» Volvo’s plug-in hybrid technology is the best solution for near-future mobility. «

Dr. Peter Mertens, Head of Research & Development, Volvo Car Corporation

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The future legal requirement to demonstrate emissions compliance in real driving conditions (RDE, real driving emissions) is presenting huge challenges to the automotive industry. This is because, given the theoretically infinite amount of driving situations, the conventional development methodology, which is primarily based on pre-defined test cycles, is reaching its limits. In future, development must take into account a variety of climatic conditions and driving situations, as well as different driver types.

AVL helps its customers to master this complex task by offering a broad scope of innovative products and services. The mobile measuring system M.O.V.E iS permits in-vehicle emission measurements with maximum precision. Along with geographic and vehicle-specific data, the measured values then become available for development on the chassis dyno, engine and powertrain testbed. With its virtual testbed XIL.STATION, AVL additionally provides a cutting-edge lab environment that allows model-based engine- and exhaust gas aftertreatment development with superior efficiency.

With these AVL solutions, we support our customers to meet the challenges posed by the Real Driving Emissions legislation in the best way possible.

Helmut List
» VOLVO’S PLUG-IN HYBRID TECHNOLOGY IS THE BEST SOLUTION FOR NEAR-FUTURE MOBILITY «

Interview with Dr. Peter Mertens, Head of Research & Development, Volvo Car Corporation
Dr. Mertens, please tell us about the technical innovations in the Volvo Drive-E Powertrain Family, which was introduced in 2013, and is being extended this year to include further performance levels, both in terms of enhanced fuel efficiency and superior performance.

Dr. Peter Mertens: After separating from Ford, Volvo had to replace all engines by ones of its own by 2015. This was a huge challenge, but also a great opportunity to refresh the entire engine range. We got the chance to question everything we had ever done before. We felt it was really important for us to create a good basis for the future. So we concentrated on the engine’s basic attributes like friction, combustion, charging, compactness, high power density and modularity. Back then, we made up our minds to limit displacement to 2 liters with four cylinders – an aspect that is also a key part of our brand strategy, focusing on environmental sustainability across all performance classes. This has resulted in an engine family with maximum similarities between gas and diesel engines and a level of efficiency that has reached new record highs.

All of our engines are charged and they are paired with highly efficient six- and eight-speed automatic or six-speed manual transmissions. In the case of the high-performance gasoline engines, we decided in favor of a combination of exhaust turbocharging and compressor charging. The higher performing diesel engines are twin-turbocharged. All diesel engines are additionally equipped with what we call i-art injection technology (cylinder-specific injection pressure control) with an injection pressure of 2500 bar.

The powertrain’s compact size allows my colleagues in design to create optimal vehicle proportions with smaller vehicle overhang and plenty of space. The new XC90, which is based on our new Scalable Product Architecture (SPA), speaks for itself. Further models underpinned by this platform will follow soon, and our customers are going to get very excited when they see the new language of design.

We completed the launch of the Volvo Drive-E Powertrain this year in May. For the first time in 40 years, all Volvo models are powered exclusively by Volvo engines. I’m extremely proud of this achievement. Practically all of the powertrain was developed in-house and has been receiving excellent reviews in the press.

Based on this engine, Volvo teamed up with AVL to develop a 450-bhp high-performance engine, producing 228 hp for every liter of engine displacement (168 kW/l). This is the highest liter output ever to be achieved by a four-cylinder engine. The project demonstrated that a four-cylinder engine could in fact achieve performance levels that were previously only believed possible with a V8 engine. Are you planning to pursue this high-performance concept, which also utilizes an electrically powered supercharger, any further?

Dr. Peter Mertens: The 450-bhp concept vehicle, developed in close cooperation with AVL, was a success all round. After unveiling it in Aachen, we gave several journalists a chance to take the vehicle for a spin. The feedback we got was breathtaking. With this concept, we’ve demonstrated what a four-cylinder engine is capable of. The triple boost – two parallel turbochargers and an electric 48-volt supercharger – produces spontaneity and sportiness, even at low engine speeds. We managed to close the turbo lag completely, so that the vehicle feels as if it were powered by a voluminous, naturally aspirated engine. Volvo was one of the first mass manufacturers to introduce turbo technology on petrol engines, and we are determined to continue this history. Is there any better way than with this concept?

With its V60 Plug-in Hybrid, Volvo was one of the very first to combine a hybrid drive with a diesel engine and an all-wheel drive system. Now, with the XC90 T8 Twin Engine, Volvo is presenting an all-new plug-in hybrid model. Could you tell us more about the technology in this vehicle?

Dr. Peter Mertens: The V60 Diesel Plug-in Hybrid is unique; our sales estimations were exceeded by far. To give you an impression, here are some of the specifications: 0–100 km/h in 6.1 s, 48 g/km CO₂ emissions or 1.8 l/100 km fuel consumption. The pure electric range is 50 km.

For our performance-oriented customers, the new XC90’s efficient
four-cylinder powertrain is combined with our plug-in hybrid technology. The T8 Twin Engine has a 46-hp (34 kW) crankshaft mounted integrated Starter Generator (CISG); an 87-hp (64 kW) electric motor on the rear axle and 240 Nm of torque. The total system output is 407 hp with 640 Nm of torque with only 49 g of CO₂ emissions per kilometer. With a capacity of more than 9 kWh, the 96-cell lithium-ion battery installed inside the vehicle tunnel achieves a range of 43 km on electricity alone.

The new XC90 combines several vehicles all rolled into one. The main driving modes are ‘Pure,’ ‘Hybrid’ and ‘Power.’ ‘Pure’ allows largely electric driving at speeds up to around 130 km/h. The ‘Hybrid’ mode combines dynamic driving with optimum fuel consumption. In the ‘Power’ mode, the entire powertrain is optimized to top performance – a fully-fledged substitute for the V8.

-F: What is your view on the future of all-electric vehicles over the next years? What technical breakthrough could help to make the electric drive more widely accepted?

-Dr. Peter Mertens: For some markets – particularly ones with a high population density – the all-electric vehicle is becoming more and more relevant. However, the ranges, the time needed for charging and the costs will continue to limit its acceptance. Already today, good ranges can be achieved with small, light vehicles (e.g. with the Volvo C30 Electric), but customer acceptance remains limited due to the high purchase price. From a current point of view, the Volvo plug-in hybrid technology with high electric range is the best solution for the mobility of the near future. Regarding technical breakthroughs, the battery costs have already started to fall, but a technical breakthrough is needed in the power density. The costs of the overall system need to decline further to reach customer acceptance, and that without receiving subsidies.

-F: Europe is an automotive market which is heavily dominated by the diesel engine. How would you view the future of the diesel engine against the backdrop of the increasingly rigorous emission limits? Can the diesel engine help to meet the fleet CO₂ emission limits required by the EU? And will Volvo still be offering a model with diesel hybrid drive in the future?

-Dr. Peter Mertens: The more stringent exhaust emission limits are leading to increased cost pressure on diesel-powered engines. Moreover, the gasoline engine is rapidly approaching the specific fuel consumption figures of compression-ignition engines, primarily due to downsizing and downspeeding. But, obviously, development efforts focusing on the diesel engine have not come to a standstill either. The proportion of diesel engines in our European sales is high, and we expect them to remain so for the next 20 years. Volvo’s Drive-E diesel powertrain is contributing substantially to reaching the average fleet CO₂ emission levels, and I’m excited to see the way my engineers are already working on solutions for the 95 g CO₂ limit.

