31ST INTERNATIONAL VIENNA MOTOR SYMPOSIUM

As every year, more than 1,000 leading automotive engineers and scientists from all over the world met at the 31st International Vienna Motor Symposium, which was held on April 29 and 30, 2010. They presented the latest findings in engine developments and provided an outlook for future trends in the automotive industry. This report contains a summary of the lectures presented in the individual sessions.

AUTHOR

UNIV.-PROF. DR. TECHN. HANS PETER LENZ
is President of the Austrian Society of Automotive Engineers (ÖKV) in Vienna (Austria).

INTRODUCTION

After a welcome fanfare, which was performed by members of the orchestra of the Vienna University of Technology, **Prof. Lenz**, ❶, welcomed the participants to the fully booked 31st International Vienna Motor Symposium, ❷.

As in previous years, all lectures are contained in the VDI progress reports including a CD with the texts in English. The lectures presented by university staff were, for the first time, peer reviewed by the Wissenschaftliche Gesellschaft für Kraftfahrzeug- und Motorentechnik e.V (WKM – Scientific Society for Automotive and Engine Technology). Prof. Lenz also drew attention to the search system of the Austrian Society of Automotive Engineers, which, by entering a search term or the lecturer's name or company, indicates who spoke when on a particular subject (www.oevk.at).

Prof. Lenz stated at the outset that electro mobility was being hyped in a way that was not justified. Electronics and electric assist systems for auxiliary units and the drivetrain, which are increasingly in use, are a valuable technology for internal combustion engines. In the meantime, new small diesel engines have demonstrated that in the EU, the US, not to mention China, are on a par with electric motors in terms of CO_2 emission levels.

If an emission level of 50 g CO_2/km is a stated goal, it can only be hazard a guess as to whether this value will be reached either by electric cars – in such a case 70 % of the electric energy would have to come from renewable sources – or by combustion engines using a large percentage of fuels derived from renewable energy sources.

Every expert knows that internal combustion engines offer more driving comfort, have a longer range and are far cheaper than electric motors. Nevertheless, a car manufacturer can hardly afford to present its product range in public without a futuristic electric vehicle if the company does not want to run the risk of being considered behind the curve.

The apprehension that these vehicles would actually have to be produced one day seems just as widespread as the joy of researchers about their freedom to engage in such developments. The situation, however, becomes crucial when such research efforts are made at the expense of internal combustion engines which will remain the main drive units for decades, even though electric vehicles will over time be equipped with range extenders. It will be exciting to see whether millions of electric cars will indeed be on our roads in the coming decades or if this bubble will burst?

It is also a critical issue as to whether states, instead of defining clear goals, believe that a particular technology should be subsidised. Will a race for subsidies be the consequence of this trend? And if so, would it not be better to give priority to Euro 6 diesel engines and subsidise these? Only a fraction of the subsidies for electric vehicles would suffice to develop vehicles with virtually zero emissions and the same low emissions of climate relevant gases as electric vehicles which have a number of drawbacks of their own, such as short range, high costs and poor driving comfort.

After the joint plenary opening session, technical lectures were presented in two parallel sections, ❸ and ❹, which were chaired by **Professors H. Eichlseder, B. Geringer, G. Jürgens** and **G. Brasseur**. A comprehensive and impressive exhibition of new engines, components and vehicles complemented the technical presentations, ❺, ❻ and ❼.

Accompanying persons were offered a culturally ambitious social programme

❶ Prof. Lenz

which included a trip through the picturesque Danube valley to the Benedictine monastery of Melk and guided tours of the Vienna city centre. The participants and accompanying persons spent the evening at the wine tavern Fuhrgassl-Huber in Neustift at the invitation of the Mayor of Vienna.

❷ Prominent guests, from left to right: Rector of the Vienna University of Technology, Prof. Skalicky, Prof. Winterkorn, Dr. Mitterbauer, and Prof. List

PLENARY OPENING SESSION

The first lecture of the plenary opening session was delivered by **Dipl.-Betr.-Wirt R. Stadler**, ❽, Chairman of the Board of Management, Audi AG, Ingolstadt, on the topic "Superior Efficiency – Groundbreaking Drive Concepts for the Pinnacle of Premium Automotive Engineering":

The demands made upon premium car brands have undergone a fundamental change in recent years. Their top-of-the-line cars, in particular, have to satisfy new customer requirements while bridging the ever-widening gap between the expression of prestige and social acceptance. The social acceptability of top class models is crucial for the success and innovative power of the premium carmakers.

Audi sees the shift in paradigm in the car industry as an opportunity to once again demonstrate its "Lead through Technology" and to further strengthen the brand's competitive position. The new Audi A8 stands out with its superior fuel economy and CO_2 values, thus demonstrating the success of the Audi efficiency strategy featuring light-weight design as a key element. The future hybrid model will further consolidate the brand's leading position.

Audi sees the medium-term future of the top-class car category primarily in the systematic further development of conventional and electrified drive systems. The rapid build-up of electric drive expertise and work on renewable fuels are central elements of Audi's strategy for the future.

Dr. B. Bohr, ❾, Member of the Board of Management, Chairman of the Automotive Group, Robert Bosch GmbH, Stuttgart: "Powertrain Diversity and Electrification: Challenges and Chances for the Automotive Industry":

Both diesel and gasoline engines continue to offer great potential for reducing fuel consumption and emissions. However, massive investments will be required in order to tap this potential. In the long run, the electrification of the powertrain will lead to purely electric powertrains. The route to this objective will be a dual one, with hybrids as an interim technology on the one hand and the further evolution of the internal combustion engine on the other. In the short and medium term, this will mean a diversification of powertrain technologies. The need to invest in the development of the internal combustion engine and electric powertrains while at the same time analysing the different drive train concepts present major challenges to the automotive industry. The standardisation of non-distinctive functions, major components, and interfaces acts as a lever for reducing costs, especially for the electric powertrain, the development of which is only just getting under way. Innovation partnerships, alliances, and pre-competitive co-operation agreements are a further way to reduce investment costs of the individual market players, increase the speed of development, and thus heighten the industry's competitiveness.

The skills and know-how required for producing electric vehicles differ from those needed for manufacturing vehicles with internal combustion engines. This can be ascribed to the far higher share of electric systems and electronics in the value added chain, the need for reliable batteries and the emergence of new business models. These skills and this know-how must now be acquired in all operational areas of the company as this will, to a great extent, determine the future success or failure of the market players in the automotive industry.

H.-G. Härter, ❿, President and Chief Executive Officer (lecturer), **Dr. G. Gumpoltsberger, Dr. F.-D. Speck**, ZF Friedrichshafen AG, Friedrichshafen: "Innovations for Commercial Vehicles in a Difficult Market Environment":

Operators of commercial vehicles are currently going through a crisis that poses a threat to their existence. This was triggered by the worldwide recession as well as by the shrinking volume of freight transport, combined with cost increases. Cost reductions remain an absolute must for the entire industry and will become an increasingly important driver for technological innovation. The optimisation of the classical drive train offers potential for reducing operating costs. Ideal scenarios, which can never be expected to be feasible in the real world, demonstrate different theoretical options for saving costs. The drive train of long-haul commercial trucks offers less potential for cost reductions than that of city buses. Nevertheless, for these trucks the use of ZF products, such as the automatic AS Tronic transmission system, is worthwhile as not only fuel costs can be brought down by approximately 4 % but also, due to lower clutch wear, maintenance costs can be lowered. The Intarder transmission brake relieves the load on the drive brake which also results in a reduction of maintenance costs. Hybrid-electric drive systems are particu-

larly well suited for urban delivery vans and city buses, as these have a particularly positive effect in short-haul applications. Thanks to ZF products, which will soon be series-produced, better fuel economy of city buses of up to 30 % can be attained.

