TU Darmstadt

Institute for Internal Combustion Engines and Powertrain Systems

TECHNISCHE UNIVERSITÄT DARMSTADT

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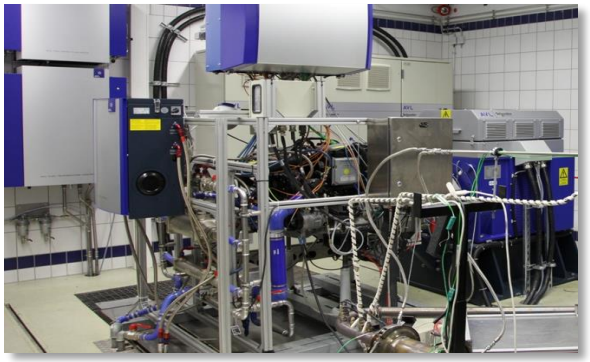

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Institute for Internal Combustion Engines and Powertrain Systems – Staff

TECHNISCHE UNIVERSITÄT DARMSTADT

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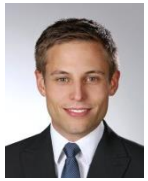

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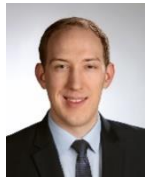

Henning Nies

David Töpfer

Nicolas Hummel

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VKM – Research Areas

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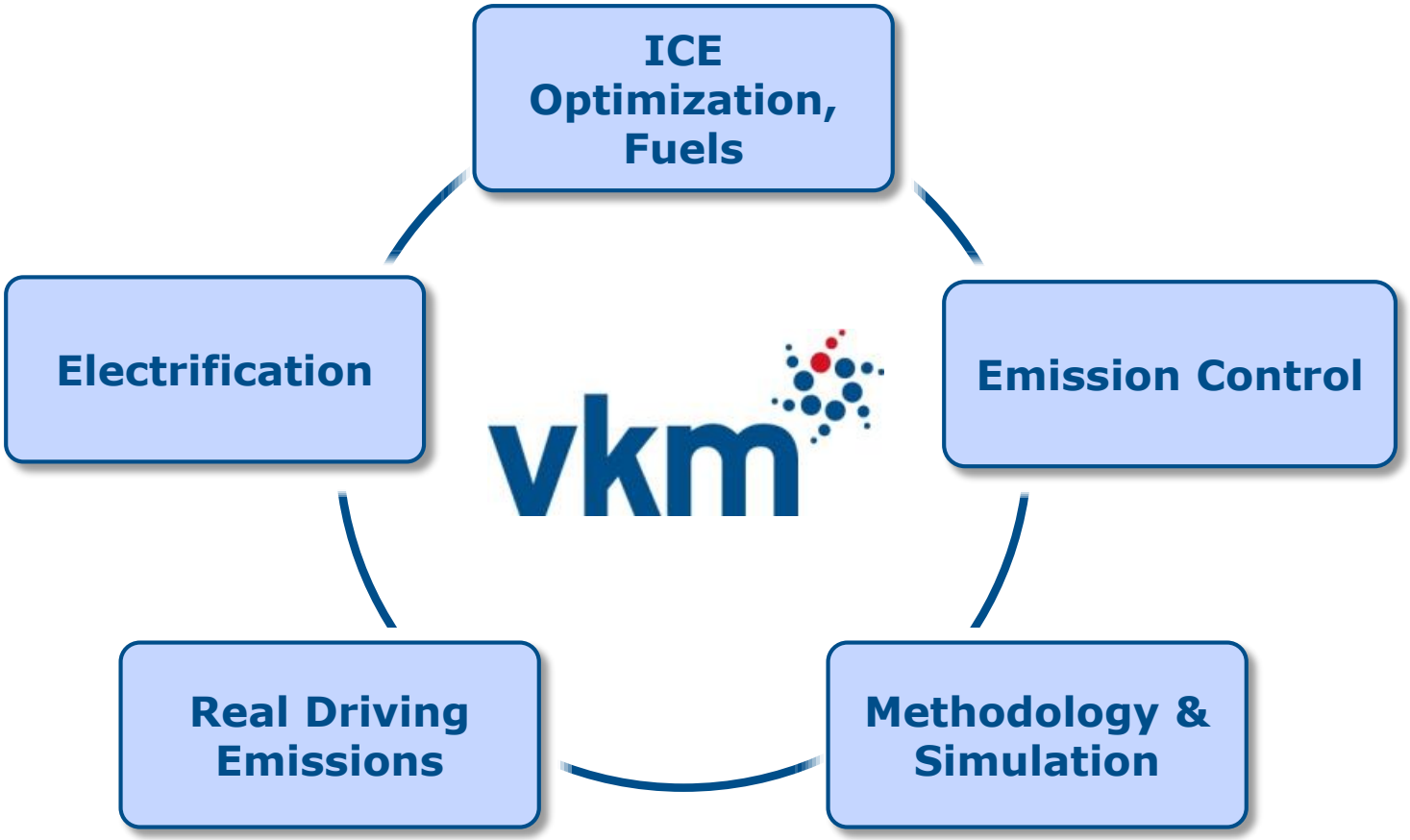