We want the plug-in hybrid development – following the successful V60 plug-in hybrid electric vehicle (PHEV), the XC90 Twin Engine model – to be a global solution for our most important markets China, Europe and the U.S. That’s why we decided in favor of the gasoline-powered PHEV. Our next step will be to develop an affordable hybrid concept for the mass market. Our modular systems also allow us to represent a PHEV with our diesel powertrain in a very short time, but it is essential that the sales figures and investments are properly balanced.

-F: As part of its ‘Towards Zero’ mission, Volvo is constantly working on the continued reduction of consumption and CO₂ emissions. What technical powertrain measures play a key role in this process?

-Dr. Peter Mertens: With the Drive-E powertrain, we already have the perfect basis for further reductions in CO₂. Our engines and transmissions today are regarded as benchmarks – and we want them to stay that way! Aside from further improvements to friction, injection
pressure and combustion, new features are to be expected in exhaust gas recirculation, charging, as well as other measures to ensure engine operation at the ideal load point, for example cylinder cut-off. We already know now that Volvo is going to be one of the few automative manufacturers to meet the 95 g CO₂ limit – even without the help of powertrain electrification.

-F: With ‘Volvo on Call,’ Volvo has implemented a modern onboard communication system for emergency calls and a host of comfort features. Could you tell us some more about ‘Volvo on Call’ and what plans you have for the future in this respect, also in connection with smartphones?

-Dr. Peter Mertens: Volvo has been successful on the market with ‘Volvo on Call’ since the early noughties. By 2010, we’d already implemented the handling of comfort functions, e.g. programming the parking heater via smartphone apps – a feature offered today on all of the common platforms. Nowadays the service is extremely popular and, thanks to our almost global availability, we are seeing two-digit take rates – some markets have even integrated the system into their basic services. In addition to safety features like eCall, emergency assistance or stolen vehicle tracking, customers today can either contact the call center or, as I mentioned earlier, conveniently use their smartphone app to locate, lock, unlock the vehicle, get information about its location, condition, range or similar, run an electronic driving journal or, as I already said, air-conditioning and (since 2014) cool the vehicle. The offered features have meanwhile been extended to include Volvo Connectivity (multimedia) and Connected Navigation, providing customers with services like internet radio, on-demand music, online weather, travel information, Send-to-Car (destination found on phone is sent to navigation system), etc.

We are exceptionally proud of our park-and-pay service, an advanced mobility concept that helps customers find suitable parking and pay for it automatically from their car. Connected-Service-Booking is the first step in integrating dealership workshop processes in our services. We tell our customers when it’s time to have their car serviced. The system can even suggest appointments at the local dealership. In the case of an emergency, it’s possible to read the vehicle’s error memory remotely and initiate the most suitable and cost-effective support measures.

-F: Safety has traditionally been one of Volvo’s core values. Volvo’s ‘Vision 2020’ initiative states that by 2020 no one will be killed or critically injured in a new Volvo car. What are the technical means by which you want to achieve this goal? And what role does the vehicle’s connectivity to other vehicles have in this respect?

-Dr. Peter Mertens: Volvo has been studying accidents and accident causes for many decades. Drawing on this knowledge, we have identified various types of collisions. For instance, accidents at intersections or ones in which the driver departs from the road. Knowing this helps us get closer to our vision.
In our effort to prevent accidents, we’ll continue to improve our passive safety technologies and protection against accidental road departure. An excellent example for this is our new Volvo XC90.

Active safety, however, shows the greatest potential for achieving our vision, i.e. to help drivers to avoid collisions. Volvo uses radar, camera and communication technologies to monitor the vehicle in road traffic, assisting the driver with information, warnings and automatic intervention. To make sure that this technology helps to avoid accidents to the greatest extent possible, we decided to integrate the entire suite of safety features into the standard safety package of the new Volvo XC90. This standard safety package is totally unique in the automotive industry and illustrates clearly that we are bent on getting closer to our vision.

Car-to-car communication is employed in addition to the vehicle sensors to obtain information about traffic and road conditions beyond the driver’s visual range, or about features that are difficult to measure. For example, we are conducting a large-scale test on road conditions; 1000 vehicles are collecting information about slippery road surfaces (position and type), which can then be shared with other vehicles using our ‘Volvo cloud’.

F: Right now everyone is talking about 'piloted driving.' How do you see partially autonomous and autonomous driving in the near future? And do you think it will only be used in special driving situations, e.g. stop-and-go traffic, or universally, i.e. anytime and anywhere?

Dr. Peter Mertens was born in Germany in 1961 and has been interested in cars since he was a young boy. Following an apprenticeship as a toolmaker he completed a Master’s degree in Industrial Engineering and Operations Research at the Virginia Polytechnic Institute in the US in 1985. He later went on to complete his doctorate in Production Engineering and Industrial Engineering at the University of Kaiserslautern.

Peter Mertens started his career in the automotive industry in 1990. He has since had broad experience in different countries in Europe, as well as the USA and Asia. He also has experience across a wide variety of roles including product development and aftersales engineering at Mercedes Benz. More recently he held the position of Global Vehicle Line Executive at General Motors. In 2010 he was responsible for Jaguar Land Rover’s quality and safety performance globally. He reported directly to Jaguar Land Rover Chief Executive Officer, Dr. Ralf Speth.

Since April 1, 2011 Dr. Peter Mertens has been Senior Vice President, Head of Research & Development, of the Volvo Car Corporation.

Dr. Peter Mertens is married and he has three children.
Dr. Peter Mertens: In theory, autonomous driving has huge potential to make traffic safer, more environmentally friendly and more efficient. Apart from that, an autonomous vehicle gives drivers time to do other things. Our research is focusing on how to derive the maximum potential from this technology in practice.

It is our objective to put 100 self-driving vehicles on the road in the City of Gothenburg in 2017, as part of the ‘Drive Me’ project. With this project, we are collecting valuable insights with regard to technology and customer acceptance. We’ll also be getting a chance to analyze legal issues. These autonomous vehicles are designed for normal Volvo customers, travelling on selected roads typical of daily commuter routes with stop-and-go traffic.

This is a first significant step that brings us closer to highly automated real driving, but I expect that it will be a long time before this is possible in all markets and on all types of roads. Our priority, to begin with, is therefore to focus on automatizing unattractive driving situations, e.g. parking or stop-and-go traffic. Already today, the new Volvo XC90 features semi-autonomous functions such as the pilot assistant or the parking assistant. This range of features is undergoing constant further development and is available in other vehicles as well.

Pioneering Demonstration vehicle with pure electric drive: Volvo C30 electric.

"F:" Emotion plays a key role when buying a car. Do you think it will remain this way in the future? And how are you going to offer Volvo drivers a good portion of driving enjoyment in your models, despite all the demands on efficiency and environmental considerations.

Dr. Peter Mertens: Purchasing a vehicle will always be an emotional experience, particularly in the vehicle segments Volvo caters to. We have demonstrated that there is no contradiction between environmental sustainability and driving pleasure. In this respect, charging, which is one of Volvo’s core competencies, is the key technology. The consistent implementation of the SPA platform combined with our highly efficient and agile Drive-E powertrain have given engineers a great amount of freedom of design. This allows us to put extremely attractive and spacious vehicles on the road. Paired with our leadership in active and passive safety technologies, we offer a line-up that is hard to resist. Arrange a test drive to convince yourself of our new XC90.
AFFORDABLE CO₂ REDUCTION WITH BALANCED DRIVING PLEASURE

Measures to reduce CO₂ emissions are often believed to come at the expense of driving enjoyment and the agility that drivers expect from their vehicles. This conflict of objectives, however, is resolved by regarding the vehicle in its entirety. For this to be achieved, a substantial number of vehicle attributes need to be optimized in parallel, starting with the powertrain. AVL offers its customers an interlinked development solution, permitting the simulation and objective assessment of several driving attributes at the same time using AVL DRIVE and VSM. By employing these tools, an ideal balance is achieved very efficiently between reduced CO₂ emissions and an enjoyable driving experience.
Today, the CO₂ optimization process must consider the complete vehicle together with a variety of different systems. Peter Schöggl, Head of Business Field Racing and Vehicle, explains the situation: “There’s one program for simulating CO₂ emissions, another one for calculating the exhaust gas emissions, a third deals with certain driving characteristics and a fourth, for example, that focuses on noise, vibration and harshness (NVH). Each simulation seeks its own optimum, but without directly taking into account the way they impact each other. But it is in fact these interactions that are critical for the vehicle’s character – the brand’s DNA. With our approach, we combine multiple driving characteristics into a single system, which allows us to deliver better answers to our customers in a shorter period of time.”

