technik heutiger Kraftfahrzeuge zu verstehen. Funktionen, Arbeitsweise, Komponenten und Systeme entwickeln sich rasant. In immer schnelleren Zyklen verbreitet sich aktuelles Wissen gerade aus Konferenzen, Tagungen und Symposien in die Fachwelt. Den raschen Zugriff auf diese Informationen bietet diese Reihe Proceedings, die sich zur Aufgabe gestellt hat, das zum Verständnis topaktueller Technik rund um das Automobil erforderliche spezielle Wissen in der Systematik der Konferenzen und Tagungen zusammen zu stellen und als Buch in Springer.com wie auch elektronisch in SpringerLink und Springer für Professionals bereit zu stellen.

Die Reihe wendet sich an Fahrzeug- und Motoreningenieure sowie Studierende, die aktuelles Fachwissen im Zusammenhang mit Fragestellungen ihres Arbeitsfeldes suchen. Professoren und Dozenten an Universitäten und Hochschulen mit Schwerpunkt Kraftfahrzeug- und Motorentechnik finden hier die Zusammenstellung von Veranstaltungen, die sie selber nicht besuchen konnten. Gutachtern, Forschern und Entwicklungsingenieuren in der Automobil- und Zulieferindustrie sowie Dienstleistern können die Proceedings wertvolle Antworten auf topaktuelle Fragen geben.

Michael Bargende · Hans-Christian Reuss
Jochen Wiedemann (Hrsg.)

14. Internationales Stuttgarter Symposium

Automobil- und Motorentechnik

Band 1

 Springer Vieweg

Herausgeber

Prof. Dr.-Ing. Michael Bargende
Prof. Dr.-Ing. Hans-Christian Reuss
Prof. Dr.-Ing. Jochen Wiedemann
FKFS Forschungsinstitut für Kraftfahrwesen
Stuttgart, Deutschland

ISBN 978-3-658-05129-7

ISBN 978-3-658-05130-3 (eBook)

DOI 10.1007/978-3-658-05130-3

Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über <http://dnb.d-nb.de> abrufbar.

Springer Vieweg

© Springer Fachmedien Wiesbaden 2014

Das Werk einschließlich aller seiner Teile ist urheberrechtlich geschützt. Jede Verwertung, die nicht ausdrücklich vom Urheberrechtsgesetz zugelassen ist, bedarf der vorherigen Zustimmung des Verlags. Das gilt insbesondere für Vervielfältigungen, Bearbeitungen, Übersetzungen, Mikroverfilmungen und die Einspeicherung und Verarbeitung in elektronischen Systemen.

Die Wiedergabe von Gebrauchsnamen, Handelsnamen, Warenbezeichnungen usw. in diesem Werk berechtigt auch ohne besondere Kennzeichnung nicht zu der Annahme, dass solche Namen im Sinne der Warenzeichen- und Markenschutz-Gesetzgebung als frei zu betrachten wären und daher von jedermann benutzt werden dürften.

Umschlagbild: © [M] Peugeot

Gedruckt auf säurefreiem und chlorfrei gebleichtem Papier.

Springer Vieweg ist eine Marke von Springer DE. Springer DE ist Teil der Fachverlagsgruppe Springer Science+Business Media
www.springer-vieweg.de

WELCOME

Within the field of mobility, an independent turnaround in the energy policy is taking place. Environmental protection and the conservation of dwindling resources are important driving forces of this development, which represents major technological challenges for companies and research institutes. For this purpose, new technologies must be developed and existing ones improved. Accordingly, the Research Institute of Automotive Engineering and Vehicle Engines in Stuttgart is placing the 14th Stuttgart International Symposium on Automotive and Engine Technology under the motto »Renewable energies and future mobility concepts«. I was very happy to assume patronage of the event.

With over 800 professional attendees, more than 110 lectures and an accompanying exhibition, the Stuttgart Symposium is considered as one of the most important discussion boards for the range of automotive and engine development in Europe. It is an excellent platform for the representatives of industry and research to discuss new ideas and to present the performance of the industry in Baden-Wuerttemberg.

With this year's focus on the main topic the symposium will go far beyond the development of vehicles and engines. It includes both the integration of diverse transport modes and systems as well as energy efficiency control of various types of motor vehicles.

Another important objective of the Baden-Wuerttemberg state government is the resource-conserving energy production. In the field of transport alternative forms of propulsion must be developed with future technologies and corresponding IT solutions, which enable an intelligent integration and application for all road users and participants.

It is about nothing less than the future of mobility! Speed, flexibility and environmental friendliness will be the main criteria. The well working cooperation between science and industry in Baden-Wuerttemberg is a key prerequisite for the development of modern mobility concepts.

My thanks go to the event organizers and promoters, whom I would like to congratulate for the extensive and exciting program of the 14th Stuttgart International Symposium of automotive and engine technology. To all indoor exhibitors, as well as visitors, I wish inspiring and productive discussions.