Research Area
ICE Optimization and Fuels

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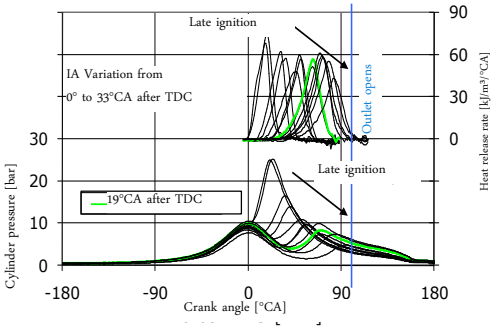
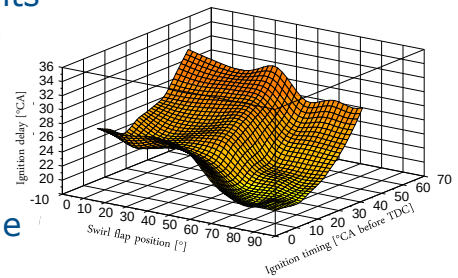
Thermodynamic Analysis

- Indicating
- Calculation
- Visualization
- Optimization of internal engine processes



Application

- Design of experiments
- Dynamic application
- Map based application
- Catalyst thermal management
- Freely programmable engine electronics



Gas Exchange

- Flow bench
- Simulation
- Optimization

Alternative Fuels

- CNG
- LPG
- GTL
- BTL
- H_2-Additives
- OME
- 1-Cylinder research engine

Special fuel supply on each testbed
World's first OME research vehicle

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Research Area
Emission Control

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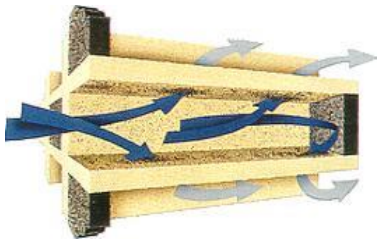
Analysis of DPF and GPF

- Heavy & light duty
- Maximum soot load
- Balance point
- Regeneration strategies
- Backpressure
- Filtration efficiency

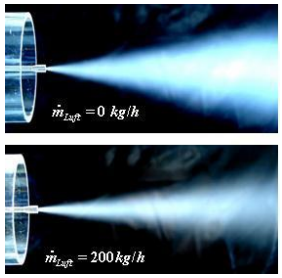


Catalyst Investigations

- Heavy & light duty
- Light-off determination
- Aging factors
- Sulphur contamination (DOC)
- Characteristics in dyn. test cycles
- Thermal management for catalysts
- Operating conditions and specific requirements in hybrid electric vehicles

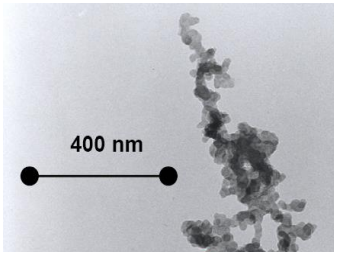
SCR-Analysis

- Heavy & light duty
- Light-off behaviour
- Dosing strategies
- NH_3-storage charact.
- NO_X-conversion
- Active / passive SCR
- Nozzle geometry / evaporation
- Catalytic reduction of particulate matter



Particulate Measurement

- Gravimetric analysis of TPM
- Extraction SOF/INSOF
- HPLC-Liquid-Chromatography
- Thermodissorption analysis
- Particle size distribution and particle counting (TSI, AVL)



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Research Area
Methodology and Simulation