NEW OTTO ENGINES 1

Dipl.-Ing. G. Doll (lecturer), **Dipl.-Ing. P. Lückert, Dipl.-Ing. H. Weckenmann, Dipl. Ing. R. Kemmler, Dipl.-Ing. A. Waltner, Dipl.-Ing. H. Herwig**, Daimler AG, Stuttgart: "The New Mercedes-Benz V8 Petrol Engine with Direct Injection and Turbocharging":

The new Mercedes-Benz 4.6 litre biturbo engine M 278 was conceived as a member of a new high-performance engine family and is derived from the V6 and V8 engines. It replaces the highly successful 5.5 litre predecessor engine M 273. This engine is based on a modular concept and on a high-grade technology portfolio comprising, as essential elements, direct injection of the third generation, turbo-charging, the Mercedes start-stop system, thermal management and a pressure-controlled oil circuit. In this engine category, the 4 litre engine boasts an exclusive driving performance combined with fuel economy that to date has rather been typical of six-cylinder engines.

In comparison with its predecessor model, which is still highly successful in tests, the new engine achieves a 12 % higher output, its torque has been increased by 32 % and fuel consumption has been lowered by more than 10 %. Thanks to its modular concept, this engine will continue to be viable in future as well.

S. Ando, MA (lecturer), **Dipl.-Ing. K. Chujo**, Nissan Motor Co., Ltd., Kanagawa, Japan: "The New NISSAN V8 Gasoline Engine with VVEL and DIG":

A continuous variable valve timing system which controls both valve opening and closing times (VVEL) as well as a direct injection gasoline system (DIG) constitute the key technologies integrated into this engine. With regard to the DIG combustion concept, a wall-guided version with side spray was selected instead of a spray-guided system with centre spray, in order to obtain high volumetric efficiency in natural aspiration. CFD (Computational Fluid Dynamics) were applied for air flow control and fuel dynamic behaviour in order to analyse mixture formation in detail. The optimised intake port, the piston crown shape and the combustion chamber with masking shape assure homogeneous combustion. In this concept, the key factors are a higher flow rate coefficient and a tumble ratio conceived both for partial load with lower valve lift and full load. In addition, stratified charge combustion permits ignition timing retard and a lean air/fuel ratio which improves catalyst warm-up and lower HC gas emissions after engine start. Alongside the higher thermal efficiency achieved with DIG, the VVEL system, which was taken over from the VK50VE and VQ37VHR engines, improves fuel economy under partial load by reducing pumping losses.

Dipl.-Ing. M. Kerkau (lecturer), **Dipl.-Ing. T. Wasserbäch, Dipl.-Ing. G. Bofinger, Dipl.-Ing.(FH) M. Stöfka, Dr.-Ing. H.-J. Neußer**, Dr.Ing.h.c.F.Porsche AG, Weissach: "Highly Efficient Performance – Powertrain of the New Porsche 911 Turbo":

The new 911 Turbo combines extensive technological innovation with the fine-tuning of its design. The powertrain of the new 911 Turbo offers significant improvement in energy efficiency and a further increase in attractiveness thanks to intelligent performance. As a high-performance sports car, it is both much more fuel efficient and lightweight as well as more powerful, more dynamic and faster than its predecessor. At its heart is the new 3.8 litre engine with a power output of 368 kW, which represents the culmination of 35 years of experience in the history of turbo models. In addition to its familiar variable valve drive, the completely redesigned engine also features direct fuel injection and a turbocharger with variable turbine geometry. A new level of efficiency, agility, responsiveness and performance has been achieved in combination with the seven-speed Porsche dual clutch (Porsche-Doppelkupplungsgetriebe PDK).

This drive package enables the 911 Turbo to accelerate from 0 to 100 km/h in just 3.4 s (predecessor 3.7 s) while also reducing CO_2 emissions by up to 18 %.

❸ Festival hall

NEW WAYS TO EMISSION REDUCTION

Dipl.-Ing. S. Pflaum, Univ.-Prof. Dr.-Ing. G. Wachtmeister (lecturer), Technical University Munich; **Dipl.-Ing. M. Mackovic, Dr.-Ing. G. Frank, Univ.-Prof. Dr.rer.nat. M. Göken**, University Erlangen-Nuremberg: "Ways to a Soot Formation Hypothesis":

Preliminary studies confirm the assumption that existing soot formation models have to be revised, or more detailed, phenomenological soot formation models must be established – especially with regard to the pre-calculation of soot emissions of internal combustion engines operated with extreme parameters (high pressure injection, high EGR, high pressure supercharging). With a view to generating the necessary basic knowledge, a novel gas sampling probe was devised which allows

the time-resolved collection of small soot samples from the combustion chamber. With the aid of the new probe extensive series of samples have been collected which show the formation and modifications of soot during the combustion cycle.

The Department for Materials Science and Engineering (Chair for Microcharacterisation WW7), in Erlangen, after analysing a series of soot samples from the combustion chamber, verified the formation, growth and oxidation of primary soot particles. Furthermore, it was possible to demonstrate characteristic changes in soot agglomerates during combustion from compact to fissured shapes. These findings permitted a first modelling of soot formation during combustion.

Dipl.-Ing. W. Maus, Dipl.-Ing. J. Hodgson, Dipl.-Ing. C. Vorsmann, Dipl.-Ing. R. Brück (lecturer), Emitec Gesellschaft für Emissionstechnologie mbH, Lohmar: "PM-Metalit Advanced – The Innovative Particulate Filter for Nanoparticle Reduction":

Future emission legislation for passenger cars (gasoline and diesel) as well as heavy-duty vehicles will require a reduction in particle numbers alongside a reduction in particle mass. Conventional filters that combine current levels of porosity with new, low soot-emitting engines cannot filter nanoparticles with sufficient effectiveness due to the absence of a soot filter cake. The necessary reduction in pore size leads to greater pressure losses.

The "PM Metalit Advanced" represents a new generation of particulate filters for the automotive industry. Building on the proven partial-flow deep-bed concept, the separation of nanoparticles, in particular, is improved through the application of electrostatic forces, which act as a diffusion and adhesion booster. The system is capable of separating well over 90 % of the particles that have been charged in an electric field without any increase in backpressure.

W. Li, Ph.D., P. M. Najt, M.S.M.E., K. Narayanaswamy, Ph.D., C. H. Kim, Ph.D., K. L. Perry, B.S., O.A. Güralp, Ph.D., J. G. Smyth, Ph.D. (lecturer), General Motors LLC, Warren, USA: "Passive Ammonia SCR – A Novel Lean NO_x Aftertreatment System":

The "Passive Ammonia SCR System" (PASS) concept is an integrated aftertreatment system that relies on the intrinsic performance characteristics of a close-coupled three-way catalyst (TWC) and an underfloor selective catalytic reduction (SCR) catalyst to holistically address both stoichiometric and oxygen-rich SI engine aftertreatment. The PASS-concept combines the performance capabilities of a conventional TWC system and a urea-based SCR system without the cost and complexity of a dosing system. In its simplest form, PASS is an oxygen tolerant aftertreatment system that has been shown to work effectively for a range of homogeneous, stoichiometric SI engine applications. In addition, the PASS concept can easily be adapted for use on lean-burn applications and has been shown to work effectively for a range of stratified-charge SI engine applications. Critical to the performance of PASS are the efficient generation of ammonia on the close-coupled TWC catalyst and the storage of ammonia on the underfloor SCR catalyst.