Winfried Kretschmann
Prime Minister
of the State of Baden-Wuerttemberg

RESEARCH AND DEVELOPMENT IN AUTOMOTIVE AND ENGINE TECHNOLOGY

The automotive industry is globally facing a number of challenges: The legal limitation of CO₂ emissions, the finite nature of reserves of fossil fuels and the increasing traffic congestion in urban areas and megacities are important issues. The need for affordable mobility systems which are resource-efficient as well as sustainable and climate neutral, but which also meet high safety standards and high levels of social and political acceptance, is increasingly clear. The automotive industry is therefore intensively working on alternative vehicle and mobility concepts. Additionally, previous research approaches are joined more and more by concepts from the fields of electricity and electronics, mechatronics, information technology and computer science. To promote research in the various areas it is important to share and unify the research results from academia and industry.

The

14th Stuttgart International Symposium Automotive and Engine Technology

18th and 19th March 2014

provides an important platform for the automotive industry. The program of the symposium was expanded from four to six parallel sessions in order to meet the increased topics as well as the very high number of excellent submissions of papers. Due to the resulting variety of topics that will be presented by leading experts in more than 110 lectures, we hope to have arranged an interesting program for you. The lecture related discussions and the accompanying exhibition offer an opportunity for further professional exchange.

We look forward to welcoming you in Stuttgart, the birthplace of the automobile and wish you enjoyable and informative days at the 14th Stuttgart International Symposium.

Prof. Dr.-Ing. Michael Bargende
Prof. Dr.-Ing. Hans-Christian Reuss
Prof. Dr.-Ing. Jochen Wiedemann

INDEX – Volume 1

SECTION 1

INNOVATIVE VEHICLES

Chairperson: Prof. Dr. Frank Gauterin

- Urban EV project Visio.M – Concept highlights and latest prototype test results** 1
Stefan Riederer, BMW Research and Technology
- Performance and efficiency – technical solutions for high-performance sports cars to achieve future CO₂ limits** 3
Bernhard Bihr, Gabriele Pieraccini, Holger Hofmann, Stefanie Freudenstein, Bosch Engineering GmbH
- E-generation / Key technologies for electric vehicles** 19
Michael Dimitrov, Dr. Ing. h.c. F. Porsche AG

CI ENGINES – COMPONENTS

Chairperson: Prof. Dr. Wolfgang Thiemann

- Advanced diesel fuel injection equipment – A never ending BOSCH story** 31
Jürgen Hammer, Michael Raff, Dirk Naber, Robert Bosch GmbH
- Cascaded indirect integrated charge air cooling for passenger car diesel engines** 47
Simon Schneider, MAHLE International GmbH; Andreas Eilemann, MAHLE Behr GmbH & Co. KG; Jürgen Stehlig, MAHLE Filtersysteme GmbH
- Thermal management for a light-duty-vehicle with diesel engine: Evaluation of an optimized cooling system with variable cooling components** 61
Wolfgang Wenzel, John Shutty, Jeri Tsai, BorgWarner, Inc.; Thomas Buchholz, BorgWarner Thermal Systems

BATTERIES

Chairperson: Prof. Dr. Werner Tillmetz

A123 battery life simulation and validation test results **79**

Jeff Kessen, Roland Jeutter, Christoph Fehrenbacher, A123 Systems

Integrated electronics for battery sensors **89**

Jürgen Kernhof, Ayman Ghazi, Marko Radovic, ZMDI

**Development of active Battery Management System
for test car and test results** **99**

Dan Jiang, M. Hübner, HTW Dresden

DRIVING DYNAMICS I

Chairperson: Prof. Dr. Ferit Kückükay

An effective process for trackside vehicle development **125**

Paolo Bortolussi, Leonardo Pascali, Dr. Ing. h.c. F. Porsche AG;
Nico Castrup, RWTH Aachen

**Integrated Vehicle Dynamics Control – an optimized approach
for linking multiple chassis actuators** **139**

Lars König, Thomas Walter, Benjamin Gutmayer, Dominik Merlein,
Bosch Engineering GmbH

**Integration of chassis control system networking into the vehicle
dynamics development process** **151**

H.-C. Reuss, Jan-Hendrik Herold, University of Stuttgart;
Leonardo Pascali, Dr. Ing. h.c. F. Porsche AG

ELECTRICAL POWER MANAGEMENT

Chairperson: Prof. Nejila Parspour

**Modular modeling of a PEM fuel cell system
for automotive applications** **167**

Raphael Hans, ETAS GmbH; Ferdinand Panik, HS Esslingen;
Hans-Christian Reuss, University of Stuttgart

Photovoltaic based inverter charger	181
Martin Neuburger, University of Applied Sciences Esslingen	

Range extending for electric vehicle operation in urban-regional areas	199
Jens Bachstein, Andreas Daberkow, Heilbronn University; Hans-Christian Reuss, University of Stuttgart, FKFS	