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CAx-Systems

- CFD
- Combustion analysis
- Gas exchange calculation
- NVH-Simulation
- Drivetrain simulation
- CAD
- 3D vehicle / driving environment simulation

GT-Power

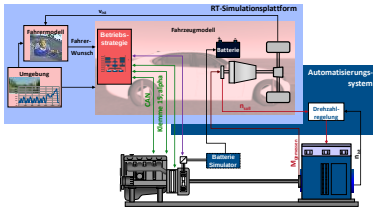
BOOST FIRE CRUISE EXCITE CATIA

Highly Dynamic Testbed

- High resolution simulation
- Driveability analysis
- Analysis of drivetrain dynamics
- Start simulation for component specification
- Drivetrain evaluation

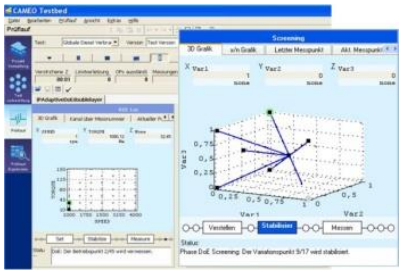
X in the Loop Test bed

- System design and construction
- Evaluation methodology
- Maneuver based testing
- Electric motor controller with universal inverter and battery simulator
- Implementation of the methodology in the development process
- Real Driving Emissions at the test bed



Test Design

- Design of Experiments
- Optimization of hybrid strategies using DoE
- Workshop for professionals and students



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Research Area Electrification

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Testbed

- X-in-the-Loop vehicle realtime simulation
- Comparison vehicle – testbed with real world driving
- Concept evaluation
- Operating strategy
- Multicriteria optimization
- Battery simulation
- Measurement of electric motors

Testing Hybrids

- 3 own plus external hybrid test vehicles
- Concept evaluation & comparison vehicle – testbed on real world test tracks
- Mobile exhaust measurement
- Mobile combustion analysis



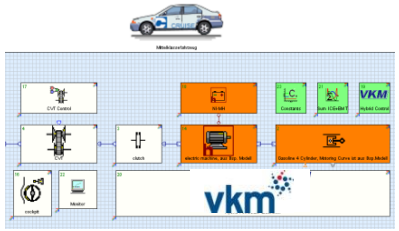


Concept development and application

- Range-Extender-Concept
- Comfort optimization
  - vibration damping with electrical motor
- NVH-Analysis and evaluation
- Operating strategy development and optimization
- Direct-start/ Hybrid-start


Simulation

- Realtime simulation
- Concept evaluation
- Fuel consumption simulation
- Driveability evaluation
- Offline optimization
- Real world driving
- RealSiMM



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Research Area
Real Driving Emissions

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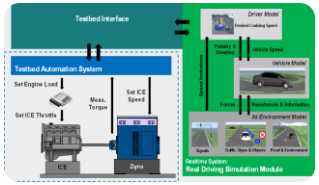
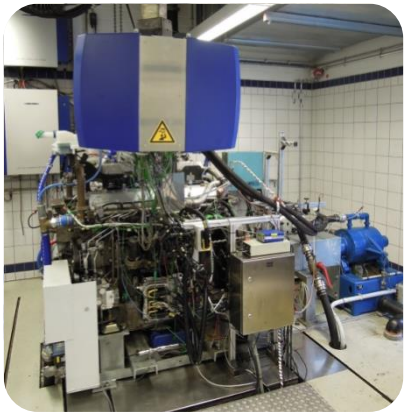
RDE at passenger car engine dyno with RDE module

- Real-time simulation of vehicle, driver, track and traffic
- Identification of critical emission relevant driving scenarios
- Evaluation using EMROAD and CLEAR
- Operating strategy development
- Multicriteria optimization



RDE at heavy duty engine dyno with RDE module

- SCR system calibration with dosing strategy development
- $DeNO_x$ Performance Optimization: stationary and transient
- RDE compliant engine design and combustion system development



RDE at chassis dyno

- Real time simulation of track and traffic
- Measurement with PEMS and stationary measurement systems
- Maneuver based RDE tests
- Robot driver or real driver

Road tests

- Measurement with PN PEMS
- Influence of real driver characteristics
- Statistical evaluation of track severity
- Effects of the evaluation to the emission result