FUTURE FUELS / EXHAUST GAS AFTERTREATMENT HYBRID

Dr. W. Warnecke, Dr. D. Liebig, Shell Global Solutions (Germany) GmbH, Hamburg; **Dr. R. Clark** (lecturer), Shell Global Solutions (UK), Chester; **M. Copson, A. Alonso**, Shell International Petroleum Co Ltd, London; **Dipl.-Ing. M. Kind, Dipl.-Ing. A. Kolbeck, Dr. M. Lamping, Dipl.-Ing. T. Körfer**, FEV Motorentechnik GmbH, Aachen; **Dr. R. van Doorn**, Audi AG, Ingolstadt: "GTL Fuel in a Dedicated Vehicle – Exploration of the Full Emissions Reduction Potential":

The start of production from Sasol's GTL plant Onyx, and the current construction of the world's largest GTL plant, Shell's Pearl plant in Qatar, signals that GTL fuel is no longer an option for the distant future, but that significant volumes will be reaching the market in the short to medium term. GTL fuels have market potential when used either neat or in blends with conventional diesel fuel. In areas that are sensitive to air quality issues (e.g. inner cities), the use of neat GTL fuel in dedicated fleets is an attractive option, because of the emission reduction effect that GTL fuel can have. The progression from using neat GTL fuel in conventional vehicles towards the possibilities of optimising engines specifically for GTL fuel constitutes the next logical step.

The lecturer emphasised that with this study, the full emissions reduction potential of GTL fuel in a dedicated vehicle was explored. The main goals of the optimisation were, on the one hand, the minimisation of NO_x emissions and the reduction of fuel consumption and hence NO_x emissions to an absolute minimum, on the other. It was sufficient to optimise the software in order to comply with the Euro 5 emission limits with a former Euro 4 production vehicle. By using GTL with optimised calibration, it was possible to bring down vehicle exhaust emissions of CO_2 by 10 %.

❹ Ceremonial hall

Prof. Dr.-Ing. S. Pischinger (lecturer), **Dipl.-Ing. M. Müther, Dipl.-Ing. A. Janssen**, RWTH Aachen University: "Tailor-made Biofuels – Results from the Cluster of Excellence at RWTH Aachen University":

Within the framework of the Cluster of Excellence, an interdisciplinary team is engaged in the research of the optimum combination of fuels and combustion processes. As a first step, the optimum fuel properties for future partially homogeneous low-temperature combustion, such as a reduced cetan number or an increased oxygen content, were identified. Experimental thermo-dynamic bench tests with butyl levulinate, a hydrocarbon made from biomass, have proved the potential of future biofuels. Nearly soot-free operation with high efficiency can be achieved simultaneously in diesel engines across the entire NEDC map area. The lecturer demonstrated the development of partially homogeneous low-temperature combustion systems using 1-decanol, a long-chain alcohol, as an example. Thanks to the oxygen contained in the fuel it is possible to achieve the highest exhaust gas recirculation rates with moderate particulate emissions. As a result, nitrogen oxide formation in the engine can be almost entirely eliminated.

Dr. P. Spurk (lecturer), **Dipl.-Ing. W. Müller**, Umicore AG & Co KG, Hanau; **Prof. Dr. C. Beidl, Dipl.-Ing. P. Weickgenannt**, Darmstadt University of Technology; **Prof. Dr. G. Hohenberg**, IVD Prof. Hohenberg, Darmstadt: "Emission Control of Hybrid Vehicles – What are the Resulting Requirements?":

Specific requirements were identified on the basis of the results obtained with the test vehicle model Toyota Prius III both on a dynamometer and in real world operation. NEDC cycle results have shown a characteristic reduction of catalyst temperature compared to a conventional powertrain as the combustion engine is in operation only during approximately 40 % of the cycle time. Hybrid-specific events present a further challenge, as the restart of the internal combustion engine following a short standstill period leads to high engine-out emissions which must be properly converted by the catalyst. The influence of different states of charge of the battery on emission behaviour has also been clearly demonstrated. The question of the impact of plug-in hybrid systems with extended periods of purely electric operation is of special significance. In this context, the cooling behaviour of the exhaust gas system during engine shut-off time is also an important aspect.

❺ Exhibition

INJECTION AND ENGINE CONTROL SYSTEMS

Dr.-Ing. Dipl.-Wirt.-Ing. M. Parche (lecturer), **Dipl.-Ing. K. P. Sassen, Dr.-Ing. R. Leonhard, Dipl.-Ing. C. Alvarez-Avila**, Robert Bosch GmbH, Stuttgart: "Bosch 2000/2200 bar Common Rail System for Commercial Vehicles":

Bosch Common Rail Systems for commercial vehicles (CRSN) have been available in the market for eleven years. In 2009, the existing CRSN product range was extended to 2,000 and 2,200 bar injection pressures. This system is designed for medium-duty and heavy-duty applications, both for on-highway (On-HW) and off-highway operation (Off-HW) and represents an evolution from the current system for an injection pressure of 1,800 bar. With this system it was possible not only to raise injection pressure, but also to achieve high hydraulic efficiency in pressure generation and during injection, thus contributing directly to the reduction of fuel consumption. In order to be able to meet even more stringent requirements, development work focuses on creating a system with an injection pressure of 2,500 bar, the lecturer explained. Thanks to its variability and the modular design of its key components, the entire system can be used over a broad range of applications in On-HW or Off-HW operation.

Dipl.-Ing. O. Predelli (lecturer), **Dipl.-Ing. R. Gratzke, Dipl.-Ing. A. Sommer, Dipl.-Ing. R. Marohn**, Ingenieurgesellschaft Auto und Verkehr GmbH, Berlin; **Dr.-Ing. F. Atzler, Dipl.-Ing. H. Schüle, Dr.-Ing. O. Kastner, Dipl.-Ing. N. Nozeran**, Continental Automotive GmbH, Regensburg: "Continuous Injection-Rate Shaping for Passenger Car Diesel Engines – Potential, Limits and Feasibility":

Fuel injection and mixture formation are determined by the injection system. With regard to mixture formation, the question arises as to what potential an injection strategy has when optimised for combustion. Should the trend towards downsizing continue, then the average number of cylinders of diesel engines for passenger cars should go down further. In the future there will be compact cars with two-cylinder engines, just like medium-sized cars with three-cylinder engines and superior class cars with four-cylinder engines.

The reduction of engine capacity, however, calls for an increase in volumetric power output, which could have a negative impact on combustion noise. In addition, thanks to hybridisation, the high performance of the engine and the electricity of the powertrain can be preserved even though the output of the downsized diesel engine should not be increased to

❻ Exhibition

that of the original engine. At any rate, drivers of passenger cars do not wish to be disturbed by the sound of a loud internal combustion engine. Thus the combustion noise of diesel engines is increasingly becoming the focus of attention for development engineers.

A. Ohata, Toyota Motor Corporation, Shizuoka, Japan: "Strategic Innovation for Engine Control System Development":

"Integrated Model-Based Development" (MBD) was introduced with a view to reducing the complexity we have to deal with as a result of the rapid advances in engine control systems. MBD requires a variety of technologies in modelling, control design, calibration, verification and validation, model execution, model/data management and process management environments. However, some of these technologies have not been developed to the required extent. Rapid modelling is a pre-requisite for MBD, because otherwise it is difficult to make available the required engine and component models to development engineers in good time. In order to overcome this problem, the desirable modelling environment was created on the basis of physical and empirical modelling environments. The empirical modelling environment comprises existing algorithms and modules which derive empirical model equations from complex physical models. For the physical modelling environment a new multi-physics modelling tool, the HLMT (High Level Modelling Tool) was introduced which is based on the relevant conservation principles and constrains. It generates non-linear differential algebraic equations of higher degrees and converts these into numerically solvable equations by "Symbolic Equation Manipulation".