PRODUCTION + DESIGN I

Chairperson: Prof. Dr. Rainer Gadow

Experimental study of unstretched fiber shifting during hemming processes for automotive aluminum alloys	215
Severin Hönle, Mathias Liewald, Philipp Schmid, IFU, University of Stuttgart; Manfred Sindel, AUDI AG	

Virtual production planning and dimensional accuracy prediction of sheet metal components in the bodyshell work	227
Christian Kästle, Daimler AG; Mathias Liewald, Karl Roll, University of Stuttgart	

SECTION 2

ADVANCED DRIVER ASSISTANCE SYSTEMS I

Chairperson: Prof. Dr. Tobias Flämig-Vetter

Ego-motion estimation in urban areas	241
Claudius Gläser, Lutz Bürkle, Frank Niewels, Robert Bosch GmbH	

New working model for collaboration of OEM and supplier in development of advanced driver assistance functionalities for series production	255
Ulrich Zoelch, Claus Dorrer, Martin Krenn, Martin Peller, Peter Varadi, BMW AG; Dirk Böttcher, Jürgen Diebold, Hagen Stübing, Continental AG	

An efficient environmental model for automated driving	267
Ralph Grewe, Andree Hohm, Stefan Lueke, Continental AG	

HYBRID I

Chairperson: Prof. Karl-Ernst Noreikat

Emission optimized hybrid vehicle operation with thermal exhaust model 281

Florian Kunkel, Rolf Isermann, TU Darmstadt, Institute for Automatic Control and Mechatronics

Automated process integration and design optimization of a mathematics-based series-hybrid electric vehicle 297

Johannes Friebe, Thanh-Son Dao, Maplesoft GmbH;
Christine Schwarz, ISKO engineers AG

Definition and implementation of a benchmarking in order to derive success factors of hybrid powertrains 321

Albert Albers, Matthias Behrendt, Friedrich Brezger, Kevin Matros, Benedikt Steiger, IPEK – Institute of Product Engineering at Karlsruhe Institute of Technology (KIT); Heidelinde Holzer, Wolfram Böhne, BMW AG

SI ENGINES – IGNITION

Chairperson: Prof. Dr. Christian Beidl

Spark plugs for modern engines: challenges and solutions 337

Igor Orlandini, Arnold Schneider, Sabrina Rathgeber, Tobias Ruf, Robert Bosch GmbH

Simultaneous spatially resolved visualization of fuel/air ratio and residual gas distribution in an optically accessible SI-engine 349

Thomas Mederer, Wolfgang Friedrich, Johannes Trost, Lars Zigan, Michael Wensing, LTT, Friedrich-Alexander-University Erlangen-Nuremberg

Potential of corona ignition on gas engines using EGR and lean combustion 373

Alexander Schenk, Georg Rixecker, Volker Brichzin, BorgWarner BERU Systems GmbH; Michael Becker, BorgWarner Inc.

DRIVING DYNAMICS II

Chairperson: Prof. Dr. Oliver Sawodny

- Improvement of collision avoidance systems by using a propulsion system for advanced brake performance** **389**
Sven Knecht, Jens Neubeck, Jochen Wiedemann, FKFS

- Design of a decision maker for an evasive or braking maneuver for collision avoidance** **401**
Carlo Ackermann, R. Isermann, Institute of Automatic Control and Mechatronics, TU Darmstadt; Sukki Min, Changwon Kim, Hyundai Motor Company

FVV PROJECTS

Chairperson: Dr. Karl Kollmann

- Characterization of gasoline biofuels regarding combustion anomalies** **417**
Marco Günther, Bastian Morcinkowski, Florian Kremer, Stefan Pischinger, RWTH Aachen University

- In-cylinder causes of particle emissions on DISI engines** **435**
Helge Dageförde, Heiko Kubach, Thomas Koch, IFKM, Karlsruhe Institute of Technology (KIT); Ulrich Spicher, MOT GmbH

- Particle number measurement techniques: PMP particle number counting methodology, PMP-HD measurement system comparison** **461**
Thomas Maier, Georg Wachtmeister, LVK, TU Munich

PRODUCTION + DESIGN II

Chairperson: Prof. Dr. Thomas Maier

- Investigation on the tribological behavior of thermally sprayed cylinder liner coatings** **477**
Andrei Manzat, Rainer Gadow, IFKB, University of Stuttgart

**Chances and risks when using high strength steel sheets
in structural parts of modern car bodies** 493

M. Liewald, S. Wagner, R. Radonjic,
University of Stuttgart, Institute for Metal Forming Technology (IFU)

**Competitive fiber reinforced composite materials for increased
service temperature usable in exhaust systems** 509

Patrick Weichand, Rainer Gadow, IFKB, IMTCCC, University of Stuttgart

SECTION 3

VEHICLE DESIGN

Chairperson: Prof. Dr. Lutz Eckstein

**Aerodynamics development of road and racing cars –
similarities and differences** 521

Jörg Müller, Jan Monchaux, AUDI AG

The role of aerodynamics at Mercedes Benz 533

Teddy Woll, Daimler AG

Potentials of virtual chassis development 535

Andreas Wagner, AUDI AG

EMISSIONS I

Chairperson: Prof. Dr. Georg Wachtmeister

Advanced systems and trends for powertrain emission measurement 549

Kozo Ishida, Masayuki Adachi, Hiroshi Nakamura, HORIBA, Ltd.