AVL can simulate and optimize several driving attributes in the context of its balanced CO₂ optimization procedure: performance, CO₂, fuel consumption, dynamics/agility, costs, drivability, driving comfort, handling and emissions.

If a manufacturer intends to lower the CO₂ emissions in its existing fleet, the process starts with an in-depth analysis of the individual models. “For measuring and assessing the mentioned attributes in the context of the AVL Global Benchmarking Program, we are provided with a globally unique tool,” explains Erich Ramschak, Lead Engineer, Vehicle Drivability and Simulation Vehicle. “The assessment of the mentioned driving attributes using AVL DRIVE 4.0 is underpinned by a vast variety of individual sub-criteria and physical parameters for further detailed analysis.” The benchmarking process results in a data package, consisting of physical measuring quantities, as well as subjective driving ratings, objectively evaluated with AVL DRIVE. With around 150 vehicles being tested, analyzed and rated each year based on this method, as part of the AVL Global Benchmarking Program, AVL is able to show how these ratings compare to the competition.

AVL offers a networked development solution, permitting the simulation and evaluation of several driving attributes at the same time using the AVL tools DRIVE 4.0 and Vehicle Simulation Model (VSM).
Irrespective of benchmarking, the vehicle has to be represented as a model in the early phase of its development, so it can be tested in a vehicle simulation model system like AVL VSM with regard to the objectives. The data for this model may stem from various sources: from the manufacturer, from measurements made by AVL or from data provided by a supplier.

The process begins by developing a catalog of technical measures together with the customer. This includes a definition of the parameter bandwidth of possible changes made to the vehicle and is usually a combination of suggestions made by AVL experts and supplied by the customer, based on the model policy and technical boundary conditions. This jointly achieved selection results in a set of measures concerning the powertrain system, the chassis and the complete vehicle, which are then simulated and assessed in all variants deploying AVL VSM.

In the course of the simulation, individual components, e.g. turbochargers, transmission, tires, etc., as well as the final drive ratio or the axle geometry, are varied. With regard to the engine, for example, one might decide to reduce the number of cylinders, apply the Miller cycle or vary the valve train. Even a demand-controlled oil and water pump may offer savings potential. “The electrification of the powertrain can lower CO₂ emissions even further. AVL offers a broad scope of systems ranging from 12/48 volt to mild and full-hybrid propulsion and even all-electric drive systems,” Peter Schöggel explains. But it is not only the powertrain components that can be “virtually” replaced. Even the way the transmission is calibrated can be modified in order to change the gear-shifting points and optimize the engine’s load range. Equally, the vehicle’s aerodynamics, which are strongly influenced by factors such as the use of underbody covers or the engine compartment airflow, can be optimized. Further areas are thermal management including heating and cooling and the vehicle mass – from weight reduction at the component level to light-weight material substitutions at the body and doors or closures respectively. Peter Schöggel: “Every single vehicle variant (virtually) completes not only the NEDC/WLTC cycle, but also, for example, a special ride-comfort test course. This means that we not only get to see which variant delivers the best result in terms of CO₂ emissions, but also which variant does best when it comes to dynamics or agility.”

Despite powerful cloud computing capabilities and the use of sophisticated algorithms, a simulation of this kind that might involve the
calculation of several tens of thousands of variants takes several days. “However the simulation algorithms are defined in such a way that only meaningful combinations of measures are simulated and assessed. If the lists of measures are very long, DoE approaches might be applied too,” points out Erich Ramschak, Lead Engineer Simulation.

**IDEALLY BALANCED SELECTION**

Upon completion of the simulation, it is necessary to choose variants, which meet the defined specifications by achieving an ideal balance of costs, CO₂ emissions, fuel consumption, longitudinal, lateral and vertical vehicle dynamic attributes. The method applied by AVL has the advantage that the large number of analyzed variants offers greater solution ranges, giving a much more precise representation of the balanced behavior. “With this selection procedure, AVL supports the OEM-specific targets definition for driving attributes including the detailed description of the technical measures that lead to the achievement of the goal,” Ramschak says.

After the vehicle targets have been agreed, including the catalog of technical measures, the optimization concept is confirmed by means of simulations or prototype vehicles. And even here, AVL is able to deliver a valuable contribution – starting with the test of individual components on the test bed and the setup of prototype hardware with a focus on the powertrain system to the verification of CO₂ reduction goals and driving attributes in the course of tests with AVL DRIVE 4.0.

“Once the concept is confirmed, the OEM creates the requirement specifications for the complete vehicle including the defined technical measures. This might be done in the course of model year updates or in the case of new vehicle variants. In particular, AVL can carry out the full integration of powertrain systems; SOP (start-of-production) projects that concern other systems at the vehicle can be implemented by AVL in cooperation with partners,” Peter Schöggl explains.

**CO₂ OPTIMIZATION WITH BALANCED DRIVING ATTRIBUTES**

All in all, the CO₂ optimization method offered by AVL along with the employed tools AVL VSM and DRIVE 4.0, offer a vast number of benefits. The optimization may take place in a pure simulation environment, but also on advanced test beds or in the vehicle itself – a fact that allows assessing the effects of CO₂ reduction measures on driving-related attributes at a very early development stage. By achieving an ideal balance of CO₂ measures, it becomes possible to develop energetically optimized and affordable vehicles which still deliver a large amount of driving pleasure.
BALANCED VEHICLE ATTRIBUTES

Interview with Uwe Dieter Grebe, Executive Vice President for Global Business Development, Sales & International Operations, Powertrain Systems

AVL’s core area of expertise is powertrain development. With regard to CO₂ optimization, however, AVL is expanding its range of activities to include attributes of the entire vehicle. What’s the reason for this move?

Uwe Dieter Grebe: The main reason is that a substantial number of CO₂ reduction measures have cross-effects on other vehicle attributes – from performance to comfort aspects and even noise and sound. But these are the very features that greatly influence purchase decisions. So AVL’s optimization task is to lower CO₂ while at the same time making sure to meet, if not exceed, the end-customer’s requirements. This goal can only be achieved by taking an integrated approach to the vehicle.

What are the areas of expertise that make AVL the perfect engineering partner of an OEM when it comes to this comprehensive optimization task?

Uwe Dieter Grebe: Based on AVL’s core capabilities in the field of powertrain engineering, we benefit from our extensive understanding of the system and state-of-the-art tool chain that covers everything from simulation to objective assessment and the optimization of driving attributes. We are already capable of optimally representing the effects of individual components on the complete vehicle in the early design stage, which allows us to define the vehicle’s operating strategy very effectively. In the subsequent development process, i.e. the calibration, we then fine-tune the components and the way they are controlled.

One thing to keep in mind is that the majority of the work we do for our customers contributes directly toward the series product’s development and design.

F: The goal is what you refer to as ‘balanced CO₂ optimization.’ What does that mean exactly?