MOBILITY 2020 PLUS

Prof. Dr.-Ing. W. Steiger, Volkswagen AG, Wolfsburg: "Technical, Social and Political Framework for Future Mobility":

Numerous signs indicate that attitudes towards individual mobility are changing around the world. Sustainable mobility is in demand. Politicians are reacting through their recovery-assistance packages and are specifically promoting alternative drives, notably electric mobility. In Japan, this is leading to a boom in hybrid vehicles. In the US, the "stimulus package" is being used to establish development and production capacities for electric vehicle modules in American companies. China has declared market leadership in electric mobility as a strategic objective, and is creating a lead market in government vehicles.

And what is happening in Europe? European politicians are promoting research on electric mobility with comparatively scant funds. Under national programmes, far more funds are mobilised, but these are not networked across Europe. At the same time, customer expectations are soaring beyond all measure. What can realistically be achieved? Therefore, on the one hand, expectations have to be met, but overtaxing technology and getting caught in a risky subsidisation mechanism needs to be avoided, on the other.

MEng. R. Bastien, Renault S.A.S., Guyancourt: "Sustainable Mobility for All":

Several years ago Renault launched a comprehensive programme for assessing the environmental impact of the operations of the automotive engineering industry. The Logan Eco2, which has lower CO_2 emissions than hybrid vehicles, was presented at the "Bibendum Challenge 2007" and can be considered as a role model. This low emission level was attained thanks to a diesel engine optimised for highest fuel economy and some low-cost vehicle features. Moreover, the Eco2 currently represents the emission threshold for the operation of cars and incorporates a number of criteria for car manufacturing and recycling in accordance with a well managed life cycle analysis (LCA).

But the Renault Nissan Alliance has also taken steps to become a market leader with its zero emission vehicles by offering a range of purely electric vehicles worldwide. This strategy is feasible with the progress in Li-Ion battery technology, electric motors and mechatronics, and it remains consistent with the Eco2 approach. Thanks to its well thought-out business model involving new partners and the building up of an infrastructure for battery charging stations, in the future, Renault will be able to offer fully electric vehicles at operating costs (total costs over a defined period of time) that will be lower than those of cars with internal combustion engines.

Dipl.-Ing. P. Langen, Dr. B. Curtius, Dipl.-Ing. W. Nehse, BMW AG, Munich; **Dipl.-Ing. T. Melcher** (lecturer): "Vision 2020 – The Combustion Engine on a Dead End Road":

We are weathering a worldwide financial crisis with still no end in sight. As a result, the financial strength of customers has become eroded; in addition, with ever more people living in densely populated metropolitan areas, their purchasing behaviour is also changing. The generating of energy from renewable sources is subsidised worldwide and is being stepped up. Together with politicians and other leading business enterprises, the automotive industry faces the challenge of formulating a

vision based on a sparing use of resources and minimum environmental impact without disregarding customer demands.

Starting from the actual status of various technologies, the lecturer analysed the potential of new drive systems in the face of growing electrification. He also dealt with energy supply and customer benefits, stressing that in view of disparate customer requirements a single solution cannot be expected. In conclusion, he stated that the survival of the internal combustion engine was nevertheless assured until 2020 and beyond.

❼ Exhibition

POWERTRAIN ELECTRIFICATION

Dipl.-Ing. K. Haupt, Continental AG, Frankfurt/Main; **Dr. S. Bocionek** (lecturer), **Dr. F. Ruf, Dipl.-Ing. G. Winkler**, Continental Automotive GmbH, Regensburg: "Open Engine Management System Platform for Future Engine Concepts and Electrification – Bringing Engines to Life":

Despite all progress in the electrification of the drivetrain, the combustion engine will continue to play a predominant role as the propulsion system of motor vehicles for many years to come. Therefore electronic engine management systems are the key element for the drivetrain of vehicles.

The lecturer illustrated on open hardware and software platform using the engine management platform of Continental AG as an example in order to show how future demands can be met by combining combustion, hybrid and electric drive systems. Thanks to the open architecture of the basic electronics, car manufacturers can concentrate on their core competences and focus their own work on innovative solutions for improving driving performance, assuring driving fun and finding environmentally sound solutions, which in the eyes of consumers are the most distinguishing characteristics of different car brands.

Dr.-Ing. S. Berns (lecturer), **Dr.-Ing. J. Hammer, Dr.-Ing. K. Benninger, Dipl.-Ing. M. Klenk, Dipl.-Ing. R. Frei**, Robert Bosch GmbH, Schwieberdingen: "Reduction of CO_2 Emissions while Maintaining Good Driveability – Suggestions for Overall Powertrain Optimization":

Alongside engine design improvements, the lecturer discussed in depth different electrification and alternative transmission concepts. In the meantime, a large volume of such novel systems has been successfully launched in the market. The lecturer gave an overview of the state-of-the-art powertrain technologies by comparing typical and promising powertrain topologies on the basis of simulation-based evaluations, and thus tried to offer some orientation for navigating through the enormous number of combinations. The lecturer illustrated potential technology concepts as well as component and system solutions for the three areas engine, transmission and electrification.

He then presented a portfolio analysis in terms of fuel consumption and driveability which allowed a comparison of the different alternatives. Subsequently he explained a cost-benefit analysis of the different methods applied for achieving CO_2 emission targets. The driveability criteria expected by consumers and the market and vehicle-segment dependent characteristics of the driving cycle served as a basis for this comparison.

Dipl.-Ing. M. Weiss (lecturer), **Dipl.-Ing. G. Henning, Dr.-Ing. A. Lamm, Dipl.-Ing. O. Bitsche, Dipl.-Ing.(FH) P. Antony, Dipl.-Ing. F. Nietfeld**, Daimler AG, Sindelfingen: "Consistent Electrification of the Powertrain in Mercedes-Benz Cars – from Micro-Hybrid to Plug-In":

Electrifying vehicle drive constitutes a major part of Daimler's strategy to assure sustained mobility. Electrification encompasses a wide range of concepts and system designs – from the micro hybrid to the plug-in. Economically priced micro hybrids were initially available in the compact car category Smart fortwo as well as in the A-Class and B-Class model series and will be successfully offered in other model series as well.

Advanced mild and full hybrids, which feature additional functionality, have already been successfully launched or will be available in the near future. The effort to continually advanced innovative drive technology will culminate in the S-Class Plug-In.

The lithium-ion battery plays a key role with its high energy density and efficiency. With these vehicles and their drive technology, the most stringent emission standards can be met while fuel consumption and CO_2 emissions can be kept at an absolute minimum.

NEW DIESEL ENGINES

Dipl.-Ing. R. Bauder (lecturer), **Dipl.-Ing. M. Bach, Dipl.-Ing.(BA) A. Fröhlich, Dipl.-Ing. W. Hatz, Dipl.-Ing. J. Helbig, Dipl.-Ing. J. Kahrstedt**, Audi AG, Neckarsulm / Ingolstadt: "The New Generation of the Audi 3.0 TDI Engine – Low Emissions, Powerful, Fuel-efficient and Lightweight":

After Audi launched its production of the first generation of the 3.0 litre V6-TDI engine in 2003, the second generation fol-

lows in 2010 with an entirely redesigned engine which successfully combines high fuel efficiency, low emissions, a high power output and, at the same time, significantly reduced weight.

This accomplishment is based on a large number of innovative design solutions, especially focused on minimising friction and on lightweight construction. The thermodynamics of the familiar Audi four-valve combustion method have been revised. The fuel injection system is an updated piezo-inline common rail unit delivering up to 2,000 bar maximum rail pressure. The turbocharger has also been modified in order to provide enhanced spontaneity. In the new Audi models, these features assure excellent driving performance with outstanding comfort and extremely high fuel efficiency.