**Reduction of engine-out emission and fuel consumption by variable
EGR distribution in diesel and multi fuel engines** 565

Yunyu Hu, Thomas Körfer, Thorsten Schnorbus, FEV GmbH;
Michele Miccio, FEV Italy S.r.l.; Joschka Schaub, RWTH Aachen

Regeneration control of a LNT via a dynamic NO_x-Sensor 581

Bernhard Breitegger, Albert Beichtbuchner, AVL List GmbH; Christian Doppler, Virtual Vehicle Research Center GmbH; Muammer Kilinc, Continental Automotive GmbH; Klaus Hadl, TU Graz

Impact of engine combustion on the reactivity of diesel soot from commercial vehicle engines 597

Sven Lindner, Alexander Massner, Uwe Gärtner, Daimler AG; Thomas Koch, Institute for Reciprocating Engines, Karlsruhe Institute of Technology (KIT)

POWER SUPPLY NETWORK

Chairperson: Prof. Dr. Klaus Dietmayer

Online thermal monitoring for power semiconductors in power electronics of electric and hybrid electric vehicles 611

Manuel Warwel, Gerd Wittler, University of Applied Sciences Esslingen; Michèle Hirsch, Robert Bosch GmbH; Hans-Christian Reuss, Institute for Internal Combustion Engines and Automotive Engineering, University of Stuttgart

Control concept for the electrical integration of thermoelectric generators into a vehicle power supply 627

Jan Hendrik Carstens, Clemens Gühmann, TU Berlin

Breakthrough of an electrically driven air-conditioning compressor due to 48V? 643

Jan Ackermann, T. Steinmetz, C. Brinkkötter, IAV GmbH; S. Hertel, Consulting4Drive; D. Kettner, A/C Innovations GmbH

48V at Mercedes-Benz – options for further applications 645

Michael Timmann, Martin Renz, Daimler AG

SECTION 4

ENERGETIC EFFICIENCY

Chairperson: Prof. Dr. Horst E. Friedrich

**Pre-development validation of an engine mounted
encapsulation approach on SUV vehicle as ‘Eco-Innovation’
by means of EU Regulation 725/2011** **665**

D. Petley, W. Jansen, B. Wicksteed, Jaguar Land Rover Cars Ltd;
D. Caprioli, T. Bürgin, Autoneum Management AG

**Efficient truck cabin cooling with waste heat
during driving and parking** **681**

Dirk Neumeister, R. Burk, L. Ludwig, A. Wiebelt,
MAHLE Behr GmbH & Co. KG

**Sensitivity analysis on factors influencing the overall
rolling resistance of commercial vehicles** **683**

Werner Krantz, Jens Neubeck, Jochen Wiedemann,
IVK/FKFS, University of Stuttgart

**Evaluation of the energy demand for air conditioning
by means of weather and mobility data** **705**

A. Basler, F. Freese, P. Megyesi, M. Roth, Dr. Ing. h.c. F. Porsche AG;
F. Gauterin, FAST, Karlsruhe Institute of Technology (KIT)

SOFTWARE PROCESSES

Chairperson: Prof. Dr. Karl-Ludwig Krieger

ISO 26262 for large SW Models **721**

Heiko Doerr, Ingo Stuermer, Model Engineering Solutions GmbH

ODX process from the perspective of an automotive supplier **727**

Dietmar Natterer, Thomas Ströbele, Franz Krauss,
ZF Friedrichshafen AG

From SULEV EAT Concept to ECU software	739
Wei Han, Daniel Heß, Olaf Friedrichs, Patrick Stracke, Frank Bunar, Stefan Schirmer, IAV GmbH	
Powertrain co-simulation on top of standards	755
Christoph Störmer, Christoph Malz, Corina Mitrohin, Ghizlane Tibba, ETAS GmbH	
 RAILWAY VEHICLES	
Chairperson: Prof. Dieter Bögle	
Future diesel engines for rail applications – efficient and low-emission	771
Andreas Wegmann, Thorsten Fuchs, Voith Turbo GmbH & Co. KG	
DynoTrain – vehicle reaction – track quality – contact geometry in realtime	783
Thomas Kolbe, R. Kratochville, DB Systemtechnik GmbH	
Road/Rail trucks – very special rail vehicles	785
Joachim Feuchter, ZWEIWEG International GmbH & Co. KG	
The new light rail vehicle DT8.12 for Stuttgart	795
Matthias Jost, Stadler Pankow GmbH	

SPEAKERS, CHAIRPERSONS – Volume 1

Carlo Ackermann

rtm, TU Darmstadt

Jan Ackermann

IAV GmbH

Dr. Masayuki Adachi

HORIBA, Ltd.