Uwe Dieter Grebe: The balance must be achieved between CO₂ reduction, the positive perception of the driving characteristics and the costs. In other words, the goal of our optimization efforts is an affordable vehicle with low CO₂ emissions that is still attractive to customers on account of its driving features – and it’s exactly this balance between efficiency and driving enjoyment that we want to achieve.

F: In what way does this procedure help to refine an automotive manufacturer’s branding?

Uwe Dieter Grebe: A brand profile is, of course, something manufacturers define for themselves. But AVL can provide support. Together with the OEM we can design a vehicle’s attributes by making sure that they perfectly match the brand character. An important contribution in this respect is our Vehicle Benchmarking Program, which we use to assess these features and compare them with the competition. This knowledge helps us to calibrate the vehicle attributes so that they perfectly reflect the brand’s DNA and the OEM’s specifications.
NEW TECH CENTER IN STUTTGART

AVL List GmbH will be putting a new test and engineering center into operation in Bietigheim-Bissingen near Stuttgart in early 2016. The new test and engineering center, which is to cover an area of 20,000 sq. m, will be available to the entire automotive industry and set new standards for innovative technologies, plant availability and confidentiality.

CEO Helmut List: “With the AVL Tech Center in Stuttgart, we have set ourselves the aim of erecting a test and engineering center that will meet the most advanced equipment and efficiency standards. Our decision takes account of the fact that Stuttgart is a key center of the automotive industry. The Tech Center will incorporate AVL expertise from Graz.”

GROUND-BREAKING CEREMONY IN JAPAN

In Japan the construction of a new Tech Center in Shinkawasaki, close to the AVL Japan Headquarter in Kawasaki, started recently. Members of the AVL Top-Management visited the site to celebrate the construction kick-off with AVL Japan president Naoki Okada in a traditional “Jichin-sai” ground-breaking ceremony. The project is planned to be completed by the end of October 2016.

SECOND TEST- AND ENGINEERING CENTER IN CHINA OPENS

In early June the second AVL Tech Center in Tianjin was opened. The AVL Tianjin Technical Center will reinforce AVL’s ability to respond to the needs of the Chinese market and further expand its local capabilities. In its final stage of expansion, the technical center, situated in the north of China, will accommodate as many as 25 engine, transmission, powertrain and hybrid testbeds. Already, on completion of the first construction stage, involving an investment volume amounting to EUR 20 million, a vehicle chassis dyno, a powertrain testbed and other test systems are scheduled to go into operation. The 12,000 square meter AVL site is located in Tianjin’s Technological Economic Development Area (TEDA).

NEW FACILITY IN INDIA INAUGURATED

In March 2015, CEO Helmut List and Shashi Singh, Managing Director AVL India, inaugurated the new expanded facility at AVL India Technical Center in Gurgaon. AVL has added a new floor at the existing facility, which will house AVL India Software in addition to the existing operations of AVL India Technical Center.
EFFICIENT RDE DEVELOPMENT ON THE TESTBED

Shifting RDE development from an on-road testing environment to various laboratory settings – from chassis dynamometers to powertrain and engine testbeds and even completely virtual development environments – can contribute substantially toward saving time and costs when performing emission optimizations in view of real-world driving situations (real driving emissions, RDE) – despite the rapidly growing complexity of the development task.

AVL has developed a methodology that allows replicating a road test on the chassis dynamometer with a very good correlation.
Emissions compliance for passenger cars and light-duty vehicles under real-world driving conditions, required by the EURO 6c standards for type approval and in-service conformity testing, will be phased in gradually from September 2017 and is posing a major challenge to OEMs. The vehicle has to be optimized to ensure emissions compliance not only over the entire operating range, but also for a host of different driving and traffic situations. Testing will additionally take into account various climatic conditions and the impact of different driver types – from the anticipatory to the decidedly sporty driver. Given these extended requirements, the conventional development methodology, which is primarily based on completing predefined and therefore known test cycles, is reaching its limits and needs to be adapted to face up to the RDE challenge.

**THE PIONEERING ROLE OF COMMERCIAL VEHICLES**

AVL’s competitive edge, when it comes to RDE development, stems from its extensive experience in the field of commercial vehicles. “When demonstrating emissions compliance in real-world driving, trucks have had a pioneering role for example due to the heavy-duty EURO VI emission standards that have been in place for some time,” says Johannes F. Kregar, Application Manager, Engine Test Systems. “For example, the type approval tests for trucks on the engine testbed already address a much wider range of the engine map than, for example, the NEDC cycles do for passenger cars. Apart from that, in the course of a complementary steady-state test, the WNTE (world-harmonized not-to-exceed) limits are already being assessed in the testing lab under extreme ambient temperature and atmospheric pressure conditions (up to an altitude of 1700 m).” Also, the periodic testing of emissions compliance over the entire market service life has already been required for the in-service conformity testing of commercial vehicles since the EURO VI was introduced. All of these measurements and tests have been successfully carried out by AVL for customers in the HD vehicle sector for quite some time.

| RDE development: the use-cases “Reproduction and Analysis”, “RDE-Reference cycles” and “Virtual Integration” are playing the key roles. |

**BRINGING THE ROAD TO THE RIG**

A fundamental focus in RDE development for passenger cars is on shifting the on-road testing environment to the different test systems in order to raise the tests’ efficiency and reproducibility. Before bringing what is referred to as a “RDE lap” from the road to the testbed, it is first necessary to record the data in the vehicle during the real-world test drive. This is done with M.O.V.E is, AVL’s mobile emission measuring system, which is capable of measuring gaseous emission components (NO/NO₂ and CO/CO₂) as well as particle numbers. “Owing to their high quality, measurements performed with the M.O.V.E is system exhibit excellent comparability...”
With high-end simulation systems, all kinds of road profiles – either generated synthetically or recorded using M.O.V.E IS – as well as a variety of maneuver-based driving situations can be reproduced on the testbed.

with the reference emission measuring technology on the testbed,” Roland Wanker, Global Business Segment Manager of Vehicle Testing Systems, explains.

In addition to emission measurements, M.O.V.E also captures geographic and climate-related data, as well as precise information about each driving situation during the test drive. All of the measured data can then be stored in a structured manner and subjected to detailed analysis and statistical evaluation using the CONCERTO M.O.V.E tool. In future, the analysis of such data will be of great value for the development of new vehicles, because the statistical evaluation of all data quantities will allow predictions to be made on the exhaust emission behavior of an engine family in a certain vehicle type. With its virtual XIL.STATION testbed, AVL offers a further ideal development environment, on which model-based RDE development for the engine and the exhaust gas aftertreatment system can be carried out efficiently and cost-effectively.

REPRODUCING TEST DRIVES ON THE TESTBED

For a road test to be reproduced on a “real” testbed, the data recorded on-road using M.O.V.E are first converted so that they can be subsequently transferred to the testbed automation system. Johannes F. Kregar: “Basically it is all about getting an RDE-representative test drive to the testbed, while obviously having to concentrate on RDE-relevant driving conditions. An example of such an RDE-critical driving situation would be a downhill drive, during which the exhaust gas aftertreatment system cools down, worsening the vehicle’s emission behavior.”

With AVL chassis dynamometers, test drives like these can be reproduced very efficiently. “AVL has developed a methodology that allows replicating a road test on the chassis dynamometer with a very good correlation,” explains Tom Dein Dias Terra, Product Manager, Chassis Dynamometer Test Systems. “This is achieved by applying a special control algorithm and
by ‘automating’ the unit under test. So after a road measurement with M.O.V.E, it is possible to operate the vehicle on the chassis dynamometer in exactly the same map point in order to take advantage of the advanced analysis options offered by the testbed environment.” This methodology will be available for the chassis dynamometer automation system PUMA Open Vehicle Testing in 2016.