Dipl.-Ing. F. Rudolph (lecturer), **Dr.-Ing. J. Hadler, Dipl.-Ing. H.-J. Engler, Dipl.-Ing. A. Krause, Dipl.-Ing. C. Lensch-Franzen**, Volkswagen AG, Wolfsburg: "The New 1.2 l TDI from Volkswagen – Innovation with 3 Cylinders for Highest Fuel Efficiency":

With its new 1.2 litre TDI Volkswagen presents an entirely new three-cylinder diesel engine, replacing the well-known and highly successful 1.4 litre TDI featuring pump/nozzle unit fuel injection technology. Based on the 1.6 litre TDI launched in early 2009, a newly developed power unit ushers in the next chapter in the successful story of three-cylinder TDI engines from Volkswagen. Maximum fuel efficiency paired with the excellent driving dynamics typical of a TDI engine, greatly improved acoustics and smooth running are the cornerstones of the 1.2 litre TDI concept. Emissions are, of course, within the limits of the Euro 5 standard.

Consistent downsizing, a comprehensive reduction in friction losses and weight, as well as state-of-the-art injection technology have resulted in emissions of a mere 87 g CO_2/km in the Polo BlueMotion – the benchmark for all five-seater models. The dynamic torque development of the compact 1.2 litre TDI, with its maximum torque of 180 Nm and a smooth power output peaking at 55 kW, guarantees a high degree of driving dynamics and superior handling.

Dr. H. Sorger (lecturer), **M. Howlett, Ing. W. Schnider, Dipl.-Ing. N. Ausserhoffer, Dr. P. Bartsch, Dipl.-Ing. M. Weißbäck**, AVL List GmbH, Graz; **O. Soustelle**, Le Moteur Moderne, Palaiseau; **P. Ragot, P. Mallet**, Renault S.A.S., Rueil Malmaison: "The CO_2 Challenge: Aggressive Downsizing for the HSDI Diesel – Engine Concept Definition":

❽ Dipl.-Betr.-Wirt Stadler, Audi

The downsizing approach is one response to customer demand for highly fuel efficient vehicles. A clear trend can be observed in the market already today: engines of 2.0 litres swept volume are being replaced by engines with a displacement in the range of 1.6 litres. The lecturer illustrated an even more extreme downsizing approach for the next generation of powertrains providing for a further reduction of engine displacement to 1.0 litre using a three-cylinder concept, with a specific power rating of 80 kW/l. AVL and Renault worked closely together in defining a suitable diesel hybrid powertrain concept that would comply with Euro 6 emission limits.

The structural concept of this high power engine is based on a peak firing pressure limit of 190 bar. The lecturer reported that Renault evaluated two and four cylinder concepts with regard to their influence on power output, emissions, fuel consumption and costs. In view of the need to meet Euro 6 emission limits, the combustion and EGR systems were designed with due regard for diesel particulate filter and NO_x-aftertreatment technologies.

TURBOCHARGING, LIGHTWEIGHT CONSTRUCTION, COOLING MANAGEMENT

Dipl.-Ing. R. Sauerstein (lecturer), Borg-Warner Turbo Systems GmbH, Kirchheimbolanden; **Dr. M. Becker, Dipl.-Ing. W. Bullmer**, Engine Systems Group, Borg-Warner Inc., Ithaca, USA, and Ludwigsburg; **MEng. Dipl.-Ing.(FH) R. Dabrowski**, Turbo Academy, Mannheim University of Applied Sciences: "Regulated Two-Stage Turbocharging for Gasoline Engines – Matching, Control Strategy and Operating Behaviour":

Single-stage turbo-charging of gasoline engines calls for compromises in design with regard to steady-state and transient behaviour. The demand for a further spread of the torque range simultaneously with an excellent dynamic response has given rise to a debate on whether regulated two-stage turbo-charging which has been successfully applied in diesel engines should also be used in gasoline engines. The lecturer described such a system for a gasoline engine with its specific characteristics.

A turbo-charging system optimised in this way significantly exceeds the performance data of single-stage turbo-charging and means significant progress on the way to better fuel efficiency and higher-performance gasoline engines.

Dr.-Ing. K. Lellig (lecturer), **Dr.-Ing. M. Nolte, Dr.-Ing. R. Gosch, Dr.-Ing. D. Kube, Dipl.-Ing. A. Gröschel, Dipl.-Ing. B. Stauder, Dipl.-Ing. D. Ragus**, Nemak Europe GmbH, Dillingen: "New Lightweight Concepts in Engine Design and Manufacturing: Responses to the New Challenges in Modern Vehicle Construction":

As a result of improved manufacturing processes, advanced high strength alloys and new running surfaces, aluminium is increasingly becoming the standard material not only for cylinder heads but also for cylinder crankcases. In the development of cylinder heads and engine blocks strict cost ceilings and time constraints can be met through the consistent application of computer simulations.

In the meantime, development engineers can rely on suitable simulation programmes from the manufacturing process of individual components to the operational reliability of engines.

Special demands are made upon cylinder running surfaces, bearing supports and

combustion chamber surfaces. Accordingly, foundries must show a particularly high degree of creativity and capability for innovation. Advanced casting processes combined with state-of-the-art materials have resulted in high strength and hardness parameters which a few years ago were conceivable for attainment only by high-grade cast iron.

Dipl.-Ing. H. Jensen (lecturer), **Dr. M. Janßen**, Mahle Filtersysteme GmbH, Stuttgart: "Potential for CO_2 Reduction through Innovative Liquid Management Systems":

Looking at the elements in oil and coolant circuits, some components can be identified that have a potential for lowering CO_2 emissions:

: Oil filter modules with optimised valves which significantly reduce the pressure drop in the module, and thus also in the entire oil circuit. Hence, the power required for driving the pump can be reduced. In addition, the thermal management of the oil circuit can also be influenced selectively.
: The oil-water exchanger with optimised turbulators, which not only raise the specific output of the heat exchanger but also counteract pressure drops in the oil circuit.
: Transmission fluid heaters have the function of rapidly warming up the transmission to the operating temperature and stabilising it at this level.
: Controlled coolant pumps which can warm up the engine to the required temperature and keep it in the optimum temperature range.

Even though the potential of the individual measures does not exceed a certain limit, the overall potential of all these measures combined can be fully tapped by a single supplier.

RACING AND HIGH PERFORMANCE ENGINES

Prof. Dr.-Ing. M. Theissen (lecturer), **Dipl.-Ing. M. Duesmann, Dipl.-Ing. J. Hartmann, Dipl.-Ing. M. Klietz, Dipl.-Ing. U. Schulz**, BMW Group, Munich: "10 Years of BMW F1 Engines":

From 2000 to 2009 BMW engines were used in Formula One racing cars. The overall project consisted of the preparatory phase, BMW's years as an engine supplier to the Williams team and its presence with its own BMW Sauber F1 team. The engine concept, its design and application were determined by the Formula One regulations which changed nearly every year. The main objective of these amendments to the rules were cost reductions. Development expenditure was scaled down step by step as a result of the technical restrictions imposed on the teams and finally through homologation or a freeze on development. Engine manufacturing costs were also brought down as increased mileages were required of every engine and restrictions on testing became ever more stringent each year; i.e. fewer engines were needed every racing season. A second goal, i.e. lower engine output, was reached when the 3.0 litre V10 was replaced by the 2.4 litre V8 engine in the 2006 season.

In the early years of its involvement in Formula One, BMW developed and manufactured a new engine for every season under extreme competitive pressure. This process saw rapid improvements in engine output and weight, and BMW engines soon attained benchmark status in Formula One. In recent years, development work focused on raising mileage capability and reliability without changing the engine concept itself. Despite a 20 % smaller displacement, the P86/9 used in the 2009 season reached the same power output as the E41/4 that was introduced at the beginning of the 2000 season, and at the same time the range of the new engine was quintupled to more than 2,000 km. The lecturer described the various engine generations with their key design features and illustrated the equipment used and expertise accumulated in the course of this project.