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Infrastructure & Equipment

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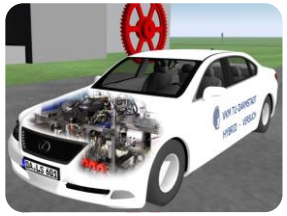
12 Testbeds
with Emission Testing &
Combustion Analysis

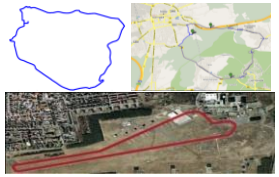
Highend-Multiflex
Testbed (VVETB)

4x4 Advanced
Chassis Dyno (TUZ)

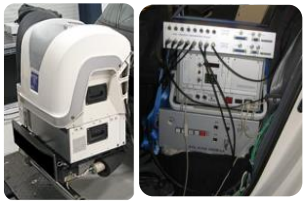


Hybrid Testbed
Engine-in-the-Loop

Test Vehicles



Test Tracks &
Real World Cycles



Vehicle Test
Instrumentation & Gas/
Particle PEMS

RT-Vehicle
Simulation

Flow Bench

Chemistry Lab

FTIR

Battery
emulator

Particle
Measurement

Simulation
Environment

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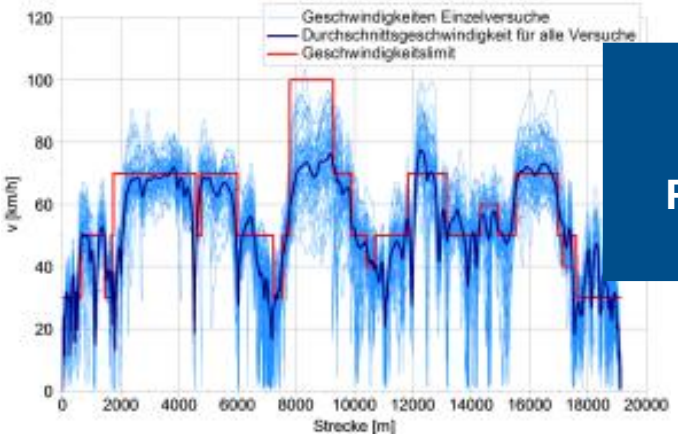
Mobile emission measurement
Real Driving Emissions

Real Driving Emissions – Development Methodology

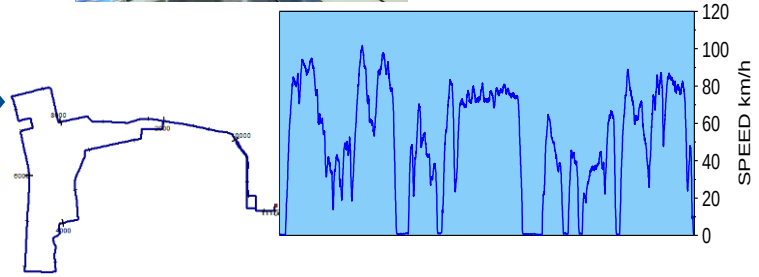


Transfer
Road-to-Rig

- Consideration of driver influence
- RDE Measurements (PEMS)

Evaluation of customer specific Real world driving scenarios

vkm - *RealSiMM*
Real World Simulation and Measurement Methodolgy
Real World Simulations- und Messmethodik



- Identification of significant scenario parameters
- Approach to parameterize for real driving scenarios
- Implementation of connected functionality