Alongside the reproduction of test drives, RDE reference cycles play a major role in RDE development on the testbed too. Such cycles are very close to real-world vehicle use. According to the experts, these reference cycles that were either developed by the OEM, created in the context of studies or recorded using M.O.V.E can be employed on all of AVL’s test systems, including chassis dynamometers, powertrain or even engine test beds. A key part of these reference cycles, compared to the previous drive cycles (e.g. NEDC), is the fact that road and environment-related information is taken into account to make the simulation of the drive cycles in the respective testing environment as close to reality as possible.

**COMBINED DEVELOPMENT ENVIRONMENT: SIMULATION TESTBED**

If the vehicle is to be operated on a testbed within a virtual environment, AVL InMotion is put to use, which is a highly advanced, maneuver-based simulation system. “A typical application case would be a powertrain including all of its control units mounted on the testbed,” explains Johannes F. Kregar. “We are provided with a huge portfolio of methodologies and simulation solutions. The high-end simulation system InMotion is capable of reproducing all kinds of road profiles – either generated synthetically or recorded using M.O.V.E iS – on the testbed, as well as a variety of maneuver-based driving situations.”

**CONSISTENT AVL RDE DEVELOPMENT TOOL CHAIN**

Thanks to AVL’s state-of-the-art tool chain that includes measuring equipment, simulation and the most advanced test systems, it can be ensured that all mechanisms of an RDE road test are reproduced as realistically as possible on the testbed. The consistent AVL tool chain has the advantage of allowing the test run on the testbed to be evaluated in exactly the same way as the test drive is on the road. Roland Wanker sums up his thoughts on RDE development: “The key to success is to ensure efficient optimization across all development environments. Given the loss of unambiguous reproducibility and the extended requirements, RDE makes it necessary to adapt the development process. The key elements to focus on in this respect are increased model-based development on the virtual testbed, highly-automated, tool-aided test runs on the various testbeds and the industrialization of the ‘on-road test environment’ for the growing number of RDE test drives and type approval tests. For all of these areas, AVL offers highly advanced solutions and products that help our customers to master the challenges which RDE entails in the best possible way.”

AVL M.O.V.E iS is a mobile emission measuring system, which is capable of measuring gaseous emission components (NO/NO₂ and CO/CO₂) as well as particle numbers.
AVL has been known for its outstanding calibration capabilities for a very long time. Aside from conventional powertrains, the experts at AVL are increasingly also carrying out calibrations on electrified drive solutions. “Lately, there has been a sharp rise in the demand from OEMs, and not just for calibration services on electrified drive systems, but also for outsourcing entire electrification projects. The reasons for this are that manufacturers are setting new priorities in their development departments, or that they simply lack the human resources for electrification projects,” explains Gerhard Kokalj, Manager of Transmission and Hybrid Calibration.

EFFICIENT CALIBRATION OF ELECTRIFIED DRIVE SYSTEMS

With a highly advanced tool chain based on the great expertise of its specialists, AVL performs the calibration of hybrid and electric vehicles with exceptional efficiency. The majority of the tasks can be performed offline and on the testbed.
The spectrum of electrification-related services AVL offers its customers is huge. Gerhard Kokalj: “In the context of overall development projects, the activities AVL is able to provide range from software and component development to hardware integration. We finish with the calibration work, but our specialists are involved in the project right from the start – which means from the moment the software functionality is specified.”

If a vehicle’s drive system hardware has already been decided upon, AVL will also exclusively take care of software development and calibration. “In cases where all drive system components are already physically available, we create the control software before we do the calibration,” the head of Hybrid Calibration explains. Should an existing drive architecture be adapted to a certain vehicle, this is done in the context of a variant calibration – a job which is also performed by AVL, both for conventional powertrains and hybrid drives.

DEFINING THE VEHICLE CHARACTER BY THE GEAR SHIFTING STRATEGY

To obtain an optimal calibration result, a clear definition of the vehicle’s character, i.e. the brand DNA, is needed. “This means that we have to implement the objectives the OEM has defined for its particular vehicle or its brand as precisely as we can in the course of the calibration. When it comes to defining the DNA, the gear shifting strategy is a key factor,” Gerhard Kokalj adds.

To make the gear shifting strategy objectively measurable, AVL has developed a new patented methodology (objectivized shift strategy analysis), which is currently exclusively being used by AVL in powertrain development. “By developing this methodology, we have managed to establish special criteria...”
that allow us to evaluate the characteristic shifting curves in view of their drivability. For example, we investigate whether the engine’s torque prior to downshifting is optimally utilized, or whether the gear shifting processes are working together smoothly. We then use these data to perform an objective assessment of the vehicle’s acceleration behavior, which plays a key role for its brand DNA,” points out Gerhard Kokalj.

One big advantage of this AVL methodology is that it can all be done offline, i.e. without a physical vehicle. The expert continues: “To be able to produce an objective evaluation of the gear-shifting strategy or the acceleration behavior, all we need are the relevant vehicle and powertrain data and the transmission’s characteristic shifting curves – and this applies for conventional and electrified drive systems alike. This novel AVL methodology, which demonstrates very clearly how the vehicle’s acceleration behavior and performance feels to the driver, is attracting great interest among our customers. It additionally allows us to compare different vehicles in view of their acceleration behavior.”

**AVL HYHAB METHODOLOGY**

After defining the vehicle DNA – and thus an essential goal for the subsequent calibration – the HyHab technique is put to use, a methodology developed by AVL. HyHab is a very efficient way to combine offline calibration with automated test bed runs. In an initial step, the simulation tool AVL CRUISE is deployed to create a model of the entire vehicle, and virtual tests are run to determine the underlying operating strategy. The resulting base data are then saved in the hybrid control unit (HCU) and the vehicle is tested on the powertrain test bed or chassis dynamometer. During the test, an event might be initiated automatically every eight seconds, for example. AVL DRIVE, another AVL tool, is then used to measure the effects on drivability. After that, the control unit parameters are optimized offline again, using the AVL CAMEO tool. In simple terms, CAMEO delivers suggestions to the calibration engineer, indicating which control unit parameters are best suited for achieving the goal. Drawing from the calibration engineers’ extensive expertise, the calibration is then completed for the respective vehicle. The validation finally takes place during test drives in a prototype vehicle.

All in all, AVL’s new methodology, which is employed both in hybrid and electric vehicles, offers a substantial number of advantages. By objectively assessing the acceleration behavior, i.e. the gear-shifting points, it is possible to define a vehicle’s DNA entirely offline, based on data. The goal of the subsequent calibration is to achieve this “target DNA.” In conjunction with the HyHab method, it is then possible to develop a vehicle in the course of the calibration process at AVL, which fully satisfies all of the customer’s specifications. Gerhard Kokalj: “With our tools, methods and processes, we can bring vehicles right up to serial production, fast and efficiently – irrespective of whether they have conventional or hybridized drives. The fact that fundamental development tasks are being shifted away from the vehicle toward the test bed and offline development environment plays a crucial role. The AVL methodology is naturally also suited for calibrating all-electric vehicles, but in my opinion, it will be a few years before they become more mainstream.”
AVL FIRE® 2015. EXCELLENCE MULTIPLIED.

AVL FIRE® is a well-established 3D Computational Fluid Dynamics (CFD) Software for simulating thermal fluid flows in internal combustion engines, engine and powertrain components, batteries and fuel cells.

► FIRE® 2015 features a number of novel capabilities in pre-processing, main program and post-processing, and will be the first FIRE® version to be integrated in the AVL Simulation Desktop (SDT). The Simulation Desktop is a new framework, offering a highly functional graphical user interface (GUI) and also providing a common project and data management system for all Advanced Simulation Technologies tools. This enables easy information sharing and supports interdisciplinary simulation tasks.