Jens Bachstein

Hochschule Heilbronn

Prof. Dr. Michael Bargende

FKFS/IVK, University of Stuttgart

Alexander Basler

Dr. Ing. h.c. F. Porsche AG

Prof. Dr. Christian Beidl

vkM, TU Darmstadt

Bernhard Bihr

Bosch Engineering GmbH

Jean-Michel Billig

Renault SAS

Prof. Dieter Bögle

Paolo Bortolussi

Dr. Ing. h.c. F. Porsche AG

Bernhard Breitegger

AVL List GmbH

Thomas Buchholz

BorgWarner Cooling Systems GmbH

Thomas Bürgin

Autoneum Management AG

Jan Handrik Carstens

TU Berlin

Andreas Daberkow

Hochschule Heilbronn

Helge Dageförde

FKM, Karlsruher Institut für Technologie
(KIT)

Dr. Volkmar Denner

Robert Bosch GmbH

Prof. Dr. Klaus Dietmayer

Universität Ulm

Michael Dimitrov

Dr. Ing. h.c. F. Porsche AG

Dr. Heiko Dörr

Model Engineering Solutions

Prof. Dr. Lutz Eckstein

ika, RWTH Aachen

Christoph Fehrenbacher

A123Systems GmbH

Joachim Feuchter

ZWEIWEG International GmbH & Co. KG

Prof. Dr. Tobias Flämig-Vetter

Duale Hochschule BW Stuttgart

Dr. Johannes Friebe

Maplesoft GmbH

Prof. Dr. Horst E. Friedrich

DLR e. V.

Olaf Friedrichs

IAV GmbH

Prof. Dr. Rainer Gadwo

IFKB, Universität Stuttgart

Prof. Dr. Frank Gauterin

FAST, Karlsruher Institut für Technologie

Dr. Claudius Gläser

Robert Bosch GmbH

Ralph Grewe

Continental

Marco Günther

RWTH Aachen University

Prof. Dr. Jürgen Hammer

Robert Bosch GmbH

Raphael Hans

ETAS GmbH

Jan-Hendrik Herold

FKFS

Severin Hönle

IFU, Universität Stuttgart

Dan Jiang

HTW Dresden

Matthias Jost

Stadler Pankow GmbH

Christian Kästle

Daimler AG

Dr. Jürgen Kernhof

ZMDI

Sven Knecht

FKFS

Thomas Kolbe

DB Systemtechnik GmbH

Dr. Karl Kollmann

Dr. Lars König

Bosch Engineering GmbH

Dr. Werner Krantz

IVK, Universität Stuttgart

Prof. Dr. Karl-Ludwig Krieger

ITEM, Universität Bremen

Prof. Dr. Ferit Küçükay

Iff, TU Braunschweig

Florian Kunkel

IAT, TU Darmstadt

Sven Lindner

Daimler AG

Thomas Maier

LVK, TU München

Prof. Dr. Thomas Maier

IKTD, Universität Stuttgart

Andrei Manzat

IFKB, Universität Stuttgart

Kevin Matros

IPEK, KIT

Thomas Mederer

LTT, Friedrich-Alexander-Universität
Erlangen-Nürnberg

Dr. Corina Mitrohin

ETAS GmbH

Dr. Jörg Müller

AUDI AG

Dietmar Natterer

ZF Friedrichshafen AG

Prof. Martin Neuburger

Hochschule Esslingen

Dr. Dirk Neumeister

MAHLE Behr GmbH & Co. KG

Prof. Karl-Ernst Noreikat

NorCon

Dr. Igor Orlandini

Robert Bosch GmbH

Prof. Nejila Parspour

IEW, Universität Stuttgart

Dean Petley

Jaguar Land Rover Cars Ltd

Prof. Dr. Wolfram Ressel

Universität Stuttgart

Prof. Dr. Hans-Christian Reuss

FKFS/IVK, Universität Stuttgart

Dr. Stefan Riederer

BMW Forschung und Technik

Dr. Georg Rixecker

BorgWarner BERU Systems GmbH

Prof. Dr. Oliver Sawodny

ISYS, Universität Stuttgart

Dr. Simon Schneider

MAHLE Behr GmbH & Co. KG

Dr. Thorsten Schnorbus

FEV GmbH

Christine Schwarz

ISKO engineers AG

Prof. Dr. Wolfgang Thiemann

HSU Hamburg

Prof. Dr. Werner Tillmetz

Zentrum für Sonnenenergie- und Wasserstoff-
Forschung BW

Michael Timmann

Daimler AG

Prof. Dr. Georg Wachtmeister

LVK, TU München

Dr. Andreas Wagner

AUDI AG

Stefan Wagner

University of Stuttgart, Institute for Metal
Forming Technology (IFU)