„Real world test“ for Engine-, Chassis- and X-in-the-Loop Testbeds

Cooperation with the Center for Innovation and Environment, TÜV Hessen

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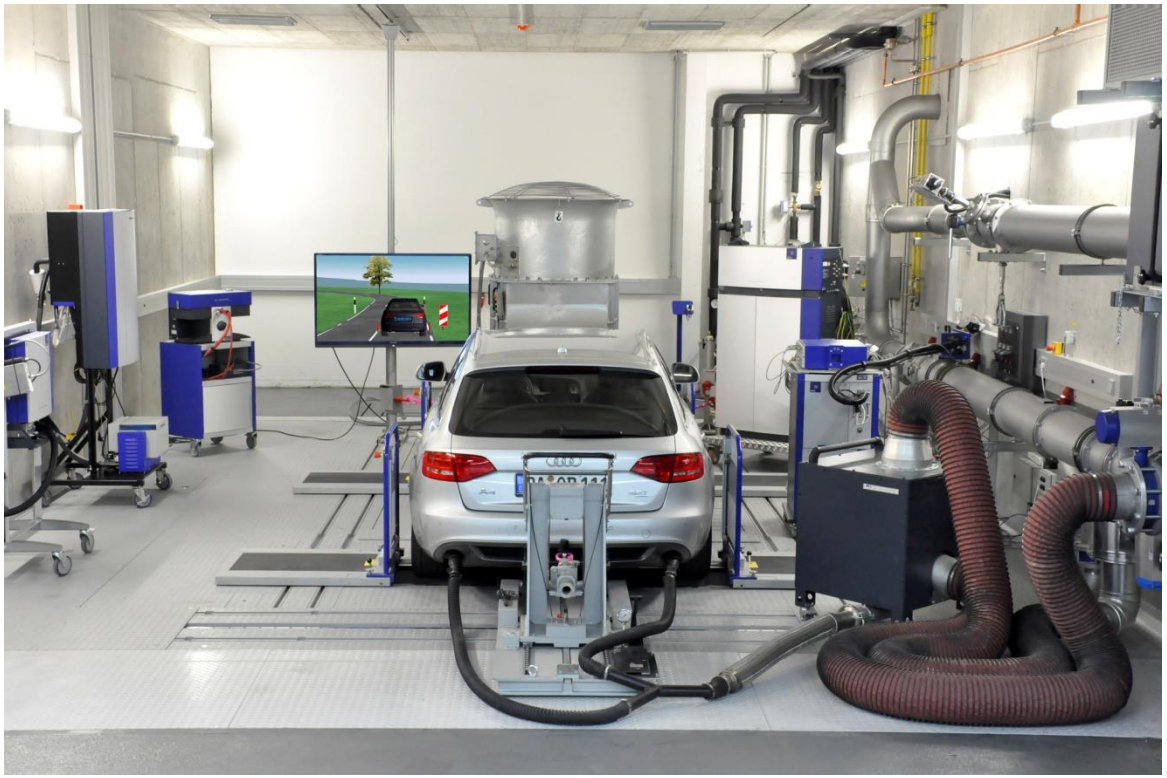
AVL 4x4 Advanced Chassis Dyno with RealTime Simulation



TUZ, TÜV Hessen, Pfungstadt

- **Consistent toolchain with engine and powertrain testbeds**
- **Idealy suited for manoeverbased testing and future RDE requirements**
- **Joint Methodology development with**

AVL

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E-Mobility and Hybrid Center

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- **Conceptualised for equipping vehicles with Conventional and Electrified Powertrains with Portable Emission Measurement Systems and other measurement devices**
- **Ideally suited for maneuver based testing and methodolody development for future RDE requirements**

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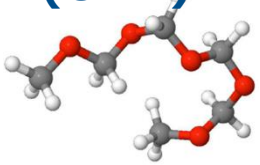
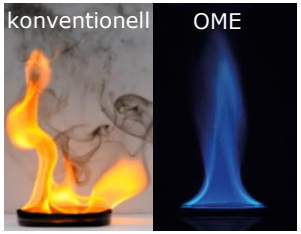
CO_2-neutral Synthetic Fuels

Example of CO_2-neutrale Synthetic Fuels : Oxymethylenether (OME)



CH_3-O(-CH_2-O)$_n$-CH_3

- Combustion process as in Diesel Engines
- Possibility of blending with conventional fuels
- Higher Oxygen Content in the molecule without C-C-Bonding
  - Soot free combustion
- Successfull Implementation and Validation in vkm-Test Vehicle



Renovation of Testbed Infrastructure 2010/2011

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Events 2018

TECHNISCHE UNIVERSITÄT DARMSTADT

- Vehicle & Powertrain Seminar, TU Darmstadt
  Invited Keynote Speakers from Industry

- HdT Tagung – Plug-In-Hybride und Range Extender
  20.11. - 21.11.2018, Darmstadt

- Workshop Design of Experiments for students and professionals,
  25. - 27. September 2018, TU Darmstadt

ATZ live

- VPC - Simulation und Test 2018, 20. MTZ-Fachtagung,
  25. - 26. September 2018, Hanau bei Frankfurt am Main