Significantly shorter model generation and execution times are the result, helping to investigate more design variants during the product development process more efficiently. The software’s user-friendliness and the high degree of automation also give a significantly larger number of people easy access to CFD.

COMING SOON

The first simulation desktop-integrated version of FIRE® will offer grid generation tools for the interactive generation of high-quality low cell-count grids and automated modelling of arbitrarily complex geometries.

Extended solver capabilities make it possible to set up multi-domain models. This is essential if classical fluid flow problems and heat transfer into adjacent structures need to be solved simultaneously.

The easy and fast assignment of material properties to individual domains with the help of the extensive AST Property Database is another highlight of the new FIRE® version.

Simulation results are assessed in the new AST Post-Processor, supporting interactive and template-based visualization and analysis of two- and three-dimensional calculation data. The post-processor also allows the creation of animations, movies and 3D PDFs, helping engineers to easily recognize and interpret the causes and effects of transient fluid flow phenomena. A built-in report generator offers creating application-specific documentation.

“AVL FIRE® 2015 brings us a huge step closer towards the seamless integration of CFD into the product creation process and opens up doors to exciting new possibilities,” Maik Suffa, Group Product Manager CFD in Advanced Simulation Technologies says, summing up the advantages of AVL FIRE® 2015.
To accomplish the driver-specific optimization of a race car, AVL RACING combines an integration test bed with a state-of-the-art driving simulator. It is this blend that makes it possible to incorporate the driver’s feedback into the optimization process and develop a vehicle that is tuned to perfection, both in view of energy management and drivability.

Matthias Dank, Global Business Segment Manager, AVL RACING, Instrumentation & Test Systems, the classic procedure is now being complemented by yet another element. “Today, we additionally test the complete powertrain, i.e. the entire vehicle on the integration testbed, which allows us to simulate driving on the racing track under conditions that are more representative of reality than ever. Apart from that, we get the feedback from the driver who’s driving the car virtually in a driving simulator. This blend of real vehicle on the integration test bed and driving simulator is a novel method for optimizing a race car to suit the needs and preferences of a specific driver.”

At this point, one may obviously ask why the race car, i.e. the
powertrain, is still physically on the testbed. Wouldn’t it be so much easier to simply create a mathematical model of the drive system (or vehicle) and feed the simulated data into the driving simulator to get the driver’s feedback? “Well, no, it wouldn’t,” explains Gerhard Schagerl, Manager of Racing Vehicle Powertrain at AVL RACING, “and there are two good reasons why this wouldn’t work. First of all, it’s a very time-consuming and complicated job to create an accurate model of the powertrain along with all of its control units. Secondly, having a real vehicle on the testbed is much closer to reality than using a model.”

**AVL COMPLETE-VEHICLE INTEGRATION TEST BED SUITED FOR FORMULA-1 RACING**

For a testbed to be able to reproduce the dynamics of a race car, it has to be capable of representing the high dynamics of a racing vehicle in terms of acceleration, rapid load changes, high torques and speeds. The complete-vehicle integration testbed at the AVL Powertrain Technology Center (PTC) was specifically designed to meet Formula-1 requirements. But according to Matthias Dank, it is capable of much more. “Any elements not physically present in the setup can be simulated – just as required by the specific testing task. This includes the entire aerodynamics and the contact between the road surface and the tires. Of course, specific characteristics and peculiarities of any individual racing circuit can be reproduced in high fidelity as well. If the vehicle isn’t being operated by the driver in the simulator, there is of course also a ‘virtual racing driver’ who drives independently, as well as the classic test automation system,” Matthias Dank explains.

**OPTIMIZING THE BRAKE-BY-WIRE SYSTEM**

Another new and patented feature of the AVL test system is that in electrified racing vehicles the entire braking system, consisting of the conventional hydraulic brake and the regenerative function, can be simulated and even tested as a real component. The reason for the growing significance of the vehicle brake is the electrification of the powertrain, which, to an increasing degree, is finding its way into the racing categories. In the case of the electrified powertrain, braking is performed to recover as much energy as possible for the drive unit. At the same time, there should be minimum impact on the subjectively perceived feel of braking. In series vehicles, this is a comfort-related issue, but in motorsport, which usually involves operating at the dynamic limits, it is a matter of drivability at the limit, which is crucial for racing drivers to achieve constantly good lap times. “Even if the battery is fully charged and temporarily unable to draw any more current, the braking sensation for the driver must be exactly the same as during a recovery process. To be able to fine-tune the control strategy (brake-by-wire) between the drive unit and the hydraulic brake, high repeatability is a major advantage – and that is exactly what our test bed delivers,” points out Gerhard Schagerl.
OVERALL ENERGY AND THERMAL MANAGEMENT

An integration test bed also allows you to optimize the race car’s entire energy management – both with regard to basic design and the specific racing track. A further benefit is that the vehicle can be operated without external engine conditioning. “The race car is operated with the very same cooling systems for engine, transmission, battery, e-motors and brakes which are also employed later on the racing track,” Gerhard Schagerl explains and continues: “As a result, these cooling circuits can be included in the optimization process, a factor which is of major significance. This is because the cooling system and, consequently, the aerodynamic efficiency is one of the fields where significant increases are expected to be obtained in the future. The critical question here is how little cooling my vehicle can make do with.” The highdynamic ventilation concept on the AVL testbed is capable of accelerating the cooling air stream to the vehicle to 360 km/h in a span of 5 seconds and decelerating down to 0 km/h within just 4 seconds. Apart from that, the air can be heated or cooled in order to simulate races in extreme climatic conditions.

H2iL – HARDWARE & HUMAN IN THE LOOP

Aside from optimizing the hardware, the control units are a further key focus in racing development. “The job of tuning the software to fit the different control units – engine, transmission, hybrid system and brake-by-wire – is extremely driver-specific,” says Gerhard Schagerl. “Specifically it is all about how the vehicle behaves, for example when accelerating out of the curve. This is because drivers have different preferences; some prefer a vehicle with a slight tendency to oversteer while others go for a more neutral vehicle or one that is more likely to understeer. So our goal is to provide a car that matches the drivers’ specific preferences – a car they can trust, and which allows them to drive at constantly high speeds.”

To be able to incorporate the driver’s feedback directly into the development process, AVL is provided with a state-of-the-art driving simulator that is operated in conjunction with the complete-vehicle testbed. “We call this combination ‘hardware & human in the loop’ (H2iL). This is because, in addition to the classic hardware-in-the-loop system (HiL), the system additionally includes the human factor (the racing driver), hence the term H2iL,” Matthias Dank explains.

The driving simulator allows drivers to do virtual laps in the cockpits they are familiar with. The cockpit’s operating elements installed on the moving simulator platform are connected to the real race car on the integration test bed. “This allows us to connect the two worlds as part of the integration and obtain the immediate feedback from the driver on any changes we make to the drive system or vehicle. Our development goal is to create a driving behavior which is predictable to the driver in each and every driving situation. For example, torque peaks have to be avoided whenever the e-motor is switched on. The brake-by-wire system has to be optimally tuned, too,” notes Gerhard Schagerl.

Any elements not physically present in the setup can be simulated – just as required by the specific testing task. This includes the entire aerodynamics and the contact between the road surface and the tires.
At the moment, electrified drive systems are being used in the Formula 1 and in the World Endurance Championship (WEC), but electrification is sure to be introduced to other racing series, too. “As a result, more and more teams will be interested in acquiring and operating this kind of complete-vehicle testing system. We offer this solution as a complete system, but it is also available in several configuration levels: from a two-machine powertrain testbed to a four-wheel drive integration test bed, like the one AVL can provide. If you already have a powerful test system, you might be interested in our special upgrade packages,” Matthias Dank points out.