Manuel Warwel

Hochschule Esslingen

Andreas Wegmann

Voith Turbo GmbH & Co. KG

Patrick Weichand

IFKB, Universität Stuttgart

Prof. Dr. Jochen Wiedemann

FKFS/IVK, University of Stuttgart

Felix Wittmeier

FKFS

Dr. Teddy Woll

Daimler AG

Dr. Ulrich Zoelch

BMW Group

Proceedings

Ein stetig steigender Fundus an Informationen ist heute notwendig, um die immer komplexer werdende Technik heutiger Kraftfahrzeuge zu verstehen. Funktionen, Arbeitsweise, Komponenten und Systeme entwickeln sich rasant. In immer schnelleren Zyklen verbreitet sich aktuelles Wissen gerade aus Konferenzen, Tagungen und Symposien in die Fachwelt. Den raschen Zugriff auf diese Informationen bietet diese Reihe Proceedings, die sich zur Aufgabe gestellt hat, das zum Verständnis topaktueller Technik rund um das Automobil erforderliche spezielle Wissen in der Systematik der Konferenzen und Tagungen zusammen zu stellen und als Buch in Springer.com wie auch elektronisch in SpringerLink und Springer für Professionals bereit zu stellen.

Die Reihe wendet sich an Fahrzeug- und Motoreningenieure sowie Studierende, die aktuelles Fachwissen im Zusammenhang mit Fragestellungen ihres Arbeitsfeldes suchen. Professoren und Dozenten an Universitäten und Hochschulen mit Schwerpunkt Kraftfahrzeug- und Motorentechnik finden hier die Zusammenstellung von Veranstaltungen, die sie selber nicht besuchen konnten. Gutachtern, Forschern und Entwicklungsingenieuren in der Automobil- und Zulieferindustrie sowie Dienstleistern können die Proceedings wertvolle Antworten auf topaktuelle Fragen geben.

Michael Bargende · Hans-Christian Reuss
Jochen Wiedemann (Hrsg.)

14. Internationales Stuttgarter Symposium

Automobil- und Motorentechnik

Band 2

Herausgeber

Prof. Dr.-Ing. Michael Bargende
Prof. Dr.-Ing. Hans-Christian Reuss
Prof. Dr.-Ing. Jochen Wiedemann
FKFS Forschungsinstitut für Kraftfahrwesen
Stuttgart, Deutschland

ISBN 978-3-658-05129-7

ISBN 978-3-658-05130-3 (eBook)

DOI 10.1007/978-3-658-05130-3

Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über <http://dnb.d-nb.de> abrufbar.

Springer Vieweg

© Springer Fachmedien Wiesbaden 2014

Das Werk einschließlich aller seiner Teile ist urheberrechtlich geschützt. Jede Verwertung, die nicht ausdrücklich vom Urheberrechtsgesetz zugelassen ist, bedarf der vorherigen Zustimmung des Verlags. Das gilt insbesondere für Vervielfältigungen, Bearbeitungen, Übersetzungen, Mikroverfilmungen und die Einspeicherung und Verarbeitung in elektronischen Systemen.

Die Wiedergabe von Gebrauchsnamen, Handelsnamen, Warenbezeichnungen usw. in diesem Werk berechtigt auch ohne besondere Kennzeichnung nicht zu der Annahme, dass solche Namen im Sinne der Warenzeichen- und Markenschutz-Gesetzgebung als frei zu betrachten wären und daher von jedermann benutzt werden dürften.

Umschlagbild: © [M] Peugeot

Gedruckt auf säurefreiem und chlorfrei gebleichtem Papier.

Springer Vieweg ist eine Marke von Springer DE. Springer DE ist Teil der Fachverlagsgruppe Springer Science+Business Media
www.springer-vieweg.de

WELCOME

Within the field of mobility, an independent turnaround in the energy policy is taking place. Environmental protection and the conservation of dwindling resources are important driving forces of this development, which represents major technological challenges for companies and research institutes. For this purpose, new technologies must be developed and existing ones improved. Accordingly, the Research Institute of Automotive Engineering and Vehicle Engines in Stuttgart is placing the 14th Stuttgart International Symposium on Automotive and Engine Technology under the motto »Renewable energies and future mobility concepts«. I was very happy to assume patronage of the event.

With over 800 professional attendees, more than 110 lectures and an accompanying exhibition, the Stuttgart Symposium is considered as one of the most important discussion boards for the range of automotive and engine development in Europe. It is an excellent platform for the representatives of industry and research to discuss new ideas and to present the performance of the industry in Baden-Wuerttemberg.

With this year's focus on the main topic the symposium will go far beyond the development of vehicles and engines. It includes both the integration of diverse transport modes and systems as well as energy efficiency control of various types of motor vehicles.

Another important objective of the Baden-Wuerttemberg state government is the resource-conserving energy production. In the field of transport alternative forms of propulsion must be developed with future technologies and corresponding IT solutions, which enable an intelligent integration and application for all road users and participants.

It is about nothing less than the future of mobility! Speed, flexibility and environmental friendliness will be the main criteria. The well working cooperation between science and industry in Baden-Wuerttemberg is a key prerequisite for the development of modern mobility concepts.