Dipl.-Ing. F. Eichler (lecturer), **Dr.-Ing. J. Gindele, Dr.-Ing. M. Hart, Dipl.-Ing. I. Brajdic, Dipl.-Ing. T. Breitinger, Dipl.-Ing. M. Burgbacher, Dipl.-Ing. M. Gruber, Dipl.-Ing. J. Schmid**, Mercedes-AMG GmbH, Affalterbach: "The Powertrain of the Mercedes SLS AMG":

The powertrain concept which was specifically devised and reviewed for this vehicle consists of three main elements: the 6.2 litre V8 engine, borrowed from previous AMG model series and thoroughly reworked, a seven-speed dual-clutch transmission, and a torque tube with carbon-fibre drive shaft, which provides for a very rigid transaxle system as a connection between the engine and the transmission.

The priority development goals focused, on the one hand, on the characteristics typical of a high-performance sports car, such as top performance, rapid speed building, responsiveness with minimum shift times, and an emotional engine sound. On the other hand, a great deal of attention was also paid to improving mechanical efficiency and integrating fuel-saving driving programmes. By making extensive changes to numerous systems, in the basic

❾ Dr. Bohr, Bosch

powertrain, very low fuel consumption was recorded in NEDC and off-cycle testing as compared to the powertrains used in other vehicles in this segment. The fuel consumption of this engine is on a par with the fuel economy of lower-displacement gasoline engines with direct injection. The entire project was carried out in line with the established development processes at Mercedes Benz Cars (MBC) with strict time constraints.

Prof. Dipl.-Ing. Dr.techn. F. Indra, Honorary Professor, Vienna University of Technology: "Formula Student Racing Engines: Formula One Serving as a Model?":

Founded in1981 by the SAE USA, Formula Student has since grown to become a fascinating global racing series. In 1998, this series was taken over by SAE England and these cars have been competing in Europe since 2006. On the basis of very logical regulations, these monoposto racing cars are designed, developed and built by students of various universities and colleges of technology around the globe, and are tested and evaluated in special competitions.

In contrast to the regular Formula One, regulations are not stringent. Hence, students have to consider carefully whether they want to design one-, two-, three- or four-cylinder engines with turbo- or supercharging or natural aspiration. The choice of engines has a decisive influence on the design concept of the car, and especially on its weight, which is not limited. Lightweight design and the right materials are the key to a successful car, and oblige students also to deal with this topical issue.

In the final evaluation, not only driving performance and fuel economy but also other criteria are taken into consideration. In 2006, approximately 400 universities in the US, Europe, Asia and Australia participated in these competitions. With a view to challenging the innovative spirit of the students, every year a new car must be developed.

PLUG-IN, HYBRID, RANGE EXTENDER

T. Takaoka (lecturer), **H. Ichinose**, Toyota Motor Corporation, Aichi, Japan: "The Newly Developed Toyota Plug-in Hybrid System":

In response to the need for finding solutions to some automotive engineering problems such as the reduction of CO_2 emissions, Toyota introduced a number of hybrid vehicles (HV) with a view to lowering emissions in urban zones and making sparing use of available resources. In a further step, the plug-in hybrid vehicle (PHV) emerged as an effective solution. These vehicles combine the advantages of electric vehicles (EV) using clean electric energy and those of hybrid vehicles which have a high ecological potential and user-friendly features, such as long cruising ranges, comparable to conventional vehicles.

The lecturer explained the newly developed plug-in hybrid system and illustrated its performance characteristics in vehicles. The system uses a lithium-ion battery with a high energy density and has an acceptable range in purely electric operation without taking up extra cabin space. This vehicle has CO_2 emissions of 59 g/km and complies with the most stringent exhaust gas regulations worldwide. The new PHV is a forerunner of the series production of PHV which is to start two years from now. PHVs have the potential to become popular as a practical solution for sustainable mobility based on the use of electricity.

Dipl.-Ing. N. Wakayama, Mazda Motor Corporation, Hiroshima, Japan: "Development of Premacy Hydrogen RE Hybrid":

In the future, hydrogen-powered internal combustion engines could play an important role as drive units as they are more reliable and more cost-efficient than fuel cells. In combination with hydrogen, Mazda's unique rotary engine (RE) offers a number of advantages, such as the absence of hydrogen pre-ignition. Since the early 1990s, Mazda has worked on the development of vehicles powered by hydrogen rotary engines. The Premacy (Mazda5) hydro-powered RE hybrid was designed as a successor model to the RX8 hydrogen-powered rotary engine introduced in 2006 and was launched in 2009. The Premacy Hydrogen RE Hybrid is equipped with an in-series hybrid system and the motor used as the drive switches the current in its windings while the vehicle is moving.

A high voltage lithium-ion battery which has excellent input-output characteristics was installed in this vehicle. Thus it has been possible to extend the driving range for hydrogen operation to 200 km and, at the same time, attain an impressive acceleration performance. The hydrogen-powered RE can also be operated with gasoline (dual fuel system). Thanks to this dual fuel system, the hydrogen-powered RE vehicle can also be driven in areas where no hydrogen filling stations are available.

Dr. G. K. Fraidl (lecturer), **Dr. P. E. Kapus, Dr. M. Korman, Dipl.-Ing. B. Sifferlinger, Dipl.-Ing. V. Benda**, AVL List GmbH, Graz: "The Range Extender in Real World Operation":

⓾ Härter, ZF

⓫ Dr. Pachta-Reyhofen, MAN

The trade-off between driving range and battery costs as well as battery weight represents the decisive challenge for the broad acceptance of electric vehicles. Depending on operating conditions, the cruising ranges attainable in real world operation sometimes deviate significantly from the nominal ranges calculated under idealised conditions. In extreme cases (very slow traffic and extreme air-conditioning requirements), the range is not only determined by the actual distance covered, but also, and essentially, by the total operating time. Whereas with conventional powertrains a high degree of flexibility of the total cruising range can be assured while hardly affecting costs, exclusive battery operation gives rise to extreme cost increases and calls for the use of extremely heavy batteries.

Based on a highly integrated combination of a rotary engine and an electric generator, AVL List succeeded in translating into reality a range extender concept which resulted not only in unheard-of packaging space and an extremely low power-to-weight ratio, but which is also convincing in real world operation because of its excellent NVH-performance. This makes range extender solutions essential enablers for affordable electric mobility.

⓬ Dipl.-Ing. Wester, Fiat (on the right)

NEW OTTO ENGINES 2

Dipl.-Ing. G. Böhler, Dr.-Ing. R. Buhr, Dr.-Ing. G. Reinheimer (lecturer), Adam Opel GmbH, Rüsselsheim: "The New Small Spark Ignited Engine Family – Ranging from the Naturally Aspirated Three-Cylinder to the Boosted Four-Cylinder".

Opel carried out a fundamental revision of its family 0 engine series and added new engine versions to its portfolio. The third generation of this engine family represents a consistent improvement of the time-tested second-generation three and four cylinder engines, millions of which are on the road. The portfolio has been upgraded through the addition of a newly developed 1.4 litre turbocharged engine, which is derived from the modular system of naturally aspirated engines and, as a downsized/downspeeded version, has led to improved fuel efficiency of up to 12 %. In the new Astra, the turbocharged engine emits a mere 139 g CO_2/km. The four-cylinder engines feature continuously variable cam phases on both the intake and the exhaust side, a volume-flow controlled oil pump, and an electrically regulated thermostat.