EFFICIENT TESTING UNDER LABORATORY CONDITIONS

Summing up the advantages of the new AVL RACING “hardware & human in the loop” method, Matthias Dank says: “With our integration test bed and the driving simulator, we test the ‘complete race car system’ under laboratory conditions, which are as close as possible to reality. And in doing so we have the huge advantage of not only being able to influence many variable conditions, such as tire grip, track temperature or wind speed, in whichever way they are needed, but also to maintain them at a constant level. This makes the tests highly reproducible, and they can also be repeated very quickly too.” AVL Racing Powertrain expert Gerhard Schagerl adds: “The teams come to AVL because they know that they’ll be getting meaningful results within a short period of time. Our engineers support our customers with their expertise, covering everything from the test preparations and their execution to specific suggestions on how one could optimize the vehicle’s energy management or drivability, etc. This means that our customers benefit not only from our highly advanced tool chain, but also from AVL’s extensive racing expertise.”
The AVL E-STORAGE LV is a low-voltage variant from the successful E-STORAGE product family and an indispensable product for the development of future sustainable 48 V powertrains.

Over the course of the last 3 years AVL has been heavily involved in 48 V hybrid powertrain development programs. A 48 V system is an upcoming trend that allows significant CO₂ reduction through electric hybridization of the drive-train with an acceptable additional cost. A battery with a maximum voltage below a critical threshold of 60 V is combined with an e-motor that is used for regeneration of the kinetic energy and optimization of the usage of the IC engine.

Since 48 V still is a new technology area and performance characteristics of the key components (48 V BSG - and E-Storage emulator systems) vary across suppliers it is very important for AVL to gain knowledge about the behavior/characteristics of these components in order to support OEMs in component supplier assessment with an objective view on component performance “Until now we had to trust manufacturer data only”.

With the new product (AVL E-STORAGE LV) AVL SCHRICK is now able to carry out 48 V key component benchmarking and independent component characterization. In situations where the battery is not available or electrical power from an
existing battery system should be available in a reproducible way the new product can be used for emulation purposes and therefore supports vehicle development, in particular the commissioning phase. The commissioning time now can be significantly reduced since the battery in many cases is the most critical component in terms of timing (availability).

The AVL E-STORAGE LV Tester is an indispensable product for the development of future sustainable 48 V powertrains and optimized for testing of low-voltage micro and mild hybrids.

The E-STORAGE LV is a low-voltage variant from the successful E-STORAGE product family that is optimized for the characterization and verification of electric driveline components in the automotive, marine, aviation and stationary power industry. The system is based on an advanced grid connected regenerative DC power supply that can be easily adapted to meet customer-specific requirements in testbeds and in dedicated laboratories.

Thanks to its excellent dynamic performance and high control accuracy the device can precisely follow a predefined duty cycle to expose the device under test to a real operating condition e.g. a cold-start of an engine. A wide voltage range, low ripple level and excellent EMC characteristics allow operating and testing of different units under test in highly sensitive environments.

The Basic Safety Concept facilitates the integration with the interlock circuit of the testbed.

The integrated safety relay (ISR) interrupts the flow of energy between the mains connection and the DC connection in the power supply completely in the case of an emergency stop and can be integrated into an additional safety circuit. Additionally adjustable monitoring limits are linked with the safety system of the E-STORAGE LV.

Equipped with the advanced AVL Battery Models, the E-STORAGE LV can accurately emulate a real battery supplying the device under test with a voltage that depends on multiple input parameters.

The E-STORAGE LV is fully compatible with AVL’s engine and vehicle test systems allowing an easy integration into existing testbeds, but can be also operated as a stand-alone application. Excellent EMC characteristics with lower noise levels enable applying sensitive measurement sensors in close proximity. Thanks to a protection class up to IP54 the system can be placed in a test cell without additional protection.
Despite many years of work on optimizing the diesel engine, advanced commercial vehicles only use about 45 percent of the consumed fuel energy for actually driving the vehicle. One of the approaches adopted to enhance overall efficiency involves recovering waste heat, a technology that can lower fuel consumption by 3 to 5 percent.

Waste heat recovery (WHR) technology, based on the Rankine cycle, is proving to be a promising method to recover heat. The circulation process involves overheating and evaporating a working fluid which is then passed into an expansion device, and finally through a condenser where it is re-condensed. The mechanical energy recovered in the expander can be used either mechanically or electrically.

WHR TECHNOLOGY CLOSE TO SERIES MATURITY

In several research programs, AVL has brought the WHR technology close to series maturity and has gained unequalled expertise in the field. Various system specifications were developed and tested in hardware. In these programs, the technology was shown to reduce fuel consumption in heavy-duty vehicles in real driving operation by around 3-5 percent, depending on the application, achieving a significant improvement in the truck’s fuel economy. At the AVL International Commercial Powertrain Conference in 2015, AVL presented a WHR truck that was developed in cooperation with IVECO and will now be starting on-road operation for the further optimization of the WHR system.

SYSTEM LAYOUT AND OPTIMIZATION

AVL has developed a specific methodology to obtain a detailed analysis of the thermodynamic cycle (Organic Rankine cycle, ORC) and for establishing the necessary component specifications and boundary conditions. The accurate representation of the fuel consumption advantage and the overall system’s behavior in real driving at a very early phase of the development process necessitates the reproduction of all of the relationships and dependencies in the vehicle subsystems in close detail. Accordingly, the individual energy flows present in the truck (of a mechanical, thermal, hydraulic or electric nature) have...
to be simulated and the interactions reproduced. To this end, AVL has built a complete vehicle system model, consisting of the main model components of the engine, the auxiliary units, the powertrain, the ORC and the vehicle cooling system. This overall model is directly linked to the control logic, so that optimal control algorithms can be developed based on the model.

Given the extensive analyses and tests that AVL has carried out on a variety of WHR system specifications, AVL can draw on a comprehensive library of parameterized and validated (sub) system models. These models allow engineers to make fast and reliable statements on the efficiency of different WHR concepts in real driving and optimize the complete system for each respective application case. This simulation-based development methodology is the only way to achieve such a high degree of optimization in a system of this complexity. Conventional hardware development of single components and subsequent development of the complete system on the test bed or in the vehicle are not suited.

INTELLIGENT CONTROL

One of the key components of safe, robust and efficient WHR system operation is the operating strategy and the control logic to which it is mapped. Over recent years, AVL has developed a model-based closed-loop control system that can be used for a variety of WHR concepts and specifications. The AVL WHR control technology enables optimum operation with maximum WHR efficiency, system security and coverage of dynamic vehicle conditions. These control algorithms are implemented in a rapid prototyping control unit to enable WHR operation on the engine test bed and in the vehicle.

RELIABLE SAFETY CONCEPT

One critical aspect, particularly when ethanol is chosen as a working fluid, is having a reliable and comprehensive safety concept in place. Based on a detailed hazard analysis, AVL has developed hardware and software measures over the last years that permit the safe operation of ethanol as WHR working fluid, both on the engine test bed and in vehicles on public roads. Aside from functional safety, a sophisticated safety concept is additionally of crucial significance in view of minimal product costs, maximum system efficiency and durability of WHR components.

TESTING AND VALIDATION

A further challenge for the integration of the WHR technology is the present lack of experience in the entire industry as to how these systems behave with regard to durability and reliability of the components and subsystems. Based on the AVL Load Matrix methodology, AVL has created corresponding test and validation plans. They are based on the possible combinations of components and damage types that are systematically analyzed and evaluated. This ensures that on the one hand the necessary reliability and durability objectives are achieved and, on the other, that the required testing measures are reduced to a minimum.