My thanks go to the event organizers and promoters, whom I would like to congratulate for the extensive and exciting program of the 14th Stuttgart International Symposium of automotive and engine technology. To all indoor exhibitors, as well as visitors, I wish inspiring and productive discussions.

Winfried Kretschmann
Prime Minister
of the State of Baden-Wuerttemberg

RESEARCH AND DEVELOPMENT IN AUTOMOTIVE AND ENGINE TECHNOLOGY

The automotive industry is globally facing a number of challenges: The legal limitation of CO₂ emissions, the finite nature of reserves of fossil fuels and the increasing traffic congestion in urban areas and megacities are important issues. The need for affordable mobility systems which are resource-efficient as well as sustainable and climate neutral, but which also meet high safety standards and high levels of social and political acceptance, is increasingly clear. The automotive industry is therefore intensively working on alternative vehicle and mobility concepts. Additionally, previous research approaches are joined more and more by concepts from the fields of electricity and electronics, mechatronics, information technology and computer science. To promote research in the various areas it is important to share and unify the research results from academia and industry.

The

14th Stuttgart International Symposium Automotive and Engine Technology

18th and 19th March 2014

provides an important platform for the automotive industry. The program of the symposium was expanded from four to six parallel sessions in order to meet the increased topics as well as the very high number of excellent submissions of papers. Due to the resulting variety of topics that will be presented by leading experts in more than 110 lectures, we hope to have arranged an interesting program for you. The lecture related discussions and the accompanying exhibition offer an opportunity for further professional exchange.

We look forward to welcoming you in Stuttgart, the birthplace of the automobile and wish you enjoyable and informative days at the 14th Stuttgart International Symposium.

Prof. Dr.-Ing. Michael Bargende
Prof. Dr.-Ing. Hans-Christian Reuss
Prof. Dr.-Ing. Jochen Wiedemann

INDEX – Volume 2

SECTION 1

E-MOBILITY

Chairperson: Prof. Johann Tomforde

Electric vehicles the solution for the future?	1
Gerhard Hettich, EAST Consulting Engineering for Automotive Systems and Technologies	
The electrification of the power train makes it possible – Realization of electric concept vehicles as a source of innovations	15
Marco Rohe, Schaeffler Engineering GmbH	
918 Spyder - Concept of a super sports car for the future	27
Frank-Steffen Walliser, Dr. Ing. h.c. F. Porsche AG	

DRIVING COMFORT

Chairperson: Prof. Dr. Stefan Böttinger

Consistent assessment of chassis relevant ride comfort on roads and test rigs	41
Markus Eisenbarth, G. Boisdequin, Dr. Ing. h.c. F. Porsche AG F. Gauterin, FAST, Karlsruhe Institute of Technology (KIT)	
Requirements for the disturbance response of steering and suspension systems based on vehicle targets	55
Martin Münster, M. Lehner, BMW AG; D. Rixen, TU München	
Approach for determination of objective characteristic parameters to predict vehicle vibrations caused by powertrain	73
Rui Cai, R. Spengler, C. Olfens, Daimler AG; A. Albers, M. Behrendt, IPEK, Karlsruhe Institute of Technology (KIT)	

EMISSIONS II

Chairperson: Prof. Dr. Thomas Koch

- Exhaust gas treatment with compact DEF mixing section
and SCR coated DPF for future emission standards** 87

Tobias Ohmberger, C. Becker, Bosch Emission Systems GmbH;
H. Härle, Robert Bosch GmbH

- Comparison of pressure and air-assisted atomizers for
Urea-SCR injection in diesel engine exhaust** 105

Alexander Spiteri, P. Dimopoulos Eggenschwiler, Y. Liao, EMPA
Swiss Federal Laboratories for Materials Science and Technology

- Effect of biofuels on particle emissions from compression
and spark ignition engines** 117

Bianca Maria Vaglieco, E. Mancaruso, S. Di Iorio,
P. Sementa, Istituto Motori – CNR

ALTERNATIVE POWERTRAIN + SMALL ENGINES

Chairperson: Prof. Dr. Cornel Stan

- Experimental study of the in-engine variability of
a free piston linear alternator** 133

Alexander Heron, H. E. Friedrich, F. Kock, F. Rinderknecht,
J. Haag, DLR e. V.