- AVL Tech Day „Indizierung“,
  28. September 2017 , TU Darmstadt

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Publications 2017

TECHNISCHE UNIVERSITÄT DARMSTADT

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- W. Hauptmann, T. Utschig, B. Barth, C. Tomanik, U. Goebel, I. Grisstede, W. Mueller Umicore AG & Co. KG, Hanau, Germany, J. Hipp, C. Beidl Technische Universitaet Darmstadt, Institute for Internal Combustion Engines and Powertrain Systems: Challenge RDE: Sustainable Diesel Exhaust Systems for Euro 6d, 26th Aachen Colloquium Automobile and Engine Technology 2017
- Fischer, S., Beidl, C.: Potentials of the Plug-in-hybrid powertrain concept „Two Drive Transmission with Range Extender" (DE-REX) to reduce pollutant emissions, E-MOTIVE 9. Expertenforum Elektrische Fahrzeugantriebe, Hannover, September 2017
- Mokros, A.; Münz, M., Beidl, C.: Potential for ultra-low emissions with OME and TWC on a CI engine. 5th TMFB International Conference 2017. Aachen, Juni 2017
- Fischer, S.; Beidl, C.; Viehmann, A., Rinderknecht, S.: Plug-in-Hybride für den Volumenmarkt, In: MTZ – Motortechnische Zeitschrift Nr. 78 (2017), Nr. 5
- Hipp, J.; Beidl, C.; Noack, H.-D.; Göbel, U.; Grisstede, I.: The Diesel in the focus of urban air quality – Exhaust concepts to fulfill RDE, 17th International Symposium, Stuttgart, 2017
- Dautfest, A.; Thiem, M.; Beidl, C.: Entwicklung eines Batteriesystems für elektrifizierte LKW-Anhänger. Kongress Elektromobilität, Juni 2017.
- Maschmeyer, H.; Beidl, C.: Methodischer Ansatz für die RDE-Entwicklung am Motorenprüfstand, AVL TechDay Emission, Bietigheim-Bissingen, Mai 2017
- Eckert, M.; Thiem, M.; Beidl, C.: Development of an Electric Powertrain System for Truck Trailers, VDI-Tagung Nutzfahrzeuge 2017, Mai 2017
- Schmidt, D.; Beidl, C.; Steffan, R.; Hofmann, P.: Hybridisierung und 48 V – Eine bestechend effiziente Kombination, Artikel in ATZ-Extra „48 V – Konzepte für die Zukunft" Springer Vieweg April 2017
- Stritzke, F.; van der Kley, S.; Feiling, A.; Dreizler A.; Wagner, S.: Ammonia concentration distribution measurements in the exhaust of a heavy duty diesel engine based on limited data absorption tomography, Optics Express, Vol. 25, Issue 7, pp. 8180-8191, 2017.
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- Schoenhaber, J.; Kuehn, N.; Bradler, B.; Richter, J. M.; Bauer, S.; Lenzen, B.; Beidl, C.: Impact of European Real-Driving-Emissions Legislation on Exhaust Gas Aftertreatment Systems of Turbocharged Direct Injected Gasoline Vehicles, SAE Technical Paper, 2017-01-0924, 2017
- Vadamalu, R.; Beidl, C.: Online Optimization based Predictive Energy Management Functionality of Plug-In Hybrid Powertrain using Trajectory Planning Methods, SAE Technical Paper 2017-01-1254, 2017
- Fischer, S.; Beidl, C.; Viehmann, A., Rinderknecht, S.: Potenziale der hybriden Betriebsmodi des Plug-in-Hybrid-Antriebskonzepts „Doppel-E-Antrieb mit Range-Extender" (DE-REX), Der Antrieb von morgen, 11. Internationale MTZ-Fachtagung Zukunftsantriebe, Frankfurt a. M., Januar 2017