EXTENSIVE WHR EXPERTISE FOR DIFFERENT MARKETS

Not least due to the use of its tools and WHR methodology, AVL has also assumed a leading role in the development and integration of these complex systems. The comprehensive experience so far gained can now be put to use in a variety of applications – on-road, off-road and steady-state applications. The specialists at AVL can design the system best suited for any of these applications and develop it to series maturity.

One of AVL’s most recent WHR projects is the development of a near-series WHR system in cooperation with CNH INDUSTRIAL for a truck for long distances that is also going to be made available at AVL in an IVECO STRALIS demonstrator vehicle. Right now, a transient optimization is being carried out on the engine test bed, then the on-road vehicle tests will follow.
GLOBAL SPARE PARTS MANAGEMENT AT AVL

AVL’s ability to supply its customers quickly and reliably with spare parts of the highest quality is based on a sophisticated global spare parts concept. A global logistics network paired with a modern spare parts online store enables safe and timely delivery of spare parts for measuring equipment and test systems from AVL.

The fast provision of spare parts reduces downtimes of equipment and test systems to a minimum and ensures high system availability.

Maximized uptime of measuring equipment and test systems is nowadays one of the key demands customers place on AVL. To meet this demand, it is crucial to ensure reliable and prompt spare parts supply. AVL offers its customers diverse, tailor-made availability concepts for spare parts supply. Its portfolio ranges from consignment stocks at customer sites, enabling spare parts availability of just a few minutes or hours, to regional central warehouses for delivery in a matter of 24 to 48 hours and distribution centers that make a substantial amount of spare parts available any time they are needed.

AVL customers also have the option of ordering spare parts from the online store (shop.avl.com) 24 hours a day, seven days a week. In the course of the order process, customers instantly receive information about availability, delivery time and prices. Should customers prefer an order method other than the online option, they can also place their order with any AVL affiliate worldwide. In addition to its central spare parts warehouse in Graz, AVL operates regional spare parts warehouses in Japan, China, Korea and the U.S. and, since 2014, also in India. Most of these regional warehouses are run in cooperation with established local partners to ensure a high standard of service.

DYNAMIC STOCK MANAGEMENT

All of the regional spare parts warehouses are managed and operated centrally from the AVL headquarters in Graz, Austria. AVL currently has an overall portfolio of around 8,000 different spare parts, so it can respond as quickly as possible to all customer needs. Globally standardized processes permit dynamic adaption of
FOCUS

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stocks to meet the specified needs and installed systems in the region. With its central spare parts warehouse in Graz, AVL supplies the entire European market and can guarantee overnight delivery across the EU. Provided that the online order reaches AVL by 3:00 p.m. CET the previous day, AVL ensures delivery of the required spare parts across the EU by 10:00 a.m. the next day, the latest.

NEW INTEGRATED AVL LOGISTICS SOLUTION IN INDIA

The latest AVL spare parts warehouse to be established is located in Sri City, a free trade zone in the State of Andhra Pradesh near Chennai. The warehouse is operated in cooperation with MIMCO DFS India of Fair-macs group, one of the largest logistics services providers on the Indian subcontinent sourced through Vidhaatri Technologies Private Limited, Bangalore. AVL customers in India wishing to benefit from this integrated logistics solution have the option of receiving spare parts in South India within at least 24 hours and, in other regions in India, between 48 and 60 hours. “On account of the country’s size, its geographical position and level of infrastructure development, logistics tasks in India present a particular challenge. Tasks like these could not be solved without having a high-quality, reliable and functioning partner network,” points out Christoph Papst, Global Business Segment Manager for AVL Customer Services. AVL also supplies to customers in Southeast Asian countries, such as Malaysia, Vietnam and Indonesia, from the duty-free bonded warehouse in Chennai within a period of 24 to 48 hours.

For the Chinese market, AVL operates a central spare parts warehouse similar to the one in India in a duty-free area in Beijing, allowing it to directly cover about 75 percent of the spare parts requirements in China. On top of that, AVL operates other regional warehouses in Asia in Japan (Tokyo) and Korea (Seoul). The North American market is supplied via a spare parts warehouse in Plymouth, Michigan. In the U.S., AVL is planning to open another warehouse on the West Coast (California) in the near future to satisfy the growing demands of customers located in this region.

HIGH AVAILABILITY ASSURED

When it comes to global spare parts supply, AVL relies on a global, integrated logistics system. In some markets AVL cooperates with local partners to assure its customers the delivery of spare parts with as little delay as possible. The fast provisioning of spare parts reduces downtimes of equipment and test systems to a minimum and ensures high system availability. “As a result, AVL’s global spare parts management, as part of Customer Services, contributes significantly toward helping customers generate maximum benefit from their investment in measuring equipment and test systems from AVL,” adds Christoph Papst.

“AVL’S GLOBAL SPARE PARTS MANAGEMENT CONTRIBUTES SIGNIFICANTLY TOWARD HELPING CUSTOMERS GENERATE MAXIMUM BENEFIT FROM THEIR INVESTMENT”

CHRISTOPH PAPST
The Technology and Environment Center (TUZ) of TÜV Hessen in Pfungstadt, which is equipped with AVL technology, receives TRIAS accreditation for the certification of vehicles for the Japanese market.

The AVL vehicle chassis dynamometer, along with the corresponding AVL emission measuring systems, was recently audited by the Japanese National Traffic Safety Environmental Laboratory (NTSEL). As a result, TÜV Hessen has obtained official approval to certify passenger cars and light-duty trucks in accordance with the Japanese TRIAS (test requirements and instructions for automobile standards) legislation.

Christof Gietzelt, Head of Automotive at TÜV Hessen, sums up the advantages for TUZ customers: “We are now able to offer our customers this additional service and carry out all the tests required for the Japanese market and even generate the necessary documents. The collaboration with AVL was very satisfactory; it was a brilliant achievement. We managed to jointly review and optimize everything in a matter of a year and coordinate it all with our Japanese partners.”

For AVL the successful audit is an important milestone too, points out Christoph Weidinger, Application Manager at AVL: “This forms official confirmation that AVL has the high levels of expertise and experience needed to build the type of certification testbed with the appropriate equipment, which is shown to satisfy the technical requirements for the Japanese market. The accreditation of this testbed at the TUZ is another major reference for AVL, with a view to equipping further testbeds of this kind worldwide, which are designed for the specific requirements of the different emission legislations.”

This certification is a prerequisite for exporting vehicles to the Japanese market, as it proves compliance with the current exhaust emissions regulations in Japan. “The Japanese authorities only accept tests that were run on their own testbeds or at accredited technical service agencies. So TÜV Hessen (with the TUZ) is an approved third party,” Christoph Gietzelt explains, adding, “We’re planning an expansion to include hybrid and electric vehicles, and we’ll be focusing on these topics in the near future.”

Konrad Hinterhofer, CEO of AVL Emission Test Systems, sums up the successful project: “The particular challenge in this project, beside the certification criteria for Japan and Europe, was to provide a very flexible system. With this system, we can test, for example, the effects of the individual driving behavior on the exhaust emissions or on fuel consumption and many other matters.”
Calibration engineers just got a head-start.
The introduction of the EU6c legislation in 2017 will require compliance with emission limits also under real driving conditions. The AVL M.O.V.E iS system represents an accurate and reliable solution for RDE testing, specifically designed for mobile operation mounted on passenger cars.

- Execution and evaluation of RDE tests in compliance with legislative requirements
- Accurate and reliable acquisition of RDE data
- Quick and easy installation inside or outside of the car
- Robust design combined with lowest maintenance effort

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