- Split-crankshaft engine: concept for a combustion engine
with a two-piece disengageable crankshaft** 147

Johannes Bergmaier, G. Wachtmeister, LVK, TU München;
P. Fischer, H. Pflaum, K. Stahl, FZG, TU München

- Potential of fuel injection in two-stroke engines
for hand-held power tools** 165

Armin Kölmel, T. Gegg, S. Meyer, ANDREAS STIHL AG & Co. KG;
A. Trattner, Stephan Schmidt, R. Kirchberger, H. Eichlseder, TU Graz

REIFEN

Chairperson: Dr. Andreas Wagner

The new Hohenheim tyre model 181

Paul Witzel, S. Böttinger, University of Hohenheim

Utilization of customer-relevant driving behavior for reliable friction potential estimation by scaling nonlinear tyre models 197

Hans-Martin Kroll, FTM, TU München; B. Buschardt, AUDI AG;
K. Schmidt, Audi AG; M. Lienkamp, FTM, TU München

Reference testing method for rolling resistance tire evaluation 213

Jakub Vidner, Kistler Automotive GmbH; F. Masera, BiA Italy;
O. Chabut, Kistler France SASU

SPITZENCLUSTER

Chairperson: Franz Loogen

Project BIPoL^{plus} - wireless electric vehicle charging with 22kW 225

Karlheinz Baier, Daimler AG; M. Scholz, P3 automotive GmbH;
A. Kilic, P. Schumann, Robert Bosch GmbH; P. Behrendt, Porsche AG;
Y. Girardey, IPT Technology GmbH; K. Knaisch, KIT; D. Martinovic,
University of Stuttgart; E. Melo, W. Schnurbusch, IPT Technology GmbH;
G. Walker, EnBW AG

ELISE – a telematic data gateway for electric vehicles 243

Thomas Kotschenreuther, A. Rupalla, RA Consulting GmbH

Epromo: Cluster project to research on process modular manufacturing assembly and testing concepts for the production of electrical traction motors 253

Günther Heidmann, teamtechnik Maschinen und Anlagen GmbH

SECTION 2

SI ENGINES

Chairperson: Prof. Dr. Stefan Pischinger

Gasoline engine – Fit for the future powertrain 255

Stefan Kampmann, R. Busch, A. Christ, Robert Bosch GmbH

BlueDirect – the technology for a globalised market 269

Anton Waltner, F. Altenschmidt, A. Kaden, R. Kemmler Daimler AG

The Porsche 918 Spyder high-performance combustion engine 285

Roland Sargenti, C. Hauck, W. Buck, J. Burckhardt, M. Gickeleiter,
D.-G. Steinhauser, H. Kristen, Dr. Ing. h.c. F. Porsche AG

The Volkswagen WRC Engine 299

Donatus Wichelhaus, Volkswagen Motorsport GmbH

HYBRID II

Chairperson: Prof. em. Dr. Günter Hohenberg

Approach of a method for functional evaluation of hybrid drivetrains 301

Jörg-Michael Birkhold, J. Kerner, L. Spiegel, I. Stache, Dr. Ing. h.c. F. Porsche AG;
A. Albers, IPEK, Karlsruhe Institute für Technology (KIT)

Analysis of the optimum drive-line configuration for a compact-class passenger car for differing usage patterns 313

Marco Warth, M. Bassett, J. Hall, B. Mahr, MAHLE Powertrain Ltd.

Research on the fuel-efficiency of parallel hybrid vehicles as a basis for the design of rule-based operating strategies 329

Daniel Görke, IVK, University of Stuttgart; M. Bargende, FKFS/IVK, University of Stuttgart; U. Keller, N. Ruzicka, S. Schmiedler, Daimler AG

Co-simulation and »control-orientated« modeling in the development of a hydraulic hybrid system 351

Agostino Gambarotta, P. Casoli, N. Pompini, L. Riccò, University of Parma

AERODYNAMICS I

Chairperson: Dr. Teddy Woll

- Electrical wind tunnel external balance system** **371**
 Tomokazu Oyama, T. Ichige, A. Inoue, A & D Company Limited
 J. Bredenbeck, A & D Europe GmbH
- Prospects of experimental aerodynamics** **387**
 Andreas Dillmann, DLR, Institute for Aerodynamics and Fluid Engineering
- 918 Spyder – the aerodynamic triathlete** **389**
 Christian del Gaizo, H. Maier, M. Roll, Dr. Ing. h.c. F. Porsche AG

ELECTRONIC ARCHITECTURE

Chairperson: Prof. Dr. Clemens Gühmann

- Real-time metrics for automotive ethernet architectures** **405**
 Kai Richter, J. Diemer, S. Schliecker, Symtavigation GmbH
- High data rates and short latencies for future vehicle networks –
 Have conventional microcontroller concepts reached their limits?** **421**
 Burkhard Triess, ETAS GmbH
- What CAN FD offers for automotive networking** **431**
 Harald Eisele, Adam Opel AG; K. P. Orlando, General Motors
- Localizing minor damages in cars by means of structure-borne
 sound analysis** **449**
 Andre Kneifel, J. Harmstorf, S. Gontscharov, K.-L. Krieger, ITEM,
 University of Bremen; K. H. Baumgärtel, Hella Fahrzeugkomponenten GmbH

SIMULATION + ANALYSIS I

Chairperson: Prof. Dr. Roland Baar

- Constraints of the combustion process for a supercharged
 DISI-engine for applications in motorsports** **463**
 Christian Pötsch, R. Kudicke, G. Wachtmeister, LVK, TU München;
 D. Wichelhaus, Volkswagen Motorsport GmbH