In the naturally aspirated engine category, the port-deactivation system introduced in the second engine generation was further developed and matched with the requirements of internal exhaust gas recirculation. A modified, naturally aspirated 1.4 litre engine with an alternative drive concept will be incorporated into the range extended Chevrolet Volt to be launched at the end of the year and will subsequently also be installed in the Opel Ampera.

These engines are produced at the manufacturing site at Aspern on the outskirts of Vienna, Austria. At the end of 2010, an additional production plant will be opened in Flint, Michigan, US, in order to enable Opel to satisfy the worldwide demand for approximately one million engines per year forecast for the years 2011 and 2012.

Dr. G. Kiesgen (lecturer), **Dr. B. Curtius, Ing. F. Steinparzer, Dr. M. Klüting, Dipl.-Ing. F. Kessler, Dipl.-Ing. J. Schopp, Dipl.-Ing. B. Lechner, Dipl.-Inform. J. Dunkel**, BMW AG, Munich: "The New 1.6 l Turbocharged MINI Cooper S Engine with Direct Injection and Fully Variable Valvetrain":

In a co-operative project led by BMW, the BMW Group and PSA developed a new family of small gasoline engines which have been installed in all versions of Mini, Peugeot and Citroën passenger cars since 2006. For this engine family, the primary development goals were higher fuel efficiency as well as an improvement of driving dynamics. In addition, the conflicting objectives of sophisticated engine technology and cost pressure in the segment of compact and micro-cars had to be addressed. In order to meet these demands, TVDI technology (twin-scroll turbo charging and continuously variable valve timing plus direct injection) was applied in a four cylinder engine for the first time worldwide; this TVDI technology was derived from the BMW twinpower turbo technology and is, to a high degree, analogous to it.

The engines designed under the lead of BMW are based on the mutual transfer of know-how of the two manufacturers, because in the designing and implementing phases both the priority goals of BMW, namely "efficient dynamics" and the PSA principle "design to cost" were consistently striven for. The lecturer described the fundamental revision of this engine family, and explained, in particular, the details and parameters of the new 1.6 litre TVDI-turbocharged engine installed in the Mini Cooper S.

Dipl.-Ing. A. Waltner (lecturer), **Dipl.-Ing. P. Lückert, Dr.-Ing. H. Breitbach, Dipl.-Ing. G. Doll, Dipl.-Ing. H. Herwig, Dipl.-Ing. R. Kemmler, Dipl.-Ing. H. Weckenmann**, Daimler AG, Stuttgart: "The New Mercedes-Benz V6 Petrol Engine with Direct Injection":

With the new six-cylinder engine, Mercedes-Benz has succeeded in creating a design which, in addition to showing out-

standing performance along with the highest degree of comfort, also appropriately addresses environmental issues and economic viability.

The new 60° V-angle and the extremely lightweight design of the powertrain result in an excellent level of comfort. With third-generation direct injection (DEO3) in combination with multi-spark ignition, Mercedes was able to devise new modes of operation, thus opening up new areas of the engine map with fuel-optimised lean combustion. The brake specific fuel consumption values set new benchmarks for the combustion engine. Together with stop/start technology, shift point adjustment and the systematic reduction of rolling resistance, improvements in fuel efficiency of up to 20 % can be achieved.

FUTURE EXHAUST EMISSION REGULATIONS AND SOLUTIONS

Dr.-Ing. U. Dohle (lecturer), Tognum AG, Friedrichshafen; **Dr.-Ing. A. Schneemann, Dr.-Ing. C. Teetz, Dr.-Ing. I. Wintruff**, MTU Friedrichshafen GmbH, Friedrichshafen: "Compliance with Future Emissions Regulations – Solutions Developed by MTU Friedrichshafen":

Between 2011 and 2015, maximum permissible exhaust gas emission levels for off-highway engines will be significantly lowered both in Europe and the US. Depending on the type of application and performance ranges, legislation is extremely heterogeneous. Therefore, engine manufacturers must adopt different approaches to emission reductions in the individual markets, in order to be able to offer optimum solutions in terms of fuel efficiency and CO_2 emissions.

⓭ Dr. Weber, Daimler

The lecturer described technological concepts for complying with existing and future emission regulations through which MTU-Friedrichshafen will adapt its current engine series to future legislation. The base engines will be upgraded in order to be able to withstand high ignition and injection pressures. Cooled exhaust gas recirculation, the Miller process and controlled two-stage turbo-charging are already in the pipeline. In individual cases, SCR technology and particulate traps will also be employed. The interactions between the subsystems will be optimised by means of new management methods. The lecturer presented and discussed solutions for selected applications.

Dipl.-Ing. C. Enderle (lecturer), **Dipl.-Ing. R. Binz, Dipl.-Ing. M. Paule, Dipl.-Ing. A. Mackensen, Dipl.-Ing. B. Lindemann**, Daimler AG, Stuttgart: "Challenges for the Next Generation of BlueTEC Emission Technology":

Mercedes-Benz BlueTEC vehicles have been leading in the application of clean diesel technologies since 2006. The SCR technology, of course, meets the most stringent exhaust gas emission standards in international markets, such as the US, Europe and Japan. Diesel engines with BlueTEC technology keep emissions at the lowest possible level while offering benefits with regard to CO_2 emissions and at the same time high torque and driving performance typical of diesel engines. For the further evolution of the BlueTEC technology, the focus is on the following challenges:

- lower costs for development and applications
- standardisation and cost savings for SCR components
- improving performance by a further reduction of emissions (i.e. SULEV) while lowering further the temperature of exhaust gases in CO_2 optimised vehicles
- extension of the BlueTEC technology by using complementary emission components and combining the BlueTEC technology with additional CO_2-reducing technologies, such as, for example, hybrids.

Dipl.-Ing. S. Pritze (lecturer), **Dipl.-Ing. A. Königstein**, Adam Opel GmbH, Rüsselsheim; **A. Rayl, M.S.E.E., C.-F. Chang, Ph. D.M.E., P. M. Najt, M.S.M.E., Prof. Dr.-Ing. U. D. Grebe**, General Motors LLC, Warren / Pontiac, USA: "GM's HCCI – In-Vehicle Experience with a Future Combustion System":

General Motors (GM)'s "Homogeneous Charge Compression Ignition" (HCCI) stands for the auto-ignition of a homogeneous air-fuel mixture in a gasoline engine. HCCI permits unthrottled operation under part load which has a high potential for the reduction of fuel consumption and assures, at the same time, minimum NO_x emission levels even with lean mixtures. If a conventional exhaust gas aftertreatment method is applied, all fuel grades available worldwide can be used.

Essential prerequisites for the application in vehicles are the need to use a large steady state map from very low engine loads to idling and an outstanding transient behaviour with regard to combustion stability and responsiveness. The prerequisites to achieve this were created on the basis of spray-guided gasoline direct injection with a strategy for controlling residual gas by trapping and compressing it in the combustion chamber and using pressure sensors for each cylinder. The lecturer highlighted the most important characteristics of the new combustion process.

The application of this method in vehicles has set new standards with regard to engine management systems and the complexity of control algorithms. As the combustion process, which is highly sensitive to external parameters, can be controlled only indirectly, robust transitions from one operating mode to another have proved extremely challenging.

PLENARY CLOSING SESSION: A VIEW INTO THE FUTURE

Dr. G. Pachta-Reyhofen, ⓫, CEO, MAN SE, Munich: "Growth in Changing Demands: From an Engine and Turbine Manufacturer to a Systems Provider – The Example of MAN Diesel & Turbo":

With its 250-year history, the MAN Group looks back on one of the longest traditions among Germany's leading companies, and its past and present innovations make it an important part of indus-

Mrs. Lenz, Mrs. Piech and Prof. Piech as interested participants in the closing section

trial history. In the recent past, in particular, major changes have occurred both in the Group's structure and in its strategic alignment.

The lecturer sketched the recent history of the MAN Group by outlining the evolution of the two Group affiliates Diesel and Turbo as examples. These two divisions realised there were changes in demand and responded to market requirements. Whereas a few years ago MAN Diesel offered its customers only diesel engines and related components, this company has now established itself as a supplier of complex systems. One of its core competences in the marine engineering segment is the design and development of complete propulsion systems including exhaust gas aftertreatment. In the power plant segment, turn-key power plant projects as well as operation and maintenance contracts today generate a significantly higher sales volume and thus help the company to better cope with the current economic crisis and to assure its competitiveness in the future.

The merger between MAN Diesel and MAN Turbo, the lecturer explained, added further dynamism to MAN's business activities. The two divisions offer complementary products and thus are able to present themselves as an integrated supplier of complete systems. Against the background of cyclical markets and changes in demand, MAN succeeded in transforming itself from a diversified manufacturer of components into a competent supplier of integrated systems by taking this step.

Dipl.-Ing. H. J. Wester, ⓬, Executive Vice President & CTO, Fiat Group S.p.A., Torino, CEO, Maserati S.p.A., Modena: "New Challenges for the World's Automotive Industry and its Consequences on the Powertrain Development":

Today road transport is probably facing the greatest challenge in its history: viable, sustainable measures must be defined and implemented in order to improve ecological and social conditions while, at the same time, safeguarding economic efficiency. Sustainability issues call into question the acceptability of currently available fossil fuels and the relevant technology. If mankind wishes to meet the targets for the reduction of greenhouse gas emissions and global warming for the coming decades, all conceivable approaches have to be analysed:

- a change in the types of energy used and thus also a shift to other energy sources (replacement of other fossil fuels)
- raising the share of carbon-neutral liquid fuels (blended with bio-fuels)
- reducing the energy required for vehicle operation
- improving the efficiency of the internal combustion engine.

Although the first option appears to be the most promising in the long term, especially with respect to electricity, it is not yet viable on a large scale in the short term, because of the technological and economic disadvantages of electric accumulators (batteries), which would be needed both for electric and plug-in hybrid vehicles.

The second option, the use of biofuels, does not seem to be the right solution to the problems of road traffic in the long run. Therefore, the lecturer pointed out,

Contented faces at the end of the Symposium, from left to right: Dr. Weber, Prof. Lenz, Dr. Pachta-Reyhofen, and Dipl.-Ing. Wester

it was expected that passenger car technology would continue to depend on the internal combustion engine for several decades to come. In the short and medium term, in particular, it would be necessary, in the speaker's opinion, to tap the existing large potential of the internal combustion engine. Priority would have to be given to minimising organic losses. In the long run, when the shift towards electric mobility will start in earnest, a holistic approach would be the most efficient option and would have to aim at involving all stakeholders in the search for solutions so that all dimensions of sustainability can be fully taken into account, the lecturer concluded.

Dr. T. Weber, ⓲, Member of the Board, Daimler AG, Stuttgart: "Shaping the Future of Individual Mobility":

The world is undergoing changes – and one of the most profound changes in everyday life lies ahead of us in the area of individual mobility: the transition from the internal combustion engine to the electric motor with zero local emissions, which is not only unavoidable in the long run but, in view of the need to protect the environment and make sparing use of the world's resources, is also highly desirable. This topic is intensively discussed in the general public and frequently the debate leads to a lot of controversies. Whereas some argue that the electric vehicle, for example, could play only a minor role, others are already predicting the death of the internal combustion engine.

Daimler is intensively and successfully working on the development of electric cars with battery and fuel cells as drive units. With the Smart fortwo electric drive and the B-Class F-CELL, the A-Class E-CELL car, which is another zero emission model, is to follow. However, a number of limitations persist in terms of smooth and comfortable operation. These limitations result, on the one hand, from the present lack of an adequate filling or charging station infrastructure and on the other hand from the extremely high costs due to small production runs. Therefore, one thing is certain: state-of-the-art diesel and gasoline engines will remain the driving force for vehicles – in individual traffic with passenger cars, especially for long distances, and even more so for freight-carrying trucks.

The following two lectures were intended as reserve or poster presentations:

Ass.Prof. Dipl.-Ing. Dr.techn. R. Kirchberger, Dipl.-Ing. Dr.techn. F. Winkler, Univ.-Prof. Dipl.-Ing. Dr.techn. H. Eichlseder, Graz University of Technology: "Are Loop Scavenged 2-Stroke Engines for Recreational Purposes able to Fulfil Future Emission Limits?":

The current state-of-the-art of two-stroke engines destined for two-wheel vehicles is based on mixture formation by means of a carburettor. This engine concept has a number of serious drawbacks with regard to torque curves and maximum power output when existing emission regulations have to be complied with.

On account of the more stringent emission limits for the year 2012 (Euro 4), which are currently being discussed as well as the additional proof of endurance, a change-over of the system to four-stroke engines or two-stroke engines with internal mixture formation appears indispensable in order to achieve a reduction of scavenging losses.

Because of high system cost, great complexity and large packaging space, the well-known high-pressure direct injection systems used in the automotive industry cannot be applied in small capacity engines. For this reason, a host of different systems and technologies was devised with a view to meeting the specific requirements of these engine versions. The paper contains a comparison of the different systems, thus giving an overview of their mode of operation, and the emission levels that can be attained.

Univ.-Prof. Dr. B. Geringer, Dipl.-Phys. S. Fischer, Assoc.Prof. Dr. P. Hofmann, Dr. T. Lauer, Dipl.-Ing.(FH) L. Möltner, Dipl.-Ing. B. Schneeweiss, Dipl.-Ing. P. Teiner, Vienna University of Technology: "New Approaches and Development Methods for Minimising NO_x-Emissions of Diesel Engines":

At the Institute for Powertrains and Automotive Technology (IFA) of the Vienna University of Technology various methods are being investigated that have the potential for achieving the required reductions:

: In selective catalytic reduction, an optimal preparation of ammonia in the exhaust system is the essential criterion for an efficient reduction of NO_x emissions. By means of state-of-the-art measuring methods, spray analyses are carried out using laser diffraction, wall cooling with infrared thermal imaging as well as spectroscopy to assess the uniformity of distribution. In parallel, the ammonia preparation was predicted by means of CFD simulations.

: The hybridisation of powertrains with diesel engines also offers promising options for avoiding NO_x raw emissions. At the IFA, specific hybrid operation strategies were conceived and optimised by means of flexible modular longitudinal dynamics simulation models. Subsequently, the results of the simulation were verified on a high-speed engine test bench in hardware in the loop environment.

Conference Documentation

All lectures presented at the 31st International Vienna Motor Symposiums are published in their in extenso version in the VDI-Fortschritt-Berichte, series 12, no. 716, volumes 1 and 2 (including a CD) and additional brochures. All documents can be obtained from the Austrian Society of Automotive Engineers (Österreichischer Verein für Kraftfahrzeugtechnik, ÖVK).

Invitation

The 32nd International Vienna Motor Symposium will take place on May 5 and 6, 2011 in the Congress Center Hofburg Vienna. We should like to extend a cordial invitation already at this point in time. After the announcement of the programme on the internet, which will probably be made around mid-December 2010, we urge you to apply in good time.

Contact

Austrian Society of Automotive Engineers (ÖVK)
A-1010 Vienna
Elisabethstrasse 26
Tel. + 43/1/5852741-0
Fax + 43/1/5852741-99
E-Mail: info@oevk.at
Homepage: www.oevk.at