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Publications 2016

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- Feiling, A.; Beidl, C.: PM-Reduktion über Vanadium-SCR-Katalysatoren, ATZlive – Heavy-Duty, On- und Off-Highway-Motoren, Ulm, November 2016.
- Münz, M.; Mokros, A.; Beidl, C.: Ermöglichen Oxygenat-Kraftstoffe den Drei-Wege-Katalysator am Dieselmotor?, 14. FAD-Konferenz „Herausforderungen – Abgasnachbehandlung für Dieselmotoren", Dresden, November 2016.
- Schmidt, D.; Maschmeyer, H.; Beidl, C.; Raß, F.: Neue Verfahren zur effizienten antriebsstrangdspezifischen RDE-Entwicklung, MTZ-Fachtagung „VPC.plus", Hanau, September 2016
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- Vadamalu, R.; Beidl, C.: Vorausschauendes Energiemanagement von Hybridantriebssträngen mit deterministischen und stochastischen Prädiktionsansätzen, 13th International Symposium on Advanced Vehicle Control, September 2016
- Kettmann, N.; Schöffel, St.; Feiling, A.; Kontin, S.; Hermann, T.; Beidl, C.: Combines Visualization and Thermography of Wall Film Formation and Deposit Build-Up for Urea-Water-Solution, 6th International Conference "MinNOx", Juni 2016.
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- Vadamalu, R.; Beidl, C.: MPC for active torsional vibration reduction of hybrid electric powertrains, IFAC international symposium on advances in automotive control, Juni 2016
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- Vadamalu, R.; Beidl, C.: Online optimization based energy management of hybrid electric vehicles using direct optimal control method, 16th Stuttgart International Symposium, März 2016.
- Feiling, A.; Japke, E., Beidl, C.; Deutschmann, O.; Grunwaldt, J.-D.: FVV-Abschlussbericht 1146 – PM Reduktion über V-SCR, FVV-Frühjahrstagung, Bad Neuenahr, März 2016

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Publications 2016/2015

TECHNISCHE UNIVERSITÄT DARMSTADT

- Münz, M.; Feiling, A.; Beidl, C.; Härtl, M.; Pélerin, D.; Wachtmeister, G.; Lehrstuhl für Verbrennungskraftmaschinen (Ivk), Technische Universität München: Oxymethylene Ether (OME1) as Synthetic Low Emission Fuel for DI Diesel Engines. 3. Internationaler Motorenkongress. Baden-Baden. Februar 2016
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- Beidl, C.; Waldhelm, A.; Rathgeber, C.; Hipp, J.; Hohenberg, G.; IVD Deutschland GmbH; Grisstede, I.; Noack, H.; Spurk, P.; Göbel, U., Umicore AG & Co. KG, Hanau-Wolfgang, Germany: Challenge Clean Diesel: Robust Exhaust Aftertreatment Fulfilling RDE and CO2, 9. Internationales Forum Abgas- und Partikel-Emissionen 23. und 24. Februar 2016 „Forum am Schlosspark" Ludwigsburg
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- Maschmeyer, H.; Schmidt, D.; Beidl, C.: Simulations- und Testmethoden für die Entwicklung von Fahrzeugantrieben unter Real Driving Emissions Randbedingungen, 6. Internationales Symposium für Entwicklungsmethodik, November, 2015
- Vadamalu R.; Beidl, C.: Methodik zur funktionalen Evaluierung und Robustheitsanalyse einer online-optimierenden Längsführung in einer vernetzten Umgebung, 17. MTZ-Fachtagung, VPC – Simulation und Test, Oktober 2015
- Vadamalu, R.; Buch, D.; Xiao, H.; Beidl, C.: Energy Management of Hybrid Electric Powertrain using Predictive Trajectory Planning Based on Direct Optimal Control, 16th IFAC workshop on control applications of optimization, Garmisch-Partenkirchen, October 2015
- Münz, M.; Beidl, C.: Indizierung am Einzylindermotor mit alternativem Kraftstoff OME (Oxymethylenether). AVL Tech Day „Indizierung". Darmstadt, September 2015
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- Dr.-Ing. F. Atzler, Dipl.-Ing. M. Wegener, Dipl.-Ing. (FH) F. Mehne, Dipl.-Ing. (FH) S. Rohrer, Continental Automotive GmbH, Regensburg; C. Rathgeber, M.Sc., S. Fischer, M.Sc., Institut für Verbrennungskraftmaschinen und Fahrzeugantriebe, TU Darmstadt: Kraftstoffverbrauch und Emissionseinflüsse der „Phlegmatisierung" von PKW-Dieselmotoren, HdT-Tagung Motorische Verbrennung, Erlangen-Nürnberg, April 2015
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Education

TECHNISCHE UNIVERSITÄT DARMSTADT

Institute for Internal Combustion Engines and Powertrain Systems

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  - Verbrennungskraftmaschinen I + II
  - Konstruktion im Motorenbau I + II
  - Berechnungsmethoden im Motorenbau I + II
- **Bachelor and Master theses**
- **Tutorial for students